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THERMOTRANSPORT OF BERYLLIUM AND MERCURY IN LIQUID SODIUM ‡

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In a thermotransport experiment where a column of liquid binary alloy is held in a temperature gradient until the stationary state is reached, the resulting segregation is related to the temperature gradient through a quantity called the heat of transport, denoted by Q*. Q* has been determined for several liquid silver base alloys in our laboratory(1)(2)(3). Attention is now being devoted to alkali metal alloy systems. In this paper the thermotransport of trace amounts of beryllium and mercury in liquid sodium are presented. These elements were chosen so as to compare the behavior of a light solute (Be) with a heavy solute (Hg).

Appropriate alloys were prepared by mixing pure liquid sodium metal with appropriate amounts of radioisotopes of beryllium (Be^{-7}) and mercury (Hg-203) respectively. Both isotopes are gamma emitters. The alloys were encapsulated in precision bore quartz capillaries with 0.5 mm i.d. These samples were held in a known temperature gradient for a sufficiently long time for the stationary state to be attained. The samples were then taken out of the furnace and cut into several pieces of approximately equal length by means of a diamond cut-off device. The sodium metal in each piece was dissolved in 2 ml of demineralized water in a glass vial. The radioactivity in each vial was counted by means of Packard automatic gamma spectrometer.

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The amount of sodium in each vial was determined by titrating against hydrochloric acid solution of known strength. The titration reaction was

$$NaOH + HCl \rightarrow NaCl + H_2O \qquad (1)$$

The specific activity was then determined for each vial and the relative concentration of solute (C/C_o) was determined. Figures (1) and (2) are the typical plots of logarithm of C/C_o vs reciprocal absolute temperature for beryllium and mercury respectively. The heats of transport were obtained from the slopes of these plots, by use of the following expression

$$\text{grad}\,(\ln C/C_o) = \frac{Q^*}{R}\,\text{grad}\,(1/T) \qquad (2)$$

The average values of the heat of transport so obtained are

$$(Q^*)\,Be = -\,6400 \pm 2100 \text{ cal/gm-atom} \qquad (3)$$

$$(Q^*)\,Hg = 1700 \pm 600 \text{ cal/gm-atom} \qquad (4)$$

As previously discussed in earlier papers(1,3) the heat of transport may be considered to consist of two different contributions

$$Q^* = Q^*_e + Q^*_i \qquad (5)$$

where Q^*_i is the intrinsic contribution and Q^*_e is the extrinsic contribution. Q^*_i has been estimated by use of Chapman's expression.(1)(4)

$$\frac{Q^*_i}{RT} = K\left\{\frac{m_2 - m_1}{m_2 + m_1} - 0.2\left(\frac{\sigma_1^2}{\sigma_{12}^2} - 1\right)\right\} \qquad (6)$$

where m_1, m_2 = atomic masses of solvent and solute respectively

δ_1, δ_2 = ionic radii of solvent and solute ions respectively

and $\delta_{12} = \frac{1}{2} (\delta_1 + \delta_2)$

K = a constant = 2.2

The values of Q_i^* calculated are

$$(Q_i^*)_{Be} = -1400 \text{ cal/gm-atom} \quad (7)$$

$$(Q_i^*)_{Hg} = 1500 \text{ cal/gm-atom} \quad (8)$$

One observes that the mass effect of a light solute such as Be is calculated to yield a negative value for Q_i^* whereas for a binary solute such as Hg Q_i^* is calculated to be positive in sign. According to equation 5, values of Q_e^* need to be calculated in order to make accurate comparisons. Q_e^* can, in principle, be calculated by a method due to Gerl[5] which employs the values of resistivity (ρ) and thermoelectric power (S) as a function of solute concentration. These values, however, are not known for beryllium and mercury in sodium. Moreover, it appears that both beryllium and mercury are only sparingly soluble in liquid sodium and hence it seems unlikely that reliable values of resistivity and thermoelectric power can be obtained as a function of composition.

If the application of the Chapman expression has approximate validity as it appears from earlier work in our laboratory[1], the observed positive value of heat of transport for Hg is accounted for mainly in terms of the mass effect. For Be on the other hand observed negative value of the heat of transport is only partially accounted for by the mass effect.

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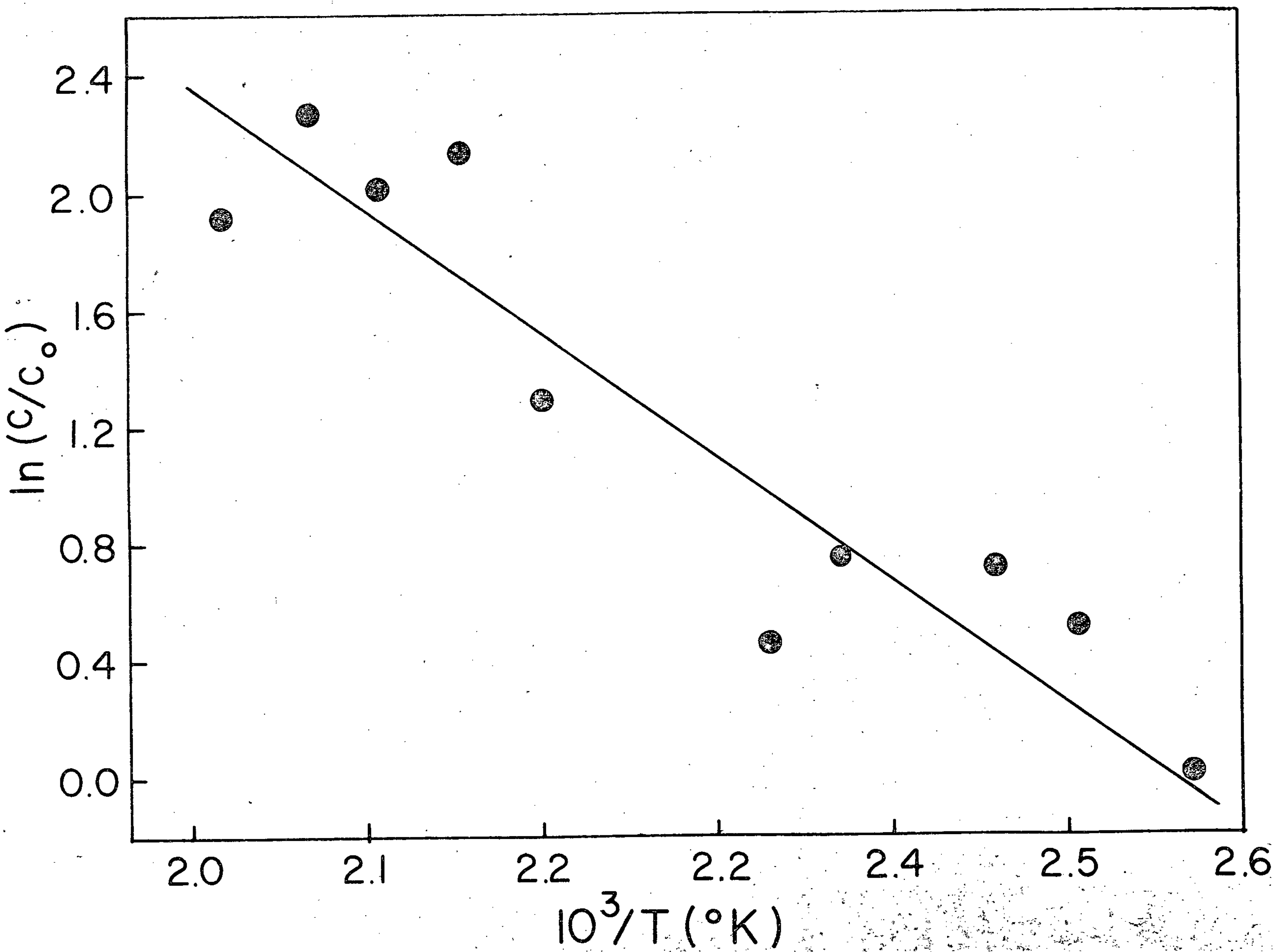
LIST OF FIGURES



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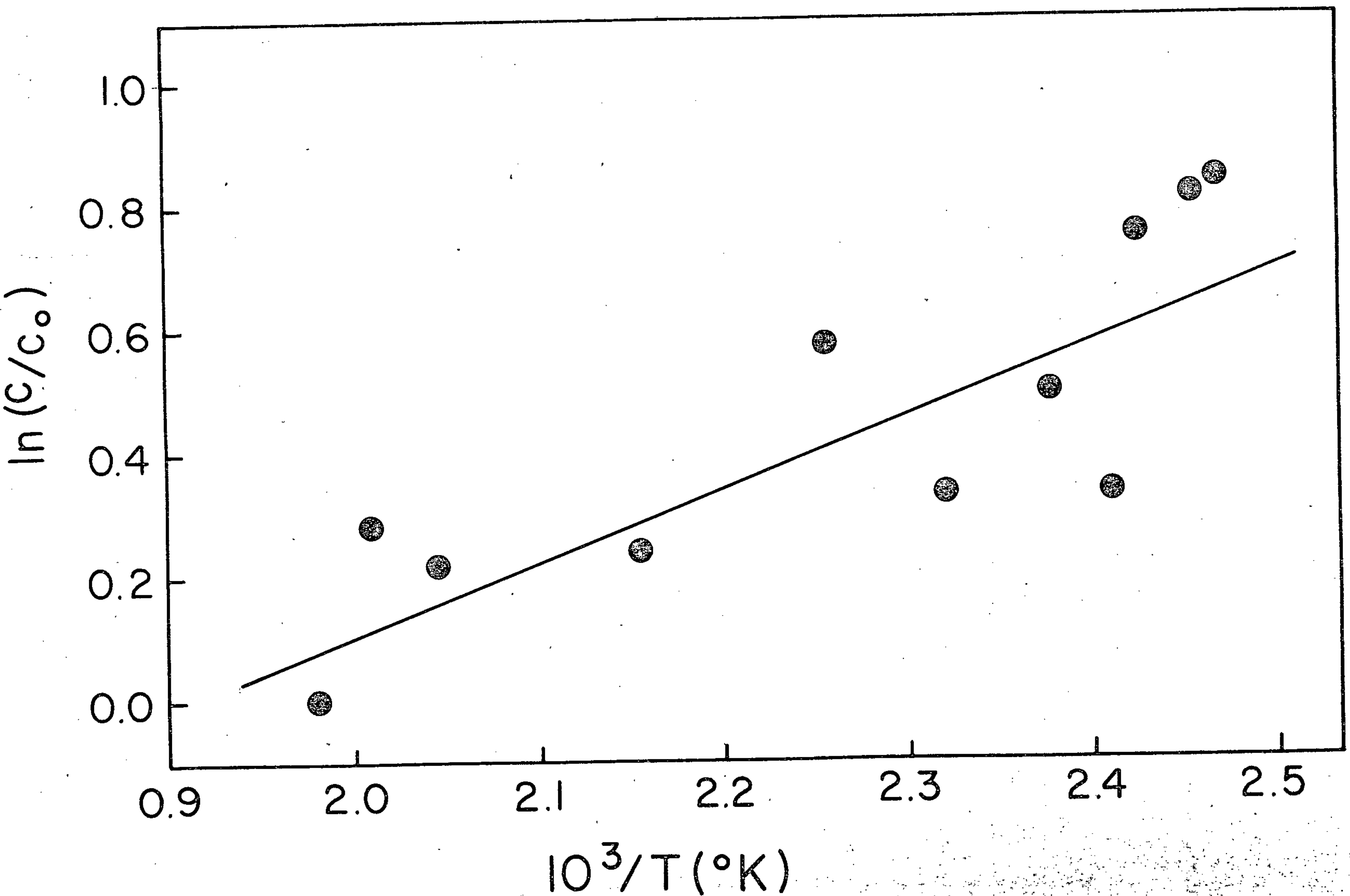

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