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¹ Salt, *Biochem. J.*, 1935, **29**, 2705.

² Mukerji, "Doctoral Dissertation on Thiocyanate metabolism in cyanide poisoning," *University of Michigan Publication*, 1936.

³ Miller and Connor, *Proc. Soc. Exp. Med. Biol.*, 1933, **30**, 630.

⁴ Abderhalden and Wertheimer, *fluger's Arch.*, 1925, **207**, 215; **209**, 611.

⁵ Miller, Siehrs and Brazda, *Ibid.*, 1933, **30**, 636.

⁶ Miller, Brazda and Elliot, 1933, *Ibid.*, **30**, 633.

The Principal Magnetic Susceptibilities of Tellurium Crystal

McLENAN AND COHEN¹ studied the magnetic properties of single crystals of tellurium and found that the diamagnetic susceptibilities along and normal to the trigonal axis had the same value. A study of the crystal structure of tellurium by Bradley² led him to emphasise the uniqueness of the trigonal axis in the crystal.

In this investigation, tellurium crystals were produced by the method³ of slow cooling. The principal magnetic susceptibilities were determined by the Guoy method.³

The principal susceptibilities are found to be -0.329 parallel to the trigonal axis and -0.296 perpendicular to the trigonal axis.⁴ This leads to a value of 1.11 for the magnetic anisotropy of the crystal. The susceptibility of well-annealed polycrystalline tellurium is found to be -0.307 . This value agrees favourably with those obtained by previous investigators.

When a tellurium crystal is heated, the susceptibility parallel to the trigonal axis decreases, while the other principal susceptibility remains constant. At about 220°C ., the two principal values become equal. When the solid

melts at 450°C ., the volume susceptibility decreases from -1.7 to -0.3 .

The influence of small admixtures of tin, cadmium, bismuth and lead on the magnetic properties of tellurium single crystal was also investigated. In all the cases, both the principal diamagnetic susceptibilities show a decrease in value. The magnetic anisotropy tends to unity. The diamagnetic susceptibility in the polycrystalline state also shows a decrease. This decrease is found to be larger, the greater the atomic radius of the element introduced. The number of valence electrons in the atom of the added element does not seem to have any influence on the decrease in the mean susceptibility of tellurium.

The atomic susceptibility of polycrystalline tellurium is found to be -39.2 while according to Kido,⁵ the susceptibility of a gram ion of tellurium (Te^{+6}) is -4.5 . The contribution to the total atomic susceptibility of the element by the six valence electrons is -34.7 . This indicates that probably the linkages of the six electrons are not metallic. Tellurium behaves like a nonmetal from the magnetic point of view. This conclusion is substantiated by the large electrical resistance of the element.

Full details will be published elsewhere.

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¹ *Roy. Soc. Canada, Trans.*, 1929, **23**, 159.

² *Phil. Mag.*, 1924, **58**, 477.

³ *Proc. Ind. Acad. Sci.*, 1936, **4**, 186.

⁴ Susceptibility values are given in 10^{-5} units.

⁵ *Sc. Rep. Tohoku Imp. Univ.*, 1933, **22**, 835.

Determination of Dipole Moment in Solution

THE apparent electric moment of ortho-, meta- and para-nitrotoluene is measured in a number of solvents. When polarization at infinite dilution is determined using P_2 - f_2 curves, it is found that wherever P_2 changes rapidly with

f_2 the extrapolated value ∞P_2 becomes uncertain. Hedestrand's method of mathematical extrapolation to infinite dilution¹ is found to be convenient so long as the variation of ϵ and d with f_2 is linear. When this is not the case graphical extrapolation of $a\epsilon_1$ and βd_1 to $f_2 = 0$ has to be used, and the values are subject to the inaccuracies of graphical methods.

The Sugden relation² $P_2 = A \pm B \frac{\epsilon - 1}{\epsilon + 2}$ is found to hold for all the solutions investigated. This relation can be used to calculate ∞P_2 which is the value of P_2 at $\frac{\epsilon_1 - 1}{\epsilon_1 + 2}$, ϵ_1 being the dielectric constant of the solvent. Since the Sugden relation is linear ∞P_2 can be calculated by mathematical computation. ∞P_2 so calculated is found to agree, wherever possible, with the values obtained from graphical extrapolation and Hedestrand's method. The constants A and B, however, do not carry the significance originally attached to them by Sugden.²

In order to correlate the values of ∞P_2 and the dielectric constant ϵ of the solvent it was assumed that $\infty P_2 = a\epsilon^b$ where a and b are constants. Hence $\log P_2 = \log a + b \cdot \log \epsilon$. The plot of $\log \infty P_2$ against $\log \epsilon$ for solutions of ortho-, meta- and para-nitrotoluene in different solvents shows three parallel straight lines. When the slope of these lines is calculated using the method of least squares the following result is obtained:

Solute	Slope	Correlation coefficient
<i>o</i> -Nitrotoluene	-0.4928	1 - 0.004
<i>m</i> -Nitrotoluene	-0.5256	1 - 0.010
<i>p</i> -Nitrotoluene	-0.5012	1 - 0.004

Thus for the substances investigated $\infty P_2 = a / \sqrt{\epsilon_{\text{solvent}}}$. This empirical relation differs from the relation $\infty P_2 \propto 1 / \sqrt{\epsilon_{\text{solvent}}}$ suggested by Jenkins.³ When ${}_{\text{gas}}P_2$ is calculated from the empirical relations by extrapolating the graph to $\epsilon = 1$ widely different values are obtained. Thus we have:

Substance	Müller	Sugden	Author	Jenkins
	c.c.	c.c.	c.c.	c.c.
<i>o</i> -Nitrotoluene ..	369	454	487	556
<i>m</i> -Nitrotoluene ..	451	552	608	692
<i>p</i> -Nitrotoluene ..	503	618	666	751

It is found that no agreement is possible between ${}_{\text{gas}}P_2$ derived from different empirical relations so long as extrapolation is carried out to $\epsilon = 1$. From a reconsideration of the data in hand it appears that there is good reason to suspect the validity of extrapolation to $\epsilon = 1$ for the gaseous state. The empirical relations have been derived from results obtained from measurement on solutions and as such may be considered as applicable only so far as the liquid state is concerned. Once the transition from a liquid state to a gaseous state sets in there is no evidence to assume that the prolongation of the graph in that form is valid. On the other hand, it seems reasonable to assume that during transition the changes in the dielectric constant are unaccompanied by changes in the molecular polarization. This leads us to assume a horizontal portion on the graph $P_2 - \frac{\epsilon - 1}{\epsilon + 2}$ after the transition point is reached. This constant value of P_2 may be taken as ${}_{\text{gas}}P_2$.

Le Fèvre⁴ has found that the dielectric constant of benzene, carbon tetrachloride, carbon disulphide and other liquids is nearly the same at the critical temperature of the respective liquids. This may be called the critical dielectric constant. Assuming the constancy of the critical dielectric constant a rough idea may be obtained about the magnitude of the dielectric constant when the transition is occurring at room temperature. For benzene the critical dielectric constant given by Le Fèvre is 1.35. The transition dielectric constant ϵ_c at temperature $t^\circ \text{C}$. may be calculated from $\epsilon_t = \epsilon_c + \frac{d\epsilon}{dt}(t - T_c)$ where T_c = critical temperature, ϵ_c critical dielectric constant, and

$\frac{d\epsilon}{dt} = -0.002$. The transition dielectric constant works out to be 1.88 for benzene at 20° C.

As a preliminary, the results of Parts⁵ for solution in benzene of *iso*-propyl chloride, *iso*-propyl bromide, *sec*-butyl bromide, and *n*-butyl iodide are recalculated using the Sugden relation $P_2 = A - B \frac{\epsilon - 1}{\epsilon + 2}$ and evaluating P_2 for $\frac{\epsilon - 1}{\epsilon + 2} = 0.2269$ ($\epsilon = 1.88$). The electric moment calculated from this value is in good agreement with the value obtained by Groves and Sugden⁶ from measurements in the gaseous state.

	Parts (recalculated)	Groves & Sugden
<i>Iso</i> -propyl chloride ..	2.14	2.15
<i>Iso</i> -propyl bromide ..	2.18	2.19
<i>Sec</i> -butyl bromide ..	2.21	2.20
<i>n</i> -butyl iodide ..	2.07	2.08

When the Sugden relation is used for one solute in different solvents it is found that a value 1.7 for the transition dielectric constant yields concordant results. It may further be noted that when the relations of Jenkins and the author are each extrapolated to $\epsilon = 1.7$ there is a general unification in the values obtained from the different relations.

$\epsilon_{23}P_2$ calculated from different relations

Substance	Müller c.c.	Sugden c.c.	Author c.c.	Jenkins c.c.
<i>o</i> -Nitrotoluene ..	369	368	374	385
<i>m</i> -Nitrotoluene ..	451	456	466	472
<i>p</i> -Nitrotoluene ..	503	513	511	521

As a further test the results of Müller⁷ for nitrobenzene, acetone and chlorobenzene in various solvents were recalculated using the Sugden relation extrapolated to $\epsilon = 1.7$. The same was done for Jenkins' results for nitrobenzene.³ The agreement between the recalculated values and those determined from measurements in the gaseous state is good enough to support the assumptions,

	μ recalculated	μ gas
Nitrobenzene ³	4.19	4.23
Nitrobenzene ⁷	4.21	
Chlorobenzene ⁷	1.69	1.69
Acetone ⁷	2.85	2.85

The results are of a preliminary character. Work is in progress and detailed calculations will be published later.

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¹ Helestrand, *Z. physikal. Chem.*, 1929, **E2**, 428.

² Sugden, *Nature*, 1934, **133**, 415.

³ Jenkins, *J.C.S.*, 1934, 482.

⁴ Le Fèvre, *Trans. Farad. Soc.*, 1938, 1131.

⁵ Parts, *Z. physikal. Chem.*, **B7**, 327; **B12**, 312.

⁶ Groves and Sugden, *J.C.S.*, 1937, 158.

⁷ Müller, *Physik. Z.*, 1933, **34**, 689.

Photo-cells and the Measurement of Quantity of Light

THE use of a photo-cell for measuring the quantity of light corresponds to the use of a galvanometer for measuring the quantity of electricity. If light from a source of candle power (C.P.) be allowed to fall on a photo-cell of area A for a time Δt , then it can be easily shown¹ that

$$S_q \theta = KA \frac{(\text{C.P.})}{r^2} \Delta t = KQ \quad \dots (1)$$

where S_q denotes the ballistic sensitivity of the galvanometer, θ the kick observed, r the distance between the photo-cell and the light source, Q the quantity of light and K is a constant.

We have determined the constant K by using two complimentary methods which may be called the light-flash method and the dark-flash method respectively.

In the light-flash method, a lamp of candle power 13.5 (15 watts) was allowed to fall from