

### Some Characteristics of Ultimate Lines

1. *Classification and Exciting Potentials.*—The ultimate lines are classified as primary, secondary, or tertiary as suggested by Russell, modifying the nomenclature in the form proposed by Catalan and by us.<sup>1</sup>

The following table gives the number of ultimate lines for the different classes and the minimum and maximum values of their exciting potentials. Those computational data are based on the table of the author published in Twyman and Smith's book.<sup>2</sup> A complete list of the exciting potentials and other data for each element will be published shortly in the "Contribución al Estudio de las Ciencias, Serie Mat.-Física" (La Plata).

Classification.	Number of Lines.	Exciting Potentials.
Arc lines Primary .	277	0.0 to 1.32
"   Secondary .	206	0.28 to 5.45
"   Tertiary .	53	0.92 to 9.15
Spark lines Primary .	170	0.0 to 0.56
"   Secondary .	109	0.14 to 11.90
"   Tertiary .	60	0.32 to 17.94
Not classified .	204	?
Total number .	1079	

Fifty per cent of the ultimate arc lines correspond to the primary lines class, and the same proportion is maintained in the spark lines. According to Meggers, Kiess, and Walters, jr.,<sup>3</sup> all the ultimate lines of the spark, with no exception whatsoever, are originated in the fundamental levels; this conclusion is also maintained by Catalan.<sup>4</sup> Our computations do not support that assertion, which is only found true regarding very few elements of the iron group.

2. *Absorption.*—Supplementing our observations regarding the ultimate lines<sup>5</sup> we have established, as the extreme limit for the appearance of the ultimate lines in absorption, the value  $N_1/N = 1/14,500$ , that—according to the equation  $N_1/N = e^{-E/RT}$ , where  $N_1$  is the number of the excited atoms and  $N$  the total number of atoms—corresponds to a value of  $E = 1.03$  volts for  $T = 1250^\circ$  and to a value of  $E = 2.06$  for  $T = 2500^\circ$ .

The value  $N_1/N = 1/14,500$ , adopted by us, corresponds to an extreme limit because, according to our experimental data,<sup>6</sup> faint absorption lines only are observed for  $N_1/N \geq 1/1600$  and lines of medium intensity for  $N_1/N \geq 1/210$ ; for the value adopted, only lines of absorption of a very faint intensity and few in number are observed. In accordance with the preceding considerations, and not taking into account other factors in the obtaining of the absorption spectra—the most important of which is the vapour tension of the element considered—it is possible to observe, in an absorption at a temperature of  $1250^\circ$ , those lines the original levels of which are the fundamental ones that are separated from it by not more than 1.03 volts; that is to say, 330 lines out of 536, and, at a temperature of  $2500^\circ$ , 414 lines out of 536. The quantities given are maxima, because if we consider the possible number of lines of absorption of medium intensity, the value  $N_1/N$  should be  $1/210$ , corresponding to a value of 1.13 volts at  $2500^\circ$ , which shows that—excluding the lines originated at the fundamental levels—only a small number of those corresponding to other levels may be observed in absorption.

3. *Multiplets.*—In the case of multiplets, the ultimate lines fulfil the conditions  $\Delta l = 1$  for  $\Delta j = 1$  and 0, and  $\Delta l = 0$  for  $\Delta j = -1$  and 0. The only exceptions to this rule are the multiplets *SP* (Mn, Cr, etc.). This conclusion is identical with the one we established<sup>7</sup> re-

garding the lines that appear in absorption and that fulfil the same conditions in the variation of the quantum numbers.

ADOLFO T. WILLIAMS.  
Instituto de Física de la  
Universidad de La Plata (E. Argentina),  
June 19.

<sup>1</sup> Twyman and Smith, "Wavelength Tables for Spectrum Analysis", p. 137.

<sup>2</sup> Op. cit., p. 135.

<sup>3</sup> *J.O.S.A.*, **9**, 355; 1924.

<sup>4</sup> *An. Soc. Esp. Fis. y Quim.*, **28**, 92; 1930.

<sup>5</sup> *Cont. Est. Ciencias, Serie Mat.-Fis.*, **5**, 512; 1931; and *Comp. rendus*, **193**, 358; 1931.

<sup>6</sup> *Cont.*, etc., **5**, 504; 1931; and *Phys. Zeit.*, **33**, 154; 1932.

<sup>7</sup> *Cont.*, etc., **5**, 511; 1931; and *Phys. Zeit.*, **33**, 157; 1932.

### Magnetic Analysis of Molecular Orientations in Crystals

BY correlating the magnetic constants of a diamagnetic crystal with those of the individual molecules constituting it, calculated from measurements on the magnetic double refraction of the substance in the liquid state, or from other considerations, it is possible to obtain direct information regarding the orientations of the molecules in the crystal. In a paper which is in course of publication, the results of some magnetic measurements by Mr. S. Banerjee and me on a number of organic crystals are discussed from this point of view.

It is found that in favourable crystals it is possible by the above method to locate the precise molecular orientations. The cases of biphenyl and dibenzyl may be quoted here as examples. Both of them crystallise in the monoclinic prismatic class, in the space group  $C_{2h}^2$ . There are two molecules in their unit cells. Their orientations determined from the magnetic measurements are as follows. Let us for brevity define the directions of the lines joining the carbon atoms 4 and 1 in the molecule (in the usual notation), or the atoms 1' and 4', as the length of the molecule, and the plane of the benzene rings as the molecular plane. We then find that the lengths of both the molecules in the unit cell lie in the (010) plane in the obtuse angle  $\beta$ , their inclination to the  $c$  axis being  $20.1^\circ$  in biphenyl and  $83.9^\circ$  in dibenzyl. As regards the molecular planes, in either crystal, one half of the molecules have their planes inclined at  $+59^\circ$  to the (010) plane and the other half at  $-59^\circ$  to it.

In the case of dibenzyl, sufficient X-ray data are not available to enable us to test the above conclusions. Our results for biphenyl, however, are fully confirmed by the recent X-ray measurements of Dhar,<sup>1</sup> whose values for the above angular parameters are  $20^\circ$  and  $58^\circ$  respectively, which are almost the same as our values.

K. S. KRISHNAN.

Physics Laboratory,  
University of Dacca, July 6.

<sup>1</sup> *Ind. J. Phys.*, **7**, 43; 1932.

### Formaldehyde in Rain Water

SINCE 1864, when Baeyer stated his formaldehyde hypothesis, numerous attempts have been made to obtain formaldehyde *in vitro* from carbon dioxide and water on exposure to light. Usher and Priestley,<sup>1</sup> Baly, Heilbron and Barker,<sup>2</sup> Dhar and co-workers,<sup>3</sup> Mezzadrolì and collaborators,<sup>4</sup> and others, obtained evidence of formaldehyde formation from carbonic acid or bicarbonates in presence or absence of catalysts when exposed to light. On the other hand, Spoehr,<sup>5</sup> Baur and Rebman,<sup>6</sup> Potter and Ramsperger,<sup>7</sup> Bell,<sup>8</sup> Emerson,<sup>9</sup> Zschiele,<sup>10</sup> and Mackinney<sup>11</sup> obtained negative results, although the last-named worker made the following statement: "The status of this problem is extraordinarily involved, though it can hardly be