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Figure 2: Fig. 2. Saturated vapor pressure of scandium: 1 –data of ([1]), 2 – experimental data

Abstract

Full Text

CHEMISTRY

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VAPOR PRESSURE OF METALLIC SCANDIUM

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Knowledge of the values of the saturated vapor pressure of scandium is of great practical interest, since sublimation in vacuum has hitherto remained the only method reported in the literature for obtaining high-purity metallic scandium. Until recently, however, there had been no work on measuring the vapor pressure of scandium. This is apparently connected with the fact that the problem of obtaining metallic scandium of high purity has begun to be solved successfully only in recent years. Thus, Spedding et al. ([1]) reported the preparation of metallic scandium of more than 99% purity and the measurement of the vapor pressure of this specimen by the Knudsen weight-loss method. But their paper does not describe the experimental procedure, and consequently it is difficult to judge the degree of reliability of the results obtained. There are no other data on the vapor pressure of scandium in the literature.

Fig. 1. Effect of the ratio S/K on the vapor pressure of scandium

Fig. 2. Saturated vapor pressure of scandium: **1** –data of ([1]), **2** –experimental data

We measured the vapor pressure of metallic scandium by the integral variant of the Knudsen effusion method on a continuously operating apparatus. The apparatus and the method for measuring vapor pressure have been described in detail previously ([2],[3]). To check the reliability of the results obtained, part of the investigations was carried out on the device described in ([4]). Evaporation was carried out from tantalum crucibles placed inside a detachable Knudsen chamber. The vapors condensed on a quartz receiver, and the amount of condensate was

determined radiometrically, using the isotope Sc^{46}. In some cases, when the experiments were performed with nonradioactive metal, the analysis was carried out by a photocolorimetric method with the aid of arsenazo ([5]). The scandium used for the investigation was obtained by us by sublimation in vacuum ([6]). According to hydrogen analysis data, its purity was 99.5%. Analysis showed the presence in the specimen of oxygen impurity, 0.1%, and tantalum, 0.01%.

The metal was irradiated in a nuclear reactor in a flux of thermal neutrons. After this, the radiochemical purity of the specimens was carefully checked. The check was carried out on a gamma spectrometer, as well as by the meth–

method of liquid chromatography on KU-2 resin with lactic acid as the eluent*.

First, a curve was obtained for the dependence of the evaporation rate at constant temperature (1430° K) on the size of the effusion orifice (see Fig. 1). It follows from this curve that, for an $S/K\sigma$ ratio ranging from 800 to 60,000, where S is the area of the evaporating surface, σ is the area of the effusion orifice, and K is the Clausing coefficient, saturation is attained in the effusion chamber.

The results of measuring the saturated vapor pressure of metallic scandium in the temperature interval 1301–1644° K are given in Table 1.

By the method of least squares, the following equation was calculated from these data:

$$\lg P(\text{mm Hg}) = 8.6553 - \frac{17576}{T}.$$

From this, for the heat of sublimation of scandium, the value $\Delta H_T = 80.42$ kcal/g-atom was found.

The heat of sublimation of scandium at 298° K was calculated by us with the aid of heat capacities taken from the handbook (7), and is equal to 82.28 kcal/g-atom.

The complete agreement of the data obtained by us on different apparatuses and with different samples of metallic scandium (both radioactive and nonradioactive) confirms the reliability of the results obtained. Our data lie somewhat above the data of the work (1) (see Fig. 2). We are inclined to think that a certain underestimation of Spedding' s results in comparison with ours may be the consequence of a small systematic error in the experiment.

The accuracy of the vapor-pressure measurements in our experiments was ±15% for radioactive samples and ±20% for nonradioactive ones.

* M. F. Tikhonov took part in the work on determining the radiochemical purity of Sc^{46}.

Table 1

Saturated vapor pressure of scandium*

τ, sec	$K\sigma$, cm^2	T, °K	$1/T$	$q \cdot 10^6$, g	G, g/cm^2 · sec	P, mm Hg	$-\lg P$	Note
10 800	$1,2184 \cdot 10^{-4}$	1323	7,561	0,33	$2,569 \cdot 10^{-7}$	$2,385 \cdot 10^{-5}$	4,62254	Radioactive sample
5400	$1,218 \cdot 10^{-4}$	1380	7,246	0,56	$8,900 \cdot 10^{-7}$	$8,536 \cdot 10^{-5}$	4,06874	Radioactive sample
3600	$1,218 \cdot 10^{-4}$	1412	7,082	0,81	$1,855 \cdot 10^{-6}$	$1,719 \cdot 10^{-4}$	3,76475	Radioactive sample
3300	$1,218 \cdot 10^{-4}$	1441	6,941	1,14	$2,835 \cdot 10^{-6}$	$2,743 \cdot 10^{-4}$	3,56120	Radioactive sample
3600	$1,218 \cdot 10^{-4}$	1501	6,661	3,43	$7,835 \cdot 10^{-6}$	$7,747 \cdot 10^{-4}$	3,11085	Radioactive sample
7200	$2,332 \cdot 10^{-4}$	1473	6,788	9	$5,006 \cdot 10^{-6}$	$5,493 \cdot 10^{-4}$	3,26017	Nonradioactive sample
3600	$2,332 \cdot 10^{-4}$	1531	6,531	27	$3,260 \cdot 10^{-5}$	$3,299 \cdot 10^{-3}$	2,48164	Nonradioactive sample
3600	$2,332 \cdot 10^{-4}$	1644	6,082	93	$1,210 \cdot 10^{-4}$	$1,042 \cdot 10^{-2}$	1,98238	Nonradioactive sample
1800	$3,572 \cdot 10^{-3}$	1608	6,218	340	$5,288 \cdot 10^{-5}$	$5,442 \cdot 10^{-3}$	2,26665	Nonradioactive sample
7200	$7,589 \cdot 10^{-3}$	1304	7,668	8,80	$1,610 \cdot 10^{-7}$	$1,483 \cdot 10^{-5}$	4,82905	Radioactive sample
3600	$7,589 \cdot 10^{-3}$	1355	7,380	13,30	$4,868 \cdot 10^{-7}$	$4,573 \cdot 10^{-5}$	4,33965	Radioactive sample
1800	$7,589 \cdot 10^{-3}$	1504	6,476	268,75	$4,973 \cdot 10^{-5}$	$4,907 \cdot 10^{-3}$	2,70747	Radioactive sample
2400	$1,098 \cdot 10^{-2}$	1517	6,591	320	$1,215 \cdot 10^{-5}$	$1,208 \cdot 10^{-3}$	2,91801	Nonradioactive sample

* The calculation was made under the assumption that scandium is monoatomic in the vapor.

The results obtained for the saturated vapor pressure of metallic scandium may be of considerable interest for the vacuum metallurgy of rare-earth elements.

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Note: Figure translations are in progress. See original paper for figures.