SPECIAL ARTICLES

NOTE ON THE EQUATIONS FOR TORTUOSITY IN THOMSON AND TAIT'S NATURAL PHILOSOPHY

The occurrence of two very different expressions for the same thing is always puzzling. It may not, therefore, be superfluous to consider them.

1. If α, β, γ, λ, μ, ν are the direction cosines of the radius of curvature R, and of the corresponding normal N to the osculating plane, respectively, the first expression in the well-known classic (section 9, edition 1879), is $t^2 = \lambda'^2 + \mu'^2 + \gamma'^2$, where the dashes denote d/ds and s is the independent variable. This is equivalent to the vector tortuosity, $T = d\ (RN)/ds = i\lambda' + j\ \mu' + k\ \nu'$, and is the obvious increment of the unit normal, RN, per cm. along *s, in full,* and in the direction $RN' + R'N$. But as both N and N′ are vector products each containing r′, this T has no projection on the tangent; and, therefore, for counter-clockwise rotation seen in the direction of the tangent, points in the direction of the radius of curvature.

2. The second expression reads:

$$t^2 = \left(\mu \frac{d\nu}{ds} - \nu \frac{d\mu}{ds} \right) + \text{etc.}$$

and is thus vectorially equivalent to
$T' = R\ N \times d\ (R\ N)\ /\ ds = R^2\ N \times N' + 0;$
and if we insert the vector equations for N and N′

$$\begin{aligned} -T' &= R^2\ (r' \times r'') \times (r' \times r''') \\ &= r'\ R^2\ (r' \times r''')\ .\ r'' \\ &= r'\ R^2\ (i\ \lambda' + j\ \mu' + k\ \nu')\ /\ R - NR'/R)\ .\ r'' \\ &= r'\ T\ .\ R_1 = r'\ (\alpha\ \lambda' + \beta\ \mu' + \gamma\ \nu'), \end{aligned}$$

the subscript denoting a unit vector. Thus, in value, T′ is again the projection of T on the radius of curvature R. The former (T′) is laid off, however, along the tangent, since T and R are opposed in direction, and is thus a very different thing from T, which is not an immediate tortuosity. The case is analogous to the occurrence of two expressions for the radius of curvature: $(r'')^{-1}$ in the osculating plane and pointing towards the center; and $(r' \times r'')^{-1}$, laid off along the corresponding normal to that plane, inward.

If the normal N had been defined (preferably here, I think) as $r'' \times r'$, rather than as above, the clockwise rotation of the osculating plane seen in the direction of the tangent would correspond to a vector T in the direction of radius of curvature. T′ would at once be positive in the direction of the tangent r′, without compromise; but opposition of sign is none the less inherent in the two projected tortuosities or angles, $d\ R_1/ds\ .\ N_1$ and $d\ N_1/ds\ .\ R_1$.

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VERY SOFT X-RAYS—THE M — SERIES FOR IRON

During the past two years several investigators have reported attempts to study the portion of the spectrum lying between the Millikan region and the X-ray region by means of the photoelectric action of the radiation. In every case the curves obtained by plotting the photoelectric current against the accelerating voltage applied to the electrons which generated the radiation showed one or two discontinuities which were interpreted as indicating the excitation of one of the X-ray series in the region under investigation. Now in the ordinary X-ray region the characteristic absorption limits have been found to possess a fine structure which has been interpreted by Kossel as corresponding to the ejection of an electron from one of the inner shells of the atom to the various optical orbits in the outer portion of the atom. If such an explanation is correct then a similar phenomenon should be observed in the soft X-ray region, and therefore we should expect to find not one break in the photoelectric current but several for each X-ray absorption limit. This has been observed by the writer in his research on the soft X-rays, and as the work is still in progress it seems advisable to make a preliminary report at this time.

The apparatus used is in principle the same as that employed by Hughes. The radiation was excited by bombarding a solid target with electrons from a hot tungsten cathode. The radiation fell on a platinum plate producing a photoelectric current which was measured by means of a Compton electrometer using the constant deflection method. Positive ions and electrons were kept from reaching the photoelectric plate by two gauzes, one of which was kept 15-20 volts negative to the negative end of the filament and the other at least 75 volts positive to the anticathode. A third gauze acted as a receiver for the photoelectrons. These gauzes were constructed on metal cylinders so arranged that the only surfaces exposed to the radiation were of metal and at known potentials. The parts of the tube around the photoelectric plate were shielded from the direct action of the radiation. Before making any measurements the tube was baked and evacuated until the pressure under conditions prevailing during experimentation was so low that it would not register on a McLeod gauge which could measure a pressure of 10^{-5} mm. It was found to be impossible to obtain reproducible results at higher pressures.

The curves obtained by plotting the total photoelectric current against the voltage applied to the exciting electrons are similar in appearance to those obtained by Franck and Einsporn for mercury using low voltages. Up to the present time nine distinct breaks have been obtained for iron in the region from 40 to 185 volts. The values for these points are:

Voltage	ν/R	λ
46.8	3.46	264 A
81.7	6.03	151
95.4	7.05	129.6
111.2	8.21	111.0
130.4	9.63	94.6
140.9	10.40	87.8
171.1	10.88	83.9
153.7	11.33	80.5
160.1	11.83	77.0

The wave length, λ, is in Angstrom units, ν is the frequency and R the Rydberg constant.

The first of these points corresponds very well with the value calculated from X-ray data for the transition from the N_5—N_6 level to the M_3—M_4 (the separation between M_3 and M_4 or N_5 and N_6 is too small to be considered in these experiments). This difference can be obtained from the ν/R values for the $K\beta$ and $K\gamma$ lines as given by Siegbahn. The values are 519.55 and 523.1 respectively, giving 3.55 as the difference which is in good agreement with the value of 3.46 as obtained by the writer. The results have also been successfully checked by using the combination principle to calculate lines in the Millikan region. A more detailed account of this work with additional results will be published in the near future.

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(Continued)

Solubility relations among aluminum and antimony salts: E. D. CRITTENDEN. Freezing point curves for pairs of (*a*) aluminum salts and (*b*) antimony salts have been determined by the closed tube method previously employed. With the exception of two compounds in the system, $SbCl_3$-$SbBr_3$, compound formation is entirely lacking in the temperature range investigated. Solubility is limited in several cases and in this regard the almost complete insolubility of AlF_3 in the other aluminum halides may be cited. In the antimony series solubility is more extensive. Several cases of partial miscibility in the solid state have been found. The results indicate that the rules already established by Kendall for binary systems in which the negative radical is constant and the positive varied as widely as possible, apply to the reverse case studied here. By comparing the results in the two series, the marked effect of unsaturation in increasing solubility is clearly indicated.

A reciprocal catalytic pair: A. W. BROWNE. In catalytic actions where the agent is of the "carrier" type, it should be possible to use interchangeably the filled and the empty carrier, particularly if these are distinct chemical compounds that may be isolated, and if therefore the filling of the carrier is a chemical process. These two forms of the carrier constitute what may be termed a *reciprocal catalytic pair*, that is, a pair of chemical compounds which undergo repeated mutual conversion into each other while exerting their catalytic effect upon a given chemical reaction. Potassium azido-dithiocarbonate, $KSCSN_3$, and azido-carbondisulphide $(SCSN_3)_2$, two new compounds that have been isolated and studied at Cornell, have been found to exert an identical catalytic effect upon the reaction between potassium trinitride andiiodine, which may be expressed by the equations:

(1) $2\ KSCSN_3 + I_2 = 2KI — (SCSN_3)_2$
(2) $2\ KN_3 — (SCSN_3)_2 = —2KSCSN_3\ 2N_3$
(3) $2N_3 = 3N_2$

Physical-chemical studies of creatine and creatinine (I) creatine hydrolysis in acid solution: GRAHAM EDGAR AND R. A. WAKEFIELD. An ex-