emission is due to recombination of electrons and self-trapped holes.[6] An I_2^{--} molecule in excited state, i.e., a self-trapped exciton, is formed from which emission occurs. In KI and RbI, the photoconductive thresholds lie at higher energies than those of emission. In particular, in the case of 3.32-eV emission of KI, the difference in the threshold energies is 0.5 eV. Thus for the low-energy emission band of KI, the formation of free electrons and holes is not necessary, for efficient emission and efficient trapping of excitons must take place. The peak positions of photoconductivity current occur 0.3 and 0.7 eV above the peak positions of 4.15-eV emission of KI and 3.88-eV emission of RbI in the excitation spectra. But the threshold values for the 4.15-eV emission of KI and 3.88-eV emission of RbI are close to the interband transition energies in these materials. For this reason, it cannot be stated definitely that the formation of free electrons and holes is not necessary for efficient stimulation of high-energy bands in KI and RbI. At 10°K both RbI [7] and KBr [8] show similar effects.

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[6] For a detailed discussion, see R. S. Knox and K. J. Teegarden, in *Physics of Color Centers*, edited by W. B. Fowler (Academic Press Inc., New York, 1968).

[7] J. Ramamurti, Ph.D. thesis, University of Rochester, 1966 (unpublished).

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Diffusion of Tin into Zinc†

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The diffusivity of tin in zinc has been measured from 298 to 400°C. The data are well represented by $D_{0\perp}=0.13\pm0.03$ cm^2/sec and $Q_\perp=18.4\pm0.2$ kcal/mole; $D_{0\parallel}=0.15\pm0.07$ cm^2/sec and $Q_\parallel=19.4\pm0.5$ kcal/mole. The general picture for the diffusion of impurities in zinc is briefly reviewed.

THE anisotropic diffusivities of several monovalent, divalent, and trivalent impurities in single-crystal zinc have been measured in this laboratory.[1–4] Recently, a quadrivalent solute, Sn^{113}, has been investigated with the following results: $D_{0\perp}=0.13\pm0.03$ cm^2/sec and $Q_\perp=18.4\pm0.2$ kcal/mole; $D_{0\parallel}=0.15\pm0.07$ cm^2/sec and $Q_\parallel=19.4\pm0.5$ kcal/mole. A brief report on this investigation follows.

As in the earlier work the method used was the standard sectioning technique. Runs were made at four different temperatures: 400, 358, 328, and 298°C, each with two specimens of different orientation.

The penetration profiles for the higher-temperature runs accurately checked with the Gaussian solution for the thin-film condition, but there was some deviation for the runs at lower temperature for which there appeared to be some upward curvature near the surface. We believe that the origin of this difficulty lies in the limited solubility of the zinc for the tin which would be more marked at the lower temperatures. Accordingly, the slopes of the deep penetration parts of the profiles were taken to determine the diffusivities. The validity of this approximation was later improved by a more refined procedure. It was found that the associated correction was of the order of 6%.

The results for $D_\parallel$ and $D_\perp$ for the four temperatures are shown in Fig. 1. The Arrhenius line, fitted by least squares to the data, corresponds to the parameters given in the first paragraph. Also shown in the same figure are similar lines obtained in earlier investigations for trivalent impurities in zinc and for the self-diffusion of zinc itself, presented for comparison. In Fig. 2(a), the changes in activation energy for all solutes in zinc studied so far are shown as a function of valence difference. While the general correlation is quite evident, there are some notable deviations. In particular, the activation energies for gallium fall about 1.5 kcal/mole below where they might be expected. The same can also be seen from a careful inspection of Fig. 1. The values for the gallium D_0's as well are small by a factor of 5. Interestingly enough the correlation of the values of the diffusivities themselves with valence is more

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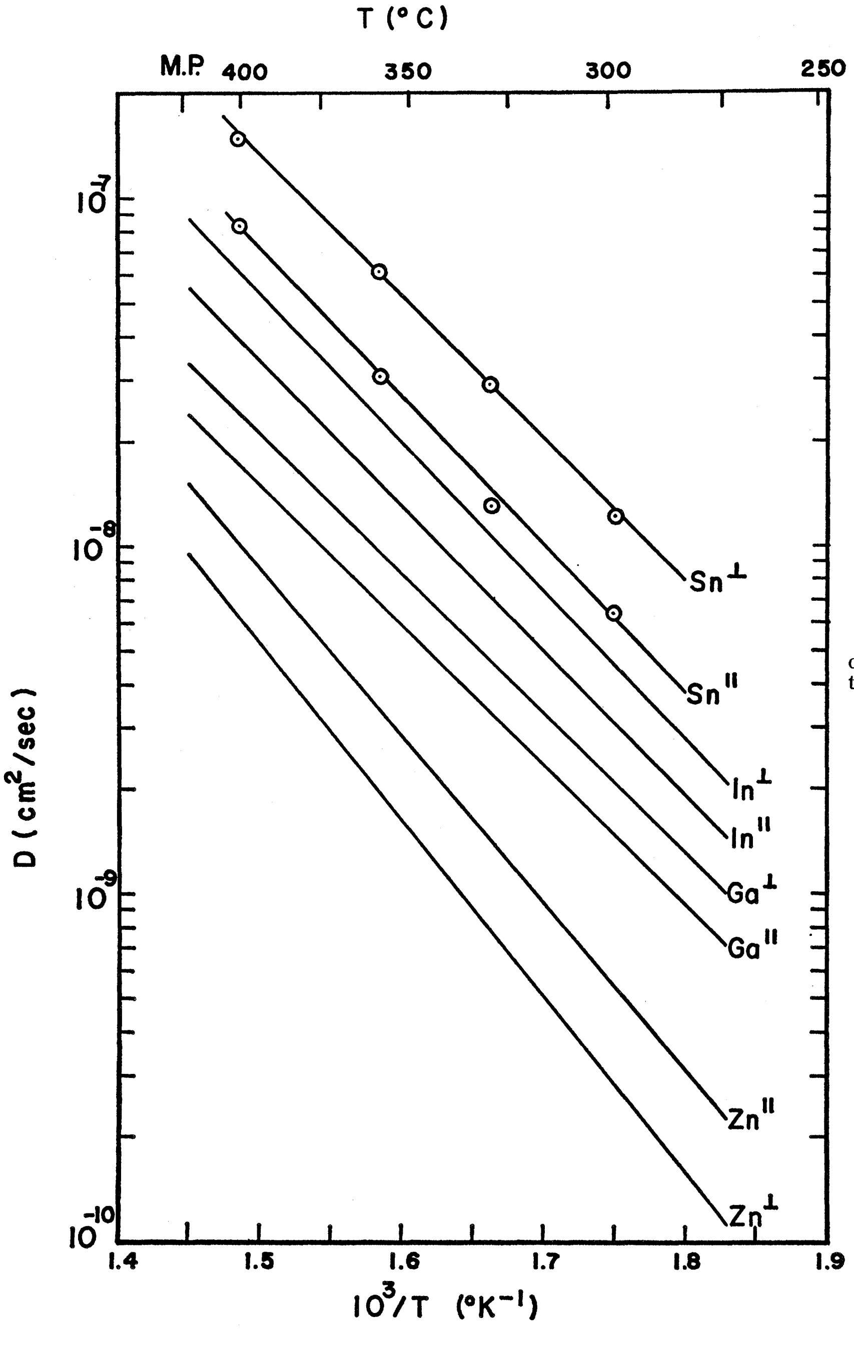

FIG. 1. Arrhenius plots for the diffusion of tin, indium, and gallium in zinc and for the self-diffusion of zinc.

regular than that of the Q's as shown in Fig. 2(b) where the values of D at 400°C are plotted versus ΔZ. In part this may be due to the correlation ceofficient whose temperature variation enters into the determination of Q. Because the influence of this factor is to reduce the effect of the more favored jump motions relative to the

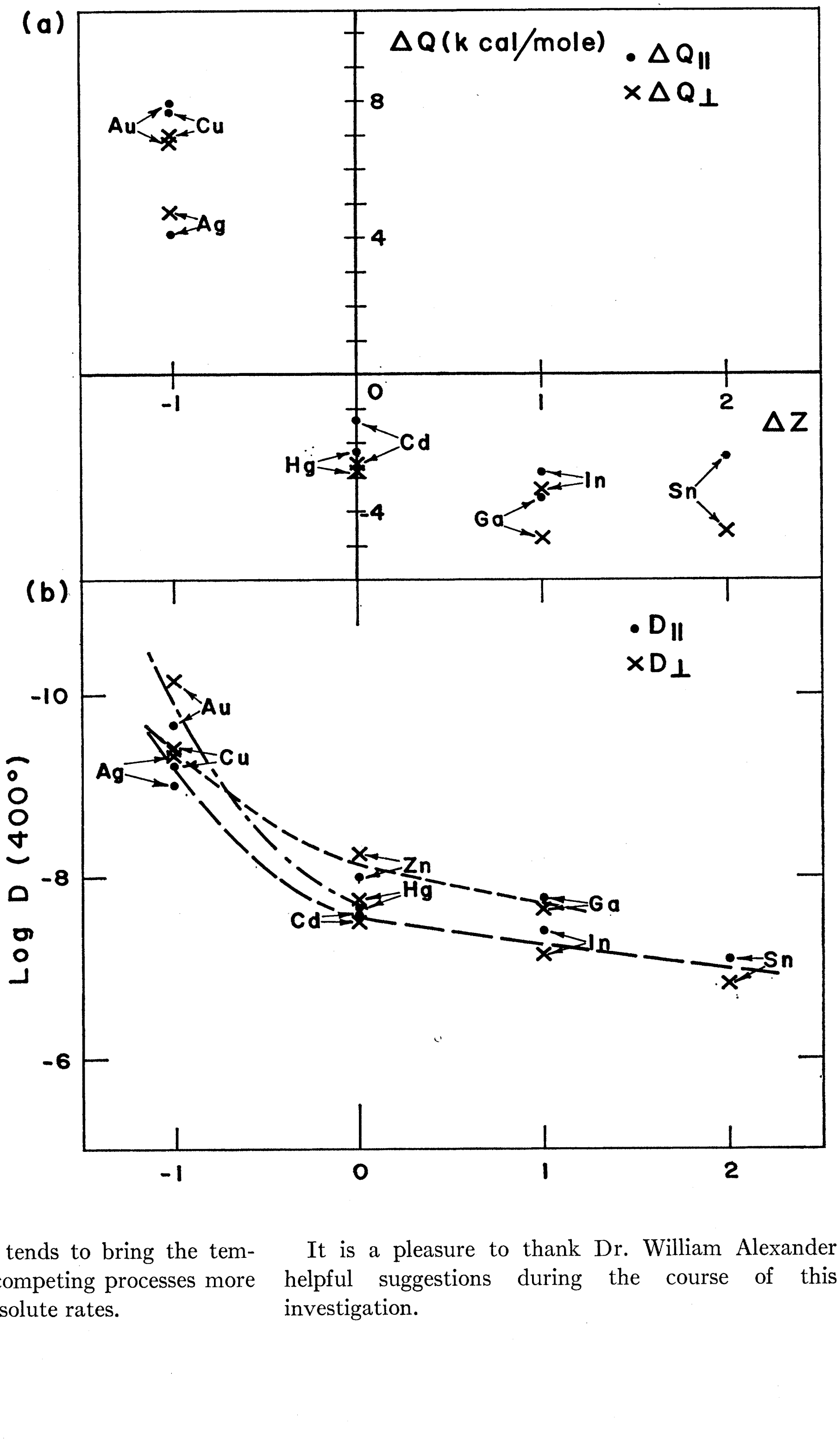

FIG. 2. Correlations with valence difference ΔZ. (a) Changes in activation energies for various impurties from that for the self-diffusion of zinc, and (b) diffusivities at 400°C, plotted as the logarithm to the base 10 of the value in cm^2/sec.

others in a nonlinear way, it tends to bring the temperature dependence of the competing processes more closely together than their absolute rates.

It is a pleasure to thank Dr. William Alexander helpful suggestions during the course of this investigation.