Ice as an Electrolyte. - Second Communication

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XX. *Ice as an Electrolyte.—Second Communication.* By W. E. AYRTON and JOHN PERRY, *Professors in the Imperial College of Engineering, Tokio, Japan.*

[Plate V.]

IN our former paper on Ice as an Electrolyte, read before the Physical Society on May 26th of this year, we described experiments which proved, among other things, that as the temperature of ice is allowed to gradually rise the conductivity increases regularly, and that there is no sudden change in passing from the solid to the liquid state. We also determined roughly the specific inductive capacity of $\left\{ \begin{smallmatrix} \text{ice} \\ \text{water} \end{smallmatrix} \right\}$ at $-13^{\circ}5$ C. and at $+8^{\circ}7$ C., and found that at the latter temperature it was about 2240 times as great as in the former. Preliminary experiments also showed us that there was very little change in the specific inductive capacity up to 0° C.; and it was anticipated that there would not be a very great change after 0° ; we therefore concluded that a very great change must occur at the melting-point. A series of further experiments made with the same apparatus, since the writing of the previous paper, have enabled us to draw approximate curves (Pl. V.), A B C, D E for the specific capacity of $\left\{ \begin{smallmatrix} \text{ice} \\ \text{water} \end{smallmatrix} \right\}$ from $-12^{\circ}2$ C. to $+5^{\circ}$ C., all tests of capacity being made by charging for ten seconds and then short-circuiting the $\left\{ \begin{smallmatrix} \text{ice} \\ \text{water} \end{smallmatrix} \right\}$ condenser for fifteen seconds. From these it will be seen that, although the change at the melting-point is not quite as sudden as we expected, our anticipations are on the whole realized. It must be remembered too (see the description of the apparatus in our former paper) that, as the present experiments were made with a gradually rising temperature, the thermometer will always indicate a temperature a little higher than that of the ice; the curve B C ought probably, therefore, to be even more vertical than it is.

Distances measured perpendicularly to Y O Y represent temperature—positive temperature if measured to the right, and negative if measured to the left. Distances measured perpendicularly to X O X represent specific capacity per cubic centi-

metre for points on the dotted lines, and conductivity for points on the continuous lines. The scale for temperature is the same for all the curves. The scale for vertical distances for the capacity-curve D E is one eighth of that for the capacity-curve A B C; and the scale for vertical distances for the conductivity-curve J K is three thousandths of that for the curve F G H.

The point A corresponds with a capacity per cubic centimetre of about 0·002 microfarad, at -12°C ; E corresponds with a capacity per cubic centimetre of about 0·1185 microfarad, at $+5^{\circ}\text{C}$.; at this apparent temperature the capacity was increasing so rapidly as to make exact measurements very difficult, although the temperature was increasing but slowly. The point F corresponds with a specific resistance per cubic centimetre of about 2240 megohms, at $-12^{\circ}\cdot 4\text{C}$.; and K with a resistance per cubic centimetre of about 0·34 megohm, at $+11^{\circ}\cdot 02\text{C}$. As in our previous experiments, the water employed in the water-condenser was distilled, and the ice was formed by freezing it with an external freezing-mixture no particle of which was allowed to fall into the distilled water.

The important theory which Prof. Clerk Maxwell has developed, by comparing the propagation of electro-magnetic disturbances through the ether with the propagation of light-vibrations, has been illustrated only by paraffin (a non-conductor); and he has not considered the propagation of electro-magnetic disturbances in a conducting medium. But according to a former paper of ours, on the "Viscosity of Dielectrics," no dielectric can be assumed to be non-conducting, and the charging of any condenser whatever is always accompanied with absorption phenomena; also absorption certainly increases with conductivity.

Hence although, if a method of experimenting were employed in which a water-condenser of great internal resistance were discharged through wires of less and less resistance for shorter and shorter periods of time, the measured specific inductive capacity might get less and less, and gradually approach a value equal to the square of the index of refraction of water for infinitely long luminous waves (the index of refraction for air being called unity), still practically the measured specific

inductive capacity can never be even approximately equal to the refractive index of water, since the absorbed charge is immeasurably greater than the surface-charge. We therefore need not expect to find the specific inductive capacity of water in its variations with temperature consistent with Dr. Gladstone's results for index of refraction. When Prof. Clerk Maxwell takes into account conductivity, his equations are not generally integrable; but even if they were they could not deal with the real case, because he leaves absorption quite out of account.

July 30, 1877.

XXI. *On a Method of measuring the Absolute Thermal Conductivity of Crystals and other rare Substances.*—Part I. By OLIVER J. LODGE, D.Sc.*

1. WHEN only a small portion of a substance is obtainable on which to experiment, the measure of conductivity by any dia-calorimetric method becomes difficult; and accordingly observers have contented themselves, in the case of the rarer crystalline bodies, with comparing their conductivities in different directions by Sénarmont's or some similar method. If the substance is sufficiently plentiful to be obtained in slabs (like rocks), then some modification of Fourier's "thermomètre de contact" will give its conductivity, though there are many objections to the use of this instrument.

But there is another method of Fourier's, applicable only to long rods, put in practice by Biot, Despretz, Forbes, and recently by Wiedemann and Franz (commonly known as Forbes's method), which it seems possible to modify so as to make it applicable to short rods or even slices†. This well-known method consists

* Read January 19, 1878.

† The method occurred to me when thinking how best to measure the conductivity of tourmaline in opposite directions along the axis, a subject which I was considering in conjunction with Mr. S. P. Thompson of Bristol; for we had reason to think that tourmaline and all other pyro-electric crystals must necessarily possess a unilateral conductivity along their axis both for heat and electricity; and this supposition has been partially confirmed, in the case of heat, by some preliminary experiments of Mr. Thompson's last summer on a very small crystal. No further con-