MEASURING THE MUTUAL GAS DIFFUSION COEFFICIENT AT LOW TEMPERATURES

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The two-volumes method was used for measuring the mutual diffusion coefficients for eight gas pairs, H_2-He, H_2-D_2, H_2-Ne, H_2-Ar, $He-Ne$, $He-Ar$, D_2-Ne, and $Ne-Ar$ within the 115-296°K temperature range. The experimental data agree closely with those obtained by other authors.

An experimental study of the dependence of the mutual gas diffusion coefficient on the temperature in the low-temperature range will make it possible to determine the far-field component of the interaction potential between different molecules. More realiable information about the far-field forces allows one to calculate all equilibrium and kinetic parameters of gas mixtures at low temperatures.

The validity of extrapolating data obtained at elevated temperatures into the low-temperature range is doubtful, because of the possibility of the formation of certain bonded states with not very well justified rules of combination.

TABLE 1. Experimental Values of Diffusion Coefficients at 760 mm Hg Pressure (T, °K; D, cm²/sec).

H_2-He		H_2-D_2		H_2-Ne		H_2-Ar	
T	D	T	D	T	D	T	D
118,0	0,318	115,0	0,253	115,0	0,225	118,0	0,151
143,0	0,443	155,0	0,418	155,0	0,392	154,0	0,247
177,0	0,657	197,0	0,649	197,0	0,588	197,0	0,391
225,0	0,985	232,0	0,857	232,0	0,778	231,0	0,510
296,0	1,550	295,0	1,280	295,0	1,170	296,0	0,821

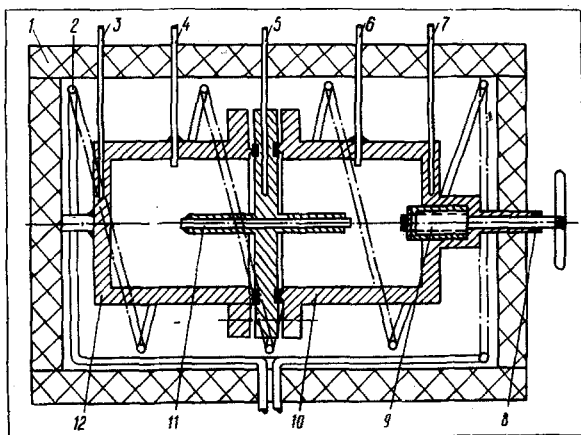| $He-Ne$		$He-Ar$		D_2-Ne		$Ne-Ar$	
T	D	T	D	T	D	T	D
118,0	0,232	118,0	0,153	115,0	0,163	118,0	0,0606
154,0	0,361	143,0	0,212	155,0	0,286	154,0	0,0984
197,0	0,557	177,0	0,304	197,0	0,434	197,0	0,155
231,0	0,716	225,0	0,463	232,0	0,569	231,0	0,207
296,0	1,080	296,0	0,735	295,0	0,875	296,0	0,317

Fig. 1. Schematic diagram of the laboratory apparatus.

A laboratory apparatus for determining the mutual gas diffusion coefficient as a function of temperature in the low-temperature range is shown schematically in Fig. 1. The diffusion chambers 10 and 12 with respective volumes $V_1 = 220.2 \pm 0.2$ cm^3 and $V_2 = 221.4 \pm 0.2$ cm^3 are coupled through a flange with a capillary tube 11. The length of this tube is $l = 7.948 \pm 0.005$ cm and its diameter is $d = 0.1983 \pm 0.0001$ cm. The chambers, the flange, and the capillary are made of Kh18N10T stainless steel. Hermetization is achieved by means of copper seals and a PSR-45 solder joint. The gasses are admitted and the gas mixture is sampled through the capillaries 4 and 6, each 15 cm long and 2 mm in diameter. By means of the stopper 9 it is possible, without changing the chamber volumes, to shut the diffusion capillary while gases are let in or a mixture is sampled. The plug 8 is packed with Teflon. A gas mixture is analyzed with an MI-1305 spectrometer by the relative method using standard mixtures. The diffusion chambers are cooled with vapors of liquid nitrogen flowing into the coiled cooler tube 2 from a Dewar tank.

Escaping through openings in the coiled tube, the nitrogen vapors wash the diffusion chambers and then enter the atmosphere through leaks in the thermal Penoplastic insulation 1. The nitrogen stream is produced in a Marsh generator with a regulating heater, both inside a Dewar tank. A signal from the thermocouple installed close to the cooler coil passes through a compensating circuit to an F-116/1 microvoltmeter for amplification. The amplified signal is fed to an EPV-2 potentiometer with a set of contractors for switching the regulating heater on or off through a thermal relay, thus causing the flow of nitrogen vapors through the cooler coil to be increased or decreased.

In the experiment the temperature was maintained precisely within $\pm 0.3°C$, the temperature drop across the length of the diffusion chamber not exceeding $0.3°C$. The temperature was checked by means of three calibrated copper–constantan thermocouples 3, 5, 7 with a P-307 potentiometer and an M-195/3 galvanometer.

A time of 3–4 h was necessary for the temperature to stabilize; during this time the diffusion chambers were filled with the test gases while the capillary was shut. The capillary was then opened for diffusion to take place. After some time, the capillary was shut again and the contents of the diffusion chambers were analyzed.

The mutual gas diffusion coefficient was calculated by the formula in [1] which describes the gas mixing process for the given apparatus geometry. The diffusion at the chambers was calculated taking into account the effective length of the capillary [2].

A correction was made in these calculations for the thermal expansion of the diffusion chambers and the capillary. The correction for thermal diffusion in the sampling capillaries did not exceed 0.1% and was disregarded. The accuracy of the measured mutual gas diffusion coefficient was within 1.5% and was basically determined by the accuracy of the concentration measurements. In this way, the diffusion coefficients for eight different gas pairs were measured within the temperature range from 115 to 296°K.

Table 1 lists values of the diffusion coefficients referred to a 760 mm Hg pressure by the standard procedure. Within several tenths of a degree the data were rounded off to the nearest degree, using the model of a scattered points center. A comparison of these experimental data with those of other authors shows a close agreement with the data in [3] pertaining the mutual gas diffusion coefficients for the following pairs: He–Ar, He–Ne, and Ne–Ar. The temperature characteristics of the mutual gas diffusion coefficients at low temperatures were obtained here for the first time.

NOTATION

V   is the volume of the diffusion chamber, cm^3;
l is the length of the capillary, cm;

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d   is the diameter of the capillary, cm;

T   is the temperature, °K;

D   is the diffusion coefficient, cm^2/sec.

LITERATURE CITED

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