dealt with, examples of practical application being furnished by the manufacture of sulphuric acid, the Deacon process for chlorine, and the drying of linseed oil. Special cases depending on the law of mass action are found in the production of nitric acid and of ether, and in the caustification of sodium carbonate. The rest of the book is chiefly concerned with applications of the phase rule to manufactures, for example, lime-burning, lead roasting, blast-furnace reactions, and the Solvay ammonia-soda process. Technical chemists and students would often find the book useful and suggestive.

OUR BOOKSHELF.

Meteorological Office. The Observer's Handbook, 1913. Pp. xxiv + 157 + plates. (London: H.M. Stationery Office, 1913.) Price 3s.

THE issue of an annual edition of this work, arranged in 1909, was very appropriate—from a scientific point of view—owing to the rapid advance of meteorological research in recent years. The progress of aerial navigation and the proposed general extension of the centimetre-gram-second system of units to meteorological measurements give greater force to the desirability of the arrangement. The work is divided into four principal sections, most carefully prepared with due regard to requirements of observers and to decisions of international conferences. Part i. relates mostly to normal climatological stations and to non-instrumental observations. The articles referring to modifications of aqueous vapour and to optical phenomena are especially interesting. Parts ii. and iii. deal with self-recording and additional instruments, special attention being given to the attainment of accuracy in their working. Part iv. contains reduction and conversion tables, including those adapted for the c.g.s. system. An introductory memorandum on the proposed new units, to be used for bringing meteorology into line with allied sciences, is most useful. Certainly the learning of them “does involve a definite effort to begin with,” but the proposed regraduation of instruments will, as pointed out elsewhere, probably remove the main objection to the innovation.

Handbuch der Hygiene. Herausgegeben von Prof. M. Rubner, Prof. M. v. Gruber, and Prof. M. Ficker. III. Band 3. Abteilung. Die Infektionskrankheiten. Pathogene tierische Parasiten. (Protozoen, Würmer, Gliederfüssler.) Pp. 392 + plates. (Leipzig: S. Hirzel, 1913.) Price 24 marks.

FOLLOWING upon an introduction of fourteen pages dealing with the general problems of parasitology, the book is divided into three sections dealing with parasitic protozoa (224 pp.), worms (101 pp.), and arthropods (28 pp.), the last section being written by W. von Schuckmann, and the rest of the book by Th. von Wasielewski. Each

section is accompanied by reference to the main literature on the subject of which it treats. The book is excellently illustrated by means of thirty-two coloured plates and 192 text-figures, many of which are original.

The section on protozoa deals in the main with the forms which are parasitic in man, the subjects of trypanosomiasis, leishmaniasis, amœbiasis, malaria, and balantidium-dysentery being treated of at length. A short section deals with organisms doubtfully related to protozoa—*Spirochæta*, *Haplosporidia*, and *Chlamydozoa*. The section on worms also deals mainly with the species which are parasitic in man. Compared with these sections the one on arthropods appears distinctly inadequate, the illustrations being mostly bad and antiquated. The legends to figures of *Hæmatopota* and *Stomoxys* (p. 76) are unfortunately reversed. Due credit is given throughout to the sources whence illustrations are borrowed. An annoying custom in bibliographies to German publications may be noted in that “Ders.” and “Dies.” printed in the same type as authors' names, are used instead of dashes beneath the name or names heading the first title—this is most distracting to the eye.

Prof. von Wasielewski may well be congratulated upon his excellent treatise, which will prove most useful to hygienists, for whom the “Handbuch der Hygiene” is primarily intended.

G. H. F. NUTTALL.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

The Pressure of Radiation.

I QUITE agree with Mr. C. G. Darwin's opinion, expressed in NATURE of January 22, that Boltzmann's proof of the fourth-power law, taken as he gave it, or as it is usually given in the text-books, cannot be applied as it stands to each separate frequency, because the adiabatic expansion, employed in performing the cycle, will bring the Doppler effect into play, and cause a small change in the frequency, thus confusing the issue. But I think the reason of this is that the proofs usually given assume too much, and neglect an essential point, expressly emphasised by Carnot himself in the application of his principle to the case of a saturated vapour. According to my view, the application of Carnot's principle to a single frequency should run somewhat as follows.

Since the emission of radiation of constant frequency, independent of the temperature, is a characteristic property of matter, we are justified, for the purpose of argument, in assuming an ideal cylinder and piston of a material capable of emitting only a single frequency, or a narrowly restricted range. Generate a *finite* volume v of radiation in such a cylinder at a constant temperature T and pressure p . The work done on the piston is $p v$, and the total heat absorbed $E + p v$, where E is the intrinsic energy of the radiation generated. Cool the cylinder at constant volume through an *infinitesimal* range, dT , by abstracting heat $C dT$, where C is the thermal capacity

of the cylinder and its contents. An infinitesimal proportion of the radiation will be condensed, and the pressure will fall to the equilibrium value, $p-dp$, corresponding to the temperature $T-dT$. There is no change of frequency since the volume is not altered. Complete the cycle by condensing the volume v at $T-dT$, and heating the cylinder to its original temperature. The cycle is reversible, and the infinitesimal CdT may be made as small as we please in comparison with $E+pv$. The external work done in the cycle is $v(dp/dT)dT$, and is equal to the fraction dT/T of the heat absorbed, $E+pv$. Whence $E/v = T(dp/dT) - p$.

I cannot see any escape from this conclusion so long as Carnot's principle is accepted for the definition of the absolute scale of temperature. Still less is there any escape from the conclusion, depending only on the first law, that the quantity measured experimentally is $E/v+p$, and not E/v , as generally assumed. Both conclusions are inconsistent with much of Wien's reasoning, but I have shown that they are not inconsistent with his displacement law. My formula satisfies all three conditions, makes the entropy of the distribution a maximum, and the thermodynamic potential the same for each frequency.

H. L. CALLENDAR.

Imperial College of Science, S.W.

Atomic Models and X-Ray Spectra.

I AM unable to agree with Sir Oliver Lodge (*NATURE*, January 29, p. 609) that the impossibility of the existence of two coplanar rings of electrons with the same angular velocity is self-evident, though it is proved very simply. For the mutual repulsions of the electrons in different rings are complicated, and their effect on any ring varies very much with the number of electrons. I think the amount of proof given in my letter is necessary, especially since, in discussions of two rings, inequality of angular velocity has not often been mentioned.

Although my illustrative case concerns rings with the same angular velocity, the greater part of the letter relates to rings with different angular velocities, as, of course, in Bohr's theory, the angular momenta of the electrons are equal, thus precluding identity of angular velocity in any two coplanar rings. It must be borne in mind that the portion of Bohr's theory which deals with coplanar rings is admittedly more tentative than that relating to spectra. The point of my letter was that this part of the theory needs modification; and, of course, it is not essential to the other. The variations from circular orbits may be shown to be cumulative, when the orbits are coplanar, and, in fact, it is possible to prove the non-existence of approximately circular orbits from considerations of angular momentum alone, and as this investigation will be published in detail shortly, there is no necessity to enter further upon it now. But, in particular, the nearest possible approximation to a circular orbit for the two inner electrons of Bohr's lithium atom makes their distances from the nucleus in the ratio 12 to 1 for certain positions.

In fact, the only possible arrangement of three electrons with equal angular momenta, in which the orbits are circular, requires all to be in the same circle, and such an atom can be shown by Bohr's method to be as inert as helium. Lithium therefore cannot have a nucleus of strength $3e$, and we cannot retain both Bohr's theory and van den Broek's hypothesis. One at least must be abandoned, and the latter must certainly, for lithium, beryllium, and boron, all of which can be treated very simply on theoretical grounds.

An important argument can be derived from astrophysics. These three elements are, so far as can be judged, practically unknown in celestial spectra, where hydrogen and helium are strong. This seems to imply no great similarity in constitution.

J. W. NICHOLSON.

University of London, King's College.

IN the recent discussion in *NATURE* on the constitution of the atom, attention has been directed mainly to the electrostatic forces exerted by the positively charged portion of the atom. Prof. Nicholson has been successful in calculating the frequencies of the lines in the nebular and coronal spectra on this basis by employing Rutherford's model atom consisting of a central nucleus surrounded by a ring (or rings) of electrons. Bohr's theory, though not dependent on the usual dynamical laws, involves the calculation by ordinary mechanics of the steady motion of the electron in the electrostatic field of the positive nucleus. In the case of a simple nucleus this procedure leads to results as to the frequencies that agree with observation. It may, however, be necessary to suppose, at least in the case of the heavier atoms, that the nucleus produces not only an electrostatic but also a magnetic field. Such a view has recently been developed by Prof. Conway using the atomic model of Sir J. J. Thomson. If we adopt Rutherford's model the expulsion of α and β particles from radio-active substances with large velocities may indicate that the particles possess these velocities *within the nucleus*. If they are in orbital motion a magnetic field would exist outside the nucleus.¹ This hypothesis may be associated with the theory of the Zeeman effect put forward by Ritz, and also with the theories of magnetic action developed by Langevin and by Weiss. According to the latter, there exists an elementary magnet, the *magneton*, which is common to the atom of a large number of different substances.

Prof. Nicholson regards Planck's universal constant h as an angular momentum. According to Bohr's theory the angular momentum of an electron is constant and is $h/2\pi$. Prof. Conway, using a different model, obtains the value h/π . Prof. McLaren identifies the natural unit of angular momentum with the angular momentum of the magneton. It has been pointed out (*Phys. Zeitsch.*, vol. xii., p. 952, 1911) that Planck's constant may be connected with the magnetic moment of the magneton. Suppose that an electron (charge e , mass m) is moving in a circular orbit (radius a) with angular velocity ω . Then its angular momentum is $ma^2\omega$, and the magnetic moment of the equivalent simple magnet is $\frac{1}{2}ea^2\omega$. Thus the magnetic moment is equal to some constant multiplied by he/m . Taking (for illustration only) Bohr's value for the angular momentum, we obtain as the magnetic moment 92×10^{-22} E.M.U. The magnetic moment of the magneton, as given by Weiss, is a quantity of about the same order of magnitude, viz. 15.94×10^{-22} .

My chief object is to direct attention to the work of Prof. Carl Størmer, of Christiania, on the path of an electron in the magnetic field of an elementary magnet. It would be of great interest if it should prove that his results, originally obtained in connection with cosmical problems, are applicable within the atom. In addition to computing the trajectories corresponding to different circumstances of projection in the field of an elementary magnet, he has investigated the corresponding problem when the electron is also under the action of a central force varying inversely as the square of the distance from the centre of the magnet (*Videnskabs-Selskabets Skrifter*, 1907, Chris-

¹ This view necessitates a larger estimate for the diameter of a complex nucleus than that at present accepted.