The Coefficient of Thermal Diffusion of Neon and Its Variation with Temperature

If a mixture of two gases is contained in a vessel consisting of two bulbs fastened together by means of a connecting tube, then as a result of the existence of thermal diffusion the relative concentrations of the two constituents will be slightly different in the two bulbs if these are at different temperatures. This effect was predicted theoretically by Enskog[1] and Chapman[2] and has been amply verified experimentally.

In the case of isotopic molecules the difference in concentration ΔC can be expressed in a particularly simple form:

$$\Delta C = \alpha C_1 C_2 \log T_1/T_0. \quad (1)$$

C_1, C_2 are the relative concentrations of the two types of molecules, $C_1+C_2=1$; T_0, T_1, are the temperatures of the two bulbs, and α is known as the coefficient of thermal diffusion. The nature of the phenomenon is such that in general the relative concentration of the heavier molecule is greater in the cooler bulb.

An experimental determination of α for methane[3] was recently made. The study has now been extended to neon for several temperature ranges. In Table I are recorded the results found.

The relative abundances of the isotopes were measured with a mass spectrometer and the general method used in computing α was similar to that employed in reference 3. The bulb system used was essentially as before. In this case the time allowed for a run was at least five times the relaxation time of the system. In making the computations corrections were made for the volume of gas in the tube connecting the two bulbs. The consistency of the isotope abundance readings and considerations of other possible errors lead one to believe that the final computed α's are accurate within about five percent.

As a first approximation for elastic spheres Enskog's results give in this case

$$\alpha = (105/118)(M_2-M_1)(M_2+M_1), \quad (2)$$

where the M's are the relative masses of the two types of molecules. In the case of Ne^{20} and Ne^{22} this gives $\alpha=0.0424$. In the last column of Table I is recorded R_T (the ratio of the experimentally found α to that computed by (2)).

The increase of α with temperature is to be expected as the atoms at higher temperature behave more nearly like perfect elastic spheres. In the highest temperature range studied the R_T has a value 0.71 as compared with a value 0.3 found previously for methane for approximately the same temperature range. Neon atoms are thus considerably "harder" than methane molecules. As α for neon varies rapidly with temperature the values given in Table I can only be considered as "average" values for the temperature intervals.

TABLE I. *Values of the coefficient of thermal diffusion α of neon in three temperature ranges and the ratio R_T of these values to those computed for elastic spheres.*

T_0	T_1	$\Delta\frac{Ne^{22}}{Ne^{20}}$	"AVERAGE" α IN TEMPERATURE RANGE	R_T
10°C	344°C	(6.6±0.1)%[a]	0.0302	0.71
−183	21	(6.1±0.1)%[b]	0.0188	0.44
−183	−78	(3.9±0.3)%[c]	0.0165	0.39

[a] This represents the percentage decrease of Ne^{22}/Ne^{20} ratio in hot bulb after five repeated runs. The number given is the average of a total of seven different determinations on three different samples. The error is the mean deviation in the seven readings.
[b] Percentage decrease after four repeated runs. The number given is the average of a total of four determinations on two different samples.
[c] Percentage decrease after five repeated runs. The number given is the average of a total of six determinations on two different samples.

Atkins, Bastick and Ibbs[4] recently measured the coefficients of thermal separation for all of the binary mixtures of helium, neon, argon, krypton and xenon in the temperature range 15°C to 100°C. The value of R_T calculated here for neon fits in well with the R_T's computed for the binary mixtures. This would seem to indicate that there is no great difference in the nature of collision processes between two isotopic gases or a mixture of two nonisotopic gases.

As neon has a relatively high α the thermal diffusion column method should be very effective in separating the isotopes.

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[1] D. Enskog, Physik. Zeits. **12**, 56, 533 (1911).
[2] S. Chapman, Phil. Trans. **A217**, 115 (1917).
[3] A. O. Nier, Phys. Rev. **56**, 1009 (1939).
[4] B. E. Atkins, R. E. Bastick and T. L. Ibbs, Proc. Roy. Soc. **A172**, 142 (1939).

Nuclear Excitation of Lead by X-Rays

The only case of nuclear excitation by x-rays[1,2] which has been reported is In^{115}, in spite of the fact that the authors, and probably others, have made attempts to find other examples of this process. The theory of metastable states,[3-5] however, predicts that, for a given spin change, the lower the excitation energy of the metastable state the longer will be its half-life. Thus states with periods long enough to be observable are more likely to come from low lying levels. This suggests the possibility that metastable states may have been excited but not observed due to the absorption of the low energy internally converted electrons by the counter walls. Accordingly, counters were constructed with the metal under investigation forming the cylindrical cathode.

The counters were irradiated by placing them directly behind a lead target which was bombarded with electrons from the electrostatic generator. After four minutes irradiation with 35 μa of 1.5-Mev electrons, a lead counter showed an activity of 40 counts per minute above background with a 1.6±0.2-minute period. Three different lead counters were used, one of which had a C.P. lead cylinder. All gave consistent results. An excitation curve for this activity was obtained and gave a threshold of 0.65±0.02 Mev corresponding to the lowest activation level.

No activity was observed when a lead foil was irradiated as above and wrapped around a thin wall counter. If the radiation emitted is mainly internally converted electrons, the upper limit of the energy can be placed at 250 kv.