LETTERS TO THE EDITORS

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IN THE PRESENT CIRCUMSTANCES, PROOFS OF "LETTERS" WILL NOT BE SUBMITTED TO CORRESPONDENTS OUTSIDE GREAT BRITAIN.

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 749. CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Relation between Breaking and Melting

IN a recent paper[1], M. Born has given a new theory of the melting of crystals which is in good agreement with the experimental facts. The stability conditions of a lattice at a certain temperature and a certain uniform pressure for arbitrary small homogeneous deformations are derived, and it is stated that melting will take place when, on raising the temperature, at least one of these conditions is violated. In another paper by Prof. Born and myself to be published shortly, an attempt is made to calculate the tensile strength of a crystal at zero temperature. Here again, the stability conditions of the lattice, stressed in the direction of one of the axes, against any small homogeneous deformation, are derived, and the crystal is supposed to break if one of these conditions is violated. Thus a close relation between the two phenomena of melting and breaking seems to exist, melting being nothing else than a breaking due to the action of the heat movement of the atoms; or putting it the other way round, breaking is nothing else than melting enforced by the action of the stress. Unfortunately, the theory mentioned above, like other former theories, gives results not in agreement with experiment: the tensile strength as well as the critical deformations calculated from this theory with plausible assumptions are about a hundred times larger than the real values given by experiment.

Now, one of the results of the theory of breaking is that the tensile strength should be of the order of magnitude of the heat of sublimation per unit of volume. But, as a consequence of what is said above about a connexion between breaking and melting, one would expect a connexion between the tensile strength and the heat of melting rather than the heat of sublimation. Indeed, comparing the experimental values, one can see immediately that the tensile strength is of the same order of magnitude as the heat of melting per unit of volume. This observation has led me to consider the connexion between these two quantities more thoroughly, and I have succeeded in deriving an equation from which the tensile strength F of an isotropic body at low temperature can be calculated exactly, if the melting heat Q (per unit of mass), the density (ρ), and the Poisson constant (μ) of the substance are known. This theory and a number of other considerations concerning Born's theory of melting and the thermodynamics of crystals, and other relations between melting and breaking will be published shortly.

The main idea of the theory is that one has to compare two 'states' of a system: (1) the uniformly stressed rod with a volume $V + \delta V$, and a certain potential energy U distributed uniformly over the whole rod; and (2) the rod just before it is broken, the energy U concentrated in the volume δV and melting the matter in it, and the rest of the matter unstressed and with no potential energy. The condition for breaking is that the energies of these two states should be equal. The external conditions must be chosen so as to prevent movement of the broken pieces and to allow of an exact energy balance, including the device for the production of the breaking force. In this way one gets the equation:

$$F = Q\rho \frac{1-2\,\mu}{3-5\,\mu}.$$

In the following table the experimental values of the tensile strength, extrapolated to very low temperatures, together with the values of Q, ρ, and μ are tabulated for all elements for which experimental data for the dependence of tensile strength on the temperature were available.

Element	$F \times 10^{-2}$(kgm./cm.^{2})	Q(cal./gm.)	ρ	μ	$\frac{Q\rho}{F}\frac{1-2\mu}{3-5\mu}$
Ag	29	25	10·5	0·38	0·85
Al	23	90	2·7	0·345	1·1
Au	27	16	19·3	0·42	0·89
Cu	32	50	8·9	0·35	1·4
Fe	80	66	7·8	0·28	0·75
Ni	55	63	8·8	0·31	1·2
Pb	4	6	11·3	0·445	1·03
Pt	34	27	21·4	0·385	1·6
Sn	12	14	7·3	0·33	1·08
Zn	30	26	7·1	0·33	0·66

The last column gives the values of $\frac{Q\rho}{F}\,\frac{1-2\,\mu}{3-5\,\mu}$, which quantity should equal unity, if our formula is correct. The average value is 1·065 and the mean deviation from that average 0·255, which is not larger than the uncertainty of the experimental values. The mean error of the average is accordingly 0·085, and the deviation of the average from unity is within the experimental error. Thus the theory is in perfect agreement with the experimental facts.

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[1] Born, M., *J. Chem. Phys.*, **7**, 591 (1939).

THE most important and conspicuous property of matter, namely, the strength of solid materials, the fundamental quantity for building, engineering and textile industries, has been hitherto completely unexplained; Prof. Fürth's results should remove physics from this embarrassing situation.

Quite apart from the theory, Fürth's empirical result, that magnitude of tensile strength and heat of melting are of the same order, is new and surprising. His formula expresses this relation quantitatively