if one uses for V_{at} (in Eqs. 4 and 5) the liquid atomic volume at the melting point and not more.

The viscosity at the melting point, η_{mp}, can be estimated for any metal from Andrade's well known expression:

$$\eta_{mp} = 5.7\,([\text{at.wt.}] \times T_{mp})^{1/2}/(10^4 \times V_{at}^{2/3}) \tag{8}$$

More data supporting the above relationship, as well as a detailed discussion of the theory, will be presented elsewhere. Suffice it to show here two typical examples, namely, Na and Zn. The diffusion measurements are due to Nachtrieb and his associates (*4*) while those on viscosity are taken from the *Liquid Metals Handbook* (*5*).

Figure 1 shows four series of experimental results—that is, the viscosity and diffusion of Na and Zn, respectively, are compared with two sets of straight lines of the same numerical slope, but of opposite sign, for viscosity and diffusion. The four specific equations of these straight lines, in the form of the general equations 2 and 3, are as follows [η in poises, D in cm^2/sec, T in deg K, $R = 1.9865$ cal(deg K)$^{-1}$ (g-atom)$^{-1}$].

For Na

$$\eta = 0.84 \times 10^{-6} T\, e^{-0.28} e^{+2500/RT}$$
$$D = 7.95 \times 10^{-4} T\, e^{+0.44} e^{-2500/RT}$$

and for Zn

$$\eta = 2.00 \times 10^{-6} T\, e^{-0.20} e^{+4800/RT}$$
$$D = 4.64 \times 10^{-4}\, e^{+0.42} e^{-4800/RT}$$

The constants B and D_0 of Eqs. 2 and 4 and Eqs. 3 and 5 were calculated by using Debye temperatures, θ_D, of 192°K and 213°K and liquid atomic volumes at the melting point, V_{at}, of 24.76 and 9.45 cm^3/g-atom for Na and Zn, respectively.

Figure 1 shows that the experimental points fit the theoretical lines very well and that the same E_{VD}, that is, 2500 cal/g-atom for Na and 4800 cal/g-atom for Zn, describes both viscosity (η/T) and self-diffusion equally well, within the accuracy of the measurements.

The adjustment of experimental points to the theoretical lines involving B, D_0, θ_D, and E_{VD}, is possible essentially only by adjustment of Frenkel's e^{γ} or $e^{-\gamma}$ factor; it is close to unity and for a perfect agreement γ should be identical in Eqs. 2 and 3.

Finally, from the general equation for E_{VD} (that is, Eq. 6) we obtain for Zn and Na, with their T_{mp} = 693°K and 371°K, respectively, heats of activation of 4700 and 2400 cal/g-atom.

In summary, one can estimate from the above relationships the viscosity or self-diffusion of any liquid metal, over a substantial temperature range, from its known melting point.

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References and Notes

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24 February 1964