COEFFICIENTS OF ENRICHMENT FOR CHLORINE AND SULFUR ISOTOPES
IN LIQUID-VAPOR EQUILIBRIUM FOR Cl₂, HCl, CH₃Cl, H₂S, AND SO₂

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In a large number of works on isotope thermodynamics it proves necessary to measure the relative difference in vapor pressure of the various isotopic species present in the various compounds. The results obtained are also of considerable practical importance in connection with the fact that the relative difference in vapor pressure determines the maximum value of the enrichment coefficient obtainable in liquid-vapor equilibrium on a length of column equivalent to one theoretical plate.

In the absence of enriched isotopic compounds, the process of exhaustive distillation, with accumulation of the less volatile component, may be used to measure the relative pressure difference for isotopes. It is, however, a difficult task to set up such a process, particularly for isotopic compounds with a small difference in saturated vapor pressure. It is essentially simpler, and apparently more reliable, to determine the relative difference in the saturated vapor pressures of isotopes by splitting up the original isotopic mixture on a column with a known number of theoretical plates.

Having determined the total enrichment coefficient for the column $\phi$, and knowing the number of theoretical plates $n$, we may calculate the relative difference in the saturated vapor pressures for the isotopes $\frac{\Delta P}{P}$ from the relationship

$$\Delta P = \phi^{1/n} - 1.$$

A diagram of the column used in our work is given in Fig. 1. The rectifying part of the column consists of a fine porous tube of external diameter 8 mm and internal diameter 7.6 mm. The packing consists of rings of internal diameter 1.2 mm made from 0.25 millimeter constantan wire. The packing was given a preliminary careful washing and etching with aqua regia. In order to achieve adiabatic conditions for the process, the rectifying tube is surrounded by a vacuum jacket in which a pressure of approximately $10^{-4}$ mm mercury is maintained. Compensation for the heat losses through the vacuum jacket is achieved by cooling the outer wall of the vacuum jacket using specially chosen coolants with boiling points approximately equal to the working temperature of the process. The column condenser is cooled using the same coolant as is used for the jacket walls. The column is thermally insulated with cotton wool. Condensation of the coolant vapor is achieved in a special heat exchanger connected to a vessel filled with liquid oxygen.

The experiments on the separation of chlorine isotopes were carried out on a column of length 1.5 m. HCl was rectified at $-88^\circ$ C. The coolant used was ethane, whose vapor pressure was maintained at 760 mm mercury. The curve was recorded showing the relationship between the coefficient of separation for the column and the specific vapor flow (Fig. 2). The maximum attainable value for the separation coefficient $\phi$, equal to $1.08 \pm 0.01$, was determined from the relationship

$$\phi = \frac{N}{1 - N} : \frac{N_0}{1 - N_0},$$

where $N$ and $N_0$ are the mole fractions of the light isotope at the top of the column and in the original mixture, respectively.

Cl₂ was rectified at $-36^\circ$ C. Freon-11 vapor, at a pressure of 450 mm mercury, was used as coolant for the condenser and the vacuum jacket. In the calculation of the elementary separation factor it was assumed that the enrichment effect is determined for the most part by the separation of a mixture of Cl$^{35}$Cl$^{35}$ and Cl$^{37}$Cl$^{37}$. This assumption is admissible at low enrichments, since the concentration of Cl$^{37}$Cl$^{37}$ molecules
In the original mixture amounts to only 6%. The maximum value of $\Phi = 1.05 \pm 0.01$ (Fig. 2).

The experiments on the separation of sulfur isotopes in the compounds $\text{H}_2\text{S}$ and $\text{SO}_2$ were carried out on a rectifying column of length $1\text{ m}$.

![Diagram of rectifying column.](image)

**Fig. 1.** Diagram of rectifying column. 1) Liquid oxygen container; 2) coolant condenser; 3) purifying column for coolant; 4) distributor; 5) column condenser; 6) rectifying tube; 7) vacuum jacket; 8) cooling system; 9) sylphon; 10) still jacket; 11) still; 12) heater.

determined by direct measurements. At a temperature

$$a = \frac{P_{\text{H}_2\text{S}} - P_{\text{H}_2\text{O}}}{P_{\text{BF}_3}} = 1.1082.$$