

is assumed to consist of one  $\alpha$  and one  $\nu$  group, with a symmetrical arrangement of the seven positive electrons. Two  $\alpha$  particles do not seem to combine, but from three to eight, and also ten,  $\alpha$  particles combine without the inclusion of any cementing electrons; but when more than ten unite, two or a

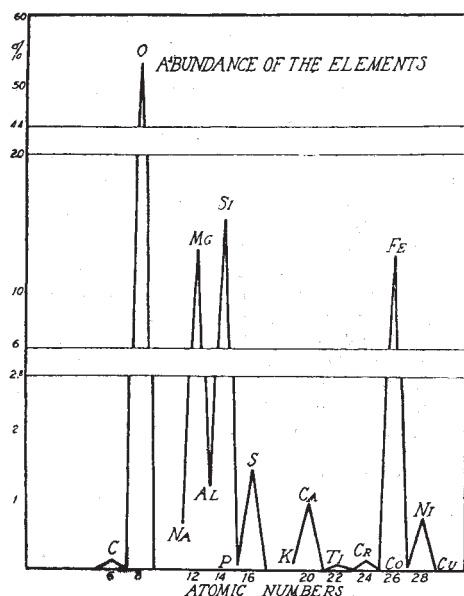


FIG. 1.

multiple of two negative electrons are used in cementing on extra  $\alpha$  particles—that is,  $\alpha$  particles which do not contribute to the positive charge on the nucleus.

Argon and calcium have isomeric atoms, the formula

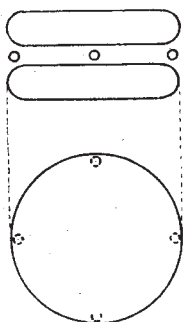


FIG. 2.

of the former being  $\alpha_{10}\beta_2e'_{18}$  and that of the latter  $\alpha_{10}e'_{18}e_2$ , so both have the general formula  $\alpha_{10}e_{20}$ . The formulæ given below represent a few characteristic atoms:—

## Even Nuclear Charge

C  $\alpha_8e'_{20}e_4$   
O  $\alpha_4e'_{20}e_8$   
S  $\alpha_8e'_{10}e_6$   
Fe  $\alpha_{14}\beta_2e'_{18}e_8$

## Thorium Series

Th  $\alpha_{58}\beta_{26}e'_{86}e_4$   
ThX  $\alpha_{56}\beta_{24}e'_{86}e_2$   
Pb(Th)  $\alpha_{82}\beta_{22}e'_{78}e_4$

## Odd Nuclear Charge

N  $\alpha_3\eta_2\beta e'_{20}e_5$   
F  $\alpha_1\nu e'_{20}e_7$   
Cl  $\alpha_8\nu e'_{10}e_7$  and  $\alpha_8\nu\mu e'_{10}e_7$   
Co  $\alpha_{14}\nu\beta_2e'_{18}e_9$

## Uranium Series

U  $\alpha_{59}\mu\beta_{26}e'_{86}e_6$   
Ra  $\alpha_{56}\mu\beta_{24}e'_{86}e_6$   
Pb(Ra)  $\alpha_{51}\mu\beta_{20}e'_{78}e_4$

Here  $e$  represents a valency electron,  $e'$  a non-nuclear electron in one of the inner shells, and  $\beta$  a cementing electron in the nucleus. The evidence for these formulæ is good, but cannot be presented here.

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It will be seen that this hydrogen-helium-meta-hydrogen theory of atom-building is based upon the atomic weight and atomic number relations; the Rutherford atom; the rule of Soddy, Fajans, and Russell for radio-active changes; and the atomic weight relations discovered by Rydberg about thirty years ago; and is dependent for its validity upon the existence of chlorine, magnesium, silicon, and the heavy atoms in isotopic forms. It is a resurrection and an extension of the hypothesis of Prout.

References.—J. Am. Chem. Soc., xxxvii., pp. 1367-96 (1915); xxxix., pp. 856-79 (1917); Phil. Mag., xxx., pp. 723-34 (1915); Science, N.S., xlv., pp. 419-27, 443-48 (1917); Proc. Nat. Acad. Sciences, i., p. 276 (1915); ii., pp. 216-24 (1916); Physical Review, February, 1920, in press.

WILLIAM D. HARKINS.

Department of Chemistry, University of Chicago, March 8.

I HAVE read Prof. Harkins's letter with great interest. If Prof. Harkins has succeeded in separating the isotopic hydrochloric acids he is certainly to be congratulated. The very meagre positive results from my work with neon described at the British Association meeting in 1913 convinced me of the extreme difficulty and labour of such diffusion experiments. In the case of neon I had only to grapple with a twentieth root in the diffusion equation, whereas with HCl it is the thirty-sixth root which is involved. In connection with the possibility of a third isotope of chlorine in the full account of my recent analysis of this element, now in the press, I have described a faint line at 39 which may be this.

More experimental results will be required before the time is ripe for the formulation of a comprehensive theory of atomic structure. I do not propose, therefore, to discuss the one put forward by Prof. Harkins, but would like to point out that his basal assumption that the positive electron has a weight 1.000 is definitely contradicted by experimental results quoted in my letter in NATURE of March 4. F. W. ASTON.

Cavendish Laboratory, Cambridge, April 20.

### On Atomic and Molecular Structure.

THE statement of Mr. S. C. Bradford in the second paragraph of his letter to NATURE of April 8, that I suppose the electrons to revolve in small circles without any constraining force, is erroneous. The fact that I reserved an opinion as to the nature of the constraining force does not imply, as he suggests, that I deny its existence. Thus (cf. Science Progress, April, 1920, and Phil. Trans. Roy. Soc., vol. ccxx., p. 247, 1920) an electron moving with speed  $v$  perpendicular to a magnetic field of intensity  $H$  (which may originate in the nucleus) describes a circular orbit of radius  $\rho = mv/He$ , and the frequency of the electron is  $\nu = He/2\pi m$ , which (and this is an advantage in the case of a radiating orbit) is independent of the speed with which the electron describes the orbit. At present we know little about the actual value of  $\nu$ . If  $H$  is of the order  $10^7$  gauss, the value ascribed to the molecular field from magnetic considerations, the frequency is that of infra-red radiation, and the correlation of the elastic properties of the medium (which are determined by this molecular field) with the infra-red vibrations, as originally pointed out by Debye, is apparent. Within an atom the controlling field may be of the order  $10^8$  gauss, which gives rise to vibrations of optical frequency. Closer to the nucleus a field of  $10^9$  gauss gives rise to frequencies comparable with those of a K series.

Finally, it should be pointed out that the ring electron theory, which Mr. Bradford attributes to

Dr. H. S. Allen, was originally expounded by Mr. A. L. Parson (Smithsonian Miscellaneous Collections, vol. lxx., p. 1, 1915). The advantages of such a theory were ably expressed recently by Dr. Allen in an opening address before the Physical Society of London. A. E. OXLEY.

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### Aquarium Cultures for Biological Teaching.

THE increase in the number of students in biology during the last few years has created a demand for large quantities of such animal types as *Amoeba*, *Actinosphaerium*, brown *Hydra*, and *Daphnia*. It is often very difficult to obtain to time vast numbers of these types; for in Nature the supply is exceedingly precarious, depending as it does on conditions which are constantly fluctuating. In endeavouring to secure a continuous and plentiful supply of *Amoeba proteus*, I have accumulated a certain amount of experience in aquarium-keeping on a large scale, the results of which will be useful to others who, like myself, have to deal with large numbers of students.

Information with regard to *Amoeba* culture has already been given in "Notes on the Collection and Culture of *Amoeba proteus* for Class Purposes" (Proc. Roy. Phys. Soc. Edin., vol. xx., part 4, p. 179). Since the publication of that note, however, I have tried, as an alternative plan for procuring the material necessary to inoculate a culture, a modification of the respective methods described by J. B. Parker ("A Method of Obtaining a Supply of Protozoa," *Science*, N.S., vol. xlii., No. 1090, p. 727, 1915), Libbie Hyman (*Journ. Exp. Zool.*, vol. xxiv., No. 1), and Asa A. Shaeffer (*ibid.*, vol. xx., No. 4), and with success.

Water from such places as the drainage-cuttings in birch, alder, and willow woods, or from the margins of ordinary pools and ponds, together with the filamentous algæ and the brown scum and included diatoms overlying the dead leaves and the other decaying organic matter forming the floor of such places, is gathered in autumn or in early spring. This is allowed to stand in tap-water for some time, until a rich brown scum appears on the top. The top water with the scum is poured off into another glass vessel, and wheat is added (1 gram to a litre of water). In February minute *Amoebæ* begin to make their appearance; these become fully grown in May and June, and will then divide rapidly, forming a luxuriant culture until the late autumn, when encystment of most individuals again takes place.

Once started, *Amoeba* cultures require no further attention than a supply of water to compensate for evaporation, and the addition of wheat from time to time.

I am indebted to Prof. Bourne, of Oxford, for information that boiled rain-water can be used in those districts, e.g. Oxford, where the tap-water contains much mineral matter.

*Actinosphaerium*.—My principal difficulty in the culture of *Actinosphaeria* has been in maintaining for them a sufficient food-supply. Stentors and vorticelloids, their favourite food, appear to require running water, and therefore quickly die off when introduced into the laboratory (except the green stentor, which thrives well when once established, and a small vorticelloid which appears in infusions of certain pond-weeds). The common rotifer is an excellent food, and this can be obtained from rubbish left over from pond-gatherings by means of wheat or hay infusion. Members of the family Cathypnadae (especially *Monostyla*, which is of

frequent occurrence in *Amoeba* cultures, and therefore easily grown in wheat-water) are the most useful of the above-mentioned foods.

Since *Actinosphaeria* disappear very quickly when their food is exhausted, and since, on the other hand, they grow and multiply very rapidly when the food-supply is good, and very quickly exhaust this food-supply, it is necessary to give the Rotifer culture a good start before introducing the *Actinosphaeria* into it. In practice I have several *Monostyla* cultures in readiness, and then, about three months before requiring large numbers of *Actinosphaeria*, I inoculate one or more of the *Monostyla* cultures with a few *Actinosphaeria* and set the jar aside. These latter soon multiply and appear in myriads.

*Hydra*.—Large brown *Hydra* showing buds and reproductive organs can be obtained in considerable numbers and very quickly in laboratory cultures (especially in rooms with a fairly uniform temperature of 60° F.) if they are systematically fed on a generous diet of Crustaceans, which latter can be obtained by the culture of *Daphnia*. The *Daphnia* should be strained off by means of a small net, and a concentrated mass of them in a small quantity of water should be added periodically to the jar containing the *Hydra*. Several hundreds of *Hydra* by this means can be obtained from one or two individuals in a few weeks.

Interesting colour-changes, varying from dingy brown to a bright pink, can easily be effected in brown *Hydra* by varying the Crustacean diet.

*Daphnia*.—I am indebted to Mr. P. Jamieson for the discovery of the value of small pieces of earthworm for the cultivation of *Daphnia*. If an infusion of dead earthworms in water be allowed to stand in a warm place (i.e. near the radiators in the laboratory) it is quickly converted into a rich food, which can be added to the *Daphnia* cultures as required. A few *Daphnia* introduced into a large wide-mouthed glass bottle or beaker of water, to which the worm-water is regularly added, very quickly multiply. Several of these cultures should be kept going if the cultivation of *Hydra* is very intensive, as they must be allowed to recuperate after they have been depleted by use.

A variety of other Protozoa, Crustaceans, Oligochaetes, etc., make their appearance in the above-mentioned cultures, commonly sufficient to supply abundant material for demonstration purposes.

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### Ionisation in the Solar Chromosphere.

It is well known that the spectrum of the upper layers of the solar chromosphere is chiefly composed of those lines which are relatively more strengthened in the spark than in the arc, and which Sir Norman Lockyer originally styled enhanced lines. The best-known examples are the calcium H and K and the strontium pair (4216, 4077). According to modern theories of spectral emission, these lines are due to an atom which has lost one electron. The principal line due to the normal atom of calcium is the *g*-line 4227, and the corresponding Sr line is 4607, both of which occur at much lower levels. According to modern theories, therefore, Ca, Sr, and Ba atoms are more and more ionised as we approach the upper layers of the solar atmosphere, while in the lower layers both normal and ionised atoms occur.

If we assume that ionisation is a sort of reversible chemical process taking place according to the scheme  $\text{Ca} = \text{Ca}^+ + e - U$ , where  $e$  is the electron,  $\text{Ca}^+$  is a positively charged Ca atom, and  $U$  is the energy of