The Effect of Hydrostatic Pressure on the Susceptibility of Rochelle Salt

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The electric susceptibility of Rochelle salt has been studied as a function of both temperature and hydrostatic pressure. Both the upper and lower critical temperatures are altered by the pressure, but the pressure coefficients for the alterations are different in the two cases. An attempt is made to correlate the experiment with statistical mechanical theory, but it is found that the theory is not sufficiently explicit to provide a quantitative explanation of the results.

THE anomalous variation of the electric susceptibility of Rochelle salt in the temperature range from $-40°C$ to $+40°C$ is so well known as to require little comment. Suffice it to say that as the temperature is increased from $-40°$, the dielectric constant rises to an effectively infinite value at $-18°$, remains infinite to $+24°$, then falls rapidly to normal values. This phenomenon has been exhaustively investigated by Mueller[1] and others. The behavior is thus characterized by two critical temperatures, $-18°$ and $+23.7°$, the explanation of which has been semi-quantitatively discussed by Fowler.[2] According to his theory, the effects are due to polar molecules within the crystal lattice: the lower critical temperature marks the onset of free dipole rotation, while the upper marks the point at which thermal agitation prevents universal alignment of the dipoles.

In the present paper, we measure the susceptibility as a function of temperature and hydrostatic pressure to 10,000 atmospheres over the temperature range $-20°$ to $+60°$. The pressure is found to produce a marked alteration of the critical temperatures; this effect is studied to an accuracy of $\pm 0.1°C$ and ± 10 kg/cm^2. The apparatus is simple and conventional. Pressure is developed within a steel cylinder whose inside dimensions are roughly $\frac{5}{8}'' \times 8''$. The equipment for producing the pressure has been exhaustively described by Bridgman.[3] The steel cylinder containing the specimen was surrounded by an oil bath whose temperature could be varied at will. The liquid used for developing the pressure was petroleum ether.

Tinfoil electrodes were cemented to the proper faces of the Rochelle salt crystals, and one lead was brought out of the pressure chamber through an insulated plug; the other lead was grounded. The crystal was freely suspended by its leads, which were as tenuous as possible, in order to eliminate mechanical constraints. The capacity from the insulated lead to ground was measured by means of a General Radio Company type 216 capacity bridge, used in a substitution method. The voltage on the crystal was controlled at 2.0 r.m.s. volts, 1000 cycles. No bias potential was used. Stray capacity effects were eliminated by a blank run made on a piece of glass similar in size and shape to the crystals used. No change in capacity with pressure was detected in this case; accordingly the correction amounted to a constant capacity to ground, which was subtracted from the capacity as measured in order to compute the true capacity of the crystal.

The crystals were furnished through the kindness of the Brush Development Company. Three crystals were used, whose dimensions were:

I. $0.424 \times 0.970 \times 3.65$ centimeters,
II. $0.356 \times 0.869 \times 2.27$ centimeters,
III. $0.313 \times 0.904 \times 2.54$ centimeters.

In all cases the shortest dimension lay along the "a" axis, and the electrodes were, of course, attached to the large faces. No attempt was made to study the effect of pressure on the normal values of the susceptibility which one obtains at right angles to this axis. The crystals are extremely fragile, and unfortunately the data from all three specimens had to be combined in order to get a complete picture of the behavior. It was

[1] Hans Mueller, Phys. Rev. **47**, 175 (1935).
[2] R. H. Fowler, *Statistical Mechanics*, second edition (Cambridge University Press, 1936) p. 816 *et seq.*
[3] P. W. Bridgman, *The Physics of High Pressure* (Bell and Sons, 1931).