

(a) Using eriochrome schwartz T (Solochrome black) to estimate zinc down to 1.5 µgm. ± 0.5 µgm., and magnesium down to 12 µgm. ± 4 µgm. (providing zinc is present at 1 per cent of magnesium), or ± 8 µgm. magnesium when zinc is absent. Calcium magnesium and zinc cannot be distinguished by the method. pH must be about 10.

(b) Using ammonium purpurate (murexide) to estimate calcium down to 10 µgm. ± 4 µgm. Any copper present is estimated as calcium. pH about 12. Magnesium has no effect.

*Method.* 5 c.c. (or even 1 c.c.) solution to be tested, of strength between 0.001 M and 0.0001 M, is run into a 1-in. specimen tube. Add for (a) 1 c.c. buffer ( $N\text{NH}_4\text{Cl} + N\text{NH}_4\text{OH}$ ) and 3 drops Solochrome (giving a dilute wine-red colour). Titrate with 0.0001 M disodium ethylene-diamine tetra-acetate for zinc, or with 0.0005 M ethylene-diamine tetra-acetate for magnesium. The titration is complete when the red colour cannot be seen, and the colour is a pale grey. Extra drops of disodium ethylene-diamine tetra-acetate produce a green colour. As soon as a colour change is seen, 30 seconds should elapse between drops, as the colour develops slowly. Add for (b) 1 c.c.  $N$  sodium hydroxide and 3 drops of saturated ammonium purpurate solution in water, and titrate with 0.001 M disodium ethylene-diamine tetra-acetate. The colour change, which is from pink to purple, cannot be seen in artificial light, but is quite sharp in good daylight from a north-facing window.

For stronger solutions, with both dyes the amount of dye must be increased. During the titration an extra 1 ml. of buffer should be added for every 5 ml. disodium ethylene-diamine tetra-acetate added. Impurities in the ammonia should be estimated, using a blank. Slight excess of Solochrome masks the wine-red colour. Although the titrations are reversible with higher concentrations, it is not quite true with the most dilute solutions. A discussion of the utilization of these methods will be published later.

ERIC W. DEBNAY

Department of Botany (Plant Physiology),  
Edinburgh and East of Scotland  
College of Agriculture,  
13 George Square,  
Edinburgh 8.  
Jan. 30.

<sup>1</sup> Bios, 421. Fiat, 644.

<sup>2</sup> Beidermann and Schwartzbach, *Chimia*, 2, 56 (1948).

<sup>3</sup> Analyst, 323 (1947).

### Dirac's New Theory of the Electron

In the last section of a recent paper<sup>1</sup>, Dirac discusses his formulae with the following words: "An important feature of the new theory is that it involves only the ratio  $e/m$ , not  $e$  and  $m$  separately. This is what one should expect in a purely classical theory. The existence of  $e$  should be looked upon as a quantum effect, and it should appear in a theory only after quantization, and not be a property of classical electrons".

If this point of view be accepted, some properties of electrons which have always been regarded as classical should be regarded as quantum effects; for example, the scattering of long electromagnetic radiation by free electrons. It is well known (see, for example, ref. 2) that the cross-section for scattering, obtained by a purely classical procedure, is:

$$\sigma = \frac{8\pi}{3} \left( \frac{e^2}{mc^2} \right)^2.$$

This does not depend on  $e/m$  alone, but on the combination  $m \left( \frac{e}{m} \right)^2$ . Therefore, the mass of the electron can be obtained by observations the interpretation of which has so far always been regarded as an example of classical theory.

Dirac's formulation of the situation needs, therefore, some comment. I personally think that the appearance of the electronic radius

$$a = \sqrt{\sigma/\pi} = \sqrt{\frac{8}{3}} \frac{e^2}{mc^2}$$

as a result of a classical reasoning indicates that the future theory should differ from the present one not only in explaining the integral values of all charges by a quantization, but also in introducing an absolute length right from the beginning. I am further convinced that it is futile to deal with the electron and its electromagnetic field separately, but that the fields of all mesons together with the electromagnetic field should be simultaneously considered. I have indicated a way of doing this elsewhere<sup>3</sup>, and though I am far from thinking that this suggestion is right, I am still convinced that the solution must be sought in this direction.

MAX BORN

Department of Mathematical Physics,  
University of Edinburgh.

May 13.

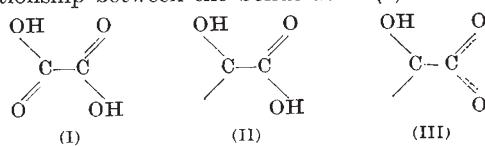
<sup>1</sup> Dirac, P. A. M., *Proc. Roy. Soc.*, 209, 19 (1951).

<sup>2</sup> Born, M., "Atomic Physics", 324 (5th edit.), Appendix VIII.

<sup>3</sup> Born, M., *Rev. Mod. Phys.*, 21, 463 (1949).

### Evidence for Intramolecular Attraction between Hydroxyl and Carbonyl Oxygen Atoms

THE accurate crystal structure analyses of  $\alpha$ -oxalic acid<sup>1</sup> and oxalic acid dihydrate<sup>2</sup> show that the length of the central C—C bond is indistinguishable from the single bond-length of 1.5445 Å. in diamond within a probable limit of ± 0.025 Å. It is inferred that there is no appreciable degree of  $\pi$ -conjugation across the central bond, presumably because of polarization of the carbon 2p electrons by the oxygen atoms; some other explanation must therefore be sought for the fact that the oxalic acid molecule is perfectly flat in both  $\alpha$  and  $\beta$  anhydrous forms and in the dihydrate. It seems unlikely that in all three crystal structures the intermolecular hydrogen-bonding system should be specifically that of lowest energy only when the molecules are planar. In both the  $\alpha$  anhydrous form and the dihydrate, the C—O bonds are distinguishable in length, one tending towards a double bond, the other towards a single bond. The centre of symmetry of the molecule requires a *trans* relationship between the bonds as in (I).



A similar *trans* planar configuration has been found in the molecules of crystalline tartaric acid<sup>3</sup> and hydrate racemic acid<sup>4</sup>. In both structures the two