

## УСПЕХИ ФИЗИЧЕСКИХ НАУК

### ТАБЛИЦА АТОМНЫХ ЯДЕР

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Ввиду того, что таблицы ядерных констант, изданные в справочниках, сравнительно быстро устаревают, представляется целесообразным периодическое публикование новых данных. Настоящая таблица в связи с ограниченностью места в журнале не может дублировать большие справочные монографии, в которых даётся полная библиография. Поэтому в ней даются ссылки только на работы, опубликованные за последний год.

Сводку различных значений и полную библиографию можно найти в справочных монографиях по физике атомного ядра (G. T. Seaborg and I. Perlman, *Reviews of Modern Physics* **20** № 4 (1948). I. Mattauch und A. Flammersfeld, *Isotopenbericht*, Verlag der Zeitschrift für Naturforschung, Tübingen, 1949).

Настоящая таблица даёт полный перечень всех стабильных и радиоактивных изотопов и сводку их важнейших свойств по данным, опубликованным до 1 января 1950 г.

В первом столбце даётся атомный номер.

Во втором столбце приведены стабильные изотопы элементов с  $Z < 84$ ; в третьем столбце —  $\beta$ -радиоактивные ядра (мы включаем в это понятие как  $\beta^-$  и  $\beta^+$ -активные ядра, так и ядра, захватывающие атомные электроны) и ядерные изомеры как стабильных, так и радиоактивных ядер.

После висмута ( $Z > 83$ ) нет стабильных ядер: все ядра либо  $\alpha$ -, либо  $\beta$ -радиоактивны.

В этой области разделение ядер между вторым и третьим столбцами произведено по новому принципу: во второй столбец помещены те  $\alpha$ -радиоактивные ядра, для которых, исходя из закономерности построения плеяд, нельзя ожидать никаких  $\beta$ -процессов.

В третий столбец помещены остальные ядра независимо от того, обнаружен ли для них на опыте  $\beta$ -распад или пока известен только  $\alpha$ -распад.

В скобках помещены массовые числа изотопов, если они недостоверны или если возможно одно из двух указанных значений. Когда недостоверен элемент или сомнителен изотоп, то весь символ ядра помещён в скобках. Кружком с точкой  $\bigcirc$  отмечены изомерные ядра.

В четвёртом столбце дана относительная распространённость изотопов в процентах к общему числу всех атомов данного элемента.

В пятом столбце приведены периоды полураспада. Буквы у цифр обозначают: г и л — годы и лета, д — дни, ч — часы, м — минуты, с — секунды, мкс — микросекунды.

В шестом столбце приводится тип превращения ядра со следующими обозначениями:

$\alpha$  — альфа-распад ядра,

$\beta^-$  — превращение с испусканием отрицательно заряженного электрона,

$\beta^+$  — испускание позитрона (положительного электрона),

$K$  — превращение с захватом электрона из  $K$ -оболочки атома,

$L$  — превращение с захватом электрона из  $L$ -оболочки атома,

$I$  — изомерный переход (переход из верхнего энергетического состояния в нижнее),

$2\beta^-$  — испускание одновременно двух электронов.

В тех случаях, когда испускание нейтронов следует за  $\beta$ -распадом, мы поместили сведения о нейтронах в одну строчку с  $\beta$ -распадом; хотя в действительности нейтрон испускается ядром-продуктом  $\beta$ -распада, но приято говорить о «запаздывающих нейтронах», приписывая им период распада родителя.

В тех случаях, когда имеется больше одного типа превращения и ядро может альтернативно распадаться тем или иным способом, соответствующие обозначения типов распада отделены запятой.

В седьмом столбце даны энергии  $\alpha$ - и  $\beta$ -частиц. У  $\alpha$ -радиоактивных изотопов приведены значения энергии и (в скобках) относительные интенсивности отдельных групп. Для  $\beta$ -частиц, кроме граничной энергии, указывается в процентах, в тех случаях, когда это возможно, доля от всех  $\beta$ -частиц, которую составляет данная группа. (Отметим, что эта величина не есть доля всех распадов; последнюю величину в большинстве случаев  $\beta^+$ -распадов оценить нельзя до тех пор, пока не исследован  $K$ -захват.)

В восьмом столбце указаны значения энергии  $\gamma$ -квантов или соответствующие разности уровней в тех случаях, когда  $\gamma$ -лучи

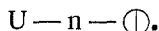
полностью конвертируют. Кроме энергии  $\gamma$ -лучей, в тех случаях, когда это возможно, указано в процентах число квантов на один распад. В тех случаях, когда известны только относительные интенсивности  $\gamma$ -линий, но неизвестно их участие в распаде, соответствующие значения даны в скобках без значка %. Гамма-лучи аннигиляции не отмечаются. Для периодов полураспада и величины энергии  $\alpha$ - и  $\beta$ -частиц и  $\gamma$ -квантов приведено, как правило, одно наиболее достоверное значение. В тех случаях, когда значения, полученные различными авторами, приблизительно равноценны и более вероятного указать нельзя, указано среднее значение, отмеченное звездочкой (\*). Сомнительные данные заключены в круглые скобки.

В последнем, девятом, столбце помещены ядерные реакции, по которым получается радиоактивное ядро. Реакции пишутся в следующей последовательности: исходное ядро, действующая частица и получающаяся частица (или частицы). Частицы обозначаются:  $\alpha$  — альфа-частица,  $t$  — тритон,  $d$  — дейтерон,  $p$  — протон,  $n$  — нейтрон,  $\gamma$  — гамма-лучи,  $x$  — рентгеновские лучи. Деление ядра обозначается перечёркнутым кружком  $\odot$ .

Когда ядро (напр.  $\text{Te}^{133}$ ) образуется из другого ядра, полученного в результате деления, реакция пишется следующим образом:



а для ядра (напр.  $\text{Sb}^{133}$ ), являющегося первоначальным продуктом деления реакция пишется так:



В тех случаях, когда ядро получается в результате цепи последовательных радиоактивных превращений, указываются только начальное ядро и ядро, предшествующее данному. Промежуточные радиоактивные ядра не указываются.

В реакциях с вылетом большого числа протонов и нейтронов эти частицы помещены в квадратных скобках, так как в этом случае возможны также вылет сложных частиц ( $\alpha$ ,  $d$  и др.) и промежуточные радиоактивные превращения.

Когда достоверно неизвестно, из какого исходного ядра получается радиоактивный изотоп, соответствующее массовое число исходного ядра помещено в скобках. Если недостоверно число вылетающих частиц или тип реакции, тоже применяются круглые скобки или знак вопроса.

Данные, полученные в 1949 г., приведены полностью. Последующего значения в квадратных скобках указана ссылка на литературу.

Литература, в соответствии с общепринятым (для аналогичных таблиц) обозначением, дана в алфавитном порядке (по первой букве).

ТАБЛИЦА АТОМНЫХ ЯДЕР

| Атомный<br>номер | Стабильное<br>ядро                 | Радиоактив.<br>ядро                | Распростра-<br>нённость<br>в %          | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния   | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                      |
|------------------|------------------------------------|------------------------------------|-----------------------------------------|----------------------------|---------------------------|----------------------------------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                  | 3                                  | 4                                       | 5                          | 6                         | 7                                                              | 8                                   | 9                                                                                                                                                                                                    |
| 1                | H <sup>1</sup><br>H <sup>2</sup>   | H <sup>3</sup>                     | 99.9844<br>0.0156                       | 12.46 г<br>[J3]            | $\beta^-$                 | 0.0179 [C2]<br>[G7, C13]<br>[B8, H10]                          | нет $\gamma$ [C2]                   | H <sup>2</sup> -d-p [R8]; Li <sup>6</sup> -n- $\alpha$ ;<br>Be <sup>9</sup> -d-Be <sup>8</sup> ; He <sup>3</sup> -n-p [I3, F6];<br>H <sup>2</sup> -n- $\gamma$ ; B-n-Be; N-n-C                       |
| 2                | He <sup>3</sup><br>He <sup>4</sup> | He <sup>5</sup><br>He <sup>6</sup> | $1.3 \times 10^{-4}$<br>[C4]<br>99.9999 | $< 10^{-8}$ с<br>0.85 с    | $\alpha + n$<br>$\beta^-$ | 3.6                                                            | нет $\gamma$                        | Li <sup>7</sup> -d- $\alpha$ ; He <sup>4</sup> -d-p<br>Be <sup>9</sup> -n- $\alpha$ ; Li <sup>6</sup> -n-p; Li <sup>7</sup> - $\gamma$ -p                                                            |
| 3                | Li <sup>6</sup><br>Li <sup>7</sup> | Li <sup>8</sup>                    | 7.30<br>92.70                           | 0.89 с                     | $\beta^-$ , 2 $\alpha$    | 12.7                                                           | нет $\gamma$                        | Li <sup>7</sup> -d-p [S32]; B <sup>11</sup> -n- $\alpha$ ; Li <sup>7</sup> -n- $\gamma$ ;<br>Be <sup>9</sup> - $\gamma$ -p; C-d; N-d; Ne-d;<br>Kr-d; Xe-d; C-p; N-p; Ne-p;<br>Ar-p; Kr-p; Xe-p [W21] |

|   |                                    |                  |                  |                                           |                   |                               |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---|------------------------------------|------------------|------------------|-------------------------------------------|-------------------|-------------------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4 |                                    | Be <sup>7</sup>  |                  | $52.9 \pm \pm 0.2$ д [S1]                 | $K, \gamma$       |                               | 0.47 *                         | Li <sup>6</sup> -p- $\gamma$ ; Li <sup>7</sup> -p-n [B7, S21, W14];<br>B <sup>10</sup> -p- $\alpha$ [C11]; Li <sup>6</sup> -d-n [M27]                                                                                                                                                                                                                                                                                                                     |
|   |                                    | Be <sup>8</sup>  |                  | <1 с                                      | 2 $\alpha$        | 0.055                         |                                | B <sup>11</sup> -d- $\alpha$ , n; Be <sup>9</sup> -p-d [T2];<br>B <sup>11</sup> -p- $\alpha$ ; Li <sup>7</sup> -p- $\gamma$ ; Li <sup>7</sup> -d-n;<br>B <sup>10</sup> -d- $\alpha$ ; Be <sup>9</sup> -e <sup>-</sup> -e <sup>-</sup> , n; Be <sup>9</sup> - $\gamma$ -n<br>[M6]; Li <sup>8</sup> (0.89 с) $\beta^-$ ;<br>Be <sup>9</sup> -n-2n; Be <sup>9</sup> -d-t; C <sup>12</sup> - $\gamma$ - $\alpha$                                              |
|   | Be <sup>9</sup>                    | Be <sup>10</sup> | 100              | $(2.7 \pm 0.4) \times \times 10^6$ л [H3] | $\beta^-$         | 0.56 * [H3, H5, F8, W19, B23] | нет $\gamma$ [H3]              | Be <sup>9</sup> -n- $\gamma$ ; Be <sup>9</sup> -d-p; B <sup>10</sup> -n-p;<br>C <sup>13</sup> -n- $\alpha$                                                                                                                                                                                                                                                                                                                                                |
| 5 | B <sup>10</sup>                    | B <sup>9</sup>   | $18.83 \pm 0.02$ | оч. мал.                                  | 2 $\alpha$ + p    |                               |                                | Li <sup>6</sup> - $\alpha$ -n; Be <sup>9</sup> -p-n [B33a]                                                                                                                                                                                                                                                                                                                                                                                                |
|   | B <sup>11</sup>                    | B <sup>12</sup>  | $81.17 \pm 0.02$ | $0.027 \pm \pm 0.002$ с                   | $\beta^-$         | 13.43                         | нет или<br>мало $\gamma$ [H24] | N <sup>15</sup> -n- $\alpha$ ; C <sup>12</sup> -n-p; B <sup>11</sup> -d-p [H24]                                                                                                                                                                                                                                                                                                                                                                           |
| 6 |                                    | C <sup>10</sup>  |                  | $19.1 \pm 0.8$ с [S2]                     | $\beta^+, \gamma$ | 2.2 [S2]                      | 1.0                            | C <sup>12</sup> - $\gamma$ -2n; B <sup>10</sup> -p-n                                                                                                                                                                                                                                                                                                                                                                                                      |
|   |                                    | C <sup>11</sup>  |                  | $20.42 \pm \pm 0.06$ м                    | $\beta^+$         | 0.98                          | нет $\gamma$ [86]              | B <sup>11</sup> -p-n; B <sup>10</sup> -p- $\gamma$ ; N <sup>14</sup> -p- $\alpha$ ;<br>B <sup>10</sup> -d-n; N <sup>14</sup> -n-p, 3n; O <sup>16</sup> -n- $\alpha$ , 2n;<br>C <sup>12</sup> -n-2n [H20]; C <sup>12</sup> - $\gamma$ -n;<br>N <sup>14</sup> - $\gamma$ - (p, 2n); O <sup>16</sup> - $\gamma$ - (2p, 3n) ?; C <sup>12</sup> -p-p, n; C <sup>12</sup> -d-d, n;<br>C <sup>12</sup> - $\alpha$ - $\alpha$ , n; Be <sup>9</sup> - $\alpha$ -2n |
|   | C <sup>12</sup><br>C <sup>13</sup> | C <sup>14</sup>  | 98.9<br>1.1      | 5700 л [E4, J6]                           | $\beta^-$         | 0.1563<br>0.155 [F2]          | нет $\gamma$                   | C <sup>13</sup> -n- $\gamma$ ; O <sup>17</sup> -n- $\alpha$ ; N <sup>14</sup> -n-p; [F6];<br>B <sup>11</sup> - $\alpha$ -p [C18]; C <sup>13</sup> -d-p                                                                                                                                                                                                                                                                                                    |

| Атомный номер | Стабильное ядро                  | Радиоактив. ядро                             | Распространённость в %   | Период полураспада                                                                                                      | Тип превращения                                             | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                                             | Энергия $\gamma$ -лучей в Мэв              | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------|----------------------------------|----------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                | 3                                            | 4                        | 5                                                                                                                       | 6                                                           | 7                                                                                                 | 8                                          | 9                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 7             | $N^{14}$<br>$N^{15}$             | $N^{12}$<br>$N^{13}$<br>$N^{16}$<br>$N^{17}$ | 99.62<br>0.38            | $0.0125 \pm \pm 0.0010$ с [A4]<br>$10.0 \pm 0.1^*$ м<br>$7.35 \pm 0.05$ с<br>$4.14 \pm 0.04$ с<br>$4.5 \pm 0.1$ с [C16] | $\beta^+$<br>$\beta^+$<br>$\beta^-, \gamma$<br>$\beta^-, n$ | 16.6 [A4]<br>1.21*<br>3.8 (40%),<br>4.3 (42%),<br>10.3 (18%)<br>3.7 ( $\beta^-$ )<br>1.6 (n) [H9] | нет $\gamma$<br>4; 5; 6.2;<br>6.7; 7 [M31] | $C^{12}$ -p-n [A4]<br>$C^{12}$ -p- $\gamma$ [W11]; $B^{10}$ - $\alpha$ -n [B15, 16]; $C^{12}$ -d-n; $N^{14}$ -n-2n; $N^{14}$ -d-t; $N^{14}$ - $\gamma$ -n; $O^{16}$ -n-p,3n; $F^{19}$ -n-2p,5n; $C^{12}$ -p-n<br>$N^{15}$ -n- $\gamma$ ; $N^{15}$ -d-p; $F^{19}$ -n- $\alpha$ ; $O^{16}$ -n-p [M31]<br>$C^{14}$ - $\alpha$ -p [S7]; $F^{19}$ -d-3p,n [A1]; $F^{19}$ -p-3p [A1]; Na-d; Mg-d; Al-d; Si-d; P-d; S-d; Cl-d; K-d |
| 8             | $O^{16}$<br>$O^{17}$<br>$O^{18}$ | $O^{(14)}$<br>$O^{15}$<br>$C^{19}$           | 99.757<br>0.039<br>0.204 | $76 \pm 2$ с [S2]<br>$118 \pm 1$ с [B6, P11]<br>$27.0 \pm 0.5$ с                                                        | $\beta^+, \gamma$<br>$\beta^+$<br>$\beta^-, \gamma$         | 1.8 [S2]<br>1.683 [P11]<br>4.5 (30%)<br>2.9 (70%)                                                 | 2.3 [S2]<br>1.6                            | $N^{14}$ -p-n<br>$C^{12}$ - $\alpha$ -n; $N^{14}$ -p- $\gamma$ [W11]; $N^{14}$ -d-n [B6]; $O^{16}$ -n-2n; $O^{16}$ - $\gamma$ -n; $F^{19}$ -n-p,4n<br>$F^{19}$ -n-p; $O^{18}$ -n- $\gamma$                                                                                                                                                                                                                                  |

|    |                                                          |                  |                                            |                      |                      |                                    |                                            |       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----|----------------------------------------------------------|------------------|--------------------------------------------|----------------------|----------------------|------------------------------------|--------------------------------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9  |                                                          | F <sup>17</sup>  |                                            | 66 ± 1 c [B6]        | $\beta^+$            | 2.1                                |                                            | (1.4) | N <sup>14</sup> - $\alpha$ -n; O <sup>16</sup> -p- $\gamma$ ; O <sup>16</sup> -d-n [B6];<br>F <sup>19</sup> - $\gamma$ -2n; F <sup>19</sup> -n-3n<br>O <sup>18</sup> -p-n [B19, B33a, B38];<br>Ne <sup>20</sup> -d- $\alpha$ ; O <sup>17</sup> -d-n; F <sup>19</sup> -n-2n<br>[F3]; F <sup>19</sup> -d-t; F <sup>19</sup> - $\gamma$ -n;<br>Na <sup>23</sup> - $\gamma$ $\alpha$ , n; O <sup>16</sup> - $\alpha$ -p, n;<br>O <sup>16</sup> -t-n<br>F <sup>19</sup> -n- $\gamma$ ; F <sup>19</sup> -d-p; Na <sup>23</sup> -n- $\alpha$ |
|    |                                                          | F <sup>18</sup>  |                                            | 107 ± 5 м            | $\beta^+$ , K        | 0.635 [B19]                        |                                            |       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|    | F <sup>19</sup>                                          | F <sup>20</sup>  | 100                                        | 12 ± 2 c             | $\beta^-$ , $\gamma$ | 5.0                                | 2.2                                        |       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 10 | Ne <sup>20</sup><br>Ne <sup>21</sup><br>Ne <sup>22</sup> | Ne <sup>19</sup> | 90.51 ± 0.15<br>0.28 ± 0.02<br>9.21 ± 0.18 | 18.2 ± 5.6 c<br>[S2] | $\beta^+$            | 2.3 [S2]                           |                                            |       | F <sup>19</sup> -p-n [S2]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|    |                                                          | Ne <sup>23</sup> |                                            | 40 ± 1 c [B6]        | $\beta^-$            | 4.2*                               |                                            |       | Na <sup>23</sup> -n-p; Mg <sup>26</sup> -n- $\alpha$ ;<br>Ne <sup>22</sup> -d-p [B6]                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 11 | Na <sup>23</sup>                                         | Na <sup>21</sup> |                                            | 23 ± 2 c             | $\beta^+$            | (2.56)                             |                                            |       | Mg <sup>24</sup> -p- $\alpha$ ; Ne <sup>20</sup> -p- $\gamma$ ; Ne <sup>21</sup> -p-n;<br>Ne <sup>20</sup> -d-n                                                                                                                                                                                                                                                                                                                                                                                                                       |
|    |                                                          | Na <sup>22</sup> |                                            | 2.6 r                | $\beta^+$ , $\gamma$ | 0.575<br>1.7 (0.004%)<br>[M29]     | 1.277 [A6]                                 |       | F <sup>19</sup> - $\alpha$ -n; Mg <sup>24</sup> -d- $\alpha$ ; Ne <sup>21</sup> -d-n;<br>Ne <sup>21</sup> -p- $\gamma$ ; Ne <sup>22</sup> -p-n; Na <sup>23</sup> -n-2n;<br>Al <sup>27</sup> -d-3p, 4n Al <sup>27</sup> - $\alpha$ -4p, 5n                                                                                                                                                                                                                                                                                             |
|    |                                                          | Na <sup>24</sup> | 100                                        | 14.8 ч               | $\beta^-$ , $\gamma$ | 1.39                               | (1.0); 1.380;<br>(2.0); 2.765;<br>3.1 [R2] |       | Na <sup>23</sup> -n- $\gamma$ ; Mg <sup>24</sup> -n-p; Al <sup>27</sup> -n- $\alpha$ ;<br>Na <sup>23</sup> -d-p; Mg <sup>26</sup> -d- $\alpha$ ;<br>Al <sup>27</sup> -d-p, $\alpha$ [H8]; Mg <sup>25</sup> - $\gamma$ -p;<br>Al <sup>27</sup> - $\gamma$ -2p, n; Si <sup>28</sup> - $\gamma$ -3p, n;<br>Al <sup>27</sup> - $\alpha$ -4p, 3n                                                                                                                                                                                           |
|    |                                                          | Na <sup>25</sup> |                                            | 58.2 ± 1.35 c        | $\beta^-$            | 2.7 (45%)<br>3.7 (55%)<br>2.8 [M6] |                                            |       | Al <sup>27</sup> - $\gamma$ -2p; Mg <sup>26</sup> - $\gamma$ -p; Mg <sup>25</sup> -n-p                                                                                                                                                                                                                                                                                                                                                                                                                                                |

| Атомный номер | Стабильное ядро                     | Радиоактивн. ядро                                        | Распространенность в %                                    | Период полураспада                                                           | Тип превращения                                                  | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв              | Энергия $\gamma$ -лучей в Мэв                        | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                |
|---------------|-------------------------------------|----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                   | 3                                                        | 4                                                         | 5                                                                            | 6                                                                | 7                                                                  | 8                                                    | 9                                                                                                                                                                                                                                                                                                                                                                              |
| 12            | $Mg^{24}$<br>$Mg^{25}$<br>$Mg^{26}$ | $Mg^{23}$<br><br>$Mg^{27}$                               | $78.60 \pm 0.13$<br>$10.11 \pm 0.05$<br>$11.29 \pm 0.008$ | $11.9 \pm 0.3$ с<br><br>$9.7 \pm 0.3$ * м                                    | $\beta^+$<br><br>$\beta^-, \gamma$                               | 2.82<br><br>0.79 (20%);<br>1.80 (80%)                              | <br><br>0.64; 0.85 *;<br>1.03 *; 1.3                 | $Na^{23}$ -p-n; $Mg^{24}$ - $\gamma$ -n [M6]<br><br>$Mg^{26}$ -d-p; $Mg^{26}$ -n- $\gamma$ ;<br>$Al^{27}$ -n-p [B4]                                                                                                                                                                                                                                                            |
| 13            | $Al^{27}$                           | $Al^{25}$<br>$Al^{26}$<br><br>$Al^{28}$<br><br>$Al^{29}$ | <br><br><br>100                                           | 7.3 с<br>$6.56 \pm 0.06$ с<br><br>$2.30 \pm 0.03$ м<br><br>$6.56 \pm 0.06$ м | $\beta^+$<br>$\beta^+$<br><br>$\beta^-, \gamma$<br><br>$\beta^-$ | 2.99 ?<br>2.99<br><br>3.05<br><br>1.4 (25%);<br>2.5 (75%)<br>[S20] | <br><br><br>1.81*; (2.2*)<br><br>1.25; 1.35<br>[S20] | $Mg^{25}$ -p-n<br>$Al^{27}$ - $\gamma$ -n [M6]; $Na^{23}$ - $\alpha$ -n;<br>$Mg^{25}$ -p- $\gamma$ ; $Mg^{26}$ -p-n; $Mg^{25}$ -d-n<br><br>$Al^{27}$ -n- $\gamma$ ; $Si^{28}$ -n-p; $P^{31}$ -n- $\alpha$ ;<br>$Al^{27}$ -d-p; $Mg^{26}$ - $\alpha$ -p; $Si^{30}$ - $\gamma$ -p<br>$Mg^{26}$ - $\alpha$ -p; $Si^{30}$ -n-p; $Si^{30}$ - $\gamma$ -p<br>$P^{31}$ - $\gamma$ -2p |
| 14            | $Si^{28}$<br>$Si^{29}$<br>$Si^{30}$ | $Si^{27}$<br><br><br><br>$Si^{31}$                       | $92.16 \pm 0.06$<br>$4.71 \pm 0.08$<br>$3.13 \pm 0.04$    | $4.92 \pm 0.1$ с<br><br><br><br>2.7* ч                                       | $\beta^+$<br><br><br><br>$\beta^-$                               | 3.64*<br><br><br><br>1.80                                          | <br><br><br><br>нет $\gamma$                         | $Si^{28}$ - $\gamma$ -n [M6]; $Al^{27}$ -p-n;<br>$Mg^{24}$ - $\alpha$ -n<br><br><br>$Si^{30}$ -n- $\gamma$ ; $P^{31}$ -n-p [B4]; $S^{34}$ -n- $\alpha$ ;<br>$Si^{30}$ -d-p                                                                                                                                                                                                     |

|    |                                                                              |                                                                                      |                                    |                                                                                                               |                                                                                       |                                                                                                                                          |                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15 | P <sup>31</sup>                                                              | P <sup>39</sup><br>P <sup>80</sup><br><br>P <sup>83</sup><br><br>P <sup>84</sup>     | 100                                | $4.6 \pm 0.2$ с<br>$2.55 \pm \pm 0.05$ м                                                                      | $\beta^+$<br>$\beta^+$<br><br>$\beta^-$<br><br>$\beta^-, \gamma$                      | 3.63<br>3.6*<br><br>1.689<br>[L9]; 1.71<br>[W18]; 1.718<br>[S31]<br><br>3.2 (25%),<br>5.1 (75%)                                          | нет $\gamma$            | P <sup>31</sup> - $\gamma$ -2n; Si <sup>29</sup> -p-n; Si <sup>28</sup> -d-n<br>Si <sup>28</sup> -He <sup>3</sup> -p; Al <sup>27</sup> - $\alpha$ -n; S <sup>33</sup> -d- $\alpha$ ;<br>P <sup>31</sup> -n-2n; P <sup>31</sup> - $\gamma$ -n [M6];<br>Si <sup>30</sup> -p-n; Si <sup>29</sup> -d-n;<br>(S <sup>33</sup> -n-p, 2n) ?; P <sup>31</sup> -d-t [K5]<br><br>P <sup>31</sup> -d-p; P <sup>31</sup> -n- $\gamma$ ; S <sup>33</sup> -n-p;<br>Cl <sup>35</sup> -n- $\alpha$ ; Si <sup>29</sup> - $\alpha$ -p; S <sup>34</sup> -d- $\alpha$<br><br>Cl <sup>35</sup> -d-p; Cu <sup>(63,65)</sup> -d-[15p,<br>(16,18) n]; S <sup>34</sup> -n-p; Cl <sup>37</sup> -n- $\alpha$ |
| 16 | S <sup>32</sup><br>S <sup>33</sup><br>S <sup>34</sup><br><br>S <sup>36</sup> | S <sup>31</sup><br><br>S <sup>35</sup><br><br>S <sup>37</sup>                        | 95.06<br>0.74<br>4.18<br><br>0.014 | $3.18 \pm 0.04$ с<br><br>87 $\pm$ 1 д<br><br>$5.04 \pm 0.02$ м                                                | $\beta^+$<br><br>$\beta^-, \gamma$<br><br>$\beta, \gamma$                             | 3.85<br><br>0.1691;<br>0.1670 [P9a];<br>0.170 [S31]<br>1.6 (90%);<br>4.3 (10%)                                                           | 2.7*                    | S <sup>33</sup> -n-2n; P <sup>31</sup> -p-n; S <sup>33</sup> - $\gamma$ -n [M6];<br>Sj <sup>38</sup> - $\alpha$ -n<br><br>Cl <sup>37</sup> -d- $\alpha$ ; Cl <sup>35</sup> -n-p [W17]<br>S <sup>34</sup> -d-p; S <sup>34</sup> -n- $\gamma$<br><br>Cl <sup>37</sup> -n-p; S <sup>36</sup> -n- $\gamma$                                                                                                                                                                                                                                                                                                                                                                           |
| 17 | Cl <sup>35</sup><br><br>Cl <sup>37</sup>                                     | Cl <sup>33</sup><br>Cl <sup>34</sup><br><br>Cl <sup>36</sup><br><br>Cl <sup>33</sup> | 75.43<br><br>24.57                 | $2.4 \pm 0.2$ с<br>$33.2 \pm 0.5$ м<br><br>$(4.4 \pm 0.5) \times \times 10^5$ л [W16]<br><br>$38.5 \pm 0.5$ м | $\beta^+$<br>$\beta^+, \gamma$<br><br>$\beta^-, \text{нет } \beta^+$<br><br>$\beta^-$ | $4.13 \pm 0.07$<br>2.4 (20%),<br>5.1 (80%)<br><br>0.65* ( $\beta^-$ )<br><br>1.19 (36%),<br>2.79 (11%),<br>4.94 (53%),<br>см. след. стр. | 3.4<br><br>1.63*, 2.15* | S <sup>32</sup> -d-n; S <sup>33</sup> -p-n<br>P <sup>31</sup> - $\alpha$ -n; S <sup>33</sup> -d-n; Cl <sup>35</sup> -n-2n;<br>Cl <sup>35</sup> - $\gamma$ -n; S <sup>32</sup> -t-n; S <sup>32</sup> - $\alpha$ -p, n<br><br>Cl <sup>35</sup> -n- $\gamma$ ; Cl <sup>35</sup> -d-p<br><br>Cl <sup>37</sup> -n- $\gamma$ [L15]; K <sup>41</sup> -n- $\alpha$ ; Cl <sup>37</sup> -d-p;<br>Cu <sup>(63, 65)</sup> -d-[13p (14, 16) n];<br>Cu <sup>(63, 65)</sup> - $\alpha$ -[14p, (15, 17) n];<br>A <sup>40</sup> -d- $\alpha$                                                                                                                                                      |

| Атомный номер | Стабильное ядро | Радиоактивное ядро                    | Распространенность в % | Период полураспада                        | Тип превращения                   | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                | Энергия $\gamma$ -лучей в Мэв | Ядерные реакции                                                                                                                                                                             |
|---------------|-----------------|---------------------------------------|------------------------|-------------------------------------------|-----------------------------------|----------------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2               | 3                                     | 4                      | 5                                         | 6                                 | 7                                                                    | 8                             | 9                                                                                                                                                                                           |
|               |                 | Cl <sup>9</sup>                       |                        | 55.5 ± 0.2 м [H21]                        | $\beta^-$                         | 1.11 (30.8%),<br>2.77 (15.8%),<br>4.81 (53.4%)<br>[L15]<br>2.5 [H21] |                               | A <sup>40</sup> - $\gamma$ -p [H21]; S <sup>36</sup> $\alpha$ -p;<br>Cu <sup>(65)</sup> -d- [13 p 15 n];<br>Cu <sup>(65)</sup> - $\alpha$ -[14, 16 n];<br>As <sup>75</sup> -d- [17 p, 21 n] |
| 18            | A <sup>36</sup> | A <sup>35</sup><br>A <sup>37</sup>    | 0.307                  | 1.85 ± 0.04 с                             | $\beta^+$                         | 4.4*                                                                 |                               | S <sup>32</sup> - $\alpha$ -n; Cl <sup>35</sup> -p-n                                                                                                                                        |
|               | A <sup>38</sup> | A <sup>39</sup>                       | 0.061                  | 34.1 ± 1.3 д                              | K (92%)<br>L (8%) [P5]            |                                                                      | нет $\gamma$                  | Ca <sup>40</sup> -n- $\alpha$ ; K <sup>39</sup> -d- $\alpha$ , S <sup>34</sup> - $\alpha$ -n;<br>Cl <sup>37</sup> -d-2n; Cl <sup>37</sup> -p-n;<br>A <sup>36</sup> -d-p [D 16]              |
|               | A <sup>40</sup> | A <sup>41</sup>                       | 99.632                 | длин. [H21]<br>109 ± 1 м<br>107 ± 3 [B11] | $\beta^-$<br>$\beta$              | 1.245 [B11]                                                          | 1.4*                          | Cl <sup>39</sup> (55.5 м) $\beta^-$ [H 21]<br>K <sup>41</sup> -n-p; A <sup>40</sup> -n- $\gamma$ ; A <sup>40</sup> -d-p [B 11]                                                              |
| 19            | K <sup>39</sup> | (K <sup>37</sup> )<br>K <sup>38</sup> | 93.305                 | 1 3 ± 0.1 с<br>7.6 ± 0.1 * м              | $\beta^+$<br>$\beta^+$ , $\gamma$ | 2.5*                                                                 | 2.1*                          | K <sup>39</sup> - $\gamma$ -2n<br>Cl <sup>35</sup> - $\alpha$ -n; Ca <sup>40</sup> -d- $\alpha$ , K <sup>39</sup> -n-2n;<br>K <sup>39</sup> - $\gamma$ -n [M6]                              |

|    |           |                                                |                   |                                 |                                                   |                                  |                   |                                                                                                                                                                                |
|----|-----------|------------------------------------------------|-------------------|---------------------------------|---------------------------------------------------|----------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | $K^{41}$  | $K^{40}$                                       | 0.011             | $4.5 \pm 10^3$ л                | $\beta^-$ (60%),<br>$K$ (40%),<br>$\gamma$ [S 30] | 1.350;<br>1.45 [F5]<br>1.40 [A3] | 1.54 <sup>±</sup> | $K^{39}$ -d-p; $A^{40}$ -p-n; $K^{39}$ -n- $\gamma$ [H 18]                                                                                                                     |
|    |           | $K^{42}$                                       | 6.683             | $12.4 \pm 0.1$ ч                | $\beta^-$ , $\gamma$ [S30]                        | 2.07 (25%),<br>3.58 (75%)        | 1.51; 2.1         | $A^{40}$ - $\alpha$ -p, n; $K^{41}$ -n- $\gamma$ ; $Sc^{45}$ -n- $\alpha$ ;<br>$Ca^{42}$ -n-p; $K^{41}$ -d-p; $Ca^{44}$ -d- $\alpha$                                           |
|    |           | $K^{(43)}$<br>$K^{(43, 44)}$<br>$K^{(43, 44)}$ |                   | 22.4 ч<br>27 м<br>$18 \pm 1$ м  | $\beta^-$ , $\gamma$<br>$\beta^-$<br>$\beta^-$    | 0.24; 0.81                       | 0.4               | $A^{40}$ - $\alpha$ -p [O 1]<br>$Ca^{(43, 44)}$ -n-p<br>$Ca^{(43, 44)}$ -n-p                                                                                                   |
| 20 | $Ca^{40}$ | $Ca^{(39)}$                                    | $96.92 \pm 0.03$  | $1.06 \pm 0.03$ с               | $\beta^+$                                         |                                  |                   | $Ca^{40}$ - $\gamma$ -n [M 6]                                                                                                                                                  |
|    |           | $(Ca^{41})?$                                   |                   | —                               | $(K)$ [S 16]                                      |                                  |                   | $Sc^{41}$ (0.83 с) $\beta^+$                                                                                                                                                   |
|    | $Ca^{43}$ |                                                | $0.64 \pm 0.01$   |                                 |                                                   |                                  |                   |                                                                                                                                                                                |
|    | $Ca^{43}$ |                                                | $0.129 \pm 0.004$ |                                 |                                                   |                                  |                   |                                                                                                                                                                                |
|    | $Ca^{44}$ |                                                | $2.13 \pm 0.04$   |                                 |                                                   |                                  |                   |                                                                                                                                                                                |
|    |           | $Ca^{45}$                                      |                   | 152 л                           | $\beta^-$                                         | 0.24*; 0.22<br>[M 21]            | нет $\gamma$      | $Ti^{48}$ -n- $\alpha$ ; $Ca^{44}$ -d-p; $Ca^{44}$ -n- $\gamma$ [M21];<br>$Sc^{45}$ -n-p; $Sc^{45}$ -d-2p; $Bi^{209}$ -d- $\odot$                                              |
|    | $Ca^{46}$ |                                                | 0.0032            |                                 |                                                   |                                  |                   |                                                                                                                                                                                |
|    | $Ca^{48}$ | $(Ca^{47})$                                    |                   | 5.8 л                           | $\beta^-$ , $\gamma$                              | 1.1                              | 1.3               | $(Ca^{46}$ -d-p)                                                                                                                                                               |
|    |           | $Ca^{49}$                                      | $0.179 \pm 0.001$ |                                 | $\beta^-$ , $\gamma$                              | 2.3                              | 0.8               | $Ca^{48}$ -d-p; $Ca^{48}$ -n- $\gamma$                                                                                                                                         |
|    |           | $Ca^{49}$                                      |                   | $2.5 \pm 0.1$ ч<br>$30 \pm 1$ м | $\beta^-$                                         |                                  |                   | $Ca^{48}$ -d-p; $Ca^{48}$ -n- $\gamma$                                                                                                                                         |
| 21 |           | $Sc^{41}$                                      |                   | 0.87 с                          | $\beta^+$                                         | 4.94                             |                   | $Ca^{40}$ -d-n                                                                                                                                                                 |
|    |           | $Sc^{43}$                                      |                   | $3.92 \pm 0.02$ ч               | $\beta^+$ , $\gamma$                              | 1.13                             | 1.0, 1.65         | $Ca^{40}$ - $\alpha$ -p; $Ca^{43}$ -d-n; $Ca^{48}$ -p-n                                                                                                                        |
|    |           | $Sc^{44}$                                      |                   | $3.92 \pm 0.03$ ч               | $\beta^+$ , $K$ , $\gamma$                        | 1.40*                            | 1.33, (1.80)      | $Sc^{45}$ -n-2n; $Sc^{45}$ - $\gamma$ -n; $K^{41}$ - $\alpha$ -n<br>$Ca^{48}$ -d-n; $Ca^{44}$ -p-n;                                                                            |
|    |           | $^{\circ}Sc^{44}$                              |                   | 58.56 ч                         | $I$ , $\gamma$ , $e^-$                            |                                  | 0.269             | $Sc^{44}$ (58 ч) $I$ ; $Ti^{46}$ -d- $\alpha$<br>$K^{41}$ - $\alpha$ -n; $Ti^{46}$ -d- $\alpha$ ; $Ca^{48}$ -d-n;<br>$Sc^{45}$ -n-2 n; $Sc^{44}$ -p-n; $Sc^{45}$ - $\gamma$ -n |
|    | $Sc^{45}$ |                                                | 100               |                                 |                                                   |                                  |                   |                                                                                                                                                                                |



|    |                                    |                                                          |                                               |             |                             |             |                         |                                                                                                                                                                                                                              |
|----|------------------------------------|----------------------------------------------------------|-----------------------------------------------|-------------|-----------------------------|-------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23 | V <sup>50</sup><br>V <sup>51</sup> | V <sup>47</sup>                                          |                                               | 33.0±0.5 м  | $\beta^+$ , $\gamma$        | 1.65 [R 10] |                         | Ti <sup>46</sup> -d-n; Ti <sup>47</sup> -p-n [K 2, K 10];<br>Ti <sup>46</sup> -p- $\gamma$ [K 2, K 10]                                                                                                                       |
|    |                                    | V <sup>48</sup>                                          |                                               | 16.0±0.2 д  | $\beta^+$ (58%)<br>K (42%)  | 0.716       | 0.99; 1.32              | Ti <sup>47</sup> -d-n; Sc <sup>46</sup> - $\alpha$ -n; Cr <sup>50</sup> -d- $\alpha$ ;<br>Ti <sup>48</sup> -p-n; Cu-d                                                                                                        |
|    |                                    | V <sup>(49)</sup>                                        | 0.23 [L 17,<br>H 26]<br>99.77 [L 17,<br>H 26] | 600 д       | $\beta^+$                   | (0.5)       | нет $\gamma$            | Ti-d V <sup>51</sup> -n-2 n; Ti <sup>49</sup> -d-n;<br>Ti <sup>47</sup> - $\alpha$ -p; Cr <sup>50</sup> -n-p                                                                                                                 |
|    |                                    | V <sup>(52)</sup>                                        |                                               | 3.74±0.01 м | $\beta^-$                   | 2.05        | 1.46; 1.3               | V <sup>51</sup> -n- $\gamma$ ; V <sup>51</sup> -d-p; Cr <sup>52</sup> -n-p;<br>Mn <sup>55</sup> -n- $\alpha$ ; Cr <sup>58</sup> - $\gamma$ -p                                                                                |
|    |                                    | V <sup>52</sup>                                          |                                               | 635 д [C 9] |                             |             | 0.0805;<br>0.1193 [C 9] | V <sup>51</sup> -n- $\gamma$ [C 9]                                                                                                                                                                                           |
| 24 | Cr <sup>50</sup>                   | Cr <sup>49</sup>                                         |                                               | 41.9±0.3 м  | $\beta^+$ , $\gamma$        | 1.45        | 0.19, 1.55              | Cr <sup>50</sup> -n-2 n; Ti <sup>46</sup> - $\alpha$ -n;<br>Cr <sup>50</sup> - $\gamma$ -n [P 6];<br>Cu <sup>(63,65)</sup> -d- [6 p, (10,12) n]                                                                              |
|    |                                    | Cr <sup>51</sup>                                         | 4.31±0.04                                     | 26.5±1 д    | K, $\gamma$                 | нет $\beta$ | 0.267, 0.323<br>[K 11]  | Ti <sup>48</sup> - $\alpha$ -n; Cr <sup>50</sup> -d-p; Cr <sup>50</sup> -n- $\gamma$ ;<br>Cr <sup>52</sup> -n-2 n; V <sup>51</sup> -p-n;<br>As <sup>75</sup> -d- [10 p, 16 n];<br>Cu <sup>(63,65)</sup> -d- [6 p, (8, 10) n] |
|    |                                    | Cr <sup>52</sup><br>Cr <sup>53</sup><br>Cr <sup>54</sup> | 83.76±0.14<br>9.55±0.09<br>2.38±0.02          |             |                             |             |                         |                                                                                                                                                                                                                              |
|    |                                    | Cr <sup>55</sup>                                         |                                               | 1.3 ч       | —                           |             |                         | Cr <sup>54</sup> -d-p; Cr <sup>54</sup> -n- $\gamma$ ; U- $\alpha$ -①                                                                                                                                                        |
| 25 |                                    | Mn <sup>51</sup>                                         |                                               | 46±2 м      | $\beta^+$                   | 2*          |                         | Cr <sup>50</sup> -d-n; Cr <sup>50</sup> -p- $\gamma$ ; Cu <sup>(63,65)</sup> -d-<br>- [5 p, (9, 11) n]                                                                                                                       |
|    |                                    | Mn <sup>52</sup>                                         |                                               | 5.8 д       | $\beta^+$ (65%),<br>K (35%) | 0.582       | 0.734, 0.940<br>1.46    | Cr <sup>52</sup> -d-2 n; Cr <sup>52</sup> -p-n; Fe <sup>54</sup> -d- $\alpha$ ;<br>Cu <sup>(63,65)</sup> -d- [5 p, (8,10) n];<br>As <sup>75</sup> -d-9 p, 16 n                                                               |

| Атомный номер | Стабильное ядро                                                                  | Радиоактив. ядро                                                                   | Распространённость в %                                | Период полураспада                                 | Тип превращения                                                                                                                        | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                                          | Энергия $\gamma$ -лучей в Мэв                                                                           | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                                                | 3                                                                                  | 4                                                     | 5                                                  | 6                                                                                                                                      | 7                                                                                              | 8                                                                                                       | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|               | Mn <sup>55</sup>                                                                 | <sup>50</sup> Mn<br>Mn <sup>53</sup> ?<br>Mn <sup>54</sup><br><br>Mn <sup>56</sup> | 100                                                   | 21±2 м<br><br>длин.<br>310±20 д<br><br>2.59±0.02 ч | $\beta^+$ ,<br>$\gamma$ ( $\approx 100\%$ ),<br>I(0.05%)<br><br>$K$ ( $\approx 100\%$ ),<br>$\beta$ (0.1%)<br><br>$\beta^-$ , $\gamma$ | 2.66<br><br>1.0 ( $\beta^-$ )<br>нет $\beta^+$<br><br>0.75 (20%),<br>1.04 (30%),<br>2.81 (50%) | 1.46 ( $\approx 100\%$ )<br>0.392 (0.05%)<br><br>0.835<br><br>0.822 (50%),<br>1.77 (30%),<br>2.06 (20%) | Fe <sup>52</sup> (7.8 ч) $\beta^+$ ; Cr <sup>52</sup> p-n;<br>Fe <sup>54</sup> -d- $\alpha$<br>Fe <sup>53</sup> (8.9 м) $\beta^+$<br>Cr <sup>53</sup> -d-n; Fe <sup>53</sup> -d- $\alpha$ [E5a]; V <sup>51</sup> - $\alpha$ -n;<br>Cr <sup>54</sup> -p-n<br><br>Fe <sup>57</sup> - $\gamma$ -p; Mn <sup>55</sup> -n- $\gamma$ ; Mn <sup>56</sup> -d-p;<br>Fe <sup>58</sup> -d- $\alpha$ ; Fe <sup>56</sup> -n-p; Co <sup>59</sup> -n- $\alpha$ ;<br>Cr <sup>58</sup> - $\alpha$ -p; As <sup>75</sup> -d- [9 p, 12 n];<br>Cu <sup>(63,65)</sup> -d- [5 p, (4,6) n] |
| 26            | Fe <sup>54</sup><br><br>Fe <sup>56</sup><br>Fe <sup>57</sup><br>Fe <sup>58</sup> | Fe <sup>52</sup><br>Fe <sup>53</sup><br><br>Fe <sup>55</sup>                       | 5.81±0.01<br><br>91.64±0.02<br>2.21±0.01<br>0.34±0.01 | 7.8 ч<br>8.9±0.2 м<br><br>$\approx 1$ ч            | $\beta^+$<br>$\beta^+$ [P6]<br><br>$K$                                                                                                 | 0.55<br><br>нет $\beta^+$                                                                      | нет $\gamma$<br>( $\gamma$ непрерывн.<br>до 150 keV);<br>0.02%                                          | Cu <sup>(63,65)</sup> -d- [4 p, (7,9) n]<br>Cr <sup>50</sup> - $\alpha$ -n; Fe <sup>54</sup> -n-2 n; Fe <sup>54</sup> - $\gamma$ -n<br>[P6, H6];<br>Cu <sup>(63,65)</sup> -d- [4 p, (8, 10) n]<br><br>Mn <sup>55</sup> -p-n; Co <sup>55</sup> (18.2 ч) $\beta^+$ ;<br>Fe <sup>54</sup> d-p; Mn <sup>55</sup> -d-2n; Fe <sup>54</sup> -n- $\gamma$                                                                                                                                                                                                                 |

|    |                  |                  |     |               |                                  |                                   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                       |
|----|------------------|------------------|-----|---------------|----------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                  | Fe <sup>51</sup> |     | 46 ± 1 д      | β <sup>-</sup> , γ               | (0.257), 0.460                    | 1.10, 1.30<br>(S 31)                                                                    | Cu <sup>(63, 65)</sup> -d- [4 p, (2,4) n];<br>As <sup>75</sup> -d-[8 p, 10 n]; Fe <sup>58</sup> -n-γ;<br>Fe <sup>58</sup> -d-p; Co <sup>59</sup> -n-p;<br>Co <sup>59</sup> -d-2 p; Bi <sup>209</sup> -d-⊙ [G 11]                                                                                                                                                      |
| 27 |                  | Co <sup>55</sup> |     | 18.2 ч        | β <sup>+</sup>                   | 1.01 (50%),<br>1.50 (50%)<br>[D7] | 0.477 (15%),<br>0.935 (70%),<br>1.41 (15%)<br>[D 7]                                     | Fe <sup>54</sup> -d-n; Fe <sup>54</sup> -p-γ;<br>As <sup>75</sup> -d-[7 p, 15 n];<br>Cu <sup>(63, 65)</sup> -d- [3 p, (7,9) n]                                                                                                                                                                                                                                        |
|    |                  | Co <sup>56</sup> |     | 79 ± 5 д      | β <sup>+</sup> , K, γ            | 0.48, 1.50                        | 0.845 (100%),<br>1.26 (50%),<br>1.74 (20%),<br>2.01 (10%),<br>2.55 (20%),<br>3.25 (20%) | Fe <sup>56</sup> -d-2 n; Fe <sup>54</sup> -α-p, n; Fe <sup>56</sup> -p-n;<br>As <sup>75</sup> -d- [7 p, 14 n];<br>Cu <sup>(63, 65)</sup> -d- [3 p, (6,8) n]                                                                                                                                                                                                           |
|    |                  | Co <sup>57</sup> |     | 270 д         | β <sup>+</sup> , K, γ            | 0 26                              | 0.117, 0.130,<br>0.202, 0.215,<br>(0.6), 0.805                                          | Fe <sup>56</sup> -d-n, Fe <sup>56</sup> -p-γ                                                                                                                                                                                                                                                                                                                          |
|    |                  | Co <sup>58</sup> |     | 69 ± 7* д     | K (85%),<br>β <sup>+</sup> (15%) | 0.470, 1.36                       |                                                                                         | Fe <sup>57</sup> -d-n; Mn <sup>55</sup> -α-n; Fe <sup>56</sup> -α-n, p;<br>Fe <sup>57</sup> -p-γ; Ni <sup>58</sup> -n-p; Fe <sup>58</sup> -p-n;<br>Ni <sup>60</sup> -d-α;<br>Cu <sup>(63, 65)</sup> -d-[3 p, (4, 6) n]                                                                                                                                                |
|    | Co <sup>59</sup> |                  | 100 |               |                                  |                                   |                                                                                         |                                                                                                                                                                                                                                                                                                                                                                       |
|    |                  | Co <sup>60</sup> |     | 5.08 г [S1]   | β <sup>-</sup>                   | 0.309*                            | 1.1715(100%),<br>1.3316(100%),<br>[L11] [A6, J1]                                        | Co <sup>59</sup> -d-p; Co <sup>59</sup> -n-γ; Ni <sup>62</sup> -d-α;<br>Cu <sup>63</sup> -n-α; Co <sup>60</sup> (10.7 м) I                                                                                                                                                                                                                                            |
|    |                  | Co <sup>60</sup> |     | 10.7 м        | I (90%),<br>β <sup>-</sup> (10%) | 1.42                              | 0.056 (90%),<br>1.3 (10%)                                                               | Co <sup>59</sup> -n-γ; Ni <sup>60</sup> -n-p; Co <sup>59</sup> -d-p                                                                                                                                                                                                                                                                                                   |
|    |                  | Co <sup>61</sup> |     | 1.75 ± 0.05 ч | β <sup>-</sup>                   | 1.1                               | нет γ                                                                                   | Cu <sup>65</sup> -n-α, n [P3]; Ni <sup>64</sup> -d-α, n [P3];<br>Ni <sup>64</sup> -p-α [P 3]; Ni <sup>62</sup> -γ-p;<br>Cu <sup>(63, 65)</sup> -d-[3 p, (1, 3) n];<br>Cu <sup>63</sup> -γ-2 p; Co <sup>59</sup> -t-p;<br>Ni <sup>61</sup> -n-p [P 3]; As <sup>75</sup> -d- [7p, 9n]<br>Ni <sup>62</sup> -n-p [P3]; Cu <sup>65</sup> -n-α,<br>Cu <sup>65</sup> -d-α, p |
|    |                  | Co <sup>62</sup> |     | 13.9 ± 0.2 м  | β <sup>-</sup> , γ               | 2.4*                              | 1.3                                                                                     |                                                                                                                                                                                                                                                                                                                                                                       |

| Атомный номер | Стабильное ядро  | Радиоактивн. ядро  | Распространённость в % | Период полураспада           | Тип превращения      | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв | Энергия $\gamma$ -лучей в Мэв            | Ядерные реакции                                                                                                                                                                                                |
|---------------|------------------|--------------------|------------------------|------------------------------|----------------------|-------------------------------------------------------|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                | 3                  | 4                      | 5                            | 6                    | 7                                                     | 8                                        | 9                                                                                                                                                                                                              |
|               |                  | Co <sup>(62)</sup> |                        | 1.6 $\pm$ 0.2 м [P3]         | —                    |                                                       |                                          | Ni <sup>62</sup> -n-p [P 3]; Ni <sup>64</sup> -d- $\alpha$ [P 3]                                                                                                                                               |
|               |                  | Co <sup>64</sup>   |                        | 4—5 м                        | —                    |                                                       |                                          | Ni <sup>64</sup> -n- (p) [P 3]                                                                                                                                                                                 |
| 28            |                  | Ni <sup>57</sup>   |                        | 36 $\pm$ 1* ч [M26]          | $\beta^+$ , $\gamma$ | 0.72 [M26]                                            | 1.97 (100%) [M26]                        | Ni <sup>58</sup> - $\gamma$ -n [P 6]; Fe <sup>54</sup> - $\alpha$ -n [M26]; Ni <sup>58</sup> -n-2n; As <sup>75</sup> -d- [6 p, 14 n]; Cu <sup>(63,65)</sup> -d- [2 p, (6, 8) n]                                |
|               | Ni <sup>58</sup> | Ni <sup>59</sup>   | 67.76 $\pm$ 0.22       | 5 $\times$ 10 <sup>4</sup> л | K, $\gamma$          |                                                       | 0.007, 0.015; 0.045; 0.075 [T14]         | Fe <sup>56</sup> - $\alpha$ -n; Ni <sup>58</sup> -n- $\gamma$ ; Ni <sup>58</sup> -d-p (?); Co <sup>59</sup> -d-2n                                                                                              |
|               | Ni <sup>60</sup> |                    | 26.16 $\pm$ 0.66       |                              |                      |                                                       |                                          |                                                                                                                                                                                                                |
|               | Ni <sup>61</sup> |                    | 1.25 $\pm$ 0.03        |                              |                      |                                                       |                                          |                                                                                                                                                                                                                |
|               | Ni <sup>62</sup> |                    | 3.66 $\pm$ 0.01        |                              |                      |                                                       |                                          |                                                                                                                                                                                                                |
|               |                  | Ni <sup>(63)</sup> |                        | 300 л                        | $\beta^-$            | 0.063 [W9]                                            | нет $\gamma$ [W9]                        | Ni <sup>62</sup> -n- $\gamma$ [W 9]                                                                                                                                                                            |
|               | Ni <sup>64</sup> | Ni <sup>65</sup>   | 1.16 $\pm$ 0. 0        | 2.564 $\pm$ 0.005 ч [S 22]   | $\beta^-$            | 0.60 (29%), 1.01 (14%), 2.10 (57%) [S19]              | 0.37 (15%), 1.12 (29%), 1.49 (15%) [S19] | Ni <sup>64</sup> -d-p; Ni <sup>64</sup> -n- $\gamma$ ; Cu <sup>65</sup> -n-p [B4]; Zn <sup>68</sup> -n- $\alpha$ ; Bi <sup>209</sup> -d - d - $\odot$ As <sup>75</sup> -d- [6 p, 6 n]; U- $\alpha$ - $\odot$ ; |
|               |                  | Ni <sup>66</sup>   |                        | 56 ч                         | $\beta^-$            |                                                       | 0.280                                    | Bi <sup>209</sup> -d- $\odot$ ; As <sup>75</sup> -d- [6 p, 5 n]                                                                                                                                                |

|    |                  |                                                                                        |                                          |                                                                         |                                                     |                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| 29 | Cu <sup>63</sup> | (Cu <sup>57,59</sup> )<br>Cu <sup>(58)</sup><br>Cu <sup>(58)</sup><br>Cu <sup>60</sup> | 81±2 с<br>3 с<br>7.9±0.5 м<br>24.6±0.3 м | β <sup>+</sup><br>—<br>β <sup>+</sup><br>β <sup>+</sup> , γ             | 1.8 (95%),<br>3.3 (5%)                              | 1.50                          | Ni <sup>58</sup> -p-?<br>Ni <sup>58</sup> -p-(n)<br>Ni <sup>58</sup> -p-(n)<br>Ni <sup>60</sup> -p-n; Ni <sup>60</sup> -d-2n; Ni <sup>58</sup> -α-p, n;<br>As <sup>75</sup> -d-[5p, 12 n];<br>Cu <sup>(63,65)</sup> -d- [p,(4,6) n]<br>Ni <sup>60</sup> -d-n; Ni <sup>61</sup> -d-2 n [O5];<br>Ni <sup>61</sup> -p-n; Ni <sup>58</sup> -α-p; Cu <sup>63</sup> -γ-2n;<br>As <sup>75</sup> -d- [5 p, 11 n];<br>Cu <sup>(63,65)</sup> -d- [p, (3,5) n];<br>Ni <sup>61</sup> -d-2 n [O 5]<br>Co <sup>59</sup> -α-n; Ni <sup>62</sup> -p-n; Ni <sup>61</sup> -p-γ;;<br>Cu <sup>63</sup> -n-2 n; Cu <sup>63</sup> -γ-n [M 6];<br>Cu <sup>63</sup> -e <sup>-</sup> -e <sup>-</sup> , n;<br>Zn <sup>64</sup> (9,5 ч) K, β <sup>+</sup> [H 28]<br>Cu <sup>(63,65)</sup> -d-[p, (2,4) n] |
|    |                  | Cu <sup>61</sup>                                                                       | 3 33 ч                                   | β <sup>+</sup> , K [O5]                                                 | 1.205                                               | нет γ                         | Cu <sup>63</sup> -n-γ [O 6]; Cu <sup>65</sup> -n-2 n;<br>Cu <sup>63</sup> -d-p; Zn <sup>64</sup> -n-p [O6];<br>Ni <sup>64</sup> -p-n; Cu <sup>65</sup> -γ-n; Zn <sup>65</sup> -d-α;<br>Cu <sup>65</sup> -p-p, n; Cu <sup>65</sup> -d-[p, 2 n];<br>As <sup>75</sup> -d-[5 p, 8 n]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|    |                  | Cu <sup>62</sup>                                                                       | 9.9±0.1 м                                | β <sup>+</sup> , γ                                                      | 2.92 [H 28]                                         | 0.56                          | Cu <sup>65</sup> -n-γ; Zn <sup>65</sup> -n-p; Ga <sup>69</sup> -n-α;<br>Cu <sup>65</sup> -d-p; Ni <sup>66</sup> (56 ч) β <sup>-</sup><br>Zn <sup>65</sup> -γ-p; Bi <sup>209</sup> -d-⊙;<br>As <sup>75</sup> -d-[5 p, 5 n]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|    |                  | Cu <sup>64</sup>                                                                       | 12.88±0.03 ч                             | β <sup>-</sup> (31%),<br>β <sup>+</sup> (15%),<br>K [54%]<br>[L18, O 6] | 0.571 (β <sup>-</sup> ),<br>0.657 (β <sup>+</sup> ) | 1.35 (0.4%),<br>(1.20) (1.5%) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|    |                  | Cu <sup>65</sup>                                                                       | 31.06±0.19                               |                                                                         |                                                     |                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|    |                  | Cu <sup>66</sup>                                                                       | 4.34±0.03 м<br>[S 22]                    | β <sup>-</sup> , γ                                                      | 2.58                                                | 1.32                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|    |                  | Cu <sup>(67)</sup>                                                                     | 56 ч                                     | β <sup>-</sup>                                                          | 0.56                                                |                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |



|    |                                                          |                                                                                |                  |                                            |                                                                           |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----|----------------------------------------------------------|--------------------------------------------------------------------------------|------------------|--------------------------------------------|---------------------------------------------------------------------------|-----------|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 31 | Ga <sup>69</sup><br><br><br><br><br><br>Ga <sup>71</sup> | Ga <sup>(64)</sup><br>Ga <sup>65</sup><br>Ga <sup>66</sup>                     | 60.16            | 48 $\pm$ 2 м<br>15 м                       | $\beta^+$<br>K <sup>+</sup> , e <sup>-</sup><br>$\beta^+$                 | 3.5 *     | 0.054; 0.117<br>0.093*, 0.174<br>0.183*, 0.297* | Zn <sup>(64)</sup> -p-n<br>Zn <sup>64</sup> -d-n; Zn <sup>64</sup> -p- $\gamma$<br>Cu <sup>65</sup> - $\alpha$ -n; Zn <sup>66</sup> -p-n; Ge <sup>66</sup> ( $\approx$ 140м);<br>As <sup>75</sup> -d-[3 p, 8 n]<br>Zn <sup>66</sup> -d-n; Zn <sup>64</sup> - $\alpha$ -p; Zn <sup>67</sup> -p-n;<br>Ge <sup>67</sup> (23 м) $\beta^+$ ; As <sup>75</sup> -d-[3p, 7n]<br>Cu <sup>65</sup> - $\alpha$ -n; Zn <sup>65</sup> -p-n; Zn <sup>67</sup> -p- $\gamma$ (?);<br>Ga <sup>69</sup> -n-2 n; Ga <sup>69</sup> - $\gamma$ -n; Zn <sup>67</sup> -d-n;<br>Ge <sup>70</sup> -d- $\alpha$ ; Ge <sup>70</sup> - $\gamma$ -p, n [P 6];<br>As <sup>75</sup> -d-[3 p, 6 n]; Ge <sup>68</sup> (250 д) |
|    |                                                          | Ga <sup>67</sup>                                                               |                  | 9.4 $\pm$ 0.2 ч                            | K <sup>+</sup> , $\gamma$ , e <sup>-</sup>                                |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|    |                                                          | Ga <sup>68</sup>                                                               |                  | 78.2 $\pm$ 0.7 ч                           | $\beta^+$                                                                 |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|    |                                                          | Ga <sup>70</sup>                                                               |                  | 6 $\pm$ 2 м                                | $\beta^+$                                                                 |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|    |                                                          | Ga <sup>71</sup>                                                               |                  | 20.3 м                                     | $\beta^-$ , $\gamma$ ,<br>( $\beta^+ < 0.5\%$ )                           |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|    |                                                          | Ga <sup>73</sup>                                                               |                  | 14.25 $\pm$ 0.2 ч                          | $\beta^-$ , $\gamma$                                                      |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 32 | Ge <sup>70</sup>                                         | Ge <sup>66</sup><br>Ge <sup>67</sup><br>Ge <sup>(68)</sup><br>Ge <sup>69</sup> | 20.65 $\pm$ 0.04 | $\approx$ 110 м<br>23 м<br>250 д<br>39.6 ч | —<br>$\beta^+$<br>—<br>$\beta^+$ (33%),<br>K <sup>+</sup> (67%), $\gamma$ | 1.0 [M30] | 1.22 [M30]                                      | Ge <sup>70</sup> -d-p, 5 n<br>Ge <sup>70</sup> -d-p, 4 n<br>As <sup>75</sup> -d-[2 p, 7 n]; (Zn <sup>70</sup> - $\alpha$ -2 n)<br>Ga <sup>69</sup> -d-2n; Zn <sup>63</sup> - $\alpha$ -n; Ge <sup>70</sup> -d-2n;<br>Ge <sup>70</sup> - $\gamma$ -n; As <sup>75</sup> -d-[2 p, 6 n];<br>As <sup>(69)</sup> (52 м) $\beta^+$                                                                                                                                                                                                                                                                                                                                                                  |
|    |                                                          | Ga <sup>(73)</sup>                                                             |                  | 4.94 ч [G11]                               | $\beta^-$                                                                 |           |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

| Атомный<br>номер | Стабильное<br>ядро                                       | Радиоактив.<br>ядро                              | Распростра-<br>нённость<br>в %                          | Период<br>полурас-<br>пада                                    | Тип<br>превраще-<br>ния           | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                                        |
|------------------|----------------------------------------------------------|--------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                                        | 3                                                | 4                                                       | 5                                                             | 6                                 | 7                                                              | 8                                   | 9                                                                                                                                                                                                                      |
|                  |                                                          | $\text{Ge}^{71}$                                 |                                                         | $11.4 \pm 0.1$ д                                              | $\beta^+$ , $K$                   | нет $\beta^+$                                                  | нет $\beta^+$                       | $\text{Ga}^{71}\text{-d-2n}$ ; $\text{Ga}^{71}\text{-p-n}$ ; $\text{Ge}^{70}\text{-d-p}$ ;<br>$\text{Ge}^{70}\text{-n-}\gamma$ ; $\text{As}^{75}\text{-d-[2 p, 4 n]}$ ;<br>$\text{As}^{71}$ (49,9 ч) $K$               |
|                  |                                                          | $^{\circ}\text{Ge}^{72}$                         |                                                         | $0.5 \pm 0.05$ мкс,<br>$0.29 \pm$<br>$\pm 0.06$ мкс<br>[M 16] | $I$<br>(эвк > 50%)                |                                                                | 0.7                                 | $\text{Ga}^{72}$ (14.25 ч) $\beta^-$ (1%) [M 16]                                                                                                                                                                       |
|                  | $\text{Ge}^{72}$<br>$\text{Ge}^{73}$<br>$\text{Ge}^{74}$ |                                                  | $27.43 \pm 0.02$<br>$7.86 \pm 0.04$<br>$36.34 \pm 0.05$ |                                                               |                                   |                                                                |                                     |                                                                                                                                                                                                                        |
|                  |                                                          | $\text{Ge}^{75}$                                 |                                                         | $82 \pm 1$ м                                                  | $\beta^-$                         | 1.15*                                                          | нет $\gamma$ [M30]                  | $\text{Ge}^{74}\text{-n-}\gamma$ ; $\text{Ge}^{76}\text{-n-2 n}$ ;<br>$\text{Ge}^{76}\text{-}\gamma\text{-n}$ [P6]; $\text{Ge}^{74}\text{-d-p}$ ;<br>$\text{As}^{75}\text{-n-p}$ ; $\text{Se}^{78}\text{-n-}\alpha$    |
|                  | $\text{Ge}^{76}$                                         |                                                  | $7.72 \pm 0.01$                                         |                                                               |                                   |                                                                |                                     |                                                                                                                                                                                                                        |
|                  |                                                          | $\text{Ge}^{77}$                                 |                                                         | 12 ч                                                          | $\beta^-$ , $\gamma$              | 1.8* [M14]                                                     | 0.5 [M14]                           | $\text{Se}^{80}\text{-n-}\alpha$ , $\text{Ge}^{76}\text{-n-}\gamma$ [W4];<br>$\text{Ge}^{76}\text{-d-p}$ ; $\text{U-n-}\odot$ ; $\text{U}^{232}\text{-n-}\odot$ ;<br>$\text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N1] |
|                  |                                                          | $^{\circ}\text{Ge}^{(77)}$<br>$\text{Ge}^{(78)}$ |                                                         | $59 \pm 2$ с<br>2.1 ч                                         | $\beta^-$<br>$\beta^-$ , $\gamma$ | 2.8<br>0.9                                                     |                                     | $\text{Ge}^{(76)}\text{-n-}\gamma$<br>$\text{U-n-}\odot$                                                                                                                                                               |
| 33               |                                                          | $\text{As}^{(69)}$                               |                                                         | 5.2 м                                                         | $\beta^+$                         |                                                                |                                     | $\text{Ge}^{(70)}\text{-d-(3)n}$ ; $\text{Se}^{(69)}$ (44 м) $\beta^+$ ;<br>$\text{As}^{75}\text{-d-[p, (7) n]}$                                                                                                       |
|                  |                                                          | $^{\circ}\text{As}^{71}$                         |                                                         | 49.9 ч                                                        | $\beta^+$ (33%),<br>$K$ (67%)     | 0.6                                                            |                                     | $\text{Ge}^{70}\text{-d-n}$                                                                                                                                                                                            |

|    |                  |                                                                     |                 |                                                        |                                                |                                           |                                                                       |                                                                                                                                                                                                                                                                                                                        |
|----|------------------|---------------------------------------------------------------------|-----------------|--------------------------------------------------------|------------------------------------------------|-------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | As <sup>75</sup> | As <sup>72</sup>                                                    | 100             | 26 ч                                                   | $\beta^+$ (33%),<br>K (67%)                    | 2.78                                      | 0.6, 1.4, (2.4)                                                       | Ga <sup>69</sup> - $\alpha$ -n; Ge <sup>72</sup> -p-n; Se <sup>74</sup> -d- $\alpha$ ;<br>Se <sup>73</sup> (9.5 д) K; As <sup>75</sup> -d-[p, 4n]                                                                                                                                                                      |
|    |                  | As <sup>73</sup>                                                    |                 | 76 $\pm$ 3 д<br>[M30]                                  | K, $\gamma$                                    | нет $\beta^+$                             | 0.10                                                                  | Ge <sup>70</sup> - $\alpha$ -p; Ge <sup>72</sup> -d-n;<br>Se <sup>73</sup> (6.9 ч) K                                                                                                                                                                                                                                   |
|    |                  | As <sup>74</sup>                                                    |                 | 17.5 $\pm$ 0.1 д                                       | $\beta^-$ , $\beta^+$                          | 0.9 ( $\beta^+$ );<br>1.25 ( $\beta^-$ )  | 0.582                                                                 | Ga <sup>71</sup> - $\alpha$ -n; As <sup>75</sup> -n-2n; Ge <sup>73</sup> -d-n;<br>Se <sup>76</sup> -d- $\alpha$ , Ge <sup>74</sup> -p-n;<br>Ge <sup>72</sup> - $\alpha$ -p, n (?);<br>As <sup>75</sup> -d-[p, 2n]; Bi <sup>209</sup> -d- $\odot$ [G11]                                                                 |
|    |                  | As <sup>76</sup>                                                    |                 | 26.75 $\pm$ 0.15 ч                                     | $\beta^-$ , (K)[G11]<br>( $\beta^+ < 0.03\%$ ) | 1.29 (15%),<br>2.49 (25%),<br>3.04 (60%), | 0.553* (38%),<br>1.21* (13%),<br>1.75* (1.5%),<br>(2.1*, 3.2)         | As <sup>75</sup> -n- $\gamma$ ; As <sup>75</sup> -d-p; Br <sup>79</sup> -n- $\alpha$ ;<br>Se <sup>76</sup> -n-p; Se <sup>78</sup> -d- $\alpha$ ; Ge <sup>76</sup> -p-n;<br>Se <sup>77</sup> - $\gamma$ -p                                                                                                              |
|    |                  | As <sup>77</sup>                                                    |                 | 40 ч                                                   | $\beta^-$                                      | 0.8                                       |                                                                       | Ge <sup>77</sup> (12 ч) $\beta^-$ [M14, N1];<br>Ge <sup>77</sup> (59 с) $\beta^-$ ; U (n, $\odot$ )Ge <sup>77</sup><br>(12 ч) $\beta^-$ ; Th <sup>232</sup> - $\alpha$ - $\odot$ ; U-n- $\odot$ ;<br>Bi <sup>209</sup> -d- $\odot$ ; Th <sup>233</sup> ( $\alpha$ - $\odot$ )Ge <sup>77</sup><br>(12 ч) $\beta^-$ [N1] |
|    |                  | As <sup>78</sup><br>As <sup>78?</sup>                               |                 | 65 м<br>90 м                                           |                                                | 1.4,<br>1.4(30%)<br>4.1 (70%)             | 0.27                                                                  | Br <sup>81</sup> -n- $\alpha$ ; Se <sup>78</sup> -n-p;<br>U (n- $\odot$ )Ge <sup>78</sup> (2.1 ч) $\beta^-$                                                                                                                                                                                                            |
| 34 | Se <sup>74</sup> | Se <sup>(69)</sup><br>Se <sup>72</sup><br>Se <sup>(73)</sup>        | 0.87 $\pm$ 0.01 | 44 м<br>9.5 д<br>6.9* ч                                | $\beta^+$<br>K<br>$\beta^+$ (50%),<br>K (50%)  | 1.29                                      |                                                                       | As <sup>75</sup> -d-8 n<br>As <sup>75</sup> -d-5 n<br>Ge <sup>70</sup> - $\alpha$ -n; As <sup>75</sup> -d-4 n                                                                                                                                                                                                          |
|    |                  | Se <sup>75</sup>                                                    |                 | 127 $\pm$ 2 д                                          | K, $\gamma$                                    | нет $\beta^+$                             | 0.077*, 0.099*,<br>0.123*, 0.138*,<br>0.267*, 0.282*,<br>0.404* [T 4] | As <sup>75</sup> -p-n; Se <sup>74</sup> -n- $\gamma$ [T 4];<br>As <sup>75</sup> -d-2 n; (Ge <sup>72</sup> - $\alpha$ -n);<br>Br <sup>75</sup> (106м) $\beta^+$ , K                                                                                                                                                     |
|    |                  | Se <sup>76</sup><br>Se <sup>77</sup><br>$^{\circ}$ Se <sup>77</sup> |                 | 9.02 $\pm$ 0.07<br>7.58 $\pm$ 0.07<br>17.5 $\pm$ 0.3 с | I, $\gamma$ , e <sup>-</sup>                   |                                           | 0.15                                                                  | Se <sup>76</sup> -n- $\gamma$ ; Se <sup>77</sup> -x                                                                                                                                                                                                                                                                    |

| Атомный номер | Стабильное ядро                                              | Радиоактив. ядро                                                                                                                 | Распространённость в %                  | Период полураспада                                                                                   | Тип превращения                                                                                                                           | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв | Энергия $\gamma$ -лучей в Мэв                                  | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                            | 3                                                                                                                                | 4                                       | 5                                                                                                    | 6                                                                                                                                         | 7                                                     | 8                                                              | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|               | Se <sup>78</sup><br>Se <sup>80</sup><br><br>Se <sup>82</sup> | Se <sup>(79)</sup><br>°Se <sup>81</sup><br><br>Se <sup>81</sup><br><br>Se <sup>83</sup><br>°Se <sup>83</sup><br>Se <sup>84</sup> | 23.52±0.02<br>49.82±0.20<br><br>9.19±20 | 7×10 <sup>6</sup> л<br>57±1 м [B35]<br><br>13.6 м;<br>19 м [B35]<br><br>25 м<br><br>67±3 с<br>≈2.5 м | <br><br>I, $\gamma$ , e <sup>-</sup><br><br>$\beta^-$<br><br>$\beta^-$ , $\gamma$<br><br>$\beta^-$ , $\gamma$<br><br>$\beta^-$ , $\gamma$ | <br><br><br><br>1.38 [B35]<br><br>1.5<br>3.4          | <br><br>0.104 [B35]<br><br>нет $\gamma$<br><br>0.17, 0.37, 1.1 | U-n-⊙ (?)<br>Se <sup>80</sup> -d-p; Se <sup>80</sup> -n- $\gamma$ ; Br <sup>81</sup> -n-p;<br>Se <sup>82</sup> - $\gamma$ -n; U-n-⊙; Bi <sup>209</sup> -d-⊙ [G 11]<br>Se <sup>80</sup> -d-p [B35]; Se <sup>80</sup> -n- $\gamma$ ; Br <sup>81</sup> -n-p;<br>Se <sup>81</sup> - $\gamma$ -n; Se <sup>81</sup> (57 м) I;<br>U (n, ⊙) °Se <sup>(81)</sup> (57 м) I<br>Se <sup>82</sup> -n- $\gamma$ ; Se <sup>82</sup> -d-p; U-n-⊙;<br>Th <sup>232</sup> -n-⊙<br>Se <sup>82</sup> -n- $\gamma$ ; U-n-⊙<br>U-n-⊙ |
| 35            |                                                              | Br <sup>75</sup><br>Br <sup>(76)</sup><br>Br <sup>(77)</sup>                                                                     |                                         | 106 м<br>15.7 ч<br>57.2 ч                                                                            | $\beta^+$ (18%),<br>K (82%)<br>$\beta^+$ , $\gamma$<br>$\beta^+$ (5%),<br>K (95%), $\gamma$                                               | 1.6<br>3.15<br>0.36                                   | нет $\gamma$<br>0.19; 2<br>0.7                                 | Se <sup>74</sup> -d-p; Se <sup>74</sup> -p- $\gamma$<br>As <sup>75</sup> - $\alpha$ -3 n<br>Se <sup>76</sup> -p- $\gamma$ ; Se <sup>76</sup> -d-n; Se <sup>74</sup> - $\alpha$ -p;<br>As <sup>75</sup> - $\alpha$ -2 n                                                                                                                                                                                                                                                                                        |

|    |                    |                     |            |                                                 |                                                      |                                                           |                                                                                                                                                                                                                                                                                                  |
|----|--------------------|---------------------|------------|-------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Br | Br <sup>(78)</sup> | 50.51±0.06          | 6.4±0.1 м  | β <sup>+</sup>                                  | 2.35*                                                | 0.046, 0.108                                              | Br <sup>79</sup> -n-2n; As <sup>75</sup> -α-n; Br <sup>79</sup> -γ-n [M 6]; Se <sup>77</sup> -d-n; Se <sup>78</sup> -p-n                                                                                                                                                                         |
|    | Br <sup>79</sup>   |                     | 4.5 ч      | I, γ, e <sup>-</sup>                            |                                                      | 0.049, 0.037                                              | Br <sup>79</sup> -n-γ [K7]; Br <sup>79</sup> -d-p;                                                                                                                                                                                                                                               |
|    | Br <sup>80</sup>   |                     | 18 м       | β <sup>-</sup> (99%),<br>β <sup>+</sup> (1%), γ | 2.0 (β <sup>-</sup> ),<br>1.0 (β <sup>+</sup> ) [D5] | (0.5)                                                     | Br <sup>81</sup> -n-2 n Se <sup>80</sup> -p-n; Br <sup>81</sup> -γ-n;<br>Se <sup>77</sup> -α-p; (Th <sup>232</sup> -n-⊙)                                                                                                                                                                         |
|    | Br <sup>81</sup>   | 49.49±0.06          | 33.9±0.3 ч | β <sup>-</sup> , γ,<br>(β <sup>+</sup> < 0.4%)  | 0.465                                                | 0.55, 0.61,<br>0.69, 0.77,<br>0.83, 1.04,<br>1.315 [S 24] | Br <sup>79</sup> -n-γ [K 7]; Br <sup>81</sup> -n-2 n;<br>Br <sup>79</sup> -d-p; Se <sup>80</sup> -p-n;<br>Br <sup>81</sup> -γ-n [M 6]; Bi <sup>80</sup> (4.5 ч) I,<br>Se <sup>80</sup> -d-2n                                                                                                     |
|    | Br <sup>82</sup>   |                     | 144 м      | β <sup>-</sup>                                  | ~1.2*                                                | нет γ                                                     | Br <sup>81</sup> -n-γ; Br <sup>81</sup> -d-p; Se <sup>82</sup> -d-2 n;<br>Se <sup>-82</sup> -p-n; Rb <sup>85</sup> -n-α; Bi <sup>209</sup> -α-⊙;<br>Bi <sup>209</sup> -d-⊙; U-n-⊙; U-α-⊙;<br>Pb-α-⊙; Tl-α-⊙; Th <sup>232</sup> -α-⊙ [N 1]                                                        |
|    | Br <sup>83</sup>   |                     | 35±5 м*    | β <sup>-</sup> , γ                              | 4.9*                                                 | нет γ                                                     | Se <sup>82</sup> -d-n; Se <sup>88</sup> (25 м) β <sup>-</sup> ;<br>Se <sup>88</sup> (67 с) β <sup>-</sup> ; Bi <sup>209</sup> -α-⊙;<br>Bi <sup>209</sup> -d-⊙; U-n-⊙;<br>Th <sup>232</sup> -n-⊙; U <sup>233</sup> -n-⊙;<br>U-α-⊙; Th <sup>232</sup> -α-⊙ [N1];<br>Pu <sup>239</sup> -n-⊙; Pb-α-⊙ |
|    | Br <sup>84</sup>   |                     | 3.0±0.5 м  | β <sup>-</sup>                                  | 2.5                                                  | нет γ                                                     | U-n-⊙; Th <sup>232</sup> -n-⊙;<br>U (n, ⊙) Se <sup>84</sup> (2.5 м) β <sup>-</sup> ;<br>Bi <sup>209</sup> -d-⊙; Rb <sup>87</sup> -n-α                                                                                                                                                            |
|    | Br <sup>85</sup>   | 56.1±0.7 с<br>[S10] | 56.1±0.7 с | β <sup>-</sup> , n                              | 0.25 (сред-<br>нее) (n)                              |                                                           | U-n-⊙<br>U-n-⊙; Pu <sup>239</sup> -n-⊙                                                                                                                                                                                                                                                           |
|    | Br <sup>87</sup>   |                     | 4.51 с     | β <sup>-</sup> , n                              | 0.43 (сред-<br>нее) (n)                              |                                                           | U-n-⊙                                                                                                                                                                                                                                                                                            |
|    | Br <sup>(87)</sup> |                     | 15.5±0.3 с | β <sup>-</sup>                                  |                                                      |                                                           | U-n-⊙                                                                                                                                                                                                                                                                                            |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро      | Распростра-<br>ненность<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния               | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                                                   |
|------------------|--------------------|--------------------------|--------------------------------|----------------------------|---------------------------------------|----------------------------------------------------------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                        | 4                              | 5                          | 6                                     | 7                                                              | 8                                   | 9                                                                                                                                                                                                                                 |
| 36               |                    | Kr <sup>77</sup>         |                                | 1.1 ч                      | K (70%),<br>$\beta^+$ (30%), $\gamma$ | 1.7                                                            |                                     | Se <sup>74-x-n</sup>                                                                                                                                                                                                              |
|                  | Kr <sup>78</sup>   |                          | 0.342                          | 34.5 ч                     | $\beta^+$ (2%),<br>K (98%), $\gamma$  | 0.6 (70%),<br>0.9 (30%)                                        | 0.2                                 | Br <sup>79-p-n</sup> ; Kr <sup>78-d-p</sup> ; Se <sup>76-a-n</sup> ;<br>Br <sup>79-d-2 n</sup> ; Kr <sup>78-n-<math>\gamma</math></sup>                                                                                           |
|                  | Kr <sup>80</sup>   | Kr <sup>79</sup>         | 2.228                          | 13 $\pm$ 1 с               | I (?), e <sup>-</sup>                 |                                                                | 0.187                               | Br <sup>(79,81)-p-n</sup> ; (Se-a-n) ?                                                                                                                                                                                            |
|                  |                    | Kr <sup>(79,81)</sup>    |                                | 55 $\pm$ 2 с               | I (?), e <sup>-</sup>                 |                                                                | 0.127                               | Br <sup>(79,81)-p-n</sup> ;                                                                                                                                                                                                       |
|                  | Kr <sup>83</sup>   |                          | 11.500                         | 113 м                      | I, e <sup>-</sup>                     |                                                                | 0.029, 0.046,<br>(0.035)            | Se <sup>88</sup> (25 м) $\beta^- \rightarrow$ Br <sup>88</sup> (140 м) $\beta^-$ ;<br>Se <sup>80-a-n</sup> ; Kr <sup>83-d-p</sup> ; U-n- $\odot$ ;<br>Th-n- $\odot$ ; Kr <sup>83-n-<math>\gamma</math></sup> ; Kr <sup>83-x</sup> |
|                  | Kr <sup>83</sup>   | $\circ$ Kr <sup>83</sup> | 11.480                         |                            |                                       |                                                                |                                     |                                                                                                                                                                                                                                   |
|                  | Kr <sup>84</sup>   |                          | 57.020                         |                            |                                       |                                                                |                                     | U-n- $\odot$<br>Kr <sup>84-n-<math>\gamma</math></sup> ; U-n- $\odot$ ; U(n, $\odot$ )                                                                                                                                            |
|                  |                    | Kr <sup>85</sup>         |                                | 9.4 ч                      | $\beta^-$                             | 0.74                                                           | нет $\gamma$                        | Kr <sup>84-d-p</sup> ; Se <sup>83-a-n</sup> ; Sr <sup>88-n-a</sup> ;                                                                                                                                                              |
|                  |                    | Kr <sup>85</sup>         |                                | 4.4 $\pm$ 0.2 ч            | $\beta^-$                             | 0.9*                                                           | 0.17, 0.37                          | Rb <sup>88-n-p</sup> ; Kr <sup>84-n-<math>\gamma</math></sup> ; Kr <sup>86-n-2n</sup> ;<br>U (n, $\odot$ ) Br <sup>85</sup> (3 м) $\beta^-$                                                                                       |
|                  | Kr <sup>86</sup>   |                          | 17.430                         |                            |                                       |                                                                |                                     | U (n, $\odot$ ) Br <sup>85</sup> (3 м) $\beta^-$                                                                                                                                                                                  |
|                  |                    | Kr <sup>87</sup>         |                                | 78 м [K 13]                | $\beta^-$                             | 3.2 [K13]                                                      |                                     | Kr <sup>86-d-p</sup> ; Kr <sup>86-n-<math>\gamma</math></sup> ; Rb <sup>87-n-p</sup> ;<br>U (n, $\odot$ ) Br <sup>87</sup> (50 с) $\beta^-$                                                                                       |
|                  |                    | Kr <sup>88</sup>         |                                | 166 м                      | $\beta^-$                             | 2.4*                                                           |                                     | U-n- $\odot$ ; Th-n- $\odot$ ;<br>U (n, $\odot$ ) Br <sup>88</sup> (15.5 с) $\beta^-$<br>[S16]                                                                                                                                    |

|    |                  |                                                                                                                                                                                                            |                              |                                                                                                                         |                                                                                                                                                                                                       |                                                                                                               |                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                  | Kr <sup>89</sup><br>Kr <sup>90</sup><br>Kr <sup>(91)</sup><br><br>Kr <sup>(92)</sup><br>Kr <sup>(93)</sup><br>Kr <sup>(94)</sup><br>Kr <sup>97</sup>                                                       |                              | 2.6 м<br>33 с<br>7.5* с<br><br>2.3 с<br>2.2 с<br>1.4 с<br>кор.                                                          | $\beta^-$<br>$\beta^-$<br>$\beta^-$<br><br>$\beta^-$<br>$\beta^-$<br>$\beta^-$<br>$\beta^-$                                                                                                           |                                                                                                               |                                                                                               | U-n- $\odot$ ; U-d- $\odot$ ; Pu <sup>239</sup> -n- $\odot$<br>U-n- $\odot$ ; Pu <sup>239</sup> -n- $\odot$<br>U-n- $\odot$ ; Th-n- $\odot$ ; U-d- $\odot$ ;<br>Pu <sup>239</sup> -n- $\odot$<br>U-n- $\odot$ ; Th <sup>233</sup> -n- $\odot$ ; Pu <sup>239</sup> -n- $\odot$<br>U-n- $\odot$ ; U-d- $\odot$ ; Pu <sup>239</sup> -n- $\odot$<br>U-n- $\odot$<br>U-n- $\odot$ ; Pu <sup>239</sup> -n- $\odot$                                                                                                                                                                                                                                                                             |
| 37 | Rb <sup>85</sup> | Rb <sup>81</sup><br><br>Rb <sup>82</sup><br>Rb <sup>(82)</sup><br>Rb <sup>(84)</sup><br><br>Rb <sup>(86)</sup><br><br>Rb <sup>87</sup><br><br>Rb <sup>88</sup><br><br>Rb <sup>89</sup><br>Rb <sup>90</sup> | 72.8<br><br><br><br><br>27.2 | 5.0 ч<br>6.4* ч<br>20 м<br>40 д<br><br>19.5 д<br><br>$6 \times 10^{10}$ л<br><br>17.5 м<br><br>$15.4 \pm 0.2$ м<br>кор. | $\beta^+$ , $\gamma$<br>$\beta^+$ , $\gamma$<br>—<br>$\beta^+$ , $\gamma$<br><br>$\beta^-$ , $\gamma$<br>( $\beta^+ < 0.3\%$ )<br>$\beta^-$ , $\gamma$<br><br>$\beta^-$<br><br>$\beta^-$<br>$\beta^-$ | 0.9 [R1]<br>0.9 [R1]<br><br><br><br>0.716 (20%),<br>1.822 (80%)<br>0.131*;<br>(0.560)<br><br>4.9*<br><br>4.2* | 0.2, 0.8 [R1]<br>1.0 [R1]<br><br><br><br>1.081<br><br>0.034, 0.053,<br>0.082, 0.102,<br>0.129 | Br <sup>79</sup> - $\alpha$ -2n [R1]<br><br>Br <sup>79</sup> - $\gamma$ -n [B1]; Kr <sup>83</sup> -d-2n<br>Br <sup>(79)</sup> - $\alpha$ -n<br>Sr <sup>86</sup> -d- $\alpha$ ; Rb <sup>85</sup> -n-2n<br><br>Sr <sup>88</sup> -d- $\alpha$ ; Rb <sup>85</sup> -n- $\gamma$ ; Rb <sup>87</sup> - $\gamma$ -n;<br>Bi <sup>209</sup> -d- $\odot$ ; U-n- $\odot$<br><br>Rb <sup>87</sup> -n- $\gamma$ ; Sr <sup>88</sup> -n-p (?); Pa <sup>231</sup> -n- $\odot$<br>U (n, $\odot$ ) Kr <sup>88</sup> (170 м) $\beta^-$ ;<br>Th (n, $\odot$ ) Kr <sup>88</sup> (170 м) $\beta^-$ ;<br>U (n, $\odot$ ) Kr <sup>89</sup> (2.6 м) $\beta^-$<br>U (n, $\odot$ ) Kr <sup>90</sup> (33 с) $\beta^-$ |

| Атомный<br>номер | Стабильное<br>ядро                                                                   | Радиоактивн.<br>ядро                                                                                 | Распростра-<br>нённость<br>в %                                                    | Период<br>полурас-<br>пада              | Тип<br>превраще-<br>ния                                                            | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                       | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                                                                    | 3                                                                                                    | 4                                                                                 | 5                                       | 6                                                                                  | 7                                                              | 8                                                                         | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|                  |                                                                                      | Rb <sup>91</sup><br>Rb <sup>92</sup><br>Rb <sup>93</sup><br>Rb <sup>94</sup><br>Rb <sup>97</sup>     |                                                                                   | кор.<br>80 с<br>кор.<br>кор.<br>кор.    | $\beta^-$<br>$\beta^-$<br>$\beta^-$<br>$\beta^-$<br>$\beta^-$                      |                                                                |                                                                           | U (n, $\oplus$ ) Kr <sup>91</sup> (9.3 с) $\beta^-$<br>U (n, $\oplus$ ) Kr( $\beta^-$ ); Th <sup>232</sup> -n- $\oplus$<br>U (n, $\oplus$ ) Kr <sup>93</sup> (2.2 с) $\beta^-$<br>U (n, $\oplus$ ) Kr <sup>94</sup> (1.4 с) $\beta^-$<br>U (n, $\oplus$ ) Kr <sup>97</sup> (кор.) $\beta^-$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 38               | Sr <sup>84</sup><br><br>Sr <sup>86</sup><br><br>Sr <sup>87</sup><br>Sr <sup>88</sup> | Sr <sup>85</sup><br>$\ominus$ Sr <sup>86</sup><br>$\ominus$ Sr <sup>87</sup><br><br>Sr <sup>89</sup> | 0.55 $\pm$ 0.01<br><br>9.75 $\pm$ 0.04<br><br>6.96 $\pm$ 0.01<br>82.74 $\pm$ 0.06 | 66 д<br>70 м<br><br>2.8 ч<br><br>54.5 д | K, $\gamma^-$<br>I, $\gamma$ , e $^-$<br><br>I, $\gamma$ , e $^-$<br><br>$\beta^-$ | <br><br><br><br>1.463<br>[P9, L9];<br>(1.6) [G11]              | 0.510 [T13a]<br>0.170<br><br>0.386, (0.55),<br>(1.10)<br><br>нет $\gamma$ | Rb <sup>85</sup> -p-n; Rb <sup>85</sup> -d-2n<br>Rb <sup>85</sup> -p-n<br><br>Sr <sup>86</sup> -d-p; Zr <sup>90</sup> -n- $\alpha$ (?);<br>Sr <sup>87</sup> -p-p (?); Y <sup>87</sup> (80 ч) K;<br>Sr <sup>88</sup> - $\gamma$ -n; Sr <sup>87</sup> -e $^-$ -e $^-$ ; Sr <sup>87</sup> -x;<br>U-n- $\oplus$<br><br>Zr <sup>92</sup> -n- $\alpha$ (?); Sr <sup>88</sup> -d-p; Sr <sup>88</sup> -n- $\gamma$ ;<br>Y <sup>89</sup> -n-p;<br>U (n, $\oplus$ ) Kr <sup>89</sup> (2.6 м) $\beta^-$ ;<br>Rb <sup>89</sup> (15.4 м) $\beta^-$ ; U- $\alpha$ - $\oplus$ ;<br>U-d- $\oplus$ ; U <sup>233</sup> -n- $\oplus$ ; Bi <sup>209</sup> -d- $\oplus$ ;<br>Bi <sup>209</sup> - $\alpha$ - $\oplus$ ; Th-n- $\oplus$ ;<br>Th- $\alpha$ - $\oplus$ [N1]; Pu <sup>239</sup> -n- $\oplus$ ;<br>Pt- $\alpha$ - $\oplus$ ; Pb- $\alpha$ - $\oplus$ |

|    |                         |                                                                                                                                                     |     |                                                                                     |                                                                                                              |                                                                          |                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|----|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                         | $\text{Sr}^{90}$<br>$\text{Sr}^{91}$<br><br>$\text{Sr}^{(92)}$<br><br>$\text{Sr}^{93}$<br>$\text{Sr}^{(94)}$<br>$\text{Sr}^{97}$<br><br>$\text{Sr}$ |     | 30 л<br>9.7 ч<br><br>2.7 ч<br><br>7 м<br>$\approx 2$ м<br>кор.<br>6-10 д            | $\beta^-$<br>$\beta^-, \gamma$<br><br>$\beta^-$<br><br>$\beta^-$<br>$\beta^-$<br>$\beta^-$                   | 0.61<br>1.3 (40%);<br>3.2 (60%)                                          | нет $\gamma$<br>1.3                                                    | $\text{U-n-}\odot$ ; $\text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N1];<br>$\text{Bi}^{209}\text{-d-}\odot$ [G11]<br>$\text{Zr}^{94}\text{-n-}\alpha$ ;<br>$\text{U (n, } \odot \text{) Rb}^{91}$ (кор.) $\beta^-$ ;<br>$\text{U-}\gamma\text{-}\odot$ ; $\text{Th}^{232}\text{-n-}\odot$ ; $\text{Th}^{232}\text{-}\alpha\text{-}\odot$ ;<br>$\text{Pu}^{239}\text{-n-}\odot$ ; $\text{Bi}^{209}\text{-}\alpha\text{-}\odot$ ;<br>$\text{Pt-}\alpha\text{-}\odot$ ; $\text{Pb-}\alpha\text{-}\odot$ ;<br>$\text{Bi}^{209}\text{-d-}\odot$ [G11]<br>$\text{U (n, } \odot \text{) Rb}^{(92)}$ (80 с) $\beta^-$ ;<br>$\text{U (n, } \odot \text{) Kr}^{92}$ (2.3 с) $\beta^-$ ;<br>$\text{U-}\gamma\text{-}\odot$ ; $\text{Th}^{232}\text{-n-}\odot$ ;<br>$\text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N1]<br>$\text{U (n, } \odot \text{) Kr}^{93}$ (2 с) $\beta^-$ ...<br>... $\text{Rb}^{93}$ (кор.) $\beta^-$<br>$\text{U (n, } \odot \text{) Kr}^{94}$ (1.4 с) $\beta^-$<br>$\text{U (n, } \odot \text{) Kr}^{(97)}$ (кор.) $\beta^-$ ...<br>... $\text{Rb}^{(97)}$ (кор.) $\beta^-$ ;<br>$\text{U-n-}\odot$ |
| 39 | <br><br>$\text{Y}^{89}$ | $\text{Y}^{84}$<br>[S17]<br>$\circ \text{Y}^{(87)}$<br>$\text{Y}^{87}$<br>$\text{Y}^{88}$<br><br>$\text{Y}^{90}$                                    | 100 | $3.7 \pm 0.14$<br><br>$14 \pm 2$ ч<br>$80 \pm 3$ ч<br>105 д<br><br>$60.5 \pm 0.2$ ч | $\beta^+, K, \gamma$<br><br>$\beta^+, I, \gamma, e^-$<br>$K$<br>$\beta^+ (0.19\%)$ ,<br>$K$<br><br>$\beta^-$ | 2.0 [S17]<br><br>1.1 [S17]<br>0.7 [S17]<br>0.83<br><br>2.180<br>[L9, P9] | <br>0.5<br><br>0.908, 1.853,<br>2.76 (1%)<br>[S17]<br><br>нет $\gamma$ | $\text{Sr}^{84}\text{-d-2n}$ [S17]<br><br>$\text{Sr}^{(86)}\text{-d-n}$ ; $\text{Sr}^{(87)}\text{-p-n}$<br>$\text{Sr}^{86}\text{-p-n}$ ; $\text{Sr}^{87}\text{-p-n}$ ; $\text{Rb}^{85}\text{-}\alpha\text{-n?}$<br>$\text{Sr}^{88}\text{-d-2n}$ ; $\text{Sr}^{88}\text{-p-n}$ ; $\text{Y}^{89}\text{-n-2n}$ ;<br>$\text{Rb}^{85}\text{-}\alpha\text{-n}$ [S17]<br><br>$\text{Y}^{89}\text{-n-}\gamma$ ; $\text{Y}^{89}\text{-d-p}$ ; $\text{Nb}^{93}\text{-n-}\alpha$ ;<br>$\text{Zr}^{90}\text{-n-p}$ ; $\text{Zr}^{92}\text{-d-}\alpha$ ; $\text{Rb}^{87}\text{-}\alpha\text{-n}$ ;<br>$\text{U (n, } \odot \text{) Sr}^{90}$ (25 л) $\beta^-$ ;<br>$\text{Bi}^{209}\text{-}\alpha\text{-}\odot$ ; $\text{Pt-}\alpha\text{-}\odot$ ; $\text{Tl-}\alpha\text{-}\odot$ ;<br>$\text{Th}^{232}$ ( $\alpha$ , $\odot$ ) $\text{Sr}^{90}$ (25 л) $\beta^-$<br>[N1]                                                                                                                                                                                                                                                   |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                                                                                                                                                           |
|------------------|--------------------|---------------------|--------------------------------|----------------------------|-------------------------|----------------------------------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                   | 4                              | 5                          | 6                       | 7                                                              | 8                                   | 9                                                                                                                                                                                                                                                                                                                                         |
|                  |                    | $^{91}\text{Y}$     |                                | 51.0 м                     | $I, \gamma, e^-$        |                                                                | 0.61                                | $\text{Zr}^{91}\text{-n-p;}$<br>$\text{U}(\text{n}, \text{O}) \text{Kr}^{91} (7.5 \text{ c}) \beta^- \dots$<br>$\dots \text{Sr}^{91} (9.7 \text{ ч}) \beta^- (40\%);$<br>$\text{Th}^{232}\text{-}\alpha\text{-O}$                                                                                                                         |
|                  |                    | $^{91}\text{Y}$     |                                | 61 д                       | $\beta^-$               | 1.537<br>[L9, P9,<br>O4]                                       | нет $\gamma$                        | $\text{Zr}^{91}\text{-n-p;}$<br>$\text{U}(\text{n}, \text{O}) \text{Kr}^{91} (7.5 \text{ c}) \beta^- \dots$<br>$\dots \text{Sr}^{91} (9.7 \text{ ч}) \beta^- (60\%);$<br>$\text{U-n-O; U-d-O; U}^{233}\text{-n-O;}$<br>$^{91}\text{Y} (51 \text{ м}) I; \text{Th}^{232}\text{-n-O;}$<br>$\text{Pu}^{239}\text{-n-O; Bi}^{209}\text{-d-O}$ |
|                  |                    | $^{92}\text{Y}$     |                                | 3.5 ч                      | $\beta^-, \gamma$       | 3.5                                                            | 1.0                                 | $\text{U}(\text{n}, \text{O}) \text{Kr}^{92} (2.3 \text{ c}) \beta^- \dots$<br>$\dots \text{Sr}^{92} (2.7 \text{ ч}) \beta^-; \text{Th}^{232}\text{-n-O;}$<br>$\text{Pu}^{239}\text{-n-O;}$                                                                                                                                               |
|                  |                    | $^{93}\text{Y}$     |                                | 10.0 ч                     | $\beta^-, \gamma$       | 3.1                                                            | 0,7                                 | $\text{Zr}^{92}\text{-n-p; Th}^{232}\text{-}\alpha\text{-O}$<br>$\text{U}(\text{n}, \text{O}) \text{Kr}^{93} (2 \text{ c}) \beta^- \dots$<br>$\dots \text{Sr}^{93} (7 \text{ м}) \beta^-; \text{U-}\alpha\text{-O;}$<br>$\text{Th-n-O; Pu}^{239}\text{-n-O}$                                                                              |
|                  |                    | $^{94}\text{Y}$     |                                | 20 м                       | $\beta^-, \gamma$       |                                                                |                                     | $\text{Zr}^{(94)}\text{-n-p; U}(\text{n}, \text{O})$<br>$\text{Kr}^{(94)} (1.4 \text{ c}) \beta^- \dots$                                                                                                                                                                                                                                  |
|                  |                    | $^{95}\text{Y}$     |                                | 1.5 ч                      |                         |                                                                |                                     | $\dots \text{Sr}^{(94)} (2 \text{ м}) \beta^-; \text{Pu}^{239}\text{-n-O}$                                                                                                                                                                                                                                                                |
|                  |                    | $^{97}\text{Y}$     |                                | кор.                       | $\beta^-$               |                                                                |                                     | $\text{U-n-O}$                                                                                                                                                                                                                                                                                                                            |
|                  |                    | $\text{Y}$          |                                | >100 д                     | —                       |                                                                |                                     | $\text{U}(\text{n}, \text{O}). \text{Kr}^{(97)}(\text{кор.}) \beta^- \dots$<br>$\dots \text{Sr}^{(97)}(\text{кор.}) \beta^-$<br>$\text{U}(\text{n}, \text{O}) \text{Sr} (7\text{--}10 \text{ д}) \beta^-$                                                                                                                                 |

|    |                                                  |                                      |                         |                              |                                        |                             |                                         |                                                                                                                                                                                                                                                                                                                                        |
|----|--------------------------------------------------|--------------------------------------|-------------------------|------------------------------|----------------------------------------|-----------------------------|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 40 |                                                  | $Zr^{87}$<br>[S17]                   |                         | 2.04±0.1 ч                   | $\beta^+$ , K, $\gamma$                | 2.0 [S17]                   | 0.35; 0.65<br>[S17]                     | $Sr^{84}\alpha$ -n [S17]                                                                                                                                                                                                                                                                                                               |
|    |                                                  | $^{\circ}Zr^{89}$                    |                         | 4.5 м                        | I, $\gamma$ , $e^-$                    |                             | 0.555                                   | $Y^{89}$ -p-n; $Zr^{90}$ -n-2n; $Zr^{90}$ - $\gamma$ -n                                                                                                                                                                                                                                                                                |
|    | $Zr^{90}$<br>$Zr^{91}$<br>$Zr^{92}$<br>$Zr^{94}$ | $Zr^{89}$                            |                         | 80.1 ч                       | $\beta^+$                              | 1.1                         | нет $\gamma$                            | [H19]<br>$Y^{89}$ -d-2n; $Zr^{90}$ -n-2n; $Y^{89}$ -p-n;<br>$Mo^{92}$ -n- $\alpha$<br>$Y^{89}$ -d-n                                                                                                                                                                                                                                    |
|    |                                                  | $Zr^{93}$ (?)                        | 51.46<br>11.23<br>17.11 | длин.                        |                                        |                             |                                         | $Y^{93}$ (10 ч) $\beta^-$ ; (Nb <sup>93</sup> -n-p)?                                                                                                                                                                                                                                                                                   |
|    |                                                  | $Zr^{95}$                            | 17.40                   | 65 д                         | $\beta^-$ , $\gamma$                   | 0.394 (98%),<br>1.0 (2%)    | 0.23 (93%),<br>0.73 (93%),<br>0.92 (7%) | $Zr^{94}$ -n- $\gamma$ ; $Zr^{94}$ -d-p; $Mo^{98}$ -n- $\alpha$ ;<br>$Zr^{96}$ -n-2n (?); U-n- $\odot$ ;<br>U- $\alpha$ - $\odot$ ; U <sup>238</sup> -n- $\odot$ ; Pu <sup>239</sup> -n- $\odot$ ;<br>Th <sup>232</sup> - $\alpha$ - $\odot$ ; Bi <sup>209</sup> -d- $\odot$ ;<br>U (n, $\odot$ ) Y <sup>(95)</sup> (<1.5 ч) $\beta^-$ |
|    |                                                  | $Zr^{96}$                            | 2.80                    |                              |                                        | 2.1*                        | 0.8                                     | $Zr^{96}$ -n- $\gamma$ ; $Mo^{100}$ -n- $\alpha$ ;<br>U (n, $\odot$ ) Kr <sup>(97)</sup> (кор.) $\beta^-$ ...<br>...Y <sup>(97)</sup> (кор.) $\beta^-$ ;<br>U- $\alpha$ - $\odot$ [N1, C16a]; Th-n- $\odot$ ;<br>Th- $\alpha$ - $\odot$ ; Pu <sup>239</sup> -n- $\odot$                                                                |
|    |                                                  | $Zr^{97}$                            |                         | 17.0±0.2 ч                   | $\beta^-$ , $\gamma$                   |                             |                                         |                                                                                                                                                                                                                                                                                                                                        |
|    |                                                  |                                      |                         |                              |                                        |                             |                                         |                                                                                                                                                                                                                                                                                                                                        |
| 41 |                                                  | N <sup>90</sup>                      |                         | 15.6 ч                       | $\beta^+$ , $\gamma$                   | 1.19 [K9]                   | 2.03 [K9]                               | $Zr^{90}$ -p-n (?); $Zr^{90}$ -d-2n [K9];<br>$Mo^{93}$ -d-( $\alpha$ ) [K9]                                                                                                                                                                                                                                                            |
|    |                                                  | $^{\circ}Nb^{91}$                    |                         | 62 д                         | I, $\gamma$ , $e^-$                    |                             | 0.15, 0.94                              | $Mo^{92}$ -n-p, n; $Mo^{94}$ -d- $\alpha$ , n;<br>$Zr^{93}$ -d-n                                                                                                                                                                                                                                                                       |
|    |                                                  | (Nb <sup>91</sup> )                  |                         | длин.                        |                                        |                             |                                         | Nb <sup>91</sup> (62 д) I (?)                                                                                                                                                                                                                                                                                                          |
|    |                                                  | Nb <sup>92</sup><br>Nb <sup>92</sup> | 21.6 ч<br>9.8±0.7 д     | длин.<br>21.6 ч<br>9.8±0.7 д | $\beta^-$<br>$\beta^-$ , (K), $\gamma$ | 1.2<br>1.38 (0.29,<br>0.59) | 0.6<br>1.0                              | Nb <sup>93</sup> -d-t; $Mo^{94}$ -d- $\alpha$<br>Nb <sup>93</sup> -n-2n; Nb <sup>93</sup> - $\gamma$ -n; $Zr^{92}$ -p-n;<br>Nb <sup>93</sup> -d-t; Y <sup>89</sup> - $\alpha$ -n;<br>$Mo^{94}$ -d- $\alpha$                                                                                                                            |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактивн.<br>ядро                                                                                                                                                                                                                     | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада                                                                                  | Тип<br>превраще-<br>ния                                                                                                                                                                           | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв           | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                                      | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                                                                                                                                                                                                                                        | 4                              | 5                                                                                                           | 6                                                                                                                                                                                                 | 7                                                                        | 8                                                                                                        | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  | Nb <sup>93</sup>   | <sup>93</sup> Nb <sup>93</sup><br><sup>94</sup> Nb <sup>94</sup><br><sup>94</sup> Nb <sup>94</sup><br><br><sup>95</sup> Nb <sup>95</sup><br><br><br><br>Nb <sup>95</sup><br>Nb <sup>96</sup><br>Nb <sup>97</sup><br><br>Nb <sup>98</sup> | 100                            | 42 д<br><br>>10 <sup>4</sup> л<br>6.6±0.3 м<br><br>37 д<br><br><br>90 ч<br>23.3 ч<br>68 м [D14]<br><br>30 м | I<br><br>$\beta^-$ (0.1%),<br>I (99.9%),<br>e <sup>-</sup> , $\gamma$<br>$\beta^-$ , $\gamma$<br><br>I (100%),<br>e <sup>-</sup><br>$\beta^-$ , $\gamma$<br>$\beta^-$ , $\gamma$<br><br>$\beta^-$ | 1.3<br><br><br>0.146 [H1]<br><br><br>1<br><br>0.67 [K9]<br>1.3*<br><br>— | 0.0415<br>[C7],<br>0.058), 1.0<br>0.758 [H1]<br>0.92<br><br>0.216 [H1]<br><br>1.03 [K9]<br>0.78<br><br>— | Nb <sup>93</sup> -x<br><br>Nb <sup>93</sup> (n, $\gamma$ ); Nb <sup>94</sup> (6.6 м) I<br>Nb <sup>93</sup> -d-p; Nb <sup>93</sup> -n- $\gamma$<br><br>U (n, $\oplus$ ) <sup>95</sup> Nb <sup>95</sup> (90 ч) I;<br>U (n, $\oplus$ ) Zr <sup>95</sup> (65 д) $\beta^-$<br>(98%) [H1]; Th <sup>232</sup> ( $\alpha$ , $\oplus$ );<br>Zr <sup>95</sup> (65 д) $\beta^-$ ; Mo <sup>97</sup> -d- $\alpha$ ;<br>Bi <sup>209</sup> -d- $\oplus$ [G11]<br>U (n, $\oplus$ ) Zr <sup>95</sup> (65 д) $\beta^-$ (62%);<br>Mo <sup>97</sup> -d- $\alpha$ ; Zr-p<br>Zr <sup>96</sup> -p-n; Zr <sup>96</sup> -d-2n; Mo <sup>98</sup> -d- $\alpha$<br>Mo <sup>97</sup> -n-p; Mo <sup>98</sup> - $\gamma$ -p [D14];<br>Mo <sup>100</sup> -d- $\alpha$ , n; U (n, $\oplus$ )<br>Kr <sup>97</sup> (кор.)... Zr <sup>97</sup> (17 ч) $\beta^-$<br>Th <sup>232</sup> ( $\alpha$ , $\oplus$ ) Zr <sup>97</sup> (17 ч) $\beta^-$ ;<br>Mo <sup>100</sup> -d- $\alpha$ |
| 42               |                    | Mo <sup>(97)</sup><br>Mo <sup>91</sup>                                                                                                                                                                                                   |                                | 75±5 с<br>15.5 м                                                                                            | $\beta^+$                                                                                                                                                                                         | 3.7 [D14]                                                                | нет $\gamma$<br>[D14]                                                                                    | Mo <sup>(92)</sup> - $\gamma$ -n [D14] [H19]<br>Mo <sup>92</sup> - $\gamma$ -n [D14];<br>Mo <sup>92</sup> -n-2n [K9]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

|    |                   |                                                                                                                                                                         |                                                           |                                                                                                                           |                                  |                                                                          |                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                  |
|----|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Mo <sup>92</sup>  | Mo <sup>98</sup><br>°Mo <sup>(93)</sup><br><br>Mo <sup>98</sup><br><br>Mo <sup>94</sup><br>Mo <sup>95</sup><br>Mo <sup>93</sup><br>Mo <sup>97</sup><br>Mo <sup>98</sup> | 15.84<br><br><br>9.04<br>15.72<br>16.53<br>9.46<br>23.78  | 15.5 м<br>6.70±0.05 ч<br><br>длин.<br>[K17a]                                                                              | β <sup>+</sup><br><br>I<br><br>— | 2.65                                                                     | 0.3, 0.7,<br>1.7 [K17a]                                                                                                                                                                                                                                                                             | Mo <sup>94</sup> -n-2n; Mo <sup>94</sup> -γ-n;<br>Mo <sup>93</sup> -d-p; Nb <sup>98</sup> -d-2n<br>Nb <sup>98</sup> -p-n; Mo <sup>92</sup> -d-p; Nb <sup>98</sup> -d-2n;<br>Zr <sup>90</sup> -α-n; Zr <sup>91</sup> -α-2n [K17a];<br>Mo <sup>94</sup> -n-2n [K17a]<br>Mo <sup>98</sup> (6.7 ч) I [K17a]          |
|    |                   | Mo <sup>99</sup>                                                                                                                                                        |                                                           | 67* ч                                                                                                                     | β <sup>-</sup> , γ               | 1.25                                                                     | 0.1396,<br>0.1676,<br>0.1793 [C9]<br>0.24, 0.4,<br>0.770, 0.815,<br>0.840                                                                                                                                                                                                                           | Mo <sup>93</sup> -n-γ; Mo <sup>98</sup> -d-p;<br>Mo <sup>100</sup> -n-2n; Zr <sup>96</sup> -α-n;<br>Mo <sup>100</sup> -γ n; U-n-⊙;<br>U <sup>233</sup> -n-⊙; Th <sup>232</sup> -n-⊙;<br>Pu <sup>239</sup> n-⊙; Th <sup>232</sup> -α-⊙ [N1];<br>Bi <sup>209</sup> -d-⊙; Bi <sup>209</sup> -α-⊙;<br>Tl-α-⊙; Pt-α-⊙ |
|    | Mo <sup>100</sup> | Mo <sup>101</sup><br>Mo <sup>(102)</sup><br>Mo <sup>105</sup>                                                                                                           | 9.63<br><br>14.6±0.3 м<br>12 м<br>кор.                    | β <sup>-</sup> , γ<br>β <sup>-</sup><br>β <sup>-</sup>                                                                    | 1.0, 2.2                         | 0.3, 0.9                                                                 | Mo <sup>100</sup> -n-γ; U-n-⊙<br>U-n-⊙<br>U-n-⊙                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                  |
| 43 |                   | Tc <sup>(92,93)</sup><br>Tc <sup>98</sup><br><br>Tc <sup>(92, 93)</sup><br>Tc <sup>94</sup><br><br>°Tc <sup>94</sup>                                                    | 4.5±0.5 м<br>2.75±0.05 ч<br><br>47 м<br><53 м<br><br>53 м | β <sup>+</sup> , γ<br>β <sup>+</sup> (7%),<br>K (93%)<br><br>β <sup>+</sup> (35%),<br>K (65%), γ<br><br>I, e <sup>-</sup> | 4.3<br>1.0*<br><br>2             | 1.3<br>2.4, 2.0<br><br>0.38), 0.869*,<br>1.48, 1.87*,<br>2.79*<br>0.0334 | Mo <sup>92</sup> -d-(2) n<br>Mo <sup>92</sup> -d-(n); Mo <sup>(93)</sup> -p-n;<br>Mo <sup>(92)</sup> -p-γ<br>Mo <sup>92</sup> -p-(n); Mo <sup>92</sup> -d-(2) n<br>Mo <sup>94</sup> -p-n; Mo <sup>94</sup> -d-2n;<br>Tc <sup>94</sup> (53 м) I<br><br>Mo <sup>94</sup> -p-n; Mo <sup>94</sup> -d-2n |                                                                                                                                                                                                                                                                                                                  |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактивн.<br>ядро                                                       | Распростра-<br>ненность<br>в % | Период<br>полурас-<br>пада   | Тип<br>превраще-<br>ния                                                              | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                  | Ядерные реакции                                                                                                                                                                                                  |
|------------------|--------------------|----------------------------------------------------------------------------|--------------------------------|------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                                                                          | 4                              | 5                            | 6                                                                                    | 7                                                              | 8                                                                                    | 9                                                                                                                                                                                                                |
|                  |                    | Tc <sup>95</sup>                                                           |                                | 20±0.5 ч                     | K, $\gamma$                                                                          | нет $\beta$                                                    | 0,762, 0.932,<br>1.071                                                               | Ru <sup>95</sup> (1.65 ч) $\beta^+$ ; Mo <sup>95</sup> -p-n;<br>Mo <sup>95</sup> -d-2n; Mo <sup>94</sup> -d-n;<br>Mo <sup>92</sup> - $\alpha$ -p                                                                 |
|                  |                    | Tc <sup>95</sup>                                                           |                                | 56 д                         | $\beta^+$ (0.8%),<br>K (99.2), $\gamma$                                              | 0.4                                                            | 0.210 (21),<br>0.570 (9),<br>0.810 (12),<br>1.017 (1)                                | Mo <sup>94</sup> -d-n; Mo <sup>95</sup> -d-2n;<br>Mo <sup>95</sup> -p-n; Mo <sup>92</sup> - $\alpha$ -p (?)                                                                                                      |
|                  |                    | <sup>96</sup> Tc <sup>97</sup><br>Tc <sup>97</sup>                         |                                | >100 л<br>90±2 д             | I                                                                                    |                                                                | 0.097                                                                                | Mo <sup>97</sup> (d, 2n) <sup>96</sup> Tc <sup>97</sup> (90 д) I<br>Mo <sup>97</sup> -d-2n; Mo <sup>(96)</sup> -d-(n,<br>Mo <sup>97</sup> -p-n; Ru <sup>97</sup> (2.8 г) K                                       |
|                  |                    | Tc <sup>(98)</sup><br>Tc <sup>(98)</sup><br><sup>99</sup> Tc <sup>99</sup> |                                | 2.8±0.1 д<br>40±5 м<br>1.0 ч | $\beta^-$ , K (?), $\gamma$<br>$\beta^-$<br>$\beta^-$ , I, $\gamma$ , e <sup>-</sup> | (0.8) 1.3<br><br>1.215<br>[M39]                                | 1.0<br>2.0<br>0.136;<br>0.1412;<br>(0.181);<br>0.360; 0.726<br>[M39]<br>нет $\gamma$ | Ru <sup>98</sup> -n-p; Mo <sup>98</sup> -d-(2) n<br>Mo-d<br>Ru <sup>99</sup> -n-p; Mo <sup>99</sup> (67 ч) $\beta^-$ ;<br>U (n, $\oplus$ ) Mo <sup>99</sup> (67 ч) $\beta^-$ ;<br>Th <sup>232</sup> -n- $\oplus$ |
|                  |                    | Tc <sup>99</sup>                                                           |                                | 4.7×10 <sup>5</sup> л        | $\beta^-$                                                                            | 0.32                                                           |                                                                                      | Mo <sup>99</sup> (6.7 ч) $\beta^-$ ; Tc <sup>99</sup> (6ч) I;<br>U-n- $\oplus$                                                                                                                                   |
|                  |                    | Tc <sup>100</sup><br>(Tc< <sup>101</sup> )<br>(Tc< <sup>101</sup> )        |                                | 80±10 с<br>36.5 ч<br>18 с    | $\beta^-$<br>$\beta^-$<br>$\beta^-$                                                  | 2.3                                                            | 0.6                                                                                  | Mo <sup>100</sup> -d-2n; Tc <sup>99</sup> -n- $\gamma$<br>Mo-p-n (?)<br>Mo-p-n (?)                                                                                                                               |

|    |                                                                                                     |                                                                      |                                          |                                              |                                           |                        |              |                                                                                                                                                                                                                                                                                                                                                |
|----|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------|----------------------------------------------|-------------------------------------------|------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                                                                                     | Tc <sup>101</sup>                                                    |                                          | 14.5 м                                       | $\beta^- \gamma$                          | 1.2*                   | 0.30         | Mo <sup>101</sup> (14.6 м) $\beta^-$ ; Mo <sup>100</sup> -d-n;<br>Ru <sup>102</sup> - $\gamma$ -p;<br>U (n, $\oplus$ ) Mo <sup>101</sup> (14.6 м) $\beta^-$<br>U (n, $\oplus$ ) Mo <sup>(102)</sup> (12 м) $\beta^-$<br>Ru-n-p<br>U (n, $\oplus$ ) Mo <sup>105</sup> (кор.) $\beta^-$                                                          |
|    |                                                                                                     | Tc <sup>(102)</sup><br>(Tc <sup>&lt;104</sup> )<br>Tc <sup>105</sup> |                                          | <1 м<br>60 д<br>кор.                         | $\beta^-$<br>K (?), $\gamma$<br>$\beta^-$ |                        |              |                                                                                                                                                                                                                                                                                                                                                |
| 44 | Ru <sup>96</sup>                                                                                    | (Ru <sup>95</sup> )<br>Ru <sup>95</sup><br>Ru <sup>97</sup>          | 5.68                                     | 24 м<br>1.65 $\pm$ 0.05 ч<br>2.8 $\pm$ 0.1 д | $\beta^+$ , K, $\gamma$<br>K, $\gamma$    | 1.1                    | 0.95<br>0.23 | Ru-n-2n (?)<br>Mo <sup>92</sup> - $\alpha$ -n; Ru <sup>94</sup> -n-2n; Ru <sup>96</sup> - $\gamma$ -n<br><br>Ru <sup>96</sup> -d-p; Ru <sup>96</sup> -n- $\gamma$ ;<br>Mo <sup>95</sup> - $\alpha$ -2n [E1]; Mo <sup>94</sup> - $\alpha$ -n;<br>Ru <sup>98</sup> -n-2n; Ru <sup>98</sup> - $\gamma$ -n;<br>(U-n- $\oplus$ )                    |
|    | Ru <sup>98</sup><br>Ru <sup>99</sup><br>Ru <sup>100</sup><br>Ru <sup>101</sup><br>Ru <sup>102</sup> |                                                                      | 2.22<br>12.81<br>12.70<br>16.98<br>31.34 |                                              |                                           |                        |              |                                                                                                                                                                                                                                                                                                                                                |
|    | Ru <sup>103</sup>                                                                                   |                                                                      |                                          | 45 $\pm$ 1 д                                 | $\beta^-$ , $\gamma$                      | 0.3 (95%),<br>0.8 (5%) | 0.4; 0.56    | Ru <sup>102</sup> -n- $\gamma$ ; Ru <sup>102</sup> -d-p;<br>Ru <sup>104</sup> -n-2n; Ru <sup>104</sup> - $\gamma$ -n; U-n- $\oplus$ ;<br>U <sup>233</sup> -n- $\oplus$ ; Th <sup>232</sup> -n- $\oplus$ ;<br>Pu <sup>239</sup> -n- $\oplus$ ; Bi <sup>209</sup> -d- $\oplus$ ; Pb- $\alpha$ - $\oplus$                                         |
|    | Ru <sup>104</sup>                                                                                   |                                                                      |                                          |                                              |                                           |                        |              |                                                                                                                                                                                                                                                                                                                                                |
|    | Ru <sup>105</sup>                                                                                   |                                                                      | 18.27                                    | 4.5 ч                                        | $\beta^-$ , $\gamma$                      | 1.35*                  | 0.76         | Ru <sup>104</sup> -n- $\gamma$ ; Ru <sup>(104)</sup> -d-p;<br>U (n, $\oplus$ ) Tc <sup>(105)</sup> (кор.) $\beta^-$ ;<br>U- $\alpha$ - $\oplus$ ; Bi <sup>209</sup> - $\alpha$ - $\oplus$ ; U <sup>233</sup> -n- $\oplus$ ;<br>Th <sup>232</sup> -n- $\oplus$ ; Pb- $\alpha$ - $\oplus$ ; Ti- $\alpha$ - $\oplus$ ;<br>Pt- $\alpha$ - $\oplus$ |
|    | Ru <sup>106</sup>                                                                                   |                                                                      |                                          | 290 д                                        | $\beta^-$                                 | 0.03                   | нет $\gamma$ | Bi <sup>209</sup> -d- $\oplus$ ; U-n- $\oplus$ ; U <sup>233</sup> -n- $\oplus$ ;<br>U-d- $\oplus$ ; U- $\alpha$ - $\oplus$ ; Th <sup>232</sup> -n- $\oplus$ ;<br>Th <sup>232</sup> - $\alpha$ - $\oplus$ [NI]; Pu <sup>239</sup> -n- $\oplus$                                                                                                  |
|    | Ru <sup>(107)</sup>                                                                                 |                                                                      |                                          | 4 м                                          | $\beta^-$                                 | $\sim 4$               |              | U-n- $\oplus$                                                                                                                                                                                                                                                                                                                                  |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро       | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния                             | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                                             | Ядерные реакции                                                                                                                                                                                                                             |
|------------------|--------------------|---------------------------|--------------------------------|----------------------------|-----------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                         | 4                              | 5                          | 6                                                   | 7                                                              | 8                                                                                                               | 9                                                                                                                                                                                                                                           |
| 45               | Rh <sup>103</sup>  | Rh                        | 100                            | 32 м                       | $\beta^+$ , $\gamma$                                | 1.65                                                           | 1.2, 1.8,<br>1.55 [E1]<br>0.35<br>(0.46)<br>0.0631,<br>0.0659,<br>(0.0019)<br><br>0.092<br>0.041, 0.18,<br>0.95 | Ru-p-(n) [E1]; Ru-d-(2) n [E1]                                                                                                                                                                                                              |
|                  |                    | Rh                        |                                | 5 ч                        | $\beta^+$ , K, $\gamma$                             | 0.6                                                            |                                                                                                                 | Ru-p-(n); Ru- $\alpha$ -p [E1];<br>U-n- $\odot$ [E1]                                                                                                                                                                                        |
|                  |                    | Rh <sup>(100)</sup>       |                                | 19.4 ч                     | $\beta^+$ (5%),<br>K (95%), $\gamma$                | 3.0; 1.3<br>[E1]                                               |                                                                                                                 | Pd <sup>(100)</sup> (4 д) K; Ru <sup>(99)</sup> -d-n                                                                                                                                                                                        |
|                  |                    | Rh <sup>(101)</sup>       |                                | 4.7 д                      | K, $\gamma$                                         |                                                                |                                                                                                                 | Pd <sup>(101)</sup> (9 ч) $\beta^+$ [E1];<br>Ru <sup>(100)</sup> -d-n; Ru <sup>98</sup> - $\alpha$ -p [E1];<br>Ru <sup>101</sup> -p-n [E1]                                                                                                  |
|                  |                    | Rh <sup>102</sup>         |                                | 210 $\pm$ 6 д              | $\beta^+$ (45%),<br>$\beta^-$ (55%),<br>K, $\gamma$ | 1.04 ( $\beta^-$ ),<br>1.13 ( $\beta^+$ )                      |                                                                                                                 | Rh <sup>102</sup> -n-2n; Ru <sup>101</sup> -d-n;<br>Rh <sup>102</sup> -t-p, 3n; Rh <sup>102</sup> - $\gamma$ -n                                                                                                                             |
|                  |                    | $^{\circ}\text{Rh}^{103}$ |                                | 45 $\pm$ 1 м               | $\gamma$<br>I, e $^-$                               |                                                                |                                                                                                                 | Rh <sup>102</sup> -n-n; Rh <sup>102</sup> - $\alpha$ ; Rh <sup>102</sup> -e $^-$ -e $^-$ ;<br>Rh <sup>102</sup> -p-p; Rh <sup>102</sup> -d-p-n;<br>U (n, $\odot$ ) Ru <sup>102</sup> (45д) $\beta^-$ ;<br>$^{\circ}\text{Rh}^{102}$ (17д) I |
|                  |                    | $^{\circ}\text{Rh}^{103}$ |                                | 17 д                       | I                                                   |                                                                |                                                                                                                 | Rh <sup>102</sup> -d-d; Ru <sup>102</sup> -d-n; Rh <sup>102</sup> -p-p                                                                                                                                                                      |
|                  |                    | $^{\circ}\text{Rh}^{104}$ |                                | 4.37 $\pm$ 0.05 м          | I, e $^-$ (100%)                                    |                                                                |                                                                                                                 | Rh <sup>102</sup> -n- $\gamma$ ; Ru <sup>104</sup> -p-n; Pd <sup>105</sup> - $\gamma$ -p                                                                                                                                                    |
|                  |                    | Rh <sup>104</sup>         |                                | 41.8 $\pm$ 0.7 с           | $\beta^-$ , $\gamma$                                | 2.60                                                           |                                                                                                                 | Rh <sup>102</sup> -n- $\gamma$ ; $^{\circ}\text{Rh}^{104}$ (4.37 м) I;<br>Rh <sup>104</sup> -p-n                                                                                                                                            |

|    |                   |                             |      |                     |                                   |                          |                                           |                                                                                                                                                                                                                                                                                                                                                                                                              |
|----|-------------------|-----------------------------|------|---------------------|-----------------------------------|--------------------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                   | Rh <sup>105</sup>           |      | 36.5 ч              | $\beta^-$ , $\gamma$              | 0.72*                    | 0.33                                      | Ru <sup>104</sup> -d-n;<br>U (n, $\oplus$ ) Ru <sup>105</sup> (4 ч) $\beta^-$ ;<br>Ru <sup>105</sup> (4 ч) $\beta^-$ ; Rh <sup>105</sup> -t-p;<br>Pu <sup>239</sup> -n- $\oplus$ ; Pd <sup>106</sup> - $\gamma$ -p;<br>Th <sup>232</sup> -n- $\oplus$                                                                                                                                                        |
|    |                   | Rh <sup>106</sup>           |      | 30 с                | $\beta^-$ , $\gamma$              | 2.30 (18%)<br>3.55 (82%) | 0.51 (17%),<br>0.73 (17%),<br>1.25 (1,5%) | U (n, $\oplus$ ) Ru <sup>106</sup> (1r) $\beta^-$ ;<br>Pu <sup>239</sup> -n- $\oplus$                                                                                                                                                                                                                                                                                                                        |
|    |                   | Rh <sup>(107)</sup><br>(Rh) |      | 24 м<br>9 ч         | $\beta^-$ , $\gamma$<br>$\beta^-$ | 1.2<br>$\approx 1.3$     | 0.8                                       | U (n, $\oplus$ ) Ru <sup>(107)</sup> (4 м) $\beta^-$<br>U-n- $\oplus$                                                                                                                                                                                                                                                                                                                                        |
| 46 |                   | Pd <sup>(100)</sup>         |      | 4.0 д               | K, $\gamma$                       |                          | 0.09, 1.8                                 | Rh <sup>108</sup> -d-5n;<br>Sb <sup>(121, 123)</sup> -d-[6p (15, 17) n]<br>Sb <sup>(121, 123)</sup> -d-[6 p (16, 18) n];<br>Ru <sup>98</sup> - $\alpha$ -n [E1]; Rh <sup>108</sup> -d-4n                                                                                                                                                                                                                     |
|    |                   | Pd <sup>(101)</sup>         |      | 9 ч                 | $\beta^+$ (10%),<br>K (90%)       | 0.53 [E1]                | нет $\gamma$                              |                                                                                                                                                                                                                                                                                                                                                                                                              |
|    | Pd <sup>102</sup> |                             | 0.8  |                     |                                   |                          |                                           |                                                                                                                                                                                                                                                                                                                                                                                                              |
|    | Pd <sup>104</sup> |                             | 9.3  |                     |                                   |                          |                                           |                                                                                                                                                                                                                                                                                                                                                                                                              |
|    | Pd <sup>105</sup> |                             | 22.6 |                     |                                   |                          |                                           |                                                                                                                                                                                                                                                                                                                                                                                                              |
|    | Pd <sup>106</sup> |                             | 27.2 |                     |                                   |                          |                                           |                                                                                                                                                                                                                                                                                                                                                                                                              |
|    | Pd <sup>107</sup> |                             | 26.8 | 8.6 $\times 10^7$ л | —                                 |                          |                                           | Rh <sup>107</sup> (24 м) $\beta^-$                                                                                                                                                                                                                                                                                                                                                                           |
|    | Pd <sup>108</sup> |                             |      | 14.1 $\pm 0.3$ ч    | $\beta^-$                         | 1.06*                    | нет $\gamma$                              | Pd <sup>108</sup> -n- $\gamma$ ; Pd <sup>108</sup> -d-p; Ag <sup>109</sup> -n-p;<br>Ag <sup>109</sup> -d-2p; Ag <sup>109</sup> -t-H <sup>3</sup> ;<br>Pd <sup>110</sup> - $\gamma$ -n; U-n- $\oplus$ ; U <sup>235</sup> -n- $\oplus$ ;<br>Th <sup>232</sup> - $\alpha$ - $\oplus$ [N1]; Pu <sup>239</sup> -n- $\oplus$ ;<br>Sb <sup>(121, 123)</sup> -d-[6p (8,10)n]<br>Bi <sup>209</sup> -d- $\oplus$ [G11] |
|    | Pd <sup>110</sup> |                             | 13.5 |                     |                                   |                          |                                           | Pd <sup>110</sup> -n- $\gamma$ ; Pd <sup>110</sup> -d-p; U-n- $\oplus$ ;<br>Th <sup>232</sup> -n- $\oplus$ ;<br>Sb <sup>(121, 123)</sup> -d-[6p (6,8)n]<br>U-n- $\oplus$ ; U- $\alpha$ - $\oplus$ [W2];<br>Th <sup>232</sup> - $\alpha$ - $\oplus$ ; Bi <sup>209</sup> -d- $\oplus$ ;<br>Sb <sup>(121, 123)</sup> -d-[6 p, (5,7)n]                                                                           |
|    | Pd <sup>111</sup> |                             |      | 26 м                | $\beta^-$                         | 3.5                      |                                           |                                                                                                                                                                                                                                                                                                                                                                                                              |
|    | Pd <sup>112</sup> |                             |      | 21 ч                | $\beta^-$                         | 0.2                      | нет $\gamma$                              |                                                                                                                                                                                                                                                                                                                                                                                                              |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро                                                          | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада      | Тип<br>превраще-<br>ния              | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                | Ядерные реакции                                                                                                                                                                                                                                                                                                         |
|------------------|--------------------|------------------------------------------------------------------------------|--------------------------------|---------------------------------|--------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                                                                            | 4                              | 5                               | 6                                    | 7                                                              | 8                                                                                  | 9                                                                                                                                                                                                                                                                                                                       |
| 47               |                    | (Ag <sup>102,104</sup> )<br>(Ag <sup>102,104</sup> )<br>(Ag <sup>105</sup> ) |                                | 16.3±0.7 м<br>73±10 м<br>45±5 д | —<br>$\beta^+$ , K<br>K, $\gamma$    |                                                                |                                                                                    | (Pd-p-n)<br>Pb <sup>(102, 104)</sup> -p-n; Sb-d<br>(Rh <sup>103-<math>\alpha</math>-2n</sup> ); (Pd <sup>105</sup> -p-n)<br>Pd-d-(1,2)n [G8]                                                                                                                                                                            |
|                  |                    | Ag <sup>106</sup>                                                            |                                | 8.2±0.3 д                       | K, $\gamma$                          | нет $\beta$                                                    | 0.286*,<br>0.345,<br>0.425*, 0.50,<br>0.635*, >1.0<br>0.70*, 1.06*,<br>1.63, (0.3) | Rh <sup>108-<math>\alpha</math>-n</sup> [G8]; Pd <sup>106</sup> -d-n;<br>Ag <sup>107</sup> -n-2n; Pd <sup>106</sup> -p-n;<br>Cd <sup>106</sup> -n-p; Sn-d;<br>Ag <sup>(107)</sup> -d-p, (2)n                                                                                                                            |
|                  |                    | Ag <sup>108</sup>                                                            |                                | 24.3 м                          | $\beta^+$                            | 2.04                                                           | нет $\gamma$                                                                       | Rh <sup>108-<math>\alpha</math>-n</sup> ; Pd <sup>108</sup> -d-n; Ag <sup>107</sup> -n-2n;<br>Pd <sup>106</sup> -p-n; (Pd <sup>105</sup> -p- $\gamma$ );<br>Cd <sup>106</sup> -n-p; Sn-d; Ag <sup>107</sup> - $\gamma$ -n;<br>Ag <sup>107</sup> -e <sup>-</sup> -e <sup>-</sup> , n;<br>Ag <sup>(107)</sup> -d-p, (2n); |
|                  | Ag <sup>107</sup>  | <sup>o</sup> Ag <sup>107</sup>                                               | 51.35±0.07                     | 44.3 с                          | I, $\gamma$                          |                                                                | 0.0935*                                                                            | Ag <sup>107</sup> -e <sup>-</sup> -e <sup>-</sup> ; Ag <sup>107</sup> -x;<br>Ag <sup>107</sup> -n-n; Cd <sup>107</sup> (6.7 ч)K                                                                                                                                                                                         |
|                  |                    | Ag <sup>108</sup>                                                            |                                | 2.44±0.06 м                     | $\beta^-$ ,<br>( $\beta^+ < 0.5\%$ ) | 2.8                                                            |                                                                                    | Ag <sup>107</sup> -n- $\gamma$ ; Ag <sup>109</sup> -n-2n;<br>Ag <sup>109</sup> - $\gamma$ -n; Pd <sup>108</sup> -p-n;<br>Cd <sup>108</sup> -n-p; Ag <sup>107</sup> -d-p;<br>Ag <sup>109</sup> -n-e <sup>-</sup> , n                                                                                                     |
|                  | Ag <sup>109</sup>  |                                                                              | 48.65±0.07                     |                                 |                                      |                                                                |                                                                                    |                                                                                                                                                                                                                                                                                                                         |

|    |                   |                                                       |       |                                                                 |                                                                                                 |                                                                                                          |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----|-------------------|-------------------------------------------------------|-------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                   | $^{109}\text{Ag}$                                     |       | $39,2 \pm 0,2 \text{ c}$                                        | $I, \gamma$                                                                                     |                                                                                                          | 0.0890                                                                                                               | $\text{Pd}^{109} (13 \text{ ч}) \beta^-; \text{Cd}^{109} (158 \text{ д}) K;$<br>$\text{Ag}^{109}\text{-n-n}; \text{Ag}^{109}\text{-e}^-\text{-e}^-;$<br>$\text{Ag}^{109}\text{-x}$<br>$\text{Cd}^{111}\text{-}\gamma\text{-p}; \text{Ag}^{109}\text{-n-}\gamma; \text{Cd}^{110}\text{-n-p}$<br>$\text{Ag}^{109}\text{-n-}\gamma; \text{Ag}^{109}\text{-d-p};$<br>$\text{Cd}^{110}\text{-n-p}; \text{Pd}^{110}\text{-d-2 n [G8];}$<br>$\text{Bi}^{209}\text{-d-}\odot \text{ [G 11]}$                                                                 |
|    |                   | $\text{Ag}^{110}$<br>$\text{Ag}^{110}$                |       | $24.5 \pm 0.3 \text{ c}$<br>$270 \text{ д [G 8]}$               | $\beta^-, \gamma$<br>$\beta^-$<br>$(\beta^+ < 0.2\%),$<br>$[\text{E}2], \gamma,$<br>$K (< 3\%)$ | 2.7<br>$0.087 (^{58\%}),$<br>$0.560^*$<br>$(> 37\%),$<br>$2.79 (< 5\%)$<br>$[\text{S } 14, \text{E}, 2]$ | 0.116, 0.656,<br>0.676, 0.706,<br>0.759, 0.814,<br>0.885, 0.935,<br>1.389, 1.516<br>$[\text{S } 14]$<br>нет $\gamma$ |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|    |                   | $\text{Ag}^{111}$                                     |       | $7.6 \text{ д [D2]}$                                            | $\beta^-$                                                                                       | 1.06 [H6]                                                                                                | нет $\gamma$                                                                                                         | $\text{Pd}^{110}\text{-d-n}; \text{Pd}^{108}\text{-}\alpha\text{-p}; \text{Cd}^{111}\text{-n-p};$<br>$\text{U (n, } \odot \text{) Pd}^{111} (26 \text{ м}) \beta^-;$<br>$\text{Cd}^{113}\text{-}\gamma\text{-p};$<br>$(\text{Ag}^{109}\text{-t-p}); \text{Th}^{232}\text{-n-}\odot;$<br>$\text{U}^{238}\text{-n-}\odot; \text{U-}\alpha\text{-}\odot;$<br>$\text{Th}^{232}\text{-}\alpha\text{-}\odot; \text{Pu}^{239}\text{-n-}\odot;$<br>$\text{Bi}^{209}\text{-d-}\odot; \text{Sb-d- [6p, (6,8) n];}$<br>$\text{Pd}^{111} (26 \text{ м}) \beta^-$ |
|    |                   | $\text{Ag}^{112}$                                     |       | $3.2 \text{ ч [D2]}$                                            | $\beta^-, \gamma$                                                                               | 3.6                                                                                                      | 0.86 •                                                                                                               | $\text{Cd}^{112}\text{-n-p}; \text{In}^{115}\text{-n-}\alpha;$<br>$\text{U (n, } \odot \text{) Pd}^{112} (2 \text{ ч}) \beta^-;$<br>$\text{Cd}^{113}\text{-}\gamma\text{-p [D2]; U}^{238}\text{-n-}\odot; \text{U-}\alpha\text{-}\odot;$<br>$\text{Th}^{232}\text{-}\alpha\text{-}\odot; \text{Bi}^{209}\text{-d-}\odot \text{ [G 8]}$                                                                                                                                                                                                               |
|    |                   | $\text{Ag}^{113}$<br>$\text{Ag}^{115}$<br>$\text{Ag}$ |       | $5.3 \text{ ч}$<br>$20 \text{ м [D2]}$<br>$\approx 3 \text{ м}$ | $\beta^-$<br>$\beta^-, \gamma$<br>$\beta^-$                                                     | 2.2<br>$3.0 \text{ [D2]}$<br>$\approx 2$                                                                 | нет $\gamma$                                                                                                         | $\text{Cd}^{114}\text{-}\gamma\text{-p}; \text{U-n-}\odot$<br>$\text{U-n-}\odot; \text{Cd}^{116}\text{-}\gamma\text{-p [D 2]}$<br>$\text{U-n-}\odot$                                                                                                                                                                                                                                                                                                                                                                                                 |
| 48 |                   | $\text{Cd}^{(105)}$                                   |       | $57 \text{ м}$                                                  | $\beta^+$                                                                                       | 1.5 [G8]                                                                                                 |                                                                                                                      | $\text{Cd-n-2 n [G 8]; Cd-}\gamma\text{-n};$<br>$\text{Pd}^{103}\text{-}\alpha\text{-n [G 8]}$                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|    | $\text{Cd}^{106}$ |                                                       | 1.215 |                                                                 |                                                                                                 |                                                                                                          |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|    |                   | $\text{Cd}^{107}$                                     |       | $6.7 \text{ ч}$                                                 | $\beta^+ (0.31\%),$<br>$K (\approx 100\%),$<br>$\gamma, \text{e}^-$                             | 0.320                                                                                                    | 0.846 (0.42%)                                                                                                        | $\text{Ag}^{107}\text{-p-n}; \text{Ag}^{107}\text{-d-2 n};$<br>$\text{Cd}^{108}\text{-n-}\gamma; \text{Ag}^{107}\text{-}\alpha\text{-3n}; \text{Sn-d-?}$<br>$\text{Sb}^{(121, 123)}\text{-d- [4 p, (12,14) n]}$                                                                                                                                                                                                                                                                                                                                      |
|    | $\text{Cd}^{108}$ |                                                       | 0.875 |                                                                 |                                                                                                 |                                                                                                          |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| Атомный<br>номер | Стабильное<br>ядро                     | Радиоактивн.<br>ядро      | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв   | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                   |
|------------------|----------------------------------------|---------------------------|--------------------------------|----------------------------|-------------------------|----------------------------------------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                      | 3                         | 4                              | 5                          | 6                       | 7                                                              | 8                                     | 9                                                                                                                                                                                                                                                                                                                                                                 |
|                  |                                        | $\text{Cd}^{109}$         |                                | 470 д                      | $K, \gamma$             | нет $\beta$                                                    | 0.0863,<br>0.3369,<br>0.086 [H7]      | $\text{Ag}^{109}\text{-d-2n}$ [G 8]; $\text{Ag}^{107}\text{-}\alpha\text{-p, n}$ ;<br>$\text{Cd}^{108}\text{-n-}\gamma$ ;<br>$\text{Sb}^{(121, 123)}\text{-d-[4 p, (10,12) n]}$ ;<br>$\text{Pd-d}$ [G8]; $\text{Ag}^{109}\text{-p-n}$                                                                                                                             |
|                  | $\text{Cd}^{110}$<br>$\text{Gd}^{111}$ | $^{\circ}\text{Cd}$       | 12.39<br>12.75                 | $48.7 \pm 0.3$ м           | $I, e^-$                |                                                                | 0.147*<br>(100%),<br>0.241*<br>(100%) | $\text{Cd}^{110}\text{-n-}\gamma$ ; $\text{Cd}^{112}\text{-}\gamma\text{-n}$ ; $\text{Cd}^{111}\text{-x}$ ;<br>$\text{U-n-}\odot$ ; $\text{Pd}^{108}\text{-}\alpha\text{-n}$ ;<br>$\text{Ag}^{109}\text{-}\alpha\text{-p, n}$ ; $\text{Cd}^{111}\text{-e}^-\text{-e}^-$ ;<br>$\text{In}^{111}$ (2,84 д) $K$ ; $\text{Cd}^{111}\text{-n-n}$                        |
|                  | $\text{Cd}^{113}$<br>$\text{Cd}^{113}$ | $^{\circ}\text{Cd}^{113}$ | 24.07<br>12.26                 | 2,3 м                      | $I$                     |                                                                |                                       | $\text{Cd}^{113}\text{-n-n}$                                                                                                                                                                                                                                                                                                                                      |
|                  | $\text{Cd}^{114}$                      | $\text{Cd}^{115}$         | 28.86                          | 2,39 д                     | $\beta^-, \gamma$       | 0.60 (60%),<br>1.13 (40%),<br>1.10 [H7]                        | 0.65, (0.337),<br>0.520 [H7]          | $\text{Cd}^{114}\text{-d-p}$ ; $\text{Cd}^{114}\text{-n-}\gamma$ ; $\text{Cd}^{116}\text{-n-2n}$ ;<br>$\text{U-n-}\odot$ ; $\text{U-}\alpha\text{-}\odot$ ;<br>$\text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N 1];<br>$\text{Cd}^{116}\text{-}\gamma\text{-n}$ ;<br>$\text{Sb}^{(121, 123)}\text{-d-[4 p, (4,6) n]}$ ;<br>$\text{Bi}^{209}\text{-d-}\odot$ [G 11] |
|                  |                                        | $^{\circ}\text{Cd}^{115}$ |                                | $43 \pm 3$ д               | $\beta^-, \gamma$       | 1.67 [H7]                                                      | 0.5                                   | $\text{Cd}^{114}\text{-n-}\gamma$ ; $\text{In}^{115}\text{-n-p}$ ; $\text{Cd}^{114}\text{-d-p}$ ;<br>$\text{U-n-}\odot$ ; $\text{U-}\alpha\text{-}\odot$ ; $\text{U}^{238}\text{-n-}\odot$ ;<br>$\text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N 1]; $\text{Pu}^{239}\text{-n-}\odot$ ;<br>$\text{Bi}^{209}\text{-d-}\odot$ ; $\text{Sn-n-}\alpha?$                |

|    | Cd <sup>116</sup> | Cd <sup>117</sup>                                                                                                                                                                                                                         | 7.58 | 2.72 ч                                                                                         | $\beta^-$                                                                                                                                                                                                                                                                   | 1.5*                                                                                                                                              |                                                                                                                                                                                                  | Cd <sup>116</sup> -d-p; Cd <sup>116</sup> -n- $\gamma$ ; U-n-①                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 49 |                   | In <sup>107</sup><br>In <sup>108</sup><br>In <sup>109</sup><br>In <sup>110</sup><br>In <sup>111</sup><br>° In <sup>112</sup><br>In <sup>112</sup><br>° In <sup>113</sup><br>In <sup>113</sup><br>° In <sup>114</sup><br>In <sup>114</sup> |      | 33±2 м<br>55 м<br>4,30±0.15 ч<br>65 м<br>2,84±0.03 д<br>23 м<br>9 м<br>105 м<br>49±3 д<br>72 с | $\beta^+$ , $\gamma$<br>$K$ , $\gamma$ , $\beta^+$<br>[M15]<br>$\beta^+$ (2%),<br>$K$ (98%), $\gamma$<br>$\beta^+$<br>$K$ , $\gamma$<br>$I$ , $\gamma$ , $e^-$<br>$\beta^+$ , $\beta^-$ (?), $K$<br>$I$ , $\gamma$ , $e^-$<br>$I$<br>$\beta^-$ , $e^-$<br>(≈100%), $\gamma$ | 2.2<br>75 [M18]<br>1.6<br>нет $\beta$<br>нет $\beta$<br>1.7* ( $\beta^+$ ),<br>1.0,<br>(0.47) ( $\beta^-$ )<br>1.98,<br>2.05 [M26],<br>1.89 [M24] | 0.65<br>0.5<br>0.173 (100%),<br>0.247 (100%),<br>0.16<br>0.39<br>0.1909,<br>0.81* (≈5%)<br>[M24, M26]<br>0.81 (≈5%)?;<br>0.830 [B27]?;<br>0.552 (47.9);<br>0.722 (47.7);<br>1.27 (3.2)<br>[M 38] | Cd <sup>106</sup> -d-p; Cd <sup>106</sup> -p- $\gamma$<br>Sb-d→Sn <sup>108</sup> (4.5 ч) $K$ [M18]<br>Ag <sup>107</sup> - $\alpha$ -2n; Cd <sup>106</sup> - $\alpha$ -p [M18];<br>Cd <sup>108</sup> -d-n [M 18];<br>Cd <sup>108</sup> -p- $\gamma$ [M 18]<br>Ag <sup>107</sup> - $\alpha$ -n; Ag <sup>109</sup> - $\alpha$ -3n; Cd <sup>110</sup> -p-n;<br>Cd <sup>110</sup> -d-2 n<br>Ag <sup>109</sup> - $\alpha$ -2n; In <sup>113</sup> -n-3n;<br>Cd <sup>111</sup> -p-n [B5]; Cd <sup>110</sup> -d-n [M18]<br>Ag <sup>109</sup> - $\alpha$ -n; Cd <sup>111</sup> -d-n; Cd <sup>112</sup> -p-n;<br>In <sup>113</sup> -n-2 n<br>Ag <sup>109</sup> - $\alpha$ -n; In <sup>113</sup> -n-2 n;<br>° In <sup>112</sup> (23 м) $I$<br>Cd <sup>112</sup> -d-n; Cd <sup>112</sup> -p-n;<br>Sn <sup>113</sup> (105 д) $K$ ; In <sup>113</sup> -x<br>In <sup>113</sup> -d-p; In <sup>113</sup> -n- $\gamma$ ; In <sup>115</sup> -n-2 n;<br>Cd <sup>114</sup> -p-n [B5]; Cd <sup>113</sup> -d-n;<br>Sn-d- $\alpha$ ; In <sup>115</sup> - $\gamma$ -n<br>° In <sup>114</sup> (50 д) $I$ ; In <sup>115</sup> - $\gamma$ -n;<br>In <sup>115</sup> -n-2 n; Cd <sup>114</sup> -p-n;<br>In <sup>113</sup> -n- $\gamma$ ; In <sup>115</sup> - $\gamma$ -n |

| Атомный номер | Стабильное ядро   | Радиоактивн. ядро                                                                                                                                                           | Распростра-<br>ненность<br>в % | Период<br>полурас-<br>пада                                                            | Тип<br>превраще-<br>ния                                                                                                                                                                   | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                                                       | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                 | 3                                                                                                                                                                           | 4                              | 5                                                                                     | 6                                                                                                                                                                                         | 7                                                              | 8                                                                                                                         | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|               | In <sup>115</sup> | <sup>o</sup> In <sup>115</sup><br><br>In <sup>116</sup><br><br>In <sup>116</sup><br>In <sup>117</sup><br><br>In <sup>118</sup><br>[D 11]<br><br>In <sup>119</sup><br>[D 11] | 95.77±0.03                     | 4.5 ч<br><br>53.93±0.13 м<br>[S 22]<br><br>13 с<br>117±3 м<br>4.5±0.5 м<br>17.5±1.0 м | $\beta^-$ , $\gamma$ ,<br>$e^-$ ( $\approx 100\%$ )<br><br>$\beta^-$ , $\gamma$ ,<br>( $\beta^+ < 0.1\%$ )<br><br>$\beta^-$<br><br>$\beta^-$<br><br>$\beta^-$ , $\gamma$<br><br>$\beta^-$ | <br><br>0.85<br><br>2.95<br>1.73<br>1.5<br>2.7                 | 0.337 [H7]<br><br>0.428, 1.12,<br>1.31, 2.32<br>(0.17, 0.36,<br>0.57, 1.02, 1.8,<br>2.08)<br>нет $\gamma$<br>нет $\gamma$ | Cd <sup>114</sup> -d-n; In <sup>115</sup> -n-n; In <sup>115</sup> -p-p;<br>In <sup>115</sup> - $\alpha$ - $\alpha$ ; In <sup>115</sup> -x [M 4];<br>Cd <sup>115</sup> (2.39 д) $\beta^-$ ; In <sup>115</sup> -e <sup>-</sup> -e <sup>-</sup> ;<br>Bi <sup>209</sup> (d, $\odot$ ) Cd <sup>115</sup> (2.39 д) $\beta^-$ ;<br>[G 11]<br><br>Cd <sup>116</sup> -p-n; In <sup>115</sup> -n- $\gamma$ ; In <sup>115</sup> -d-p;<br>Sn <sup>117</sup> - $\gamma$ -p<br><br>Cd <sup>116</sup> -p-n; In <sup>115</sup> -d-p; In <sup>115</sup> -n- $\gamma$ ;<br>Sn <sup>117</sup> - $\gamma$ -p<br>Cd <sup>116</sup> -d-n; Cd <sup>117</sup> (3.75 ч) $\beta^-$ ;<br>U (n, $\odot$ ) Cd <sup>117</sup> (3.75 ч) $\beta^-$ ;<br>Pu <sup>139</sup> -n- $\odot$<br>Sn <sup>119</sup> - $\gamma$ -p [D11]<br><br>Sn <sup>120</sup> - $\gamma$ -p [D11] |
| 50            | Sn <sup>112</sup> | Sn <sup>108</sup><br>[M18]<br>Sn <sup>111</sup>                                                                                                                             | 0,90±0,003                     | 4.5 ч<br>35.0±0.5 м                                                                   | K<br><br>$\beta^+$ (4%),<br>K' (96%), $\gamma$                                                                                                                                            | 1.45 [H17]                                                     |                                                                                                                           | Sb-d-?<br><br>Gd <sup>108</sup> - $\alpha$ -n [H17]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

|                                                                                  |                            |                                                                            |                               |                      |                                         |                                      |                                                                                                                                                                                                                                                                    |
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|                                                                                  | $\text{Sn}^{113}$          |                                                                            | $105 \pm 15$ д                | $K$                  |                                         | 0.085                                | $\text{In}^{112}\text{-p-n}; \text{Sn}^{112}\text{-d-p}; \text{Cd}^{110}\text{-}\alpha\text{-n};$<br>$\text{Sn}^{112}\text{-n-}\gamma; \text{Sn}^{114}\text{-}\gamma\text{-n}; \text{In}^{118}\text{-d-2n};$<br>$\text{Sb}^{(121, 123)}\text{-d-[2 p, (8, 10) n]}$ |
| $\text{Sn}^{114}$<br>$\text{Sn}^{115}$<br>$\text{Sn}^{116}$<br>$\text{Sn}^{117}$ | $\cdot$                    | $0.61 \pm 0.01$<br>$0.35 \pm 0.006$<br>$14.07 \pm 0.08$<br>$7.54 \pm 0.03$ |                               |                      |                                         |                                      |                                                                                                                                                                                                                                                                    |
|                                                                                  | $^{\circ}\text{Sn}^{117}$  |                                                                            | 14.5 д [M35]                  | $I$                  |                                         | 0.159; 0.162<br>[M35]<br>0.175 [M36] | $\text{Sn}^{116}\text{-n-}\gamma$ [M35]; $\text{Cd}^{114}\text{-}\alpha\text{-n};$<br>$\text{Sn}^{116}\text{-d-p}; \text{Sn}^{118}\text{-n-2 n};$<br>$\text{Sn}^{117}\text{-n-n}; \text{Cd}^{116}\text{-d-n}$ [M36]                                                |
| $\text{Sn}^{118}$<br>$\text{Sn}^{119}$<br>$\text{Sn}^{120}$                      | $^{\circ}\text{Sn}^{119}$  | $23.98 \pm 0.03$<br>$8.62 \pm 0.003$<br>$33.03 \pm 0.12$                   | $\geq 100$ д                  | $I, \gamma, e^{-}$   |                                         | 0.069 [M35]                          | $\text{Cd}^{116}\text{-}\alpha\text{-n}; \text{Sb}^{121}\text{-d-}\alpha$                                                                                                                                                                                          |
|                                                                                  | $\text{Sn}^{121}$          |                                                                            | $1.1 \pm 0.5$ д<br>[L10]      | $\beta^{-}$          | 0.385 [D19],<br>0.35 [L10]              | нет $\gamma$                         | $\text{Sn}^{120}\text{-d-p}; \text{Sn}^{130}\text{-n-}\gamma; \text{Th}^{232}\text{-}\alpha\text{-}\odot$<br>[N 1]; $\text{Sn}^{122}\text{-n-2 n}$ [L10]                                                                                                           |
| $\text{Sn}^{122}$                                                                | $\text{Sn}^{123}$          |                                                                            | $40 \pm 1$ м                  | $\beta^{-}, \gamma$  | 1.20<br>[L10, D19]                      | 0.153 [D19]                          | $\text{Sn}^{122}\text{-d-p}; \text{Sn}^{122}\text{-n-}\gamma$ [L10, D19];<br>$\text{Sn}^{124}\text{-n-2 n}$ [L10], $\text{Sn}^{124}\text{-d-t};$<br>$\text{Sn}^{124}\text{-}\gamma\text{-n}$ [H19]                                                                 |
|                                                                                  | $\text{Sn}^{123}$          |                                                                            | $130 \pm 5$ д                 | $\beta^{-}$          | 1.3 [L10]                               | 0.394 [M35]                          | $\text{Sn}^{122}\text{-d-p}; \text{In}^{123}\text{-n-}\gamma;$<br>$\text{Sn}^{124}\text{-n-2 n}$ [L10]; $\text{U-n-}\odot;$<br>$\text{U}^{233}\text{-n-}\odot; \text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N 1]                                                   |
| $\text{Sn}^{124}$                                                                |                            | $6.11 \pm 0.006$                                                           | $(0.4 - 0.9) \cdot 10^{16}$ л | $(2\beta^{-})$ [F 1] | $(1.0-1.5)$ [F1]                        |                                      |                                                                                                                                                                                                                                                                    |
|                                                                                  | $\text{Sn}^{125}$          |                                                                            | $9.8 \pm 0.2$ м<br>[L10]      | $\beta^{-}, \gamma$  | 1.3 [L10]<br>0.51; 1.17; 20.4<br>[D19a] | $\approx 0.74$                       | $\text{Sn}^{124}\text{-d-p}; \text{Sn}^{124}\text{-n-}\gamma$ [L10]                                                                                                                                                                                                |
|                                                                                  | $\text{Sn}^{125}$          |                                                                            | $1.0 \pm 0.3$ д<br>[L10]      | $\beta^{-}$          | 2.1 [L10]                               |                                      | $\text{Sn}^{124}\text{-d-p}$ [L10]; $\text{Sn}^{124}\text{-n-}\gamma$ [L10];<br>$\text{U-n-}\odot; \text{U}^{233}\text{-n-}\odot; \text{Th}^{232}\text{-}\alpha\text{-}\odot$<br>[N 1]                                                                             |
|                                                                                  | $\text{Sn}^{>125}$<br>(Sn) |                                                                            | $\approx 20$ м                | $\beta^{-}$          |                                         |                                      | $\text{U-n-}\odot$                                                                                                                                                                                                                                                 |
|                                                                                  | $\text{Sn}^{>120}$         |                                                                            | 17.5 д                        | $\beta^{-}$          | 1.7                                     |                                      | $\text{U-n-}\odot; \text{U}^{233}\text{-n-}\odot$                                                                                                                                                                                                                  |
|                                                                                  | $\text{Sn}^{(126, 128)}$   |                                                                            | $\approx 45$ ч                | $\beta^{-}$          | 0.76                                    |                                      | $\text{U-n-}\odot; \text{U-}\alpha\text{-}\odot$                                                                                                                                                                                                                   |
|                                                                                  |                            |                                                                            | 70 м                          | $\beta^{-}, \gamma$  | 0.7                                     | 1.2                                  | $\text{U-n-}\odot$                                                                                                                                                                                                                                                 |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро                                 | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния                                              | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                                                  |
|------------------|--------------------|-----------------------------------------------------|--------------------------------|----------------------------|----------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                                                   | 4                              | 5                          | 6                                                                    | 7                                                              | 8                                   | 9                                                                                                                                                                                                                                |
| 51               | Sb <sup>121</sup>  | Sb <sup>(116)</sup>                                 | 57.25±0.03                     | 60 м                       | $\beta^+$ , $\gamma$                                                 | 1.45 [Т3]                                                      | 0.156, 0.7<br>[Т3], 0.49            | In <sup>115-<math>\alpha</math>-(3) n [Т3]</sup>                                                                                                                                                                                 |
|                  |                    | Sb <sup>(117)</sup>                                 |                                | 2.8 ч                      | $K$ , $e^-$                                                          | 3.1                                                            | 0.230 [Т8],<br>1.5                  | Sn <sup>117-p-n</sup> ; Sn <sup>116-d-(n)</sup>                                                                                                                                                                                  |
|                  |                    | Sb <sup>(118)</sup>                                 |                                | 5.1±0.3 ч                  | $K$ , $\gamma$ , $e^-$                                               |                                                                |                                     | In <sup>115-<math>\gamma</math>-n</sup> ; Sn <sup>(117)-d-(n)</sup>                                                                                                                                                              |
|                  |                    | Sb <sup>(118)</sup>                                 |                                | 3.3 м                      | $\beta^+$ , $\gamma$                                                 | нет $\beta$                                                    | нет $\gamma$                        | In <sup>(115)-<math>\alpha</math>-n [Т8]</sup> ; Sn <sup>(118)-p-n</sup> ;<br>Te <sup>(118)(6.0 д) K [G 11]</sup>                                                                                                                |
|                  |                    | Sb <sup>(119)</sup>                                 | 42.75±0.03                     | 39±1 ч                     | $K$                                                                  |                                                                |                                     | Sn <sup>118-d-(n)</sup> ; Sn <sup>119-p-n</sup> ;<br>Te <sup>119(4.5 д) K</sup> ;<br>Sb <sup>(121, 123)-d-[p, (3,5) n]</sup>                                                                                                     |
|                  |                    | Sb <sup>(120)</sup>                                 |                                | 6.0 д                      | $K$ , $\gamma$ , $e^-$                                               | 1.53                                                           | 1.1                                 | Bi <sup>209-d-⊙ [G11]</sup> ; Sn <sup>120-d-2 n</sup> ;<br>Sb <sup>(121)-d-p,(2)n</sup>                                                                                                                                          |
|                  |                    | Sb <sup>120</sup>                                   |                                | 16.6 м                     | $\beta^+$                                                            |                                                                |                                     | Sn <sup>119-d-n</sup> ; Sn <sup>120-p-n</sup> ; Sn <sup>120-d-2 n</sup> ;<br>Sb <sup>121-n-2 n</sup> ; Sb <sup>121-<math>\gamma</math>-n [M 6]</sup> ;<br>Sb <sup>122-p-p, n</sup> ; Sb <sup>121-d-t</sup>                       |
|                  |                    | <sup>⊙</sup> Sb <sup>122</sup><br>Sb <sup>122</sup> | 42.75±0.03                     | 3.5 м<br>2.67 д            | $I$ , $e^-$<br>$\beta^-$ , $\gamma$ , $e^-$<br>( $\beta^+ < 0.1\%$ ) | 1.36, 1.94                                                     | 0.14<br>0.568, 0.80,<br>0.96        | Sb <sup>121-n-<math>\gamma</math></sup><br>Sb <sup>121-n-<math>\gamma</math></sup> ; Sb <sup>121-d-p</sup> ; Sn <sup>122-d-2n</sup> ;<br>Sn <sup>121-p-n</sup> ; Sb <sup>123-<math>\gamma</math>-n</sup> ; Bi <sup>209-d-⊙</sup> |
|                  | Sb <sup>123</sup>  | <sup>⊙</sup> Sb <sup>124</sup>                      |                                | 1.3 м                      | $I$ , $\beta^-$ , $\gamma$                                           | 3.2                                                            | (0.014)                             | Sb <sup>123-n-<math>\gamma</math></sup>                                                                                                                                                                                          |

|    |                   |                                                                                           |                   |                                              |                                                                         |                                                                                   |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                          |
|----|-------------------|-------------------------------------------------------------------------------------------|-------------------|----------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                   | $^{124}\text{Sb}$<br>$^{134}\text{Sb}$                                                    |                   | 21 м<br>60 д                                 | $I, \beta^-, \gamma, e^-$<br>$\beta^-, \gamma$<br>( $\beta^+ < 0.5\%$ ) | 0.02<br>0.49* (28%),<br>0.67* (35%),<br>0.99* (8%),<br>1.56* (8%),<br>2.37* (21%) | 0.121* (18%),<br>0.606* (100%),<br>0.652* (8%),<br>0.723* (25%),<br>1.708* (70%),<br>2.05 (7%)                       | $\text{Sb}^{123}\text{-n-}\gamma$<br>$\text{Sb}^{124}\text{-d-2n}$ ; $\text{Sb}^{123}\text{-d-p}$ ; $\text{Sb}^{123}\text{-n-}\gamma$ ;<br>$\text{I}^{127}\text{-n-}\alpha$                                                                                                                                                                              |
|    |                   | $\text{Sb}^{125}$                                                                         |                   | 2.7 ч                                        | $\beta^-, \gamma$                                                       | 0.288 (67%),<br>0.621 (33%),<br>[K11, M10]                                        | 0.125, 0.174,<br>0.431, 0.466,<br>0.609, 0.676<br>[K 11]                                                             | $\text{Sn}^{124}\text{-d-n}$ ; $\text{Sb}^{124}\text{-n-}\gamma$ [K 3];<br>$\text{U}^{233}\text{-n-}\ominus$ ;<br>$\text{Sn (n, } \gamma) \text{ Sn}^{125} (\beta^-)$ [K 11];<br>$\text{Th}^{232}\text{-n-}\ominus$ [N 1]; $\text{U-n-}\ominus$                                                                                                          |
|    |                   | ( $\text{Sb} > ^{125}$ )                                                                  |                   | 28 д                                         | $\beta^-$                                                               | 1.86                                                                              | 0.72                                                                                                                 | $\text{U-n-}\ominus$                                                                                                                                                                                                                                                                                                                                     |
|    |                   | $\text{Sb}^{127}$                                                                         |                   | 93 ч                                         | $\beta^-, \gamma$                                                       | $\approx 1$                                                                       |                                                                                                                      | $\text{U-n-}\ominus$ ; $\text{U}^{233}\text{-n-}\ominus$ ; $\text{Pu}^{239}\text{-n-}\ominus$                                                                                                                                                                                                                                                            |
|    |                   | $\text{Sb}^{(126, 128)}$                                                                  |                   | 60 м                                         | $\beta^-$                                                               | 2.8 или 0.7                                                                       |                                                                                                                      | $\text{U (n, } \ominus) \text{ Sn}^{(126, 128)}$ (70 м) $\beta^-$                                                                                                                                                                                                                                                                                        |
|    |                   | $\text{Sb}^{129}$                                                                         |                   | 4.2 ч                                        | $\beta^-$                                                               |                                                                                   |                                                                                                                      | $\text{U-n-}\ominus$ ; $\text{Pu}^{239}\text{-n-}\ominus$                                                                                                                                                                                                                                                                                                |
|    |                   | $\text{Sb}^{(132)}$                                                                       |                   | 5 м                                          | $\beta^-$                                                               |                                                                                   |                                                                                                                      | $\text{U-n-}\ominus$                                                                                                                                                                                                                                                                                                                                     |
|    |                   | $\text{Sb}^{133}$                                                                         |                   | $\approx 10$ м                               | $\beta^-$                                                               |                                                                                   |                                                                                                                      | $\text{U-n-}\ominus$ ; $\text{Th}^{232}\text{-n-}\ominus$                                                                                                                                                                                                                                                                                                |
|    |                   | $\text{Sb}^{(134)}$                                                                       |                   | $< 10$ м                                     | $\beta^-$                                                               |                                                                                   |                                                                                                                      | $\text{U-n-}\ominus$                                                                                                                                                                                                                                                                                                                                     |
| 52 | $\text{Te}^{120}$ | $\text{Te}^{<118}$<br>$\text{Te}^{(118)}$<br>$\text{Te}^{(119)}$<br><br>$^{121}\text{Te}$ | $0.091 \pm 0.001$ | 2.5 ч<br>6.0 д<br>4.5 д<br><br>$143 \pm 5$ д | $\beta^+$<br>$K$<br>$K, \gamma, e^-$<br><br>$I, e^-, \gamma$            |                                                                                   | нет $\gamma$<br>0.2, 0.5, 1,4<br><br>(0.0365),<br>0.0820,<br>0.0884*, 0.136,<br>0.158*, 0.212,<br>(0.05),<br>(0.185) | $\text{Sb-d-?}$<br>$\text{Sb}^{(121, 123)}\text{-d-(5,7) n}$<br>$\text{Sb}^{(121, 123)}\text{-d-(4,6) n}$ ;<br>$\text{Bi}^{(209)}\text{-d-}\ominus$<br><br>$\text{Sb}^{121}\text{-d-2 n}$ ; $\text{Sb}^{121}\text{-p-n}$ ; $\text{Sn}^{118}\text{-}\alpha\text{-n}$ ;<br>( $\text{Te}^{120}\text{-n-}\gamma$ ); $\text{Bi}^{209}\text{-d-}\ominus$ [G11] |

| Атомный номер | Стабильное ядро                        | Радиоактивн. ядро                      | Распростра-<br>нённость<br>в %   | Период<br>полурас-<br>пада       | Тип<br>превраще-<br>ния | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                            | Ядерные реакции                                                                                                                                   |
|---------------|----------------------------------------|----------------------------------------|----------------------------------|----------------------------------|-------------------------|----------------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                      | 3                                      | 4                                | 5                                | 6                       | 7                                                              | 8                                                              | 9                                                                                                                                                 |
|               |                                        | $^{131}\text{Te}$                      |                                  | $(5\pm 2)\times 10^{-8}\text{с}$ | $I, e^-$                |                                                                | 0.225                                                          | $^{131}\text{Te}$ (143 д) $I$                                                                                                                     |
|               | $\text{Te}^{133}$                      | $^{131}\text{Te}$                      |                                  | $17\pm 1\text{ д}$               | $K, \gamma$             |                                                                | 0.615                                                          | $\text{Sb}^{131}\text{-d-2 n}$ ; $\text{Sb}^{131}\text{-p-n}$ ;<br>$^{131}\text{Te}$ (143 д, $5\times 10^{-8}\text{с}$ ) $I$                      |
|               |                                        | $^{133}\text{Te}$                      | $2.49\pm 0.02$                   | $\approx 100\text{д}$ [H 15]     | $I; e^-$                |                                                                | 0.159 [H15],<br>0.1885                                         | $\text{Te}^{132}\text{-n-}\gamma$ [H 15]                                                                                                          |
|               | $\text{Te}^{123}$<br>$\text{Te}^{124}$ | $^{123}\text{Te}$<br>$^{124}\text{Te}$ | $0.89\pm 0.02$<br>$4.63\pm 0.05$ |                                  |                         |                                                                |                                                                |                                                                                                                                                   |
|               |                                        | $^{124}\text{Te}$                      |                                  | $1200\pm 400\text{мкс}$          | $I$                     |                                                                | $<0.069$                                                       | $\text{Sb}^{134}$ (60 д) $\beta^-$                                                                                                                |
|               | $\text{Te}^{125}$                      | $^{125}\text{Te}$                      | $7.01\pm 0.01$                   | $53\pm 4\text{ д}$ [H3]          | $I, \gamma, e^-$        |                                                                | 0.1093 [H3],<br>0.110 [K 3],<br>0.0355 [H15],<br>0.0354 [B 26] | $\text{Sb}^{135}$ (2.7 г) $\beta^-$ [K 3, H 3];<br>$I^{(125)}$ (56 д) $K?$                                                                        |
|               |                                        | $^{125}\text{Te}$                      |                                  |                                  |                         |                                                                | 0.0885 [H15]                                                   | $\text{Te}^{136}\text{-n-}\gamma$ ; $\text{Te}^{136}\text{-d-p}$ ; $I^{127}\text{-n-p}$ ;<br>$\text{U-n-}\odot$ ; $\text{U}^{233}\text{-n-}\odot$ |
|               | $\text{Te}^{126}$                      | $^{126}\text{Te}$                      | $18.72\pm 0.04$                  | 90 д                             | $I, \gamma, e^-$        |                                                                |                                                                | $\text{Te}^{126}\text{-d-p}$ ; $\text{Te}^{126}\text{-n-}\gamma$ ; $\text{Te}^{128}\text{-n-2n}$ ;<br>$I^{127}\text{-n-p}$ ; $\text{U-n-}\odot$   |
|               |                                        | $^{127}\text{Te}$                      |                                  | $9.3\pm 0.5\text{ ч}$            | $\beta^-$               | 0.8                                                            | нет $\gamma$                                                   | $\text{U}(\text{n}, \odot)\text{Sb}^{127}$ (93 ч) $\beta^-$ ;<br>$\text{U}(\text{n}, \odot)\text{Te}^{127}$ (10 д) $I$ ;                          |
|               | $\text{Te}^{128}$                      |                                        | $31.72\pm 0.01$                  | $> 10^{19}\text{ л}$             |                         | нет, $\beta^-$ [I2]                                            |                                                                |                                                                                                                                                   |

|                  |  |                     |                  |                       |                                             |                                                   |                                                        |                                                                                                                                                                                                                                                                                                                                   |
|------------------|--|---------------------|------------------|-----------------------|---------------------------------------------|---------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |  | $^{130}\text{Te}$   |                  | 35.5 д                | $I, \gamma$                                 |                                                   | 0.106 [H15]                                            | $\text{Te}^{128}\text{-n-}\gamma; \text{Te}^{150}\text{-n-}2\text{n}; \text{Te}^{128}\text{-d-p};$<br>$\text{Te}^{130}\text{-}\gamma\text{-n}; \text{U}^{238}\text{-n-}\odot; \text{U-n-}\odot$                                                                                                                                   |
|                  |  | $\text{Te}^{129}$   |                  | $72 \pm 3$ м          | $\beta^-, \gamma$                           | 1.8                                               | 0.3, 0.8                                               | $\text{Te}^{128}\text{-n-}\gamma; \text{Te}^{130}\text{-n-}2\text{n}; \text{Te}^{128}\text{-d-p};$<br>$\text{Te}^{130}\text{-}\gamma\text{-n};$<br>$\text{U (n, } \odot) \text{Sb}^{129} (4.2 \text{ ч}) \beta^-;$<br>$\text{U (n, } \odot) \text{}^{130}\text{Te}^{129} (35.5 \text{ д}) I;$<br>$\text{Th}^{232}\text{-n-}\odot$ |
|                  |  | $^{131}\text{Te}$   | $34.46 \pm 0.09$ | $> 8 \cdot 10^{19}$ л | $I, e^-$                                    | нет $2\beta^-$ [12]                               |                                                        | $\text{Te}^{130}\text{-n-}\gamma; \text{Te}^{130}\text{-d-p}; \text{U-n-}\odot$                                                                                                                                                                                                                                                   |
|                  |  | $\text{Te}^{181}$   |                  | $1.2 \pm 0.2$ д       | $\beta^-$                                   | 1.8 [W20]                                         | 0.177 [H15]                                            | $\text{Te}^{130}\text{-d-p}; \text{Te}^{130}\text{-n-}\gamma;$<br>$\odot \text{Te}^{131} (1.2 \text{ д}) I$ [W20]                                                                                                                                                                                                                 |
|                  |  | $\text{Te}^{(132)}$ |                  | 77 ч                  | $\beta^-, \gamma$                           | $\approx 0.3$                                     | 0.22                                                   | $\text{U (n, } \odot) \text{Sb}^{(132)} (5 \text{ м}) \beta^-;$<br>$\text{Th}^{232}\text{-n-}\odot; \text{Th}^{232}\text{-}\alpha\text{-}\odot$ [N1];<br>$\text{Pu}^{239}\text{-n-}\odot$                                                                                                                                         |
|                  |  | $\text{Te}^{133}$   |                  | 60 м                  | $\beta^-$                                   |                                                   |                                                        | $\text{U (n, } \odot) \text{Sb}^{133} (10 \text{ м}) \beta^-;$<br>$\text{Pu}^{239}\text{-n-}\odot$                                                                                                                                                                                                                                |
|                  |  | $\text{Te}^{(134)}$ |                  | 43 м                  | $\beta^-$                                   |                                                   |                                                        | $\text{U (n, } \odot) \text{Sb}^{(134)} (< 10 \text{ м}) \beta^-;$<br>$\text{Th}^{232}\text{-n-}\odot; \text{Pu}^{239}\text{-n-}\odot$                                                                                                                                                                                            |
|                  |  | $\text{Te}^{(135)}$ |                  | $< 2$ м               | $\beta^-$                                   |                                                   |                                                        | $\text{U-n-}\odot; (\text{Th}^{232}\text{-n-}\odot)$                                                                                                                                                                                                                                                                              |
| 53               |  | $^{124}\text{I}$    |                  | $13.0 \pm 0.5$ ч      | $I$ [M37]                                   |                                                   | 0.159                                                  | $\text{Sb}^{121} (\alpha, \text{n})$ [M32, M37]                                                                                                                                                                                                                                                                                   |
|                  |  | $\text{I}^{124}$    |                  | 4.3* д                | $\beta^+, (K), \gamma,$<br>$K$ [M32]        | 0.67 (5%),<br>1.50 (44%),<br>2.20 (51%),<br>[M32] | 0.603, 0.73,<br>1.72, 1.95<br>[M32],<br>(0.13), (2.24) | $\text{Sb}^{121}\text{-}\alpha\text{-n}$ [M8]; $\text{Te}^{134}\text{-p-n};$<br>$\text{Bi}^{209}\text{-d-}\odot$                                                                                                                                                                                                                  |
|                  |  | $\text{I}^{(125)}$  |                  | 56 д                  | $K$                                         | нет $\beta^+$                                     | 0.395 [M32]                                            | $\text{Te-d-(n)}; \text{Bi}^{209}\text{-d-}\odot$                                                                                                                                                                                                                                                                                 |
|                  |  | $\text{I}^{126}$    |                  | $13.1 \pm 0.5$ д      | $\beta^-, \gamma$                           | 0.85 (73%),<br>1.268 (27%)<br>[M32]               |                                                        | $\text{Sb}^{123}\text{-}\alpha\text{-n}; \text{Te}^{126}\text{-p-n}; \text{Te}^{125}\text{-d-n};$<br>$\text{I}^{127}\text{-n-}2\text{n}; \text{I}^{127}\text{-}\gamma\text{-n}$ [P6];<br>$\text{Bi}^{209}\text{-d-}\odot$                                                                                                         |
| $\text{I}^{127}$ |  | $\text{I}^{128}$    | 100              | $24.99 \pm 0.02$ м    | $\beta^-, \gamma$<br>( $\beta^+ < 0.2\%$ ), | 1.59 (7%),<br>2.02 (93%)                          | 0.428 (7%)                                             | $\text{I}^{127}\text{-d-p}; \text{I}^{127}\text{-n-}\gamma; \text{Te}^{128}\text{-d-}2\text{n};$<br>$\text{Te}^{128}\text{-p-n}$                                                                                                                                                                                                  |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро    | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                                                  | Ядерные реакции                                                                                                                                                                                                                                                                                                    |
|------------------|--------------------|------------------------|--------------------------------|----------------------------|-------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                      | 4                              | 5                          | 6                       | 7                                                              | 8                                                                                                                    | 9                                                                                                                                                                                                                                                                                                                  |
|                  |                    | $I^{129}$<br>$I^{130}$ |                                | $> 10^8$ л<br>12.6 ч       | $\beta^-$ , $\gamma$    | 0.61, 1.03                                                     | 0.417, 0.536*,<br>0.669*,<br>0.742*                                                                                  | U-n- $\bigcirc$ Te <sup>130</sup> (72 м) $\beta^-$<br>Cs <sup>133</sup> -n- $\alpha$ ; Te <sup>130</sup> -d-2n; Te <sup>130</sup> -p-n;<br>I <sup>130</sup> -n- $\gamma$ ; Th <sup>232</sup> -n- $\bigcirc$ ; (U-n- $\bigcirc$ )                                                                                   |
|                  |                    | $I^{131}$              |                                | 8.0 д                      | $\beta^-$ , $\gamma$    | 0.250 (14%),<br>0.605 (86%)<br>[K11]                           | 0.080133<br>(18%),<br>0.28413<br>(14%),<br>0.36418<br>(82%),<br>[L7, K11],<br>0.637 (14%),<br>0.1636, 0.1770<br>[C5] | U (n, $\bigcirc$ ) Te <sup>131</sup> (25 м) $\beta^-$ ;<br>U <sup>238</sup> -n- $\bigcirc$ ; Te <sup>131</sup> (25 м) $\beta^-$ ;<br>U-n- $\bigcirc$ ; Pu <sup>239</sup> -n- $\bigcirc$ ;<br>Th <sup>232</sup> - $\alpha$ - $\bigcirc$ [N1]; Bi <sup>209</sup> - $\alpha$ - $\bigcirc$ ;<br>Te <sup>130</sup> -d-n |
|                  |                    | $I^{(132)}$            |                                | 2.30 ч                     | $\beta^-$ , $\gamma$    | 1.0 ( $\approx 50\%$ );<br>2.2* ( $\approx 50\%$ )             | 0.6, 0.85,<br>1.4                                                                                                    | U (n, $\bigcirc$ ) Sb <sup>(132)</sup> (5 м) $\beta^-$ ...<br>Te <sup>(132)</sup> (77 ч) $\beta^-$ ;<br>Th <sup>232</sup> (n, $\bigcirc$ ) Te <sup>(132)</sup> (77 ч) $\beta^-$ ;<br>U <sup>238</sup> -n- $\bigcirc$                                                                                               |
|                  |                    | $I^{133}$              |                                | 20.5 ч                     | $\beta^-$ , $\gamma$    | 1.3*                                                           | 0.528                                                                                                                | U (n, $\bigcirc$ ) Sb <sup>133</sup> (10 м) $\beta^-$ ...<br>... Te <sup>133</sup> (60 м) $\beta^-$ ; U- $\alpha$ - $\bigcirc$ ;<br>Pu <sup>239</sup> -n- $\bigcirc$ ; Th <sup>232</sup> - $\alpha$ - $\bigcirc$ [N1]                                                                                              |

|    |                                        |                        |                          |                                           |                                   |                                          |                               |                                                                                                                                                                                                                                                                                               |
|----|----------------------------------------|------------------------|--------------------------|-------------------------------------------|-----------------------------------|------------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                        | $I^{(134)}$            |                          | 54 м                                      | $\beta^-, \gamma$                 |                                          | $>1$                          | $U(n, \bigcirc) Sb^{(134)} (< 10 \text{ м}) \beta^- \dots$<br>... $Te^{(134)} (43 \text{ м}) \beta^-$ ; $U-\alpha-\bigcirc$ ;<br>$Pu^{239-n-\bigcirc}$ ; $Th^{232-n-\bigcirc}$                                                                                                                |
|    |                                        | $I^{135}$              |                          | 6.7 ч                                     | $\beta^-, \gamma$                 | 0.47 (35%),<br>1.00 (40%),<br>1.40 (25%) | 1.27, 2.00                    | $U(n, \bigcirc) Te^{135} (< 2 \text{ м}) \beta^-$ ;<br>$U-\alpha-\bigcirc$ ; $Pu^{239-n-\bigcirc}$ ;<br>$Th^{232-n-\bigcirc}$                                                                                                                                                                 |
|    |                                        | $I^{136}$<br>$I^{137}$ |                          | 86 с<br>$19.3 \pm 0.5 \text{ с}$          | $\beta^-, \gamma$<br>$\beta^-, n$ | 6.5<br>0.63*                             | 2.9                           | $U-n-\bigcirc$<br>$U-n-\bigcirc$ ; $Pu^{239-n-\bigcirc}$                                                                                                                                                                                                                                      |
|    |                                        | $I^{(138)}$            |                          | $5.9 \pm$<br>$\pm 0.4 \text{ с [S10]}$    | $\beta^-$                         |                                          |                               | $U-n-\bigcirc$ [S10]                                                                                                                                                                                                                                                                          |
|    |                                        | $I^{(139)}$            |                          | $2.7 \pm$<br>$\pm 0.01 \text{ с [S10]}$   | $\beta^-$                         |                                          |                               | $U-n-\bigcirc$ [S10]                                                                                                                                                                                                                                                                          |
|    |                                        | (I)                    |                          | 30 д                                      | —                                 |                                          |                               | $Xe-n-p (?)$                                                                                                                                                                                                                                                                                  |
| 54 | $Xe^{134}$<br>$Xe^{136}$               | $Xe^{(127)}$           | 0.095<br>0.088           | $75 \pm 1 \text{ с}$                      | (I), $e^-, \gamma$                |                                          | 0.125,<br>0.175, 0.35<br>0.9  | $I^{127-p-(n)}$<br>$I^{127-p-n}$ ; $I^{127-d-2n}$ ; $Xe^{136-n-\gamma}$                                                                                                                                                                                                                       |
|    | $Xe^{128}$<br>$Xe^{129}$<br>$Xe^{130}$ | $Xe^{127}$             | 1.916<br>26.235<br>4.051 | 34.2 д                                    | $\gamma, e^-$                     |                                          |                               |                                                                                                                                                                                                                                                                                               |
|    |                                        | $^{\circ}Xe^{181}$     |                          | 12 д [B17]                                | $I$ [B17],<br>$e^-, \gamma$       |                                          | 0.163 [K11]<br>0.165 [B17]    | $Xe^{132-n-(2)} n$ ;<br>$I^{181} (8 \text{ д}) \beta^- (1\%)$ [B17];<br>$U-n-\bigcirc$                                                                                                                                                                                                        |
|    | $Xe^{181}$<br>$Xe^{182}$               | $Xe^{183}$             | 21.240<br>26.925         | $5.271 \pm$<br>$\pm 0.002 \text{ д [M5]}$ | $\beta^-, \gamma$                 | 0.315 [T11]                              | 0.083, 0.0952,<br>0.236 [T11] | $Te^{130-\alpha-n}$ ; $Xe^{132-d-p}$ ; $Ba^{136-n-\alpha}$ ;<br>$Cs^{133-n-p}$ ; $Xe^{132-n-\gamma}$ ;<br>( $Xe^{134-n-2n}$ ); $Th^{232-\alpha-\bigcirc}$ [N1];<br>$U(n, \bigcirc) Sb^{183} (< 10 \text{ м}) \beta^- \dots$<br>... $I^{183} (20.5 \text{ ч}) \beta^-$ ; $Th^{232-n-\bigcirc}$ |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактив.<br>ядро | Распростра-<br>ненность<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния      | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                          |
|------------------|--------------------|---------------------|--------------------------------|----------------------------|------------------------------|----------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                   | 4                              | 5                          | 6                            | 7                                                              | 8                                   | 9                                                                                                                                                                                                        |
|                  | Хе <sup>184</sup>  | Хе <sup>185</sup>   | 10.520                         | 9.2 ч                      | $\beta^-$ , $\gamma$         | 0.930 [T11]                                                    | 0.247                               | *Хе <sup>185</sup> (15.6 м) I; Хе <sup>184</sup> -d-p;<br>Ba <sup>188</sup> -n- $\alpha$ ;<br>U (n, $\bigcirc$ ) Те <sup>185</sup> ( $\leq 2$ м) $\beta^-$ ...<br>... I <sup>185</sup> (6.7 ч) $\beta^-$ |
|                  |                    | *Хе <sup>185</sup>  |                                | 15.6 м                     | I, $\gamma$ , e <sup>-</sup> |                                                                | 0.52                                | Хе <sup>184</sup> -n- $\gamma$ ; Хе <sup>186</sup> -n-2n;<br>U (n, $\bigcirc$ ) I <sup>185</sup> (6.7 ч) $\beta^-$ ;<br>Ba <sup>188</sup> -n- $\alpha$                                                   |
|                  | Хе <sup>136</sup>  | Хе <sup>137</sup>   | 8.930                          | 3.9 м                      | $\beta^-$                    | $\approx 4$                                                    |                                     | Хе <sup>136</sup> -n- $\gamma$ ;<br>U (n, $\bigcirc$ ) I <sup>137</sup> (22.0 с) $\beta^-$ [S10]                                                                                                         |
|                  |                    | Хе <sup>(137)</sup> |                                | 68 м                       | —                            |                                                                |                                     | Хе <sup>136</sup> -d-p                                                                                                                                                                                   |
|                  |                    | Хе <sup>138</sup>   |                                | 17 м                       | $\beta^-$                    | 2.680 [T11]                                                    |                                     | U (n, $\bigcirc$ ) I <sup>138</sup> (5.9 с) $\beta^-$ [S10];<br>Th <sup>232</sup> -n- $\bigcirc$                                                                                                         |
|                  |                    | Хе <sup>139</sup>   |                                | 41 с                       | $\beta^-$                    |                                                                |                                     | U (n, $\bigcirc$ ) I <sup>139</sup> (2.7 с) $\beta^-$ [S10];<br>Th <sup>232</sup> -n- $\bigcirc$                                                                                                         |
|                  |                    | Хе <sup>140</sup>   |                                | 16 с                       | $\beta^-$                    |                                                                |                                     | U-n- $\bigcirc$ ; Th <sup>232</sup> -n- $\bigcirc$ ; U-d- $\bigcirc$                                                                                                                                     |
|                  |                    | Хе <sup>141</sup>   |                                | 1.7 с                      | $\beta^-$                    |                                                                |                                     | U-n- $\bigcirc$ ; U-d- $\bigcirc$                                                                                                                                                                        |
|                  |                    | Хе <sup>(142)</sup> |                                | кор.                       | $\beta^-$                    |                                                                |                                     | U-n- $\bigcirc$                                                                                                                                                                                          |
|                  |                    | Хе <sup>143</sup>   |                                | $\approx 1.3$ с            | $\beta^-$                    |                                                                |                                     | U-n- $\bigcirc$                                                                                                                                                                                          |
|                  |                    | Хе <sup>144</sup>   |                                | кор.                       | $\beta^-$                    |                                                                |                                     | U-n- $\bigcirc$                                                                                                                                                                                          |
|                  |                    | Хе <sup>(145)</sup> |                                | 0.8 с                      | $\beta^-$                    |                                                                |                                     | U-n- $\bigcirc$                                                                                                                                                                                          |

|    |                   |                                                                                                           |                                                    |                                                                                                  |                                                        |                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----|-------------------|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 55 |                   | Cs <sup>(130)</sup><br>Cs <sup>(131)</sup>                                                                | 30 м<br>9.6±0.1 д                                  | —<br>K, γ (3%),<br>e <sup>-</sup> (97%)                                                          | нет β+                                                 | 0.145                                                                                      | (I <sup>137</sup> -α-n)<br>Ba <sup>131</sup> (11.7 д) K [Y1]; U <sup>233</sup> -n-⊙                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|    | Cs <sup>133</sup> | Cs <sup>(132)</sup><br>°Cs <sup>134</sup><br>Cs <sup>134</sup>                                            | 100<br>7.1 д<br>3.15 ч<br>0.8 г [G11],<br>2.3 г    | K, γ, e <sup>-</sup><br>I, β <sup>-</sup> , γ, e <sup>-</sup><br>β <sup>-</sup> , γ,<br>(K < 5%) | нет β+                                                 | 0.64* [G11]                                                                                | Cs <sup>133</sup> -n-2n; Bi <sup>209</sup> -d-⊙ [G11]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|    |                   | Cs <sup>135</sup><br>Cs <sup>136</sup>                                                                    | 6×10 <sup>5</sup> л [I3]<br>13.7 д<br>(19 д) [G11] | β <sup>-</sup><br>β <sup>-</sup>                                                                 | 2.4<br>0.090 (31%),<br>0.658 (69%)<br>[M21, S31]       | 0.2, 0.7<br>0.566 (25%),<br>0.603 (95%),<br>0.798 (95%),<br>1.35 (5%)<br>нет γ<br>0.9, 1.2 | Cs <sup>133</sup> -n-γ; Cs <sup>133</sup> -d-p; U <sup>233</sup> -n-⊙<br>Ba <sup>135</sup> -d-α; Cs <sup>133</sup> -n-γ;<br>Cs <sup>133</sup> -d-p; (U-n-⊙);<br>(Bi <sup>209</sup> -d-⊙) [G11]                                                                                                                                                                                                                                                                                                                                                             |
|    |                   | Cs <sup>137</sup>                                                                                         | 33 г                                               | β <sup>-</sup>                                                                                   | 0.21 [S15]<br>0.3*                                     | нет γ                                                                                      | U (n, ⊙) Xe <sup>135</sup> (9.2 ч) β <sup>-</sup><br>Cs <sup>135</sup> -n-γ [S 6, S 15]; Ba <sup>136</sup> -n-p;<br>La <sup>139</sup> -n-α; U <sup>233</sup> -n-⊙; U-n-⊙;<br>Th <sup>232</sup> -α-⊙; Pu <sup>239</sup> -n-⊙;<br>Bi <sup>209</sup> -d-⊙ [G11]                                                                                                                                                                                                                                                                                               |
|    |                   | Cs <sup>(138)</sup>                                                                                       | 33 м                                               | β <sup>-</sup> , γ                                                                               | 0.521 (95%),<br>1.2 (5%) [P7]<br>1.18 (2%)<br>[O4, L9] | 1.2                                                                                        | U (n, ⊙) I <sup>137</sup> (22.5 с) β <sup>-</sup> ...<br>...Xe <sup>137</sup> (68 м) β <sup>-</sup> [S10];<br>U <sup>233</sup> -n-⊙; Th <sup>232</sup> -α-⊙;<br>Pu <sup>239</sup> -n-⊙;<br>Xe <sup>136</sup> (n, γ) Xe <sup>137</sup> (3.9 м) β <sup>-</sup><br>U (n, ⊙) I <sup>138</sup> (5.9 с) β <sup>-</sup> ...<br>...Xe <sup>138</sup> (17 м) β <sup>-</sup> [S10];<br>Ba <sup>138</sup> -n-p;<br>U (n, ⊙) Xe <sup>139</sup> (17 м) β <sup>-</sup> ;<br>Th <sup>232</sup> (n, ⊙) Xe <sup>138</sup> (17 м) β <sup>-</sup> ;<br>Pa <sup>231</sup> -n-⊙ |
|    |                   | Cs <sup>139</sup><br>Cs <sup>(140)</sup>                                                                  | 9.7 м<br>65 с                                      | β <sup>-</sup><br>β <sup>-</sup>                                                                 |                                                        |                                                                                            | U (n, ⊙) Xe <sup>139</sup> (41 с) β <sup>-</sup> ;<br>Th <sup>232</sup> (n, ⊙) Xe <sup>139</sup> (41 с) β <sup>-</sup><br>U (n, ⊙) Xe <sup>140</sup> (16 с) β <sup>-</sup> (?);<br>Th <sup>232</sup> (n, ⊙) Xe <sup>140</sup> (16 с) β <sup>-</sup> (?)                                                                                                                                                                                                                                                                                                    |
|    |                   | Cs <sup>141</sup><br>Cs <sup>(142)</sup><br>Cs <sup>143</sup><br>Cs <sup>144</sup><br>Cs <sup>(145)</sup> | кор.<br>1--2 м<br>кор.<br>кор.<br>кор.             | β <sup>-</sup><br>β <sup>-</sup><br>β <sup>-</sup><br>β <sup>-</sup><br>β <sup>-</sup>           |                                                        |                                                                                            | U (n, ⊙) Xe <sup>141</sup> (1.7 с) β <sup>-</sup><br>U-n-⊙<br>U (n, ⊙) Xe <sup>143</sup> (1.3 с) β <sup>-</sup><br>U (n, ⊙) Xe <sup>144</sup> (кор.) β <sup>-</sup><br>U (n, ⊙) Xe <sup>(145)</sup> (0.8 с) β <sup>-</sup>                                                                                                                                                                                                                                                                                                                                 |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактивн.<br>ядро | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния      | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                                                                                     |
|------------------|--------------------|----------------------|--------------------------------|----------------------------|------------------------------|----------------------------------------------------------------|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                    | 4                              | 5                          | 6                            | 7                                                              | 8                                   | 9                                                                                                                                                                                                                                                                   |
| 56               | Ba <sup>130</sup>  | (Ba)                 |                                | 5 ч                        |                              |                                                                |                                     | Ba- $\gamma$ -n                                                                                                                                                                                                                                                     |
|                  |                    | Ba <sup>131</sup>    | 0.102                          | 11.7 ± 0.3 д               | K, $\gamma$ , e <sup>-</sup> |                                                                | 0.26, 0.5, 1.2,<br>1, 7             | Ba <sup>130</sup> -n- $\gamma$ ; Ba <sup>130</sup> -d-p;<br>Bi <sup>209</sup> -d-⊖ [G11]                                                                                                                                                                            |
|                  | Ba <sup>132</sup>  | Ba <sup>133</sup>    | 0.098                          | > 20 л                     | K, $\gamma$ , e <sup>-</sup> |                                                                | 0.085, 0.36                         | Cs <sup>133</sup> -d-2n; Ba <sup>133</sup> (38 ч) I;<br>(Ba <sup>133</sup> -n- $\gamma$ )                                                                                                                                                                           |
|                  |                    | °Ba <sup>133</sup>   |                                | 38 ± 1 ч                   | I, $\gamma$ , e <sup>-</sup> |                                                                | 0.276,<br>0.28 [G7]                 | Ba <sup>133</sup> -d-p; (Ba <sup>133</sup> -n- $\gamma$ );<br>Ba <sup>134</sup> -n-2n; Cs <sup>133</sup> -p-n;<br>Cs <sup>133</sup> -d-2n; Ba <sup>134</sup> - $\gamma$ -n;<br>Pb- $\alpha$ -⊖; Bi <sup>209</sup> - $\alpha$ -⊖;<br>Bi <sup>209</sup> - $\alpha$ -⊖ |
|                  | Ba <sup>134</sup>  | °Ba <sup>(135)</sup> | 2.42                           | 28.7 ч                     | I, $\gamma$ , e <sup>-</sup> |                                                                | 0.34                                | Ba <sup>134</sup> -n; Ba <sup>134</sup> -d-p; [R9]; U- $\alpha$ -⊖                                                                                                                                                                                                  |
|                  | Ba <sup>135</sup>  |                      | 6.59                           |                            |                              |                                                                |                                     |                                                                                                                                                                                                                                                                     |
|                  | Ba <sup>136</sup>  |                      | 7.81                           |                            |                              |                                                                |                                     |                                                                                                                                                                                                                                                                     |
|                  | Ba <sup>137</sup>  | °Ba <sup>137</sup>   | 11.32                          | 156 ±<br>± 3 с [M1]        | I, $\gamma$ , e <sup>-</sup> |                                                                | 0.666*<br>[P7, O4]                  | Ba <sup>136</sup> -n- $\gamma$ ; Ba <sup>137</sup> -n-n<br>Cs <sup>137</sup> (33 г) $\beta^-$ (95%) [M1]                                                                                                                                                            |
|                  | Ba <sup>138</sup>  |                      | 71.66                          |                            |                              |                                                                |                                     |                                                                                                                                                                                                                                                                     |
|                  |                    |                      |                                |                            |                              |                                                                |                                     |                                                                                                                                                                                                                                                                     |

|    |                                        |                                        |                          |                              |                                                                                   |                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----|----------------------------------------|----------------------------------------|--------------------------|------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                        | Ba <sup>139</sup>                      | 85.6 м                   | $\beta^-$ , $\gamma$ , $e^-$ | 2.27                                                                              | 0.163, 1.05                                                          | Ba <sup>138</sup> -n- $\gamma$ ; Ba <sup>138</sup> -d-p; La <sup>139</sup> -n-p;<br>Ce <sup>142</sup> -n- $\alpha$ ;<br>U (n, $\bigcirc$ ) Xe <sup>139</sup> (41 с) $\beta^-$ ...<br>...Cs <sup>139</sup> (9.7 м) $\beta^-$ [S10];<br>Th <sup>232</sup> (n, $\bigcirc$ ) Xe <sup>139</sup> (41 с) $\beta^-$ ...<br>...Cs <sup>139</sup> (9.7 м) $\beta^-$ ; U- $\gamma$ - $\bigcirc$ ;<br>Pu <sup>239</sup> -n- $\bigcirc$ |
|    |                                        | Ba <sup>140</sup>                      | 12.8 д                   | $\beta^-$ , $\gamma$         | 0.34 (25%),<br>1.04 (75%),<br>(0.91) [M24]<br>0.48 (40%),<br>1.022 (60%)<br>[B34] | 0.529 (25%),<br>(0.14),<br>(0.6) [M24],<br>0.16, 0.31,<br>0.54 [B34] | U (n, $\bigcirc$ ) Xe <sup>140</sup> (16 с) $\beta^-$ ...<br>...Cs <sup>140</sup> (65 с) $\beta^-$ ;<br>Th <sup>232</sup> (n, $\bigcirc$ ) Xe <sup>140</sup> (16 с) $\beta^-$ ...<br>...Cs <sup>140</sup> (65 с) $\beta^-$ ; U-d- $\bigcirc$ ;<br>U <sup>238</sup> -n- $\bigcirc$ ; Th <sup>232</sup> - $\alpha$ - $\bigcirc$ [N1],<br>U- $\gamma$ - $\bigcirc$ ; Pu <sup>239</sup> -n- $\bigcirc$                         |
|    |                                        | Ba <sup>141</sup>                      | 18 м                     | $\beta^-$ , $\gamma$         |                                                                                   |                                                                      | U (n, $\bigcirc$ ) Cs <sup>141</sup> (кор.) $\beta^-$ ;<br>Th <sup>232</sup> -n- $\bigcirc$ ; U- $\gamma$ - $\bigcirc$                                                                                                                                                                                                                                                                                                     |
|    |                                        | Ba <sup>(142)</sup>                    | 6 м                      | $\beta^-$                    |                                                                                   |                                                                      | U (n, $\bigcirc$ ) Cs <sup>(142)</sup> (1—2 м) $\beta^-$ ;<br>Th <sup>232</sup> -n- $\bigcirc$ ; U- $\gamma$ $\bigcirc$                                                                                                                                                                                                                                                                                                    |
|    |                                        | Ba <sup>(143)</sup>                    | < 1 м                    | $\beta^-$                    |                                                                                   |                                                                      | U-n- $\bigcirc$ ;<br>U (n, $\bigcirc$ ) Cs <sup>143</sup> (кор.) $\beta^-$                                                                                                                                                                                                                                                                                                                                                 |
|    |                                        | Ba <sup>144</sup>                      | кор.                     | $\beta$                      |                                                                                   |                                                                      | U (n, $\bigcirc$ ) Xe <sup>144</sup> (кор.) $\beta^-$ ...<br>...Cs <sup>144</sup> (кор.) $\beta^-$                                                                                                                                                                                                                                                                                                                         |
|    |                                        | Ba <sup>(145)</sup>                    | кор.                     | $\beta^-$                    |                                                                                   |                                                                      | U (n, $\bigcirc$ ) Xe <sup>(145)</sup> (0.8с) $\beta^-$ ...<br>...Cs <sup>(145)</sup> (кор.) $\beta^-$                                                                                                                                                                                                                                                                                                                     |
| 57 |                                        | La                                     | 10 м                     | $\beta^+$                    | 2.1                                                                               |                                                                      | Ba-d-n                                                                                                                                                                                                                                                                                                                                                                                                                     |
|    |                                        | La <sup>135</sup>                      | 19.5 ч                   | K, $\gamma$                  | нет $\beta^+$                                                                     | 0.82*                                                                | Ba <sup>135</sup> -p-n; Ba <sup>134</sup> -d-n;<br>Cs <sup>133</sup> - $\alpha$ -2n; Ce <sup>135</sup> (16 ч) $\beta^+$                                                                                                                                                                                                                                                                                                    |
|    |                                        | La <sup>136</sup>                      | 9.0 $\pm$ 0.5 м<br>[R9a] | $\beta^+$ , K, $\gamma$      | 1.8 [R9a]                                                                         |                                                                      | Cs <sup>133</sup> - $\alpha$ -n; Ba <sup>135</sup> -d-n;<br>Ba <sup>136</sup> -d-2n [R9a]                                                                                                                                                                                                                                                                                                                                  |
|    |                                        | La <sup>136</sup><br>La <sup>137</sup> | 2.1 ч<br>> 400 л         | $\beta^+$<br>—               | 0.84                                                                              | нет $\gamma$                                                         | Cs <sup>133</sup> - $\alpha$ -n<br>(Ce <sup>137</sup> (36 ч) K)                                                                                                                                                                                                                                                                                                                                                            |
|    | La <sup>138</sup><br>La <sup>139</sup> |                                        | 0.089<br>99 911          |                              |                                                                                   |                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                            |

| Атомный<br>номер | Стабильное<br>ядро | Радиоактивн.<br>ядро                   | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния                   | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв                                  | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                                           | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------|--------------------|----------------------------------------|--------------------------------|----------------------------|-------------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                  | 3                                      | 4                              | 5                          | 6                                         | 7                                                                                               | 8                                                                                                             | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                  |                    | La <sup>140</sup>                      |                                | 40.0 ч                     | $\beta^-$ , $\gamma$                      | 0.90 (20%);<br>1.40 (70%);<br>2.12 (10%);<br>1.32 (70%);<br>1.67 (20%);<br>2.26 (10%);<br>[B34] | 0.335* (2%)*,<br>0.49* (6%)*,<br>0.84* (12%)*,<br>1.63* (75%)*,<br>2.3* (5%)*,<br>(2.51) (сл.)<br>[B34] [C19] | La <sup>139</sup> -d-p; La <sup>139</sup> -n- $\gamma$ ;<br>(Ba <sup>138</sup> -d- $\gamma$ ); Ce <sup>140</sup> -n-p;<br>U (n, $\odot$ ) Xe <sup>140</sup> (16 с) $\beta^-$ ...<br>...Ba <sup>140</sup> (12,8 д) $\beta^-$ ;<br>Th <sup>232</sup> -n- $\odot$ ; U <sup>233</sup> -n- $\odot$ ;<br>Pu <sup>239</sup> -n- $\odot$ ;<br>Th <sup>232</sup> ( $\alpha$ , $\odot$ ) Ba <sup>140</sup> (12.8 д) $\beta^-$<br>[NI] La <sup>139</sup> -n- $\gamma$<br>U (n, $\odot$ ) Xe <sup>141</sup> (1.7 с) $\beta^-$ ...<br>...Ba <sup>141</sup> (18 м) $\beta^-$ ; Th <sup>232</sup> -n- $\odot$<br>U (n, $\odot$ ) Cs <sup>(142)</sup> (кор.) $\beta^-$ ...<br>...Ba <sup>(142)</sup> (6 м) $\beta^-$ ; Th <sup>232</sup> -n- $\odot$<br>U (n, $\odot$ ) Xe <sup>143</sup> (1.6 с) $\beta^-$ ...<br>...Ba <sup>143</sup> (< 1 м) $\beta^-$<br>U (n, $\odot$ ) Xe <sup>144</sup> (кор.) $\beta^-$ ...<br>...Ba <sup>144</sup> (кор.) $\beta^-$<br>U (n, $\odot$ ) Xe <sup>145</sup> (0.8 с) $\beta^-$ ...<br>...Ba <sup>(145)</sup> (кор.) $\beta^-$ |
|                  |                    | La <sup>(140)</sup>                    |                                | $\approx 3$ г              | $\beta^-$ , $\gamma$                      | 0.90                                                                                            | 0.79                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                  |                    | La <sup>141</sup>                      |                                | 3.7 ч                      | $\beta^-$                                 | 2.8*                                                                                            |                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                  |                    | La <sup>(142)</sup>                    |                                | 74 м                       | $\beta^-$ , $\gamma$                      |                                                                                                 |                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                  |                    | La <sup>143</sup>                      |                                | 20 м                       | $\beta^-$                                 |                                                                                                 |                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                  |                    | La <sup>144</sup>                      |                                | кор.                       | $\beta^-$                                 |                                                                                                 |                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                  |                    | La <sup>(145)</sup>                    |                                | кор.                       |                                           |                                                                                                 |                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 58               | Ce <sup>136</sup>  | Ce <sup>135</sup><br>Ce <sup>137</sup> | 0.193                          | $\approx 16$ ч<br>36 ч     | $\beta^+$<br>K, $\gamma$ , e <sup>-</sup> | 0.4                                                                                             | 0.28, 0.75                                                                                                    | La <sup>139</sup> -d-( $\delta$ ) n<br>La <sup>139</sup> -d-4n; Ce <sup>136</sup> -n- $\gamma$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

|    |                   |                     |       |              |                    |                                                      |                              |                                                                                                                                                                                                                                                                                                                                        |
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|    | Ce <sup>138</sup> | Ce <sup>139</sup>   | 0.250 | 140 ± 1 д    | K                  |                                                      | 0.18, (0.8)                  | Ba <sup>136-α-n</sup> ; La <sup>139-d-2 n</sup> ;<br>La <sup>139-p-n</sup> ; Ce <sup>140-n-2 n</sup> ;<br>Bi <sup>209-d-⊖</sup>                                                                                                                                                                                                        |
|    | Ce <sup>140</sup> | Ce <sup>141</sup>   | 88.49 | 30.6 ± 0.7 д | β <sup>-</sup> , γ | 0.560 (30%),<br>0.420 (70%)<br>[T 12, M 17,<br>S 25] | 0.146, 0.315<br>[T 12, M 17] | Ba <sup>138-α-n</sup> ; Ce <sup>140-d-p</sup> ;<br>Ce <sup>142-n-2 n</sup> ; Ce <sup>140-n-γ</sup> ;<br>Pr <sup>141-n-p</sup> ;<br>U (n, ⊖) Xe <sup>141</sup> (1.7 с) β <sup>-</sup> ...<br>... La <sup>141</sup> (3.7 ч) β <sup>-</sup> ;<br>Bi <sup>209-d-⊖</sup> [G 11];<br>U-d-⊖; Th <sup>232-n-⊖</sup> ;<br>Pu <sup>239-n-⊖</sup> |
|    | Ce <sup>142</sup> | Ce <sup>143</sup>   | 11.07 | 33 ч         | β <sup>-</sup> , γ | 1.3*                                                 | 0.5, 0.6                     | Ce <sup>142-d-p</sup> ; Ce <sup>142-n-γ</sup> ;<br>U (n, ⊖); Xe <sup>143</sup> (1.3 с) β <sup>-</sup> ...<br>... La <sup>143</sup> (20 м) β <sup>-</sup> ; U-d-⊖;<br>Th <sup>232-n-⊖</sup> ; Th <sup>232-α-⊖</sup> [N1];<br>U-α-⊖; Pu <sup>239-n-⊖</sup>                                                                               |
|    |                   | Ce <sup>144</sup>   |       | 275 д        | β <sup>-</sup>     | 0.348                                                | нет γ                        | U (n, ⊖) Xe <sup>144</sup> (кор.) β ...<br>... La <sup>144</sup> (кор.) β <sup>-</sup> ;<br>U-d-⊖; U-α-⊖; U <sup>233-n-⊖</sup> ;<br>Pu <sup>239-n-⊖</sup> ; Th <sup>232-α-⊖</sup> [N1];                                                                                                                                                |
|    |                   | Ce <sup>(145)</sup> |       | 1.8 ч        | β <sup>-</sup>     |                                                      |                              | U (n, ⊖) Xe <sup>145</sup> (0.8 с) β <sup>-</sup> ...                                                                                                                                                                                                                                                                                  |
|    |                   | Ce <sup>(146)</sup> |       | 14.6 м       | β <sup>-</sup>     |                                                      |                              | ... La <sup>145</sup> (кор.) β <sup>-</sup><br>U-n-⊖                                                                                                                                                                                                                                                                                   |
| 59 |                   | Pr <sup>140</sup>   |       | 3.4 ± 0.1 м  | β <sup>+</sup>     | 2.4                                                  |                              | Pr <sup>141-n-2 n</sup> ; Pr <sup>141-γ-n</sup> [P6];<br>Nd <sup>142</sup> (3.3 д) K [W 12]                                                                                                                                                                                                                                            |
|    | Pr <sup>141</sup> | oPr <sup>141</sup>  | 100   | 70 ± 20 мкс  | I, e <sup>-</sup>  |                                                      | 0.2                          | Ce <sup>141</sup> (30 д) β <sup>-</sup>                                                                                                                                                                                                                                                                                                |

| Атомный номер | Стабильное ядро | Радиоактивн. ядро   | Распространённость в % | Период полураспада | Тип превращения         | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв | Энергия $\gamma$ -лучей в Мэв | Ядерные реакции                                                                                                                                                                                                                      |
|---------------|-----------------|---------------------|------------------------|--------------------|-------------------------|-------------------------------------------------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2               | 3                   | 4                      | 5                  | 6                       | 7                                                     | 8                             | 9                                                                                                                                                                                                                                    |
|               |                 | Pr <sup>142</sup>   |                        | 19.3 ± 0.1 ч       | $\beta^-$ , $\gamma$    | 2.14; 0.35, 2.52 [J 5]                                | 1.6*, 2.0*                    | Ce <sup>142</sup> -d-2 n; Pr <sup>141</sup> -d-p; Ce <sup>142</sup> -p-n; La <sup>139</sup> - $\alpha$ -n; Pr <sup>141</sup> -n- $\gamma$ ; Nd <sup>142</sup> -n-p                                                                   |
|               |                 | Pr <sup>143</sup>   |                        | 13.6 д*            | $\beta^-$               | 0.92 [T 12, F 10, M 17, S 25, B 32a]                  | нет $\gamma$                  | Ce <sup>142</sup> -d-n; Ce <sup>143</sup> (33 ч) $\beta^-$ ; U(n, $\oplus$ ) Ce <sup>143</sup> (33 ч) $\beta^-$ ; U-d- $\oplus$ ; Pu <sup>239</sup> -n- $\oplus$                                                                     |
|               |                 | Pr <sup>144</sup>   |                        | 17.5 м             | $\beta^-$ , $\gamma$    | 3.03*                                                 | 0.135, 0.22, 1.25             | U (n, $\oplus$ ) La <sup>(144)</sup> (кор.) $\beta^-$ ...<br>...Ce <sup>144</sup> (275 д) $\beta^-$ ; U-d- $\oplus$ ; Pu <sup>239</sup> -n- $\oplus$ ; Th <sup>232</sup> ( $\alpha$ , $\oplus$ ) Ce <sup>144</sup> (275 д) $\beta^-$ |
|               |                 | Pr <sup>(145)</sup> |                        | 4.5 ч              | $\beta^-$               | 3.2                                                   | нет $\gamma$                  | U (n, $\oplus$ ) Xe <sup>(145)</sup> (0.8 с) $\beta^-$ ...                                                                                                                                                                           |
|               |                 | Pr <sup>(146)</sup> |                        | 24.6 м             | $\beta^-$               | 3                                                     | 1.4                           | ...Ce <sup>(145)</sup> (1.8 ч) $\beta^-$<br>U (n, $\oplus$ ) Ce <sup>(146)</sup> (14,6 м) $\beta^-$                                                                                                                                  |
| 60            |                 | Nd <sup>140</sup>   |                        | 3.3±0.1 д [W 12]   | K, $\gamma$             |                                                       | 1.2 [W 12]                    | Pr <sup>141</sup> -d-3 n [W 12]                                                                                                                                                                                                      |
|               |                 | Nd <sup>141</sup>   |                        | 145 ± 3 м [W 12]   | $\beta^+$ (2.5%) [W 12] | 0.78                                                  | 1.05                          | Nd <sup>142</sup> - $\gamma$ -n; Nd <sup>142</sup> -n-2 n; Pr <sup>141</sup> -p-n [W 12]; (Nd <sup>142</sup> -p-t); Pr <sup>141</sup> -d-2 n [W 12]                                                                                  |
|               |                 | Nd <sup>142</sup>   | 27.13 ± 0.2            |                    |                         |                                                       |                               |                                                                                                                                                                                                                                      |
|               |                 | Nd <sup>143</sup>   | 12.20 ± 0.1            |                    |                         |                                                       |                               |                                                                                                                                                                                                                                      |
|               |                 | Nd <sup>144</sup>   | 23.87 ± 0.2            |                    |                         |                                                       |                               |                                                                                                                                                                                                                                      |
|               |                 | Nd <sup>145</sup>   | 8.30 ± 0.5             |                    |                         |                                                       |                               |                                                                                                                                                                                                                                      |

|    |                   |                          |             |                          |                      |                         |                     |                                                                                                             |
|----|-------------------|--------------------------|-------------|--------------------------|----------------------|-------------------------|---------------------|-------------------------------------------------------------------------------------------------------------|
|    | Nd <sup>146</sup> | Nd <sup>147</sup>        | 17.18 ± 0.2 | 11.1 ± 0.2 д             | β <sup>-</sup> , γ   | 0.4 (40%),<br>0.9 (60%) | 0.45, 0.58,<br>0.72 | Nd <sup>146</sup> -n-γ; U-n-⊖                                                                               |
|    | Nd <sup>148</sup> | Nd <sup>149</sup>        | 5.72 ± 0.06 | 1.7 ч                    | β <sup>-</sup> , γ   | 1.55*                   |                     | Nd <sup>148</sup> -d-p; Nd <sup>148</sup> -n-γ;<br>(Nd <sup>150</sup> -n-2 n); Nd <sup>150</sup> -γ-n [H19] |
|    | Nd <sup>150</sup> | Nd                       | 5.60 ± 0.06 | ≈ 5 × 10 <sup>10</sup> л | β <sup>-</sup> , γ   | 0.011                   |                     |                                                                                                             |
|    |                   | (Nd)                     |             | 1.7 г                    | β <sup>-</sup>       | 0.74                    |                     | (Nd-n)                                                                                                      |
|    |                   | Nd <sup>(151)</sup>      |             | 21 м                     | β <sup>-</sup>       |                         |                     | (Nd <sup>150</sup> -n-?)                                                                                    |
|    |                   | (Nd <sup>151</sup> )     |             | кор.                     | β <sup>-</sup>       |                         |                     | (Nd <sup>150</sup> -n-γ)                                                                                    |
| 61 |                   | Pm <sup>(143)</sup>      |             | ≈ 200 д                  | K, γ, e <sup>-</sup> |                         | 0.67                | Pr <sup>141-α-(2) n</sup> ; Nd <sup>(143)</sup> -d-2n                                                       |
|    |                   | (Pm <sup>145</sup> )     |             | длин.                    | β <sup>-</sup>       | 1.7                     |                     | Sm <sup>144</sup> (n, γ) Sm <sup>145</sup> (> 150 д)                                                        |
|    |                   | Pm                       |             | 16 д                     | β <sup>-</sup>       | 0.2232 [P9a]            | нет γ               | Nd-d-?                                                                                                      |
|    |                   | Pm <sup>147</sup>        |             | 3.7 г                    | β <sup>-</sup>       |                         |                     | Nd <sup>146</sup> (n, γ) Nd <sup>147</sup> (11.1 д) β <sup>-</sup> ;<br>U-n-⊖; U <sup>238</sup> -n-⊖        |
|    |                   | Pm <sup>148</sup>        |             | 5.3 д                    | β <sup>-</sup>       | 2.5                     | 0.8                 | Nd <sup>148</sup> -p-n; Nd <sup>148</sup> -d-2n; Nd <sup>145</sup> -α-p;<br>Pm <sup>147</sup> -n-γ          |
|    |                   | Pm <sup>149</sup>        |             | 55 ч                     | β <sup>-</sup>       | 1.1                     | 0.25                | Nd <sup>148</sup> (n, γ) Nd <sup>149</sup> (1.7 ч ?) β <sup>-</sup> ;<br>U-n-⊖; Pu <sup>239</sup> -n-⊖      |
|    |                   | (Pm <sup>&gt;147</sup> ) |             | 47 ч [M19]               | β <sup>-</sup>       | 0.98 [M19]              |                     | (Nd-d-n)                                                                                                    |
|    |                   | (Pm)                     |             | 12.5 ч                   | β <sup>-</sup> , γ   | 2                       |                     | Nd-p-n, Nd-d-n; Nd-α-p                                                                                      |
|    |                   | (Pm <sup>151</sup> )     |             | 2.7 ч                    | β <sup>-</sup>       |                         |                     | Nd <sup>(150)</sup> (n, γ)Nd <sup>(151)</sup> (кор.) β <sup>-</sup> (?)                                     |
|    |                   |                          |             | 12 м                     |                      |                         |                     |                                                                                                             |
|    |                   | Pm <sup>153</sup>        |             | < 5 м                    | β <sup>-</sup>       |                         |                     | U-n-⊖                                                                                                       |
|    |                   | Pm <sup>156</sup>        |             | < 5 м                    | β <sup>-</sup>       |                         |                     | U-n-⊖                                                                                                       |
| 62 | Sm <sup>144</sup> | (Sm <sup>145</sup> )     | 3.16 ± 0.10 | > 150 д                  | (K), γ               |                         | 0.242, 0.95         | Sm <sup>144</sup> -n-γ                                                                                      |

| Атомный номер | Стабильное ядро                                                                                       | Радиоактив. ядро                                                                                                                  | Распространённость в %                                            | Период полураспада                                                                                       | Тип превращения                                                                              | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                         | Энергия $\gamma$ -лучей в Мэв                         | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                                                                     | 3                                                                                                                                 | 4                                                                 | 5                                                                                                        | 6                                                                                            | 7                                                                             | 8                                                     | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|               | Sm <sup>147</sup><br>Sm <sup>148</sup><br>Sm <sup>149</sup><br>Sm <sup>150</sup><br>Sm <sup>153</sup> | Sm <sup>151</sup><br><br><br><br>Sm <sup>153</sup><br><br><br>Sm <sup>154</sup><br><br>Sm <sup>155</sup><br><br>Sm <sup>156</sup> | 15.07±0.15<br>11.27±0.11<br>13.87±0.14<br>7.47±0.07<br>26.63±0.26 | 1000±350 л<br>1.3×10 <sup>11</sup> л<br>6.7×10 <sup>11</sup> л<br>[P6]<br>47±1 ч<br><br>25 м<br><br>10 ч | $\beta^-$<br>$\alpha$<br><br><br>$\beta^-, \gamma$<br><br>$\beta^-, \gamma$<br><br>$\beta^-$ | 0.079 [K15]<br>2.2<br><br><br>0.75, (1.23)<br>[C 11]<br><br>1.85*<br><br>≈0.8 | <br><br><br><br>0.0695,<br>0.1021,<br>0.57<br><br>0.3 | Sm <sup>149</sup> -n- $\gamma$<br>Sm <sup>150</sup> -n- $\gamma$ ; U-n- $\odot$<br><br><br>Sm <sup>152</sup> -n- $\gamma$ ; Nd <sup>150</sup> - $\alpha$ -n; Sm <sup>152</sup> -d-p;<br>(Sm <sup>154</sup> - $\gamma$ -n); Sm <sup>154</sup> -n-2n;<br>Th <sup>232</sup> - $\alpha$ - $\odot$ ; U-n- $\odot$ ; U <sup>238</sup> -n- $\odot$ ;<br>Pu <sup>239</sup> -n- $\odot$<br><br>Sm <sup>154</sup> -n- $\gamma$ ; Sm <sup>154</sup> -d-p; Nd <sup>154</sup> -d-n;<br>U-n- $\odot$<br>U-n- $\odot$ ; Th <sup>232</sup> - $\alpha$ - $\odot$ |
| 63            | Eu <sup>151</sup>                                                                                     | Eu <sup>(147)</sup><br>Eu <sup>(149)</sup><br>(Eu <sup>150</sup> )                                                                | 47.77                                                             | 21 д<br>53 д<br>27 ч                                                                                     | —<br>—<br>$\beta^+$                                                                          |                                                                               |                                                       | Sm <sup>147</sup> -d-2n; Bi <sup>209</sup> -d- $\odot$ [G 11]<br>Sm <sup>(148)</sup> -d-n<br>(Eu-n-2n)                                                                                                                                                                                                                                                                                                                                                                                                                                          |

|    |                   |                     |       |             |                                                         |                              |                                                                                                                         |                                                                                                                                                                                                                                     |
|----|-------------------|---------------------|-------|-------------|---------------------------------------------------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Eu <sup>158</sup> | Eu <sup>152</sup>   | 52.23 | 9.3±0.2 ч   | $\beta^-$ (82%),<br>K (18%), $\gamma$<br>[H 12]         | 1.885                        | 0.123, 0.163,<br>0.725;<br>0.040, 0.350,<br>0.900, 1.0<br>(См. Eu <sup>154</sup> )<br>[S 26]                            | Eu <sup>151</sup> -n- $\gamma$ [H12]; Eu <sup>158</sup> -n-2 n;<br>Eu <sup>151</sup> -d-p                                                                                                                                           |
|    |                   | Eu <sup>153</sup>   |       | 5.3 г [H12] | $\beta^-$ (26%),<br>K (74%),<br>[H12],<br>нет $\beta^+$ | 0.751 (80%),<br>(1.575)(20%) | (См. Eu <sup>154</sup> )<br>[S 26]                                                                                      | Eu <sup>151</sup> -n- $\gamma$ [H12]                                                                                                                                                                                                |
|    |                   | Eu <sup>154</sup>   |       | 5.4 г [H12] | $\beta^-$ , (K<5%)<br>$\gamma$ [H 12],<br>нет $\beta^+$ | 1.4                          | 0.0399,<br>0.1228*,<br>0.245*,<br>0.2862*,<br>0.3432*,<br>0.412, 0.442,<br>0.773, 0.959,<br>1.082, 1.23,<br>1.402 [S26] | Eu <sup>152</sup> -n- $\gamma$ [H12]<br>Eu <sup>158</sup> -n- $\gamma$ [H12]; Eu <sup>158</sup> -d-p                                                                                                                                |
|    |                   | Eu <sup>155</sup>   |       | 1.7 г [H12] | $\beta^-$ , $\gamma$                                    | 0.23                         | 0.084                                                                                                                   | Sm <sup>154</sup> (n, $\gamma$ ) Sm <sup>155</sup> (25 м) $\beta^-$<br>[H12]; U-n- $\odot$ ; Th <sup>232</sup> - $\alpha$ - $\odot$ ;<br>Sm <sup>154</sup> -d-n                                                                     |
|    |                   | Eu <sup>(156)</sup> |       | 15.4 д      | $\beta^-$ , $\gamma$                                    | 0.5 (60%),<br>2.5 (40%)      | 2.0 (60%)                                                                                                               | Eu <sup>155</sup> -n- $\gamma$ [H12];<br>U (n, $\odot$ ) Sm <sup>156</sup> ( $\approx 10$ ч) $\beta^-$ ;<br>U-n- $\odot$ ; U- $\alpha$ - $\odot$ ; Th <sup>232</sup> - $\alpha$ - $\odot$ ;<br>Pu <sup>239</sup> -n- $\odot$ [H 12] |
|    |                   | Eu <sup>(157)</sup> |       | 15.4 ч      | $\beta^-$ , $\gamma$                                    | 1.0 (75%),<br>1.8 (25%)      | 0.2, 0.6                                                                                                                | U-n- $\odot$ ; Th <sup>232</sup> - $\alpha$ - $\odot$ ; Pu <sup>239</sup> -n- $\odot$                                                                                                                                               |
|    |                   | Eu <sup>158</sup>   |       | 60 м        | $\beta^-$                                               | 2.5                          |                                                                                                                         | U-n- $\odot$ ;                                                                                                                                                                                                                      |
| 64 |                   | (Gd)                |       | 7 м         | $\alpha$ , $\beta^+$ , K<br>[T 13]                      | 4.2 ( $\alpha$ )             |                                                                                                                         | Gd-d [T 13]; Dy-d [T 13]                                                                                                                                                                                                            |
|    |                   | (Gd)                |       | 4 ч         | $\alpha$ , $\beta^+$ , K<br>[T 13]                      | 4.0 ( $\alpha$ )             |                                                                                                                         | Gd-d [T 13]; Dy-d [T 13]                                                                                                                                                                                                            |

| Атомный<br>номер | Стабильное<br>ядро       | Радиоактив.<br>ядро | Распростра-<br>нённость<br>в % | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                      |
|------------------|--------------------------|---------------------|--------------------------------|----------------------------|-------------------------|----------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------|
| 1                | 2                        | 3                   | 4                              | 5                          | 6                       | 7                                                              | 8                                   | 9                                                                    |
|                  | Gd <sup>152</sup>        | Gd <sup>(153)</sup> | 0.20                           | 155 д                      | K, $\gamma$             |                                                                | 0.083, 0.102,<br>0.270, 0.45        | Eu <sup>(153)</sup> -d-2n; Gd <sup>152</sup> -n- $\gamma$            |
|                  | Gd <sup>154</sup>        |                     | 2.15                           |                            |                         |                                                                |                                     |                                                                      |
|                  | Gd <sup>155</sup>        |                     | 14.78                          |                            |                         |                                                                |                                     |                                                                      |
|                  | Gd <sup>156</sup>        |                     | 20.59                          |                            |                         |                                                                |                                     | Gd <sup>155</sup> -n- $\gamma$                                       |
|                  | Gd <sup>157</sup>        |                     | 15.71                          |                            |                         |                                                                |                                     | Gd <sup>157</sup> -n- $\gamma$                                       |
|                  | Gd <sup>158</sup>        |                     | 24.78                          |                            |                         |                                                                |                                     | Gd <sup>(160)</sup> -n- $\gamma$                                     |
|                  | Gd <sup>160</sup>        |                     | 21.79                          |                            |                         |                                                                |                                     | Gd-n- $\gamma$ ; Gd-d-p                                              |
|                  | Gd <sup>(161)</sup>      |                     |                                | 4.5 м                      | $\beta^-$ , $\gamma$    | 1.5                                                            | 0.37                                | Gd <sup>(160)</sup> -n- $\gamma$                                     |
|                  | Gd <sup>(159, 161)</sup> |                     |                                | 18.0±0.2 ч                 | $\beta^-$               | 0.95 [B10]                                                     | 0.055, 0.38,<br>[B10]               | Gd-n- $\gamma$ ; Gd-d-p                                              |
|                  | (Gd <sup>161</sup> )     |                     |                                | 9.5 ч                      | $\beta^-$               |                                                                |                                     | Gd <sup>160</sup> -n- $\gamma$                                       |
|                  | Gd <sup>(161)</sup>      |                     |                                | 218±5 с<br>[B10]           | $\beta^-$               |                                                                |                                     | Gd <sup>(160)</sup> -n- $\gamma$ [B10]                               |
|                  | Gd                       |                     |                                | 8.6 д                      |                         |                                                                |                                     | Gd-n- $\gamma$                                                       |
| 65               |                          | Tb <sup>(152)</sup> |                                | 4.5 ч                      | K                       |                                                                |                                     | Eu <sup>151</sup> - $\alpha$ -3 n                                    |
|                  |                          | Tb <sup>(153)</sup> |                                | 5.1 д                      | K, $\gamma$             |                                                                | 0.15, 0.4                           | Eu <sup>151</sup> - $\alpha$ -2 n                                    |
|                  |                          | Tb <sup>(154)</sup> |                                | 17.2 ч                     | $\beta^+$ , K, $\gamma$ | 2.6                                                            | (0.27), (1.0),<br>1.4               | Eu <sup>(151, 153)</sup> - $\alpha$ -(1,3) n; Gd <sup>154</sup> -p-n |
|                  |                          | Tb <sup>(155)</sup> |                                | ≈1 г                       | K, e <sup>-</sup>       |                                                                | 0.1                                 | Eu <sup>153</sup> - $\alpha$ -2 n                                    |

|    |            |                              |                              |                                  |                                        |                     |                                                                     |                                                                                   |
|----|------------|------------------------------|------------------------------|----------------------------------|----------------------------------------|---------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|    | $Tb^{159}$ | $Tb^{160}$<br>$Tb^{160}$     | 100                          | 3.9 ч<br>$73.5 \pm 1$ д          | $\beta^-$<br>$\beta^-$                 | 0.546, 0.882        | 0.0856,<br>0.1948,<br>0.2121,<br>0.2965, 1.15<br>$\approx 0.1, 0.5$ | $Tb^{159-n-\gamma}$<br>$Tb^{159-n-\gamma}; Gd^{160-d-2n}$                         |
|    |            | $(Tb^{161})$<br>$Tb^{(161)}$ |                              | 420 д<br>$6.8 \pm 0.1$ д         | $\beta^-, \gamma$<br>$\beta^-, \gamma$ | 0.23<br>0.52 [B10]  | 0.05, (1.28)<br>[B 10]                                              | U-n- $\oplus$<br>$Gd^{(161)} (218 \text{ c}) \beta^- [B10];$<br>$Gd^{(160)} -d-n$ |
| 66 | $Dy^{156}$ | $Dy^{(157, 159)}$            | $0.0524 \pm$<br>$\pm 0.0005$ | $140 + 10$ д<br>[C 16]           | $K$                                    |                     |                                                                     | $Dy^{(156, 158)-n-\gamma} [T13]$                                                  |
|    | $Dy^{158}$ |                              | $0.0902 \pm$<br>$\pm 0.009$  |                                  |                                        |                     |                                                                     |                                                                                   |
|    | $Dy^{160}$ |                              | $2.294 \pm 0.011$            |                                  |                                        |                     |                                                                     |                                                                                   |
|    | $Dy^{161}$ |                              | $18.88 \pm 0.09$             |                                  |                                        |                     |                                                                     |                                                                                   |
|    | $Dy^{163}$ |                              | $25.53 \pm 0.13$             |                                  |                                        |                     |                                                                     |                                                                                   |
|    | $Dy^{163}$ |                              | $24.97 \pm 0.12$             |                                  |                                        |                     |                                                                     |                                                                                   |
|    | $Dy^{164}$ |                              | $28.18 \pm 0.14$             |                                  |                                        |                     |                                                                     |                                                                                   |
|    |            | $Dy^{165}$                   |                              | $140 \pm 1.5$ м<br>$138$ м [C16] | $\beta^-, \gamma$                      | 0.42, 0.88,<br>1.25 | $0.091,$<br>$0.37,$<br>$0.83,$<br>$1.0$ } (25%)                     | $Dy^{164-n-\gamma}; Ho^{165-n-p}$                                                 |
|    |            | $^{\circ}Dy^{165}$           |                              | 1.25 м                           | $I (99\%), \gamma$<br>$\beta^- (1\%),$ |                     | $0.1090 [C 7),$<br>$(0.093),$<br>$(0.130)$                          | $Dy^{164-n-\gamma}$                                                               |
|    |            | $Dy^{166}$                   |                              | 81 ч [C16]                       | $\beta^-$                              | 0.4 [C 16]          |                                                                     | $Dy^{165-n-\gamma} [C 16]$                                                        |
|    |            | $Dy?$                        |                              | $\approx 20$ м<br>[T 13]         | $\alpha, K [T13]$                      | 4.1 ( $\alpha$ )    |                                                                     | $Dy-d [T 13]$                                                                     |
|    |            | (Dy)                         |                              | 2.2 м                            | $\beta^+$                              |                     |                                                                     | (Dy-n-?)                                                                          |

| Атомный номер | Стабильное ядро                                                                                                                | Радиоактив. ядро                                                                                                                                        | Распростра-<br>нённость<br>в %                 | Период<br>полурас-<br>пада                                  | Тип<br>превраще-<br>ния                                                                         | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                          | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------|--------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                                                                                              | 3                                                                                                                                                       | 4                                              | 5                                                           | 6                                                                                               | 7                                                              | 8                                                                            | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 67            |                                                                                                                                | $\text{Ho}^{(160)}$<br>$\text{Ho}^{(161)}$<br>$\text{Ho}^{(162)}$<br>$\text{Ho}^{(163)}$<br>$\text{Ho}^{164}$<br>$\text{Ho}^{165}$<br>$\text{Ho}^{166}$ | 100                                            | $\approx 20$ м<br>60 д<br>4.5 ч<br>7 д<br>38.6 м<br>27.3* ч | $(K)$<br>$(K), \gamma$<br>$\beta^+, K, \gamma$<br>$K, \gamma$<br>$\beta^-$<br>$\beta^-, \gamma$ | <br><br>2.0<br><br>0.7<br>1.64 [C15]                           | <br>0.16, 0.6<br><br>0.3, 1.1<br>0.4<br><br>0.081 [C15],<br>1.0* [G3]        | $\text{Tb}^{159-\alpha-(3)} n$<br>$\text{Tb}^{159-\alpha-(2)} n$ ; $\text{Dy}^{161-\text{d}-(2)} n$ ;<br>$\text{Dy}^{161-\text{p}-n}$<br>$\text{Tb}^{159-\alpha-n}$ ; $\text{Dy}^{162-\text{p}-n}$<br>$\text{Dy}^{163-\text{p}-n}$<br>$\text{Dy}^{164-\text{p}-n}$ ; $\text{Ho}^{165-\text{n}-2n}$ ; $\text{Ho}^{165-\gamma-n}$<br>$\text{Ho}^{165-\text{n}-\gamma}$ [C15];<br>$\text{Dy}^{165} (n, \gamma) \text{Dy}^{166} (81 \text{ ч}) \beta^-$<br>[C 16] |
| 68            | $\text{Er}^{163}$<br>$\text{Er}^{164}$<br>$\text{Er}^{166}$<br>$\text{Er}^{167}$<br>$\text{Er}^{168}$<br><br>$\text{Er}^{170}$ | <br>$(\text{Er}^{165})$<br><br>$\text{Er}^{(169)}$                                                                                                      | 0.1<br>1.5<br>32.9<br>24.4<br>26.9<br><br>14.2 | <br>1.1 м<br><br>9.4 $\pm$ 0.2 д                            | <br>$\beta^+$<br><br>$\beta^-$                                                                  | <br><br><br>0.33                                               | <br><br>0.0921, 0.1093,<br>0.1377, 0.1383,<br>0.1613, 0.1770,<br>0.1977 [C4] | <br>$(\text{Er}^{166-\text{n}-2n})$<br><br>$\text{Er}^{(168)} -\text{n}-\gamma$                                                                                                                                                                                                                                                                                                                                                                               |

|    |                   |                                                                                                                                                                           |                   |                                                                                                                                               |                                                                                                                            |                                                                                          |                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                   | $\text{Er}^{(171)}$                                                                                                                                                       |                   | $7,5 \pm 0.2$ ч                                                                                                                               | $\beta^-, \gamma$                                                                                                          | $0.67$ (22%),<br>$1.05$ (72%),<br>$1.49$ (6%)                                            | $0.113$ (71%),<br>$0.31$ (71%),<br>$0.81$ (22%),<br>$0.1135, 0.1200,$<br>$0.1303, 0.1311,$<br>$0.1535$ [C4]                              | $\text{Er}^{170-n-\gamma}$                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|    |                   | $(\text{Er}^{169, 171})$<br>$(\text{Er}^{171})$<br>$^{\circ}\text{Er}$                                                                                                    |                   | $6$ м<br>$20$ ч<br>$2.5$ с [D12]                                                                                                              | $\beta^-, \gamma$<br>$I, \gamma$                                                                                           | $0.85$                                                                                   | $0.180$ [D 12]                                                                                                                           | $\text{Er-n-}$<br>$(\text{Er-n-}\gamma)$ [C4]<br>$\text{Er-n}$ [D 12]                                                                                                                                                                                                                                                                                                                                                                                                  |
| 69 | $\text{Tm}^{169}$ | $\text{Tm}^{166}$<br>$\text{Tm}^{167}$<br>$\text{Tm}^{168}$<br>$^{\circ}\text{Tm}^{(169)}$<br>$\text{Tm}^{170}$<br><br>$^{\circ}\text{Tm}^{(171)}$<br>$\text{Tm}^{(171)}$ | 100               | $7.7 \pm 0.1$ ч<br>[W10]<br>$9.6 \pm 0.1$ д<br>[W10]<br>$85 \pm 2$ д<br>[W10]<br>$1$ мкс<br>$127 \pm 5$ д<br><br>$2.5$ мкс<br>$500 \pm 100$ д | $\beta^+, K, \gamma$<br>$K, \gamma$<br>$(K)$<br>$I, \gamma, e^-$<br>$\beta^-, \gamma$<br><br>$I, \gamma, e^-$<br>$\beta^-$ | $2.1$<br><br><br>$0.975^*;$<br>$0.886$ (10%)<br>[F 9, S 18,<br>C 15, G 4]<br><br>$0.100$ | $1.5, 0.24, 1$<br>$0.22, 0.95$<br>$0.16, 0.5$<br>$0.12$<br>$0.0843$ [C15],<br>$0.0855$ [S18],<br>$0.2, 0.44$<br>[G 4], $0.83$<br>$0.113$ | $\text{Ho}^{165-a-3n}; \text{Er}^{166-p-n}$ [W10]<br>$\text{Ta}^{181-d-5p, 11n}; \text{Ho}^{165-a-2n};$<br>$\text{Er}^{167-p-n}$ [W10]<br>$\text{Ho}^{165-a-n}$ [W10]; $\text{Er}^{168-p-n}$<br>[W10];<br>$\text{Tm}^{169-n-2n}$ [W10]<br>$\text{Yb}^{169}$ (33 д) $K$<br>$\text{Tm}^{169-n-\gamma}; \text{Tm}^{169-d-p}$<br><br>$\text{Er}^{171}$ (7.5 ч) $\beta^-$ (70%)<br>$\text{Er}^{171}$ (7.5 ч) $\beta^-$ (30%),<br>$^{\circ}\text{Tm}^{171}$ (2.51 мкс) $I$ ? |
| 70 | $\text{Yb}^{168}$ |                                                                                                                                                                           | $0.140 \pm 0.002$ |                                                                                                                                               |                                                                                                                            |                                                                                          |                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

| Атомный<br>номер | Стабильное<br>ядро                                                                                                         | Радиоактив.<br>ядро | Распростра-<br>нённость<br>в %                                      | Период<br>полурас-<br>пада | Тип<br>превраще-<br>ния | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                         | Ядерные реакции                                                                                  |
|------------------|----------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------------------------------------------------------|----------------------------|-------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| 1                | 2                                                                                                                          | 3                   | 4                                                                   | 5                          | 6                       | 7                                                              | 8                                                                           | 9                                                                                                |
|                  | Yb <sup>160</sup><br>Yb <sup>170</sup><br>Yb <sup>171</sup><br>Yb <sup>173</sup><br>Yb <sup>178</sup><br>Yb <sup>174</sup> | Yb <sup>160</sup>   |                                                                     | 33±1.5 д                   | K, $\gamma$             |                                                                | 0.2, 0.4,<br>(0.0969),<br>0.1370, 0.1384,<br>0.1478, 0.1623,<br>0.2583 [C4] | Yb <sup>168</sup> -n- $\gamma$ ; Tm <sup>169</sup> -d-2n                                         |
|                  | Yb <sup>175</sup>                                                                                                          | Yb <sup>175</sup>   | 3.034±0.030<br>14.34±0.14<br>21.88±0.22<br>16.18±0.16<br>31.77±0.32 | 99±3 ч                     | $\beta^-$ , $\gamma$    | 0.48*                                                          | (0.0842),<br>(0.0859),<br>(0.1103),<br>(0.2069)<br>[C4]; 0.35               | Yb <sup>174</sup> -n- $\gamma$                                                                   |
|                  | Yb <sup>176</sup>                                                                                                          | Yb <sup>177</sup>   | 12.65±0.13                                                          | 1.8±0.1 ч<br>[M34]         | $\beta^-$ , $\gamma$    | 1.22*                                                          |                                                                             | Yb <sup>176</sup> -n- $\gamma$                                                                   |
|                  |                                                                                                                            | <sup>o</sup> Yb     |                                                                     | 6с, 5с [D12]               | I                       |                                                                |                                                                             | Yb-n- $\gamma$ [D12]                                                                             |
| 71               |                                                                                                                            | Lu <sup>(170)</sup> |                                                                     | 2.15 д                     | $\beta^+$ , K, $\gamma$ | 1.7                                                            | 0.1, 1.5                                                                    | Tm <sup>169</sup> - $\alpha$ -(3)n; Yb <sup>168</sup> -d-(2)n;<br>Ta <sup>181</sup> -d-3p, (10)n |
|                  |                                                                                                                            | Lu <sup>(171)</sup> |                                                                     | 9 д                        | (K), $\gamma$           |                                                                | 0.17, 0.7                                                                   | Tm <sup>169</sup> - $\alpha$ -(2)n; Ta <sup>181</sup> -d-3p, (9)n;<br>Yb <sup>169</sup> -d-(2)n  |

|    |                                                                                                                                                                                          |                                                                                                               |                                                      |                                                                                                                     |                                                                                                   |                                                                                                                                            |                                                                                                                                                                                                                 |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Lu <sup>175</sup>                                                                                                                                                                        | Lu <sup>(172)</sup><br>Lu <sup>176</sup><br>°Lu <sup>176</sup><br>Lu <sup>177</sup><br><br>°Lu <sup>177</sup> | 97.45<br>2.55                                        | >100 д<br>2.4×10 <sup>10</sup> л<br>3.67±0.03 ч<br>6.6±0.05 д;<br>6.98±0.1 д<br>[D10]<br><br>1.3×10 <sup>-7</sup> с | K?, γ<br>β <sup>-</sup> (33%),<br>K (67%), γ<br>β <sup>-</sup> , K<br>β <sup>-</sup> , γ<br><br>I | 0.11, 0.22<br>0.215; (0.4)<br>1.2<br>0.169 (18%)<br>0.366 (17%),<br>0.495 (65%)<br>[D10]                                                   | Tm <sup>169</sup> -α-(1)n; Yb <sup>172</sup> -d-(2)n<br>0.260, (0.52)<br>her γ<br>0.1131, 0.2086<br>[C15]<br><br>Yb <sup>177</sup> (1.8 ч)β <sup>-</sup> [M34]                                                  |
| 72 | Hf <sup>174</sup><br><br>Hf <sup>176</sup><br>Hf <sup>177</sup><br>Hf <sup>178</sup><br>Hf <sup>179</sup><br>Hf <sup>180</sup><br><br>°Hf<br>Hf <sup>181</sup><br><br>°Hf <sup>181</sup> | (Hf)<br>Hf <sup>175</sup><br><br><br><br><br><br>°Hf<br>Hf <sup>181</sup><br><br>°Hf <sup>181</sup>           | 0.18<br><br>5.30<br>18.47<br>27.10<br>13.84<br>35.11 | 10 м<br>70±2 д<br>[W3]<br><br><br>19±0.5 с<br>46±3 д<br><br>5.7 ч [B39]                                             | K, γ<br><br><br><br><br>I<br>β <sup>-</sup> , γ                                                   | <br><br><br><br><br>0.404 [C1],<br>0.410 [I7]<br><br><br>0.190<br>0.087,<br>0.131*(120%),<br>0.343*(20%),<br>0.477*(80%)<br>[C1, I7] [L20] | Hf-n-γ<br>Lu <sup>175</sup> -p-n [W3]; Lu <sup>175</sup> -d-2n [W3]<br><br><br><br><br><br>°Hf-n-γ)<br>Hf <sup>180</sup> -n-γ; Ta <sup>181</sup> -n-p<br><br>Hf <sup>180</sup> -n-γ [B39]                       |
| 73 |                                                                                                                                                                                          | Ta <sup>(176)</sup><br>Ta <sup>(177)</sup><br><br>Ta <sup>(178)</sup>                                         |                                                      | 8.0 ч<br>2.66 д<br><br>16 д                                                                                         | K, γ<br>K, γ<br><br>K, γ                                                                          | 0.12, 0.18, 1.2<br>0.1<br><br>1.1                                                                                                          | Ta <sup>181</sup> -d-p, (6)n; Lu <sup>(175)</sup> -α-(3)n<br>Lu <sup>(175)</sup> -α-(2)n; Ta <sup>181</sup> -d-p, (5)n,<br>Hf <sup>(177)</sup> -d-(2)n<br>Lu <sup>175</sup> -α-(n); Hf <sup>(178)</sup> -d-(2)n |

| Атомный<br>номер | Стабильное<br>ядро                                                                                           | Радиоактив.<br>ядро                                                                                                      | Распростра-<br>нённость<br>в %                                                  | Период<br>полурас-<br>пада                                           | Тип<br>превраще-<br>ния                                                                                                     | Энергия<br>$\beta^-$ , $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                           | Ядерные реакции                                                                                                                                                                                                                                                                   |
|------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                                                                                            | 3                                                                                                                        | 4                                                                               | 5                                                                    | 6                                                                                                                           | 7                                                              | 8                                                                                             | 9                                                                                                                                                                                                                                                                                 |
|                  | Ta <sup>181</sup>                                                                                            | Ta <sup>180</sup><br><br>°Ta <sup>181</sup><br><br>Ta <sup>183</sup><br><br>°Ta <sup>182</sup><br>( °Ta <sup>182</sup> ) | 100                                                                             | 8.2 ч<br><br>20.1±0,7 мкс<br><br>117±3 д<br><br>16.2±0.5 м<br>0.40 с | K, $\gamma$ , ( $\beta^-$ )<br><br>I, $\gamma$<br><br>$\beta^-, \gamma$<br><br>$\beta^-, \gamma$<br>I <sup>2</sup> $\gamma$ | <br><br><br><br>0.52* [B33]<br><br><br>0.2                     | 0.48<br><br><br><br>0.133<br>[C1, J7, L20]<br>от 0.0462<br>до 1.23<br>(31 линия)<br>[C6, G14] | Ta <sup>181</sup> -n-2n; Ta <sup>181</sup> - $\gamma$ -n [M6]<br>Ta <sup>181</sup> -p-p, n [B28]<br><br>Hf <sup>181</sup> (46 д) $\beta^-$<br><br>Ta <sup>181</sup> -n- $\gamma$ ; Ta <sup>181</sup> -d-p<br><br>Ta <sup>181</sup> -n- $\gamma$<br>Ta <sup>181</sup> -n- $\gamma$ |
| 74               | W <sup>180</sup><br><br><br>W <sup>182</sup><br>W <sup>183</sup><br>W <sup>184</sup><br><br>W <sup>186</sup> | W <sup>(178, 179)</sup><br><br>W <sup>181</sup><br><br><br>W <sup>185</sup>                                              | 0.126±0.006<br><br><br>26.31±0.03<br>14.28±0.01<br>30.64±0.03<br><br>28.64±0.01 | 135 м<br><br>140±2 д<br><br><br>73.2±0.5 д                           | K, $\gamma$<br><br>K, $\gamma$<br><br><br><br>$\beta^-$                                                                     | <br><br><br><br><br><br>0.430                                  | 0.15, 0.5, 1.2<br><br><br><br><br><br>нет $\gamma$                                            | Ta <sup>181</sup> -d-(4,5)n<br><br>Ta <sup>181</sup> -d-2n; Ta <sup>181</sup> -p-n [B28]<br><br><br><br><br>W <sup>186</sup> -n-2n; W <sup>184</sup> -n- $\gamma$ ; W <sup>184</sup> -d-p;<br>(Re <sup>187</sup> -d- $\alpha$ )                                                   |

|    |                   |                                                |                  |                                                        |                                               |                                                                       |                                                                                      |                                                                                                                                                                     |
|----|-------------------|------------------------------------------------|------------------|--------------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                   | W <sup>187</sup>                               |                  | $24.1 \pm 0.1$ ч<br>25 ч [C9]                          | $\beta^-$ , $\gamma$                          | 0.63 (70%);<br>1.33 (30%)                                             | 0.082*,<br>0.101,<br>0.138*,<br>0.21,<br>0.48, 0.62,<br>0.69 [B3]<br>$\approx 0.080$ | W <sup>187</sup> -d-p; W <sup>187</sup> -n- $\gamma$ [B3, C9];<br>U- $\alpha$ [20p, 35n]                                                                            |
|    |                   | $^{\circ}\text{W}$                             |                  | 5.5 с                                                  | $I, e^-$                                      |                                                                       |                                                                                      | W-n- $\gamma$                                                                                                                                                       |
| 75 | Re <sup>185</sup> | Re <sup>(182)</sup>                            |                  | 64 ч                                                   | $K$ , $\gamma$                                |                                                                       | 0.22, 1.5<br>(0.34, 0.6)                                                             | Ta <sup>181-<math>\alpha</math></sup> (3) n; W <sup>(182)</sup> -p-n                                                                                                |
|    |                   | Re <sup>(183,184)</sup>                        |                  | $\approx 80$ д                                         | $K$ , $\gamma$                                |                                                                       | 0.1, 1.0                                                                             | W <sup>(183,184)</sup> -p-n; Ta <sup>181-<math>\alpha</math></sup> (1,2) n                                                                                          |
|    |                   | Re <sup>(183,184)</sup>                        |                  | 13 ч                                                   | $K?$                                          |                                                                       | 1, 6                                                                                 | W <sup>(183,184)</sup> -p-n; Ta <sup>181-<math>\alpha</math></sup> (1,2) n                                                                                          |
|    |                   | Re <sup>184</sup>                              | 37.07 $\pm$ 0.06 | 50 д                                                   | $\beta^-$ , $K$ , $\gamma$                    | 0.24*                                                                 | 0.17*, 1.0*                                                                          | W <sup>183</sup> -d-n; Re <sup>185</sup> -n-2n; W <sup>184</sup> -p-n                                                                                               |
|    |                   | Re <sup>186</sup>                              |                  | 92.8 $\pm$ 0.1 ч                                       | $\beta^-$ , $\gamma$<br>( $\beta^+ < 0.1\%$ ) | 1.068 (100%)<br>[L9], 1.07<br>(100%)<br>[B24],<br>1.095 [G4]<br>0.043 | 0.138,<br>0.214 [B24],<br>(0.275)<br>[G4]                                            | W <sup>186</sup> -p-n; W <sup>186</sup> -d-2n, Re <sup>185</sup> -n- $\gamma$ ;<br>Re <sup>187</sup> -n-2n; Re <sup>185</sup> -d-p; Re <sup>187</sup> - $\gamma$ -n |
|    |                   | Re <sup>187</sup><br>$^{\circ}\text{Re}^{187}$ | 62.93 $\pm$ 0.06 | 5.8 $\times 10^{12}$ л<br>0.55 $\pm$ 0.05 мкс<br>[M16] | $\beta^-$<br>$I, \gamma, e^-$                 |                                                                       |                                                                                      | W <sup>187</sup> (24.1 ч) $\beta^-$                                                                                                                                 |
|    |                   | Re <sup>188</sup>                              |                  | 18.9 $\pm$ 0.2 ч                                       | $\beta^-$ , $\gamma$                          | 2.10 [B33]                                                            | 0.12;<br>0.16 (4),<br>0.48 (1),<br>0.64 (2),<br>0.94 (2),<br>1.41 (1)                | Re <sup>187</sup> -n- $\gamma$ ; Re <sup>187</sup> -d-p; U- $\alpha$                                                                                                |
| 76 | Os <sup>184</sup> |                                                | 0.018            |                                                        |                                               |                                                                       |                                                                                      |                                                                                                                                                                     |
|    | Os <sup>186</sup> | Os <sup>185</sup>                              | 1.582            | 94.7 $\pm$ 2.0 д                                       | $K$ , $\gamma$                                | нет $\beta^+$                                                         | 0.75                                                                                 | Os <sup>184</sup> -n- $\gamma$ ; Re <sup>185</sup> -d-2n                                                                                                            |

| Атомный<br>номер | Стабильное<br>ядро                                                               | Радиоактив.<br>ядро                                            | Распростра-<br>нённость<br>в %  | Период<br>полурас-<br>пада         | Тип<br>превраще-<br>ния                              | Энергия<br>$\beta^-$ ; $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв                                                                     | Ядерные реакции                                                                                                                                                                                                                                                                                                                          |
|------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------|---------------------------------|------------------------------------|------------------------------------------------------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                                                                | 3                                                              | 4                               | 5                                  | 6                                                    | 7                                                              | 8                                                                                                       | 9                                                                                                                                                                                                                                                                                                                                        |
|                  | Os <sup>187</sup><br>Os <sup>188</sup><br>Os <sup>189</sup><br>Os <sup>190</sup> | Os <sup>(191)</sup>                                            | 1.64<br>13.27<br>16.14<br>26.38 | 16.1±0.2 д                         | $\beta^-$ , $\gamma$                                 | 0.142,<br>(0.35),<br>(0.64)                                    | 0.039, 0.1291<br>(100%)                                                                                 | Os-n- $\gamma$ ; U- $\alpha$ [W2]                                                                                                                                                                                                                                                                                                        |
|                  | Os <sup>192</sup>                                                                | Os <sup>193</sup>                                              | 40.97                           | 31.8±0.2 ч                         | $\beta^-$ , $\gamma$                                 | 1.0                                                            | 0.22, 1.17,<br>1.58                                                                                     | Os <sup>192</sup> -n- $\gamma$ ; Os <sup>192</sup> -d-p; Ir <sup>193</sup> -d-2p.<br>U- $\alpha$ [W2]                                                                                                                                                                                                                                    |
| 77               | Ir <sup>191</sup>                                                                | Ir <sup>(190)</sup><br>°Ir <sup>192</sup><br>Ir <sup>192</sup> | 38.5                            | 10,7±0.3 д<br>1.42±0.1 м<br>75±3 д | (K), $\gamma$<br>I, $\gamma$<br>$\beta^-$ , $\gamma$ | 0.63±                                                          | 0.091; 0.25<br>0.056;<br>0,0574; [C7]<br>0.137,<br>0.208*,<br>(0.269),<br>0.295*,<br>0.307*,<br>0.316*, | Os <sup>189</sup> -d-n; Ir <sup>191</sup> -n-2n; Ir <sup>191</sup> - $\gamma$ -n<br>Ir <sup>191</sup> -n- $\gamma$<br>Ir <sup>191</sup> -n- $\gamma$ ; Ir <sup>193</sup> -n-2n; In <sup>193</sup> - $\gamma$ -n;<br>Ir <sup>191</sup> -d-p; Pt <sup>194</sup> -d- $\alpha$ ; Os <sup>192</sup> -d-2n;<br>U- $\alpha$ [W2] °Ir (1.42 м) I |

|    |                                                             |                                 |                            |                           |                        |      |                      |       |                                                                                                                                                               |                                                                                                                                                                                                                                                    |
|----|-------------------------------------------------------------|---------------------------------|----------------------------|---------------------------|------------------------|------|----------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                                             | Ir <sup>193</sup>               |                            | Ir <sup>194</sup>         | 61.5                   | 19 ч | $\beta^-$ , $\gamma$ | 2,2   | (0.401),<br>(0.408),<br>(0.454),<br>0.467*,<br>0.483*,<br>0.589*,<br>(0.601),<br>0.609*,<br>(0.615),<br>(0.651),<br>0.19,<br>0.40 <sup>a</sup> , 0.6,<br>1.5* | Ir <sup>193</sup> -d-p; Pt <sup>196</sup> -d- $\alpha$ ; Ir <sup>193</sup> -n- $\gamma$ ;<br>Au <sup>197</sup> -d- $\alpha$ , p                                                                                                                    |
| 78 | Pt <sup>190</sup>                                           | Pt <sup>191</sup>               | 0.006 [D6],<br>0.012 [L13] | 3.00 $\pm$ 0.02 д         | $K$ , $\gamma$ , $e^-$ |      |                      |       | 0.57,<br>1.5, (1.8)                                                                                                                                           | Ir <sup>191</sup> -d-2n; Pt <sup>192</sup> -n-2n;<br>Au <sup>191</sup> ( $\approx$ 1 д) $K$ ?                                                                                                                                                      |
|    | Pt <sup>192</sup>                                           | Pt <sup>(193)</sup>             | 0.78                       | 4.33 $\pm$ 0.03 д<br>[W6] | $K$ , $\gamma$ , $e^-$ |      |                      |       | 0.11, 0.18,<br>1.5 [W6]                                                                                                                                       | Pt <sup>193</sup> -n- $\gamma$ , Ir <sup>193</sup> -d-2n [W6];<br>Pt <sup>192</sup> -d-p [W6]; Pt <sup>194</sup> -n-2n [W6],<br>Ir <sup>(191)</sup> - $\alpha$ -p, n [W6]; Hg <sup>196</sup> -n- $\alpha$<br>Au <sup>(193)</sup> (15.8 ч) $K$ [W6] |
|    | Pt <sup>194</sup><br>Pt <sup>195</sup><br>Pt <sup>196</sup> | $\circ$ Pt <sup>(195,196)</sup> | 32.8<br>33.7<br>25.4       | 87 $\pm$ 5 м              | $I$ , $\gamma$         |      |                      |       | 0.337                                                                                                                                                         | Pt <sup>(194,195)</sup> -d-p; Hg <sup>(198,199)</sup> -n- $\alpha$ ;<br>Pt <sup>196</sup> - $\gamma$ -?; (Pt-n-?)                                                                                                                                  |
|    |                                                             | Pt <sup>(197)</sup>             |                            | 18 $\pm$ 1 ч              | $\beta^-$ , $\gamma$   |      |                      | 0.7*  |                                                                                                                                                               | Pt <sup>196</sup> -n- $\gamma$ ; Pt <sup>196</sup> -d-p; Hg <sup>200</sup> -n- $\alpha$ ;<br>Pt <sup>199</sup> -n-2n; Pt <sup>198</sup> - $\gamma$ -p; U- $\alpha$<br>[W2]                                                                         |
|    |                                                             | Pt <sup>(197)</sup>             |                            | 3.1 д                     | $\beta^-$ , $\gamma$   |      |                      | 0.126 |                                                                                                                                                               | Pt <sup>196</sup> -d-p; Pt <sup>196</sup> -n- $\gamma$ ; Hg <sup>(200)</sup> -n- $\alpha$                                                                                                                                                          |

| Атомный номер | Стабильное ядро   | Радиоактивн. ядро     | Распространённость в % | Период полураспада | Тип превращения                                                     | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв | Энергия $\gamma$ -лучей в Мэв                                            | Ядерные реакции                                                                                |
|---------------|-------------------|-----------------------|------------------------|--------------------|---------------------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| 1             | 2                 | 3                     | 4                      | 5                  | 6                                                                   | 7                                                     | 8                                                                        | 9                                                                                              |
|               | Pt <sup>198</sup> | Pt <sup>199</sup>     | 7.23                   | 32±1 м             | $\beta^-$                                                           | 1.8                                                   |                                                                          | Pt <sup>198</sup> -n- $\gamma$ ; Pt <sup>198</sup> -d-p; Hg <sup>202</sup> -n- $\alpha$        |
| 79            |                   | (Au< <sup>190</sup> ) |                        | 4.3 м              | $\alpha$ (10 <sup>-2</sup> %),<br>$\beta^+$ , K<br>(≈100%)<br>[T13] | 5.2 (α)                                               |                                                                          | Au <sup>197</sup> -d                                                                           |
|               |                   | Au <sup>(191)</sup>   |                        | ≈1 д [W6]          | K                                                                   |                                                       |                                                                          | Ir <sup>191</sup> -α-(4) n; Pt <sup>193</sup> -d-(3)n                                          |
|               |                   | Au <sup>(192)</sup>   |                        | 4.0±0.2 ч [W6]     | K, $\beta^+$ (≈1%)                                                  | 1.9 [W6]                                              | 0.4; 1.5 2.5* [W6]                                                       | Ir <sup>191</sup> -α-(3) n; Pt <sup>192</sup> -d-2n                                            |
|               |                   | Au <sup>(193)</sup>   |                        | 15.8±0.3 ч         | K                                                                   |                                                       | <0.2                                                                     | Ir <sup>191</sup> -α-2n; Pt <sup>194</sup> -d-(3)n                                             |
|               |                   | Au <sup>(194)</sup>   |                        | 39.5±0.5 ч         | $\beta^+$ (3%), K [W6], $\gamma$                                    | 1.8 [W6]                                              | 0.291 (70%),<br>0.328 (70%),<br>0.466,<br>1.48 (70%),<br>2.1 (30%) [S13] | Ir <sup>193</sup> -α-(3) n; Pt <sup>(194,195)</sup> -d-(2,3)n;<br>Pt <sup>194</sup> -p-n [S13] |
|               |                   | Au <sup>195</sup>     |                        | 185±3 д            | K, $\gamma$                                                         | нет $\beta^+$                                         | 0.096 (90%),<br>0.129 (10%), [S13], (1.6)                                | Ir <sup>198</sup> -α-2n; Pt-d; Pt <sup>195</sup> -p-n [S13]                                    |

|                   |                                                                                                                              |                                                                  |       |                                    |                                                                                               |                                                                         |                                                                                      |                                                                                                                                                                  |
|-------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-------|------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Au <sup>197</sup> | Au <sup>196</sup><br><br>°Au <sup>197</sup><br><br>Au <sup>198</sup><br><br>Au <sup>199</sup><br><br>Au <sup>(200,202)</sup> | Au <sup>196</sup><br><br><br><br><br><br>Au <sup>(200,202)</sup> | 100   | 14.0±0.3 ч<br>5.60±0.05 д<br>[S13] | K, γ,<br>β <sup>-</sup> (20%)<br>[W6],<br>β <sup>-</sup> (4.5%)<br>[S13]<br>I, e <sup>-</sup> | 0.3 [S13,<br>W6]                                                        | 0.175 (4.5%),<br>0.330 (36%),<br>0.358 (95%),<br>[S13]                               | Pt <sup>196</sup> -p-n; Au <sup>197</sup> -n-2n [W6]<br>Pt <sup>196</sup> -p-n [S13]; Au <sup>197</sup> -γ-n;<br>Au <sup>197</sup> -n-2n; Pt <sup>196</sup> -d-n |
|                   |                                                                                                                              |                                                                  |       | 7.5±0.5 с                          |                                                                                               |                                                                         | 0.273,<br>(0.077),<br>(0.38)                                                         | Au <sup>197</sup> -x; Au <sup>197</sup> -n-n;<br>Hg <sup>197</sup> (25 ч) K (4%)                                                                                 |
|                   |                                                                                                                              |                                                                  |       | 2.69±0.02 д<br>[S9]                | β <sup>-</sup> , γ,<br>(β <sup>+</sup> <0.1%)                                                 | 0.601 (15%),<br>0.966 (85%)<br>[L4]                                     | 0.4112<br>[D21],<br>(0.070),<br>(0.157),<br>(0.208),<br>(0.268)<br>[S5, S13,<br>S27] | Au <sup>197</sup> -n-γ; Au <sup>197</sup> -d-p; Pt <sup>198</sup> -p-n<br>[S13]; Hg <sup>198</sup> -n-p; Pt <sup>198</sup> -d-2n;<br>U-α                         |
|                   |                                                                                                                              |                                                                  |       | 3.3 д                              | β <sup>-</sup> , γ                                                                            | 0.975 [S13],<br>0.970 [S27],<br>0.96 [S9],<br>0.955 [D4],<br>0.956 [L9] | 0.024,<br>0.051,<br>0.156,<br>0.207<br>[B33, M21]                                    | Hg <sup>199</sup> -n-p; Pt <sup>198</sup> -d-n; U-α<br>Pt <sup>199</sup> (32 м) β <sup>-</sup> [M21];                                                            |
|                   |                                                                                                                              |                                                                  |       | 48±1 м                             | β <sup>-</sup>                                                                                | 0.32 [M2<br>1,333]                                                      |                                                                                      | Hg <sup>(200,202)</sup> -n-p; Tl <sup>(203,205)</sup> -n-α                                                                                                       |
| 80                | Hg <sup>196</sup><br><br>Hg <sup>197</sup>                                                                                   | (Hg <sup>&lt;195</sup> )<br><br>Hg <sup>197</sup>                | 0.155 | 0.7 м<br><br>64 ч                  | α (≈10 <sup>-2</sup> %),<br>K<br><br>K, γ, e <sup>-</sup>                                     | 5.7 (α)                                                                 | <br><br>0.077<br>(100%)                                                              | Au <sup>197</sup> -d<br><br>Au <sup>197</sup> -d-2n; Au <sup>197</sup> -p-n;<br>Hg <sup>198</sup> -n-2n; Hg <sup>196</sup> -n-γ                                  |

| Атомный<br>номер | Стабильное<br>ядро                                          | Радиоактивн.<br>ядро                         | Распро-<br>странён-<br>ность<br>в % | Период<br>полурас-<br>пада                                                                                                                            | Тип<br>превраще-<br>ния                                                                     | Энергия<br>$\beta^-$ ; $\beta^+$ и<br>$\alpha$ -лучей<br>в Мэв | Энергия<br>$\gamma$ -лучей<br>в Мэв | Ядерные реакции                                                                                                                                                                                         |
|------------------|-------------------------------------------------------------|----------------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                | 2                                                           | 3                                            | 4                                   | 5                                                                                                                                                     | 6                                                                                           | 7                                                              | 8                                   | 9                                                                                                                                                                                                       |
|                  | Hg <sup>198</sup>                                           | Hg <sup>197</sup><br><br>°Hg <sup>198</sup>  | 10.12                               | 25±1 ч<br><br>(2.5·10 <sup>-7</sup> с);<br><2·10 <sup>-7</sup> с<br>[M 16];<br>(2.3·10 <sup>-8</sup> с)<br>[M 20];<br><3·10 <sup>-9</sup> с<br>[B 32] | $K, \gamma$<br>{ Au <sup>197</sup> →(96%)<br>°Au <sup>197</sup> →4%<br><br>$I, \gamma, e^-$ |                                                                | 0.135, 0.165<br><br>0.4112          | Hg <sup>196</sup> -n-γ; Pt <sup>194</sup> -α-n; Hg <sup>198</sup> -n-2n;<br>Au <sup>197</sup> -p-n; Au <sup>197</sup> -d-2n;<br>Hg <sup>196</sup> -d-p<br><br>Au <sup>198</sup> (2.69 д) β <sup>-</sup> |
|                  | Hg <sup>199</sup>                                           | °Hg <sup>199</sup>                           | 17.01                               | 44.4±0.5 м                                                                                                                                            | $I: e^-$ (100%)                                                                             |                                                                | 0.155, 0.368<br>[H 25]              | Hg <sup>198</sup> -d-p; Hg <sup>200</sup> -n-2 n [M 16];<br>Pt <sup>196</sup> -α-n; Hg <sup>199</sup> -n-n [M 16];<br>Hg <sup>199</sup> -x                                                              |
|                  | Hg <sup>200</sup><br>Hg <sup>201</sup><br>Hg <sup>202</sup> |                                              | 23.21<br>13.15<br>29.66             |                                                                                                                                                       |                                                                                             |                                                                |                                     |                                                                                                                                                                                                         |
|                  | Hg <sup>204</sup>                                           | Hg <sup>(203)</sup><br><br>Hg <sup>205</sup> | 6.69                                | 43.5±0.5 д<br><br>5.5±0.2 м                                                                                                                           | β <sup>-</sup> , γ, e <sup>-</sup><br><br>β <sup>-</sup>                                    | 0.208 [S4]<br><br>1.62                                         | 0.272[S4,531]                       | Tl-n-p; Hg-d-p; Hg-n-γ<br><br>Pb <sup>208</sup> -n-α; Tl <sup>206</sup> -n-p; Hg <sup>204</sup> -d-p;<br>Hg <sup>204</sup> -n-γ                                                                         |

|    |                   |                              |            |             |                           |                      |                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                            |
|----|-------------------|------------------------------|------------|-------------|---------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 81 |                   | Tl <sup>(198)</sup>          |            | 1.8 ч       | K, γ, e <sup>-</sup>      |                      | 0.4, 1.3                                                                                                                                                                                                                                   | Au <sup>197</sup> -α-3n [O 3]                                                                                                                                                                                                                                                              |
|    |                   | Tl <sup>(199)</sup>          |            | 7.5 ч       | K, γ, e <sup>-</sup>      |                      | 1.5, 0.5                                                                                                                                                                                                                                   | Au <sup>197</sup> -α-2n [O 3];<br>Bi <sup>(199)</sup> (27 м) K...Pb <sup>(199)</sup> (1—<br>2 ч) K                                                                                                                                                                                         |
|    |                   | Tl <sup>(200)</sup>          |            | 27 ч        | K, γ, e <sup>-</sup>      |                      | 0.4                                                                                                                                                                                                                                        | Au <sup>197</sup> -α-n [O 3];<br>Bi <sup>(200)</sup> (62 м) K...<br>...Pb <sup>(200)</sup> (18 ч) K                                                                                                                                                                                        |
|    |                   | Tl <sup>(201)</sup>          |            | 75 ч        | K                         |                      |                                                                                                                                                                                                                                            | Pb <sup>(201)</sup> (8 ч) K                                                                                                                                                                                                                                                                |
|    | Tl <sup>203</sup> | Tl <sup>(202)</sup>          | 29.43±0.05 | 13 д        | K, γ, e <sup>-</sup>      |                      | 0.40                                                                                                                                                                                                                                       | Hg <sup>202</sup> -d-2n; Tl <sup>203</sup> -n-2n                                                                                                                                                                                                                                           |
|    | Tl <sup>205</sup> | Tl <sup>204</sup>            | 70.54±0.05 | 2.7 г       | β <sup>-</sup>            | 0.783 [S 23]         | нет γ                                                                                                                                                                                                                                      | Tl <sup>203</sup> -d-p; Tl <sup>203</sup> -n-γ; Tl <sup>205</sup> -γ-n                                                                                                                                                                                                                     |
|    |                   | Tl <sup>206</sup>            |            | 4.23±0.03 м | β <sup>-</sup>            | 1.7*                 | нет γ                                                                                                                                                                                                                                      | Tl <sup>205</sup> -n-γ; Tl <sup>206</sup> -d-p; Pb <sup>207</sup> -γ-p;<br>Bi <sup>210</sup> (5 д) α <sup>+</sup>                                                                                                                                                                          |
|    |                   | Tl <sup>207</sup><br>{AcC''} |            | 4.77±0.05 м | β <sup>-</sup> , γ        | 1.47                 |                                                                                                                                                                                                                                            | Pb <sup>207</sup> -n-p; Pa <sup>227</sup> (38 м)...<br>... Bi <sup>211</sup> (2.16 м) α [M 3];<br>U <sup>235</sup> (α)...Bi <sup>211</sup> (2.16 м) α<br>Pa <sup>228</sup> (22 ч) α...<br>... Bi <sup>212</sup> (60.5 м) α [M 3];<br>Th <sup>232</sup> (α)... Bi <sup>212</sup> (60.5 м) α |
|    |                   | Tl <sup>208</sup><br>{ThC''} |            | 3.1 м       | β <sup>-</sup> , γ [B 37] | 1.792, 1.82<br>[M 3] | 0.0405,<br>0.2109,<br>0.2518,<br>0.2766 (10.6),<br>0.3012,<br>0.3227;<br>0.3300,<br>0.5110 (5.6),<br>0.5823 (5),<br>0.8118,<br>1.35 (0.036),<br>1.50 (0.037),<br>1.60 (0.1),<br>1.80 (0.06),<br>2.20 (0.05),<br>2.62 (1),<br>(3.24) (0.09) |                                                                                                                                                                                                                                                                                            |

| Атомный номер | Стабильное ядро      | Радиоактивн. ядро                                                                                                                                                                                                                                     | Распространённость в % | Период полураспада                                                                                            | Тип превращения                                                                                                  | Энергия $\beta^-$ ; $\beta^+$ и $\alpha$ -лучей в Мэв | Энергия $\gamma$ -лучей в Мэв                                 | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                    | 3                                                                                                                                                                                                                                                     | 4                      | 5                                                                                                             | 6                                                                                                                | 7                                                     | 8                                                             | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|               |                      | Tl <sup>209</sup><br>Tl <sup>210</sup><br>{RaC''}                                                                                                                                                                                                     |                        | 2.2 м<br>1.32 м                                                                                               | $\beta^-$<br>$\beta^-$                                                                                           | 1.8<br>1.8                                            |                                                               | Bi <sup>213</sup> (47 м) $\alpha$<br>U <sup>238</sup> ( $\alpha$ )... Bi <sup>214</sup> (19.7 м) $\alpha$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 82            | (Pb <sup>202</sup> ) | Pb <sup>(199)</sup><br>Pb <sup>(200)</sup><br>Pb <sup>(201)</sup><br>Pb <sup>(203)</sup><br>Pb <sup>204</sup><br>ePb <sup>204</sup><br>Pb <sup>206</sup><br>Pb <sup>207</sup><br>Pb <sup>208</sup><br>Pb <sup>209</sup><br>Pb <sup>210</sup><br>{RaD} |                        | 1—2 ч<br>18 ч<br>8 ч<br>52±1 ч<br>68 м<br>25.15±0.04<br>21.11±0.04<br>52.38±0.10<br>3.32±0.03 ч<br>22.1±0.4 г | K<br>K<br>K, $\gamma$<br>(I), (K), $\gamma$<br>I, $\gamma$ , e <sup>-</sup><br>$\beta^-$<br>$\beta^-$ , $\gamma$ |                                                       | 0.27, 0.47<br>0.90, 1.1<br>нет $\gamma$<br>(0.0073)<br>(~10), | Bi <sup>(199)</sup> (27 м) K<br>Bi <sup>(200)</sup> (62 м) K<br>Tl <sup>(203)</sup> -d-(4) n<br>Po <sup>206</sup> (9 д) $\alpha$<br>Tl <sup>203</sup> -d-2 n; Pb <sup>204</sup> -n-2n;<br>Pb <sup>204</sup> - $\gamma$ -n; Tl <sup>203</sup> -p-n<br>Tl <sup>203</sup> -d-n; Tl <sup>205</sup> -d-3n; Pb <sup>204</sup> -x;<br>Pb <sup>204</sup> -n-n; Bi <sup>204</sup> (12 ч) K<br>Pb <sup>206</sup> -n- $\gamma$ ; Pb <sup>208</sup> -d-p; Bi <sup>209</sup> -n-p;<br>U <sup>229</sup> (57 м) $\alpha$ ...<br>...Po <sup>213</sup> (4 мкс) $\alpha$ [МЗ]<br>U <sup>238</sup> $\alpha$ ... Po <sup>214</sup> (1.5×10 <sup>-4</sup> с) $\alpha$ ; |

|  |                      |        |                   |                       |                                                                                                                                             |                                                                                                     |                                                          |
|--|----------------------|--------|-------------------|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------|
|  |                      |        |                   |                       |                                                                                                                                             | 0.0232 (1.0),<br>0.032 (0.4),<br>0.037 (0.2),<br>0.043 (0.2),<br>0.0467 (2.8),<br>(0.065)( $<0.2$ ) | $U^{288} \alpha \dots Th^{210} (1.32 \text{ м}) \beta^-$ |
|  | $Pb^{211}$<br>{Ac B} | 36.1 м | $\beta^-, \gamma$ | 0.5, 1.40             | 0.06524,<br>0.0829,<br>0.4040,<br>0.4258,<br>0.4871,<br>0.7640,<br>0.8296                                                                   | $U^{285} \alpha \dots Po^{215} (1.83 \times 10^{-3} \text{ с}) \alpha$                              |                                                          |
|  | $Pb^{212}$<br>{Th B} | 10.6 ч | $\beta^-, \gamma$ | 0.355, 0.589<br>(сл.) | 0.1130,<br>0.1151 (16),<br>0.1354,<br>0.1641,<br>0.1765 (0.4),<br>0.2381 (165),<br>0.2505 (0.3),<br>0.3001 (6.0)                            | $Th^{282} \alpha \dots Po^{216} (0.158 \text{ с}) \alpha$                                           |                                                          |
|  | $Pb^{214}$<br>{RaB}  | 26.8 м | $\beta^-, \gamma$ | 0.65                  | 0.0529,<br>0.0649,<br>0.0862,<br>0.0888,<br>0.0921, 0.104,<br>0.190, 0.2406<br>(11%),<br>0.2571,<br>0.2937 (26%),<br>0.3499 (45%),<br>0.471 | $U^{288} \alpha \dots Po^{218} (3.05 \text{ м}) \alpha$                                             |                                                          |

| Атомный номер | Стабильное ядро   | Радиоактивн. ядро          | Распространённость в % | Период полураспада          | Тип превращения                                                          | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                                                            | Энергия $\gamma$ -лучей в Мэв                                  | Ядерные реакции                                                                                                                                                                      |
|---------------|-------------------|----------------------------|------------------------|-----------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                 | 3                          | 4                      | 5                           | 6                                                                        | 7                                                                                                                | 8                                                              | 9                                                                                                                                                                                    |
| 83            | Bi <sup>209</sup> | Bi <sup>(197)</sup>        | 100                    | 2 м                         | $\alpha$                                                                 | 6.2                                                                                                              | 0.2, 0.8                                                       | Pb-d                                                                                                                                                                                 |
|               |                   | Bi <sup>(198)</sup>        |                        | 9 м                         | $\alpha$                                                                 | 5.8                                                                                                              |                                                                | Pb-d                                                                                                                                                                                 |
|               |                   | Bi <sup>(199)</sup>        |                        | 27 м                        | $\alpha$                                                                 | 5.47                                                                                                             |                                                                | Pb-d                                                                                                                                                                                 |
|               |                   | Bi <sup>(200)</sup>        |                        | 62 м                        | $\alpha$                                                                 | 5.15                                                                                                             |                                                                | Pb-d                                                                                                                                                                                 |
|               |                   | Bi <sup>204</sup>          |                        | 12 ч                        | $K, \gamma, e^-$                                                         | нет $\beta^+$                                                                                                    | 0.4, 0.74, 1.1                                                 | Pb <sup>204</sup> -d-2n; Tl <sup>(203)</sup> - $\alpha$ -3n                                                                                                                          |
|               |                   | Bi <sup>206</sup>          |                        | 6.35 $\pm$ 0.2 д            | (K) $\gamma, e^-$                                                        |                                                                                                                  |                                                                | Pb <sup>207</sup> -d-3n; Tl <sup>(205)</sup> - $\alpha$ -3n;                                                                                                                         |
|               |                   | Bi <sup>207</sup>          |                        | (длин.)                     |                                                                          |                                                                                                                  |                                                                | Pb <sup>(206)</sup> -d-2n; Po <sup>206</sup> (9 д) K                                                                                                                                 |
|               |                   | Bi <sup>208</sup>          |                        | (длин.)                     |                                                                          |                                                                                                                  |                                                                | Po <sup>207</sup> (5.7 ч) K; At <sup>211</sup> (7.5 ч) $\alpha$                                                                                                                      |
|               |                   | Bi <sup>210</sup><br>{RaE} |                        | 5.02 $\pm$ 0.01 д           | $\alpha$ (5 $\times$ 10 <sup>-5</sup> %),<br>$\beta^-$ ( $\approx$ 100%) | 4.77 ( $\alpha$ )<br>1.16 ( $\beta^-$ )<br>[Z4]                                                                  | нет $\gamma$                                                   | Bi <sup>209</sup> -n- $\gamma$ ; Bi <sup>209</sup> -d-p; U <sup>238</sup> $\alpha$ ...                                                                                               |
|               |                   | Bi <sup>211</sup><br>{AcC} |                        | 2.16 м                      | $\alpha$ (99.68%),<br>$\beta^-$ (0.32%), $\gamma$                        | 6.618 (100),<br>6.272 (19)( $\alpha$ )                                                                           |                                                                | ... Pb <sup>210</sup> (22.1 г) $\beta^-$ ;<br>(Pb <sup>208</sup> - $\alpha$ -p, n); Pa <sup>226</sup> (1.7 м) $\alpha$ ...                                                           |
|               |                   | Bi <sup>213</sup><br>{ThC} |                        | 60.47 $\pm$<br>$\pm$ 0.04 м | $\alpha$ (33.7%),<br>$\beta^-$ (66.3%)                                   | $\alpha$ : 6.0930 (27),<br>6.0537 (68),<br>5.7709 (1.8),<br>5.6283 (0.16),<br>5.6095 (1.1),<br>$\beta^-$ : 2.24* | 0.350                                                          | ... At <sup>214</sup> (10 <sup>-6</sup> с) $\alpha$ [M3]<br>U <sup>235</sup> $\alpha$ ... Pb <sup>211</sup> (36.1 м) $\beta^-$ ;<br>Pa <sup>227</sup> (38 м) $\alpha$ ...            |
|               |                   |                            |                        |                             |                                                                          |                                                                                                                  | 0.0398;<br>0.1243;<br>0.1446;<br>0.1624;<br>0.2878;<br>0.3271; | ... At <sup>215</sup> ( $\approx$ 10 <sup>-4</sup> с) $\alpha$ [M3]<br>Pa <sup>228</sup> (22 ч) $\alpha$ ...<br>... At <sup>216</sup> (3 $\times$ 10 <sup>-4</sup> с) $\alpha$ [M3]; |

|    |                                                                                          |                                                            |                                                                                                                              |                                                                                                                  |                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                        |
|----|------------------------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                                                                          | $\text{Bi}^{213}$<br>$\text{Bi}^{214}$<br>$\{\text{RaC}\}$ | 47 м<br>$19.72 \pm 0.04$ м                                                                                                   | $\alpha$ ( $\approx 4\%$ ),<br>$\beta^-$ ( $\approx 96\%$ )<br>$\alpha$ (0.04%),<br>$\beta^-$ (99.96%), $\gamma$ | $\alpha$ : 5.86<br>$\beta$ : 1.25<br>$\alpha$ : 5.333 (7),<br>5 466 (16%),<br>5.517 (20)<br>$\beta^-$ : 3.173 (23%),<br>1.650 (77%)<br>[K 18] | 0.4316;<br>0.05417;<br>0.0000;<br>0.4708;<br>0.4908;<br>0.6157;<br>0.7195;<br>1.797<br>0.0589, 0.275,<br>0.332, 0.389,<br>0.429, 0.503,<br>0.6067,<br>(65.8%),<br>0.766 (6.5%),<br>0.933 (6.7%),<br>1.120 (19%)*,<br>1.238 (5%)*,<br>1.379 (8%)*,<br>1.414 ( $e^-$ ),<br>1.761 (22%)*,<br>1.820 (3%),<br>2.090 (2.5%),<br>2.200 (7.4%),<br>2.420 (3.7%)* | $\text{Th}^{233}$ ( $\alpha$ )... $\text{Pb}^{212}$ (10.6 ч) $\beta^-$<br><br>$\text{At}^{217}$ (0.021 с) $\alpha$<br>$\text{U}^{238}$ $\alpha$ ... $\text{Pb}^{214}$ (26.8 м) $\beta$ |
| 84 | $\text{Po}^{(203)}$<br>$\text{Po}^{(205)}$<br>$\text{Po}^{206}$<br><br>$\text{Po}^{207}$ | 40 м<br>4 ч<br>9 д<br><br>$5.7 \pm 0.1$ ч                  | $\alpha$ , K<br>$\alpha$ , K<br>$\alpha$ (10%),<br>K (90%), $\gamma$<br>$\alpha$ (0.01%),<br>K ( $\approx 100\%$ ), $\gamma$ | 5.56<br>5.35<br>5.2<br><br>5.1                                                                                   | <br><br>0.8<br><br>1.3                                                                                                                        | $\text{Pb}^{(206)}-\alpha-(7)$ п<br>$\text{Pb}^{(206)}-\alpha-(5)$ п<br>$\text{Pb}^{204}-\alpha-2$ п<br><br>$\text{Pb}^{206}-\alpha-3$ п                                                                                                                                                                                                                 |                                                                                                                                                                                        |

\*) Более слабые линии RaC см. П.161. [Е6].

\*) Более слабые линии RaC см. [L16], [E6].

| Атомный номер | Альфа-радио-активное ядро                                               | Радиоактив. ядро           | Распространённость в % | Период полураспада   | Тип превращения                                                        | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв    | Энергия $\gamma$ -лучей в Мэв                                           | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------|-------------------------------------------------------------------------|----------------------------|------------------------|----------------------|------------------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                                       | 3                          | 4                      | 5                    | 6                                                                      | 7                                                        | 8                                                                       | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|               | Po <sup>208</sup><br>(Po <sup>209</sup> )<br>Po <sup>210</sup><br>{RaF} |                            |                        | 3.0±0.2 г            | $\alpha$<br><br>( $\alpha$ )<br>$\alpha$ , $\gamma$                    | 5.14<br><br>5.297                                        | нет $\gamma$<br><br>0.015 (4) сл.,<br>0.084 (15) сл.,<br>0.773 (15) сл. | Pb <sup>206</sup> - $\alpha$ -2п; Pb <sup>207</sup> - $\alpha$ -3п;<br>Bi <sup>209</sup> -d-3п; Bi <sup>209</sup> -p-2п<br>(Bi <sup>209</sup> -d-2п) ?<br>At <sup>210</sup> (8.3 ч) K; Pa <sup>226</sup> (1.7 м) $\alpha$ ...<br>...Bi <sup>210</sup> (5 д) $\beta^-$ ; U <sup>233</sup> ( $\alpha$ )...<br>...Ra <sup>226</sup> ( $\alpha$ )... Bi <sup>210</sup> (5 д) $\beta^-$<br>Pb <sup>208</sup> -d-2п; Bi <sup>209</sup> >d-п<br>At <sup>211</sup> (7.5 ч) K; Pa <sup>227</sup> (38 м) $\alpha$ ...<br>...Bi <sup>211</sup> (2.16 м) $\beta^-$ ; U <sup>235</sup> $\alpha$ ...<br>...Bi <sup>211</sup> (2.16 м) $\beta^-$<br>U <sup>228</sup> (9.3 м) $\alpha$ ... Em <sup>216</sup> ( $\approx$<br>$\approx 10^{-5}$ с) $\alpha$ ; Pa <sup>228</sup> (22 м) $\alpha$ ...<br>...Bi <sup>212</sup> (60.5 м) $\beta^-$ ; Th <sup>232</sup> ( $\alpha$ )...<br>...Bi <sup>212</sup> (60.5 м) $\beta^-$<br>U <sup>239</sup> (38 м) $\alpha$ ... Em <sup>217</sup> ( $\approx 10^{-3}$<br>с) $\alpha$ ; Bi <sup>213</sup> (47 м) $\beta^-$ Ra <sup>223</sup><br>U <sup>238</sup> ( $\alpha$ )... Ra <sup>226</sup> ( $\alpha$ )...<br>...Bi <sup>214</sup> (19.72 м) $\beta^-$<br>( $\alpha$ )... Em <sup>218</sup> (0.019 с) $\alpha$<br>U <sup>235</sup> ( $\alpha$ )... Em <sup>219</sup> (3.92 с) $\alpha$ |
|               | Po <sup>211</sup><br>{AcC'}                                             |                            |                        | 5×10 <sup>-3</sup> с | $\alpha$                                                               | 7.434                                                    |                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|               | Po <sup>212</sup><br>{ThC'}                                             |                            |                        | 0.30±<br>±0.02 мкс   | $\alpha$                                                               | 8.776 (10 <sup>6</sup> ),<br>9.491 (34),<br>10.542 (190) |                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|               | Po <sup>213</sup>                                                       |                            |                        | 4.2±0.8 мкс          | $\alpha$                                                               | 8.336                                                    |                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|               | Po <sup>214</sup><br>{RaC'}                                             |                            |                        | 155±5 мкс            | $\alpha$                                                               | 7.680 (10 <sup>6</sup> ),<br>9.080 (30)                  |                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|               |                                                                         | Po <sup>215</sup><br>{AcA} |                        | 1830±40 мкс          | $\alpha$ ( $\approx 100\%$ ),<br>$\beta^-$ (5×<br>×10 <sup>-4</sup> %) | 7.365                                                    |                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

|    |                                                                                                          |                                                                                                                                                                                                      |                   |                                                                                                                                             |                                                                                                                                                    |                                                                         |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----|----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                                                                                                          | $\text{Po}^{216}$<br>{ThA}<br>$\text{Po}^{218}$<br>{RaA}                                                                                                                                             |                   | $0.158 \pm \pm 0.008$ c<br>$3.05 \pm 0.01$ м                                                                                                | $\alpha$ (100%),<br>$\beta^-$ (0.014%),<br>$\alpha$ (99.96%),<br>$\beta^-$ (0.04%)                                                                 | 6.7744<br>5.9981                                                        |     | Th <sup>232</sup> ( $\alpha$ )... Em <sup>230</sup> (54,5 c) $\alpha$<br>U <sup>238</sup> ( $\alpha$ )... Em <sup>223</sup> (3,823 д) $\alpha$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 85 |                                                                                                          | At <sup>(207)</sup><br>At <sup>(208)</sup><br>At <sup>210</sup><br>At <sup>211</sup><br>At <sup>213</sup><br>At <sup>(214)</sup><br><br>At <sup>216</sup><br>At <sup>217</sup><br>A <sup>(218)</sup> | At <sup>215</sup> | 1.7 ч<br>4.5 ч<br>8,3 ч<br>$7.5 \pm 1$ ч<br>0.25 c<br>$\approx 10^{-6}$ c<br><br>$\approx 10^{-4}$ c<br>300 мкс<br>0.021 c<br>$\approx 2$ c | $\alpha$<br>$\alpha$<br>$K, \gamma$<br>$\alpha$ (60%),<br>$K$ (40%)<br>$\alpha$<br>$\alpha$<br><br>$\alpha$<br>$\alpha$<br>$\alpha, \beta^-$ [W 5] | 5.76<br>5.66<br>5.89<br><br>8.78<br>8.00<br><br>7.79<br>7.023<br>(6.72) | 1.0 | Bi <sup>209</sup> - $\alpha$ -(6) n<br>Bi <sup>209</sup> - $\alpha$ -(3) n<br>Bi <sup>209</sup> - $\alpha$ -3 n<br>Bi <sup>209</sup> - $\alpha$ -2 n; Th <sup>232</sup> - $\alpha$ -[7 p, 18 n];<br>U <sup>238</sup> - $\alpha$ -[9 p, (22) n]<br>Bi <sup>209</sup> - $\alpha$ -n<br>Pa <sup>226</sup> (1.7 м) $\alpha$ ...<br>...Fr <sup>218</sup> ( $\approx 10^{-2}$ c) $\alpha$<br>Po <sup>215</sup> ( $1.83 \times 10^{-3}$ c) $\beta^-$ ;<br>Pa <sup>227</sup> (38 м) $\alpha$ ...<br>...Fr <sup>219</sup> ( $\approx 10^{-4}$ c) $\alpha$<br>Pa <sup>228</sup> (22 ч) $\alpha$ ... Fr <sup>220</sup> (27,5 c) $\alpha$ ;<br>Po <sup>216</sup> (0.145 c) $\beta^-$<br>Fr <sup>221</sup> (4.8 м) $\alpha$<br>Po <sup>218</sup> (3.05 м) $\beta^-$ ? |
| 86 | Em<br><br>Em <sup>216</sup><br><br>Em <sup>217</sup><br>Em <sup>218</sup><br>Em <sup>219</sup><br>{EmAc} |                                                                                                                                                                                                      |                   | 23 м. и 21 ч<br>[G 13]<br>$\approx 10^{-5}$ c<br><br>$\approx 10^{-3}$ c<br>0.019 c<br>$3.92 \pm 0.015$ c                                   | $\alpha$<br>$\alpha$<br>$\alpha$<br>$\alpha$<br>$\alpha$                                                                                           | 8.07<br><br>7.74<br>7.12<br>6.826 (10)<br>6.436 (1),<br>6.561 (1)       |     | Th <sup>232</sup> -p [G 13]<br>U <sup>238</sup> (9,3 м) $\alpha$ ...<br>... Ra <sup>220</sup> ( $\approx 10^{-2}$ c) $\alpha$<br>U <sup>239</sup> (58 м) $\alpha$ ... Ra <sup>221</sup> (31 c) $\alpha$<br>Ra <sup>223</sup> (38 c) $\alpha$<br>U <sup>235</sup> $\alpha$ ... Ra <sup>223</sup> (11,2 д) $\alpha$                                                                                                                                                                                                                                                                                                                                                                                                                                        |

0.0679; 0.1234;  
0.1980; 0.2667;  
0.321; 0.392;  
0.589

| Атомный номер | Альфа-радио-активное ядро                                                                                        | Радиоактив. ядро  | Распростра- нённость в % | Период полурас- пада                                            | Тип превраще- ния                                         | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв              | Энергия $\gamma$ -лучей в Мэв                                     | Ядерные реакции                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------|------------------------------------------------------------------------------------------------------------------|-------------------|--------------------------|-----------------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                                                                                | 3                 | 4                        | 5                                                               | 6                                                         | 7                                                                  | 8                                                                 | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|               | Em <sup>230</sup><br>{EmTh}<br>Em <sup>232</sup><br>{EmRa}                                                       |                   |                          | 54.50±0.03 с<br>3.823±0.002 д                                   | $\alpha$<br>$\alpha$                                      | 6.2818<br>5.4860                                                   |                                                                   | Th <sup>232</sup> $\alpha$ ... Ra <sup>224</sup> (3.64 д) $\alpha$<br>U <sup>238</sup> $\alpha$ ... Ra <sup>226</sup> (1622 г) $\alpha$                                                                                                                                                                                                                                                                                                                                              |
| 87            | Fr <sup>218</sup><br>Fr <sup>219</sup><br>Fr <sup>220</sup><br>Fr <sup>221</sup><br>Fr <sup>223</sup><br>{AcK}   |                   |                          | 0.02 с<br>≈0.02 с<br>27.5±1.5 с<br>4.8 м<br>21±1 м              | $\alpha$<br>$\alpha$<br>$\alpha$<br>$\alpha$<br>$\beta^-$ | 7.85<br>7.30<br>6.69<br>6.293<br>1.2                               | 0.095*                                                            | Pa <sup>226</sup> (1.7 м) $\alpha$ ... Ac <sup>223</sup> (≈10 с) $\alpha$<br>Pa <sup>227</sup> (38 м) $\alpha$ ... Ac <sup>223</sup> (≈2 м) $\alpha$<br>Pa <sup>238</sup> (22 ч) $\alpha$ ... Ac <sup>234</sup> (2.9 ч) $\alpha$<br>Ac <sup>235</sup> (10 д) $\alpha$<br>U <sup>235</sup> $\alpha$ ... Ac <sup>227</sup> (21.7 г) $\alpha$                                                                                                                                           |
| 88            | Ra <sup>230</sup><br>[M3]<br>31+2 с<br>[M3]<br>38 с<br>11.2 д<br>Ra <sup>233</sup><br>Ra <sup>233</sup><br>{AcX} | Ra <sup>231</sup> |                          | ≈10 <sup>-2</sup> с<br>[M3]<br>31+2 с<br>[M3]<br>38 с<br>11.2 д | $\alpha$<br>$\alpha$<br>$\alpha$<br>$\alpha$              | 7.49<br>6.71<br>6.51<br>5.717 (55%);<br>5.606 (36%);<br>5.531 (9%) | 0.0262,<br>0.0637,<br>0.0809,<br>0.0991;<br>0.1163,<br>0.144 (8), | U <sup>238</sup> (9.3 м) $\alpha$ ... Th <sup>234</sup> (≈1 с) $\alpha$<br>U <sup>239</sup> (58 м) $\alpha$ ...<br>...Th <sup>225</sup> (7.8 м) $\alpha$ [M 2]<br>Th <sup>226</sup> (30.9 м) $\alpha$<br>U- $\alpha$ -[6 p, (13) n];<br>U-d-[5 p, (12) n]; Ac <sup>227</sup> ( $\alpha$ )...<br>...Fr <sup>223</sup> (21 м) $\beta^-$ ;<br>Ac <sup>228</sup> (2.2 м) K; U <sup>235</sup> ( $\alpha$ )...<br>...Pa <sup>231</sup> ( $\alpha$ )... Th <sup>227</sup> (18.6 д) $\alpha$ |

|    |                            |                                           |                 |                                                  |                                                          |        |                                                                                                                                                                                                    |  |
|----|----------------------------|-------------------------------------------|-----------------|--------------------------------------------------|----------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|    |                            |                                           |                 |                                                  |                                                          |        | 0.1539 (10),<br>0.1615,<br>0.1797,<br>0.2318,<br>0.2677 (10),<br>0.2798, 0.322,<br>0.3476,<br>0.444                                                                                                |  |
|    | Ra <sup>224</sup><br>{ThX} |                                           | 3.64 д          | $\alpha$                                         | 5.6813                                                   |        | U- $\alpha$ -[6 p, (12) n];<br>U-d-[5p, (11) n];<br>Ac <sup>224</sup> (2.9 ч) K; Th <sup>232</sup> ( $\alpha$ )...<br>...Th <sup>228</sup> (1.9 г) $\alpha$<br>Th <sup>229</sup> (7000 л) $\alpha$ |  |
|    | Ra <sup>226</sup>          | Ra <sup>225</sup>                         | 14.8 д          | $\beta^-$                                        | 0.2                                                      |        |                                                                                                                                                                                                    |  |
|    |                            | Ra <sup>227</sup>                         | 1622 г          | $\alpha, \gamma$                                 | 4.793                                                    | 0.188  | U <sup>238</sup> ( $\alpha$ )... Th <sup>232</sup> ( $8.0 \times 10^4$ л) $\alpha$                                                                                                                 |  |
|    |                            | Ra <sup>228</sup><br>(MsTh <sub>1</sub> ) | ?<br>6.7 г      | $\beta^-$<br>$\beta^-$                           | 0.053                                                    |        | Ra <sup>226</sup> -n- $\gamma$<br>Th <sup>232</sup> ( $1.4 \times 10^{10}$ л) $\alpha$                                                                                                             |  |
| 89 |                            | Ac <sup>222</sup>                         | 10 с            | $\alpha$                                         | 6.96                                                     |        | Pa <sup>226</sup> (1.7 м) $\alpha$ [M 3]                                                                                                                                                           |  |
|    |                            | Ac <sup>223</sup>                         | $2.2 \pm 0.1$ м | $\alpha$ (99.9%),<br>K (0.1%)                    | 6.64                                                     |        | Pa <sup>227</sup> (38 м) $\alpha$ [M 3]                                                                                                                                                            |  |
|    |                            | Ac <sup>224</sup>                         | $2.9 \pm 0.2$ ч | $\alpha$ ( $\approx 10\%$ ),<br>K (90%)          | 6.17                                                     |        | Pa <sup>228</sup> (22 ч) $\alpha$                                                                                                                                                                  |  |
|    | Ac <sup>225</sup>          |                                           | 10.0 д          | $\alpha$                                         | 5.801                                                    |        | Ra <sup>225</sup> (4.8 д) $\beta^-$ ; Th <sup>225</sup> (7.8 м) K;<br>Pa <sup>229</sup> (1.5 д) $\alpha$ ; U-d-[4p, (11) n]                                                                        |  |
|    |                            | Ac <sup>226</sup>                         | 22 ч            | $\beta^-$                                        |                                                          | 0.0368 | U- $\alpha$ -[5 p, (11) n]                                                                                                                                                                         |  |
|    |                            | Ac <sup>227</sup><br>{Ac}                 | 21.7 г          | $\alpha$ (1.25%)<br>$\beta^-$ (98.75%), $\gamma$ | $\alpha$ : 4.6 (15%),<br>4.95 (85%);<br>$\beta^-$ : 0.01 |        | Ra <sup>227</sup> ( $\beta^-$ ); U <sup>235</sup> ( $\alpha$ )...<br>...Pa <sup>231</sup> ( $3.4 \times 10^4$ л) $\alpha$<br>Pa <sup>231</sup> ( $3.4 \times 10^4$ л)                              |  |

| Атомный номер | Альфа-радио-активное ядро                                                            | Радиоактивн. ядро                        | Распростра-нённость в % | Период полурас-пада                                      | Тип превраще-ния                                                                        | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                                              | Энергия $\gamma$ -лучей в Мэв                                                                                                                                                               | Ядерные реакции                                                                                                                                                                                                                                                                                    |
|---------------|--------------------------------------------------------------------------------------|------------------------------------------|-------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                                                                                    | 3                                        | 4                       | 5                                                        | 6                                                                                       | 7                                                                                                  | 8                                                                                                                                                                                           | 9                                                                                                                                                                                                                                                                                                  |
|               |                                                                                      | $\text{Ac}^{228}$<br>{ $\text{MsTh}_2$ } |                         | 6.13 ч                                                   | $\beta^-$ , ( $\alpha$ ), $\gamma$                                                      | 1.55 ( $\beta^-$ )<br>(4.54) ( $\alpha$ )                                                          | 0.0581 (250),<br>0.0795 (15),<br>0.1294 (100),<br>0.184 (50),<br>0.2497 (18),<br>0.3190 (16),<br>0.338 (8),<br>0.408 (3),<br>0.462 (8),<br>0.915 (6),<br>0.970 (3),<br>(см. также<br>[L 2]) | $\text{Th}^{232}$ ( $\alpha$ )... $\text{Ra}^{228}$ (6.7 г) $\beta^-$                                                                                                                                                                                                                              |
| 90            | $\text{Th}^{234}$<br><br>$\text{Th}^{236}$<br>$\text{Th}^{237}$<br>{ $\text{RdAc}$ } | $\text{Th}^{235}$                        |                         | $\approx 1$ с<br>$7.8 \pm 0.3$ м<br><br>30.9 м<br>18.6 д | $\alpha$<br>$\alpha$ (91%),<br>$K$ ( $\approx 9\%$ )<br>$\alpha$<br>$\alpha$ , $\gamma$ | 7.20<br>6.57<br><br>6.30<br>5.672 (10),<br>5.717 (60),<br>5.742 (15),<br>5.764 (80),<br>5.815 (5), | 0.032 (2),<br>0.0437 (4),<br>0.0533 (4),<br>0.0614 (9),<br>0.1007 (7),                                                                                                                      | $\text{U}^{238}$ (9.3 м) $\alpha$<br>$\text{U}^{239}$ (58 м) $\alpha$<br><br>$\text{U}^{230}$ (20.8 д) $\alpha$ ; $\text{Ac}^{226}$ (22 ч) $\beta^-$<br>$\text{U-d-}$ [3 p, (10) n]; $\text{U}^{235}$ $\alpha$ ...<br>... $\text{Ac}^{227}$ (21.7 г) $\beta^-$ ; ,<br>$\text{Pa}^{237}$ (38 м) $K$ |

|    |                                                                                                         |     |                                                    |                                                                                                                  |                                                                                                                     |                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                       |
|----|---------------------------------------------------------------------------------------------------------|-----|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | Th <sup>228</sup><br>{RaTh}<br>Th <sup>229</sup>                                                        |     | 1.9 г<br>7×10 <sup>3</sup> л                       | α, γ<br>α                                                                                                        | 5.868 (10),<br>5.922 (5),<br>5.966 (15),<br>5.988 (100),<br>6.017 (15),<br>6.049 (80)<br>(см. также<br>[S 28, F 9]) | 0.1491 (8),<br>0.1954 (3),<br>0.2539 (4),<br>0.2821 (2),<br>0.3002 (2),<br>(см. также<br>[S 28, F 9]) | Pa <sup>228</sup> (22 ч) K; U <sup>232</sup> (30 л) α;<br>Th <sup>232</sup> α... Ac <sup>228</sup> (6.2 ч) β <sup>-</sup><br>U <sup>233</sup> (1.6×10 <sup>5</sup> л) α                                                                                                                                                                                               |
|    | Th <sup>230</sup><br>{Jo}                                                                               |     | 80×10 <sup>4</sup> л                               | α, γ                                                                                                             | 4.509; 4.612;<br>4.682                                                                                              | 0.068; 0.140;<br>0.240; 0.190<br>[C17]                                                                | Pa <sup>230</sup> (17.7 д) K; U <sup>238</sup> (α)...<br>...U <sup>234</sup> (2.7×10 <sup>5</sup> л) α<br>U <sup>235</sup> (7×10 <sup>8</sup> л) α; Th <sup>232</sup> -n-2 n                                                                                                                                                                                          |
|    | Th <sup>231</sup><br>{UY}                                                                               | 100 | 25.5 ч                                             | β <sup>-</sup> , γ                                                                                               | 0.210 [K 1]                                                                                                         | 0.035 [K 1]<br>0.065                                                                                  | (Pu <sup>240</sup> α... U <sup>236</sup> α)<br>Th <sup>232</sup> -n-γ; Th <sup>232</sup> -d-p<br>U <sup>238</sup> (4.5×10 <sup>9</sup> л) α                                                                                                                                                                                                                           |
|    | Th <sup>232</sup><br>Th <sup>233</sup><br>Th <sup>234</sup><br>{UX <sub>1</sub> }                       |     | 1.389×10 <sup>10</sup> л<br>23.5 м<br>24.10±0.02 д | α<br>β <sup>-</sup><br>β <sup>-</sup> , γ                                                                        | 3.98<br>1.2<br>0.112 (20%),<br>0.205 (80%)                                                                          | нет γ<br>0.094*                                                                                       |                                                                                                                                                                                                                                                                                                                                                                       |
| 91 | Pa <sup>(226)</sup><br>Pa <sup>227</sup><br>Pa <sup>228</sup><br>Pa <sup>229</sup><br>Pa <sup>230</sup> |     | 1.70±0.15 м<br>38±1 м<br>22±1 ч<br>1.5 д<br>17.7 д | α<br>α (≈80%),<br>K (20%)<br>α (≈2%),<br>K (≈98%)<br>α (≈1%),<br>K (≈99%)<br>β <sup>-</sup> (≈10%),<br>K (≈90%)γ | 6.81<br>6.46<br>6.09<br>5.68*<br>1.1                                                                                | 0.94                                                                                                  | Th <sup>232</sup> -d-8 н<br>Th <sup>232</sup> -d-7 н; U-α-[3 p, (12) n];<br>Np <sup>231</sup> (53 м) α<br>Th <sup>232</sup> -d-6 н; U <sup>238</sup> (9.3 м) K<br>Th <sup>230</sup> -d-3 н<br>Th <sup>232</sup> -d-4 н; Th <sup>232</sup> -α-p, 5 н;<br>Th <sup>230</sup> -d-2 н; Pa <sup>231</sup> -d-p, 2 н;<br>Pa <sup>231</sup> -α-α, n; U <sup>233</sup> -d-α, n |

| Атомный номер | Альфа-радио-активное ядро | Радиоактив. ядро                                | Распростра-нённость в % | Период полурас-пада      | Тип превраще-ния                    | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв                    | Энергия $\gamma$ -лучей в Мэв         | Ядерные реакции                                                                                                                                               |
|---------------|---------------------------|-------------------------------------------------|-------------------------|--------------------------|-------------------------------------|--------------------------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                         | 3                                               | 4                       | 5                        | 6                                   | 7                                                                        | 8                                     | 9                                                                                                                                                             |
|               | $\text{Pa}^{231}$         |                                                 |                         | $3.43 \times 10^4$ л     | $\alpha$ , $\gamma$                 | 4.736 (13%),<br>5.012, (87%)<br>[S 29];<br>5.032, 5.069,<br>5.131 [R 10] | 0.294, 0.323,<br>(0.095)              | $\text{U}^{235}$ ( $8 \times 10^8$ л) $\alpha$ ;<br>$\text{Th}^{231}$ (25.5 ч) $\beta^-$ ; $\text{Th}^{232}$ -d-3 n                                           |
|               |                           | $\text{Pa}^{232}$                               |                         | 1.32 д                   | $\beta^-$ , $\gamma$                | 0.28                                                                     | 0.23, 1.05                            | $\text{Th}^{232}$ -d-2 n; $\text{Th}^{232}$ - $\alpha$ -p, 3 n;<br>$\text{Pa}^{231}$ -d-p                                                                     |
|               |                           | $\text{Pa}^{233}$                               |                         | $27.4 \pm 0.4$ д         | $\beta^-$ , $\gamma$                | 0.23                                                                     | 0.084, 0.298,<br>0.309, 0.337         | $\text{Th}^{233}$ (23.5 м) $\beta^-$ ;<br>$\text{Np}^{237}$ ( $2.2 \times 10^6$ л) $\alpha$ ;<br>$\text{Th}^{232}$ -d-n; $\text{Th}^{232}$ - $\alpha$ -p, 2 n |
|               |                           | $^{\circ}\text{Pa}^{234}$<br>{UX <sub>2</sub> } |                         | 1.22 м                   | $\beta^-$ , $\gamma$<br>I: (0, 15%) | 1.52 (5%),<br>2.32 (95%)                                                 | 0.394, 0.782,<br>0.822, 0.802<br>(5%) | $\text{U}^{238}$ $\alpha$ ... $\text{Th}^{234}$ (24.1 д) $\beta^-$                                                                                            |
|               |                           | $\text{Pa}^{234}$<br>{UZ}                       |                         | 6.69 ч                   | $\beta^-$ , $\gamma$                | 0.45 (90%),<br>1.2 (10%)                                                 | 0.70                                  | $^{\circ}\text{Pa}^{234}$ (1.22 м);<br>$\text{U}^{238}$ ( $\alpha$ )... $\text{Th}^{234}$ (24.1 д) $\beta^-$                                                  |
| 92            |                           | $\text{U}^{238}$                                |                         | $9.3 \pm 0.5$ м<br>[M 3] | $\alpha$ (80%),<br>K (20%),<br>[M3] | 6.72 [M3]                                                                |                                       | $\text{Th}^{232}$ - $\alpha$ -8 n [M 3]; $\text{Pu}^{232}$ (22 м) $\alpha$                                                                                    |
|               |                           | $\text{U}^{239}$                                |                         | $58 \pm 3$ м [M3]        | $\alpha$ (17%),<br>K (83%)          | 6.42 [M3]                                                                |                                       | $\text{Th}^{232}$ - $\alpha$ -7 n                                                                                                                             |

|    |                                                         |                    |                             |                                                     |                                                         |                                                        |                               |                                                                                                                                                                                                                                                                                                     |
|----|---------------------------------------------------------|--------------------|-----------------------------|-----------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    | U <sup>230</sup>                                        | U <sup>(231)</sup> |                             | 20.8 д                                              | $\alpha$                                                | 5.86                                                   |                               | Pa <sup>230</sup> (17.7 д) $\beta^-$ ; Th <sup>233</sup> - $\alpha$ -6 n;<br>Pu <sup>234</sup> (8.5 ч) $\alpha$ ; Pa <sup>231</sup> -d-3 n;<br>Pa <sup>231</sup> - $\alpha$ -p, 4 n; U <sup>238</sup> -d-p, 9 n                                                                                     |
|    | U <sup>232</sup>                                        |                    |                             | 4.2 д<br>70 л                                       | K<br>$\alpha$                                           | 5.29*                                                  |                               | Pa <sup>231</sup> -d-2 n; Pa <sup>231</sup> - $\alpha$ -p, 3 n<br>Pa <sup>232</sup> (1.33 д) $\beta^-$ ; Pu <sup>236</sup> (2.7 г) $\alpha$ ;<br>Th <sup>232</sup> - $\alpha$ -4 n; Pa <sup>231</sup> -d-n;<br>Pa <sup>231</sup> - $\alpha$ -p, 2 n                                                 |
|    | U <sup>233</sup>                                        |                    |                             | $1.62 \times 10^5$ л                                | $\alpha$ , $\gamma$                                     | 4.823                                                  | 0.040, 0.080,<br>0.31         | Pu <sup>233</sup> (27.4 д) $\beta^-$                                                                                                                                                                                                                                                                |
|    | U <sup>234</sup><br>{U II}<br>U <sup>235</sup><br>{AcU} | U <sup>237</sup>   | 0.005481<br>[K 19]<br>0.714 | 2.522 $\pm$ 0.008<br>[K 19]<br>$8.91 \times 10^3$ л | $\alpha$ , $\gamma$                                     | 4.71 [B14]<br>4.56 (20%)<br>4.396 (80%);<br>4.52 [B14] | 0.17*                         | U <sup>233</sup> $\alpha$ ... $\circ$ Pa <sup>234</sup> (1.22 м) $\beta^-$ ;<br>U <sup>238</sup> $\alpha$ ... Pa <sup>234</sup> (6.69 ч) $\beta^-$ ;<br>Pu <sup>239</sup> ( $2.4 \times 10^4$ л) $\alpha$                                                                                           |
|    | (U <sup>236</sup> )?                                    |                    |                             | оч. больш. ?<br>$6.63 \pm 0.05$ д                   | ( $\alpha$ )<br>$\beta^-$ , $\gamma$                    | 0.24*                                                  | 0.032, 0.057,<br>0.204, 0.260 | (Pu <sup>240</sup> (6000 л) $\alpha$ )<br>U <sup>238</sup> -n-2n; U <sup>238</sup> -d-p, 2 n;<br>U <sup>238</sup> - $\alpha$ - $\alpha$ , n; Pu <sup>241</sup> ( $\approx 10$ л) $\alpha$                                                                                                           |
|    | U <sup>238</sup><br>{U I}                               | U <sup>239</sup>   | 99.28                       | $4.498 \times 10^9$ л<br>23.54 м                    | $\alpha$<br>$\beta^-$ , $\gamma$ , $e^-$                | 4.180,<br>4.15 [B14]<br>1.12 (97%),<br>2.06 (3%)       | 0.076,<br>0.3 (сл.)<br>0.92   | U <sup>238</sup> -n- $\gamma$ ; U <sup>238</sup> -d-p                                                                                                                                                                                                                                               |
| 93 | Np <sup>231</sup><br>Np <sup>(234)</sup>                |                    |                             | 53 м<br>4.40 д                                      | $\alpha$ (5%),<br>K (99%)<br>K, $\gamma$                | 6.2                                                    | 1.9                           | U <sup>238</sup> -d-9 n; U <sup>235</sup> -d-6 n; U <sup>238</sup> -d-4 n<br>Pu <sup>234</sup> (8 ч) K; Pa <sup>231</sup> - $\alpha$ -n;<br>U <sup>235</sup> - $\alpha$ -p, 4 n; U <sup>235</sup> -d-3 n;<br>U <sup>238</sup> -d-n; U <sup>238</sup> - $\alpha$ -p, 2 n;<br>U <sup>235</sup> -p-2 n |
|    | Np <sup>(235)</sup>                                     |                    |                             | 435 д                                               | $\alpha$ ( $\approx 0.1\%$ ),<br>K ( $\approx 99.9\%$ ) | 5.06                                                   | нет $\gamma$                  | U <sup>235</sup> - $\alpha$ -p, 3 n; U <sup>235</sup> -d-2 n;<br>U <sup>238</sup> - $\alpha$ -p, n                                                                                                                                                                                                  |
|    | Np <sup>236</sup>                                       |                    |                             | 22 ч                                                | $\beta^-$ , $\gamma$                                    | 0.5                                                    |                               | U <sup>238</sup> -d-4 n; U <sup>235</sup> - $\alpha$ -p, 2 n; U <sup>235</sup> -d-n;<br>U <sup>238</sup> - $\alpha$ -p; Np <sup>237</sup> - $\alpha$ - $\alpha$ , n;<br>Np <sup>237</sup> -d-(p, 2 n)                                                                                               |
|    | Np <sup>237</sup>                                       |                    |                             | $2.25 \times 10^6$ л                                | $\alpha$                                                | 4.7                                                    |                               | U <sup>237</sup> (6.8 д) $\beta^-$ ; Am <sup>241</sup> (500 л) $\alpha$                                                                                                                                                                                                                             |

| Атомный номер | Альфа-радио-активное ядро | Радиоактив. ядро    | Распростра-нённость в % | Период полурас-пада      | Тип превраще-ния                             | Энергия $\beta^-$ , $\beta^+$ и $\alpha$ -лучей в Мэв     | Энергия $\gamma$ -лучей в Мэв                     | Ядерные реакции                                                                                                                                                                                                                                                                         |
|---------------|---------------------------|---------------------|-------------------------|--------------------------|----------------------------------------------|-----------------------------------------------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | 2                         | 3                   | 4                       | 5                        | 6                                            | 7                                                         | 8                                                 | 9                                                                                                                                                                                                                                                                                       |
|               |                           | Np <sup>238</sup>   |                         | 2.10 д                   | $\beta^-$ , $\gamma$                         | 0.22, 1.39                                                | 0.075, 1.2                                        | U <sup>238</sup> - $\alpha$ -p, 3 n; U <sup>235</sup> - $\alpha$ -p;<br>U <sup>238</sup> -d-2 n; Np <sup>237</sup> -n- $\gamma$ ;<br>Np <sup>237</sup> -d-p; Am <sup>242</sup> ( $\approx 400$ л) $\alpha$                                                                              |
|               |                           | Np <sup>239</sup>   |                         | 2.35 д                   | $\beta^-$ , $\gamma$                         | 0.288 (51%);<br>0.403 (42%);<br>0.678 (6%);<br>1.178 (1%) | 0.057, 0.061,<br>0.067, 0.208*,<br>0.228*, 0.275* | U <sup>238</sup> - $\alpha$ -p, 2 n; U <sup>238</sup> -d-n;<br>U <sup>239</sup> (23 м) $\beta^-$                                                                                                                                                                                        |
| 94            |                           | Pu <sup>(232)</sup> |                         | 22 м                     | $\alpha$                                     | 6.6                                                       |                                                   | U <sup>235</sup> - $\alpha$ -7 n                                                                                                                                                                                                                                                        |
|               | Pu <sup>236</sup>         | Pu <sup>234</sup>   |                         | 8.5 ч<br>2.7 г           | $\alpha$ (1%),<br>K (99%)<br>$\alpha$        | 6.1*<br>5.78*                                             |                                                   | U <sup>238</sup> - $\alpha$ -3 n<br>Np <sup>236</sup> (22 ч) $\beta^-$ ; Cm <sup>240</sup> (26.8 д) $\alpha$ ;<br>U <sup>238</sup> - $\alpha$ -6 n; U <sup>235</sup> - $\alpha$ -3 n; U <sup>233</sup> - $\alpha$ -n;<br>Np <sup>237</sup> - $\alpha$ -p, 4 n; Np <sup>237</sup> -d-3 n |
|               |                           | Pu <sup>(237)</sup> |                         | 40 д                     | K                                            |                                                           | нет $\gamma$                                      | U <sup>238</sup> - $\alpha$ -(5) n; U <sup>235</sup> - $\alpha$ -(2) n;<br>Np <sup>237</sup> -d-(2) n                                                                                                                                                                                   |
|               | Pu <sup>238</sup>         |                     |                         | 92 г                     | $\alpha$                                     | 5.493                                                     |                                                   | Np <sup>238</sup> (2.1 д) $\beta^-$ ;<br>Cm <sup>242</sup> (150 д) $\alpha$ ; Np <sup>237</sup> -d-n;<br>U <sup>238</sup> - $\alpha$ -4 n; U <sup>235</sup> - $\alpha$ -n                                                                                                               |
|               | Pu <sup>239</sup>         |                     |                         | $2.411 \times 10^4$ л    | $\alpha$ , $\gamma$                          | 5.15                                                      | 0.05, (0.3),<br>(0.2), (0.42)                     | U <sup>238</sup> - $\alpha$ -3 n; Np <sup>239</sup> (2.3 д) $\beta^-$                                                                                                                                                                                                                   |
|               | Pu <sup>240</sup>         | Pu <sup>241</sup>   |                         | $\approx 6000$ л<br>10 л | $\alpha$<br>$\beta^-$ , $\alpha$<br>(0.002%) | 5.1<br>5.0 ( $\alpha$ ),<br>0.01 ( $\beta^-$ )            |                                                   | U <sup>238</sup> - $\alpha$ -2 n<br>U <sup>238</sup> - $\alpha$ -n                                                                                                                                                                                                                      |

|    |                                                                   |                          |        |                                     |                       |       |                                                                                                                |
|----|-------------------------------------------------------------------|--------------------------|--------|-------------------------------------|-----------------------|-------|----------------------------------------------------------------------------------------------------------------|
| 95 | Am <sup>241</sup>                                                 | Am <sup>(238)</sup>      | 1.5 ч  | (K)                                 |                       |       | Pu <sup>239-d-(3)</sup> n                                                                                      |
|    |                                                                   | Am <sup>(239)</sup>      | 12 ч   | K (≈100%)<br>α (≈0.1%), γ           | 5.77                  | 0.285 | Pu <sup>239-d-(2)</sup> n; Pu <sup>239-p-(n)</sup> ;<br>Np <sup>237-α-(2)</sup> n                              |
|    |                                                                   | Am <sup>(240)</sup>      | 53 ч   | K, γ                                |                       | 1.3   | Pu <sup>239-d-(n)</sup> ; Np <sup>237-α-n</sup>                                                                |
|    |                                                                   | Am <sup>242</sup>        | 500 л  | α, γ                                | 5.48*                 | 0.062 | Pu <sup>241</sup> (≈10 л) β <sup>-</sup>                                                                       |
|    |                                                                   | °Am <sup>242</sup>       | 400 л  | β <sup>-</sup> (≈100%),<br>α (0.2%) | 0.5 (β <sup>-</sup> ) |       | Am <sup>241-n-γ</sup>                                                                                          |
|    |                                                                   |                          | 16 ч   | β <sup>-</sup>                      | 0.8                   |       | Am <sup>241-n-γ</sup>                                                                                          |
| 96 | Cm <sup>(238)</sup><br>Cm <sup>240</sup><br><br>Cm <sup>242</sup> | (Cm <sup>241</sup> )     | 2.5 ч  | α                                   | 6.50                  |       | Pu <sup>239-α-(5)</sup> n                                                                                      |
|    |                                                                   |                          | 26.8 д | α                                   | 6.26                  |       | Pu <sup>239-α-3</sup> n                                                                                        |
|    |                                                                   |                          | 55 д   | K                                   |                       |       | Pu <sup>239-α-(2)</sup> n                                                                                      |
|    |                                                                   |                          | 150 д  | α                                   | 6.08                  |       | Pu <sup>239-α-n</sup> ; Am <sup>242</sup> (400 л) β <sup>-</sup> ;<br>°Am <sup>242</sup> (16 ч) β <sup>-</sup> |
| 97 | Bk                                                                | Bk <sup>(243, 244)</sup> | 4.8 ч  | K (99,9%)<br>α (0,1%)               | 6.72                  |       | Am <sup>241-α-(1,2)</sup> n [T15]                                                                              |

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