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The effect of pressure on the electrical resistance of lithium, sodium and potassium at low temperatures

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Measurements have been made of the electrical resistivity of lithium, sodium and potassium at temperatures between 2 and 300 °K and at pressures up to 3000 atm. From our results we have calculated the ideal electrical resistivity, ρ_i, and its volume derivative as functions of temperature for conditions of constant density. It is shown that, as predicted by simple theory, there is a linear relation between the temperature and volume coefficients of ρ_i for each metal. We conclude that the magnitude of the volume coefficient of ρ_i does not, at high temperatures at least, agree with present theoretical predictions and that this coefficient is closely connected with the high-temperature value of the thermoelectric power.

1. Introduction

In order to obtain a general understanding of how the effect of pressure on the electrical resistivity of a pure metal changes with temperature it is convenient to make use of the following simple expression for the ideal electrical resistivity of a metal:

$$\rho_i = \frac{KT}{M\theta_R^2} f(T/\theta_R). \tag{1}$$

θ_R is here a constant, having the dimensions of temperature, which characterizes the resistive properties of the metal, M is the mass of the metallic ions, and K is a parameter which measures the interaction between the conduction electrons and the lattice vibrations. f is a function which becomes constant at high temperatures and which at very low temperatures is expected to vary as $(T/\theta_R)^4$. One example of such a function occurs in the Bloch–Grüneisen expression for the temperature dependence of the ideal resistivity of a metal, but for our present purposes we do not need to make any assumption about the form of f except that it is independent of volume. We emphasize, however, that K and θ_R are assumed to be independent of temperature and to depend only on the volume.

Under these conditions, the *volume* coefficient of the ideal resistivity is related to the temperature coefficient of the ideal resistivity in the following way:

$$\left(\frac{\partial \ln \rho_i}{\partial \ln V}\right)_T = \frac{\mathrm{d}\ln K}{\mathrm{d}\ln V} - \frac{\mathrm{d}\ln \theta_R}{\mathrm{d}\ln V}\left\{1 + \left(\frac{\partial \ln \rho_i}{\partial \ln T}\right)_V\right\}. \tag{2}$$

At high temperatures ($T \gtrsim \theta$) $\partial \ln \rho_i/\partial \ln T$ tends to unity for most metals (at least at constant density) so that in this region we may write:

$$\partial \ln \rho_i/\partial \ln V = (\mathrm{d}\ln K/\mathrm{d}\ln V) + 2\gamma_R, \tag{3}$$