

theory of evolution," somewhat like that of the botanist Reinke. Man, the growing-point of progressive life, is conscious of directive control. Is there anything more real and certain to him, and is it not the x factor in all life and evolution? "The master-word is nature's will to live," and as man is not an outside observer of the universe, but an organic part of it, the author goes on to show, in very interesting chapters, that ethics is for life, and that art is man's expression of life. J. A. T.

A Course of Pure Mathematics. By G. H. Hardy. Pp. xvi+428. (Cambridge: University Press, 1908.) Price 12s. net.

THE title of this book is rather a misnomer. As a matter of fact, the most interesting part of it is in the last two chapters, which contain an excellent discussion of the logarithmic and exponential functions based upon the definition of $\log z$ as an integral. The preceding eight chapters deal with real and complex variables, limits, convergence of series, and the fundamental theorems of the differential and integral calculus. They are chiefly interesting as an illustration of the fact that there is a growing number of university teachers who are resolved that, if they have to teach elementary calculus, they will do it in the most rigorous way that they can, exposing the fallacies which used to be calmly ignored. There is a large number of examples, many of which show how much more attention has been given of late years in Cambridge to the elements of general function-theory. Mr. Hardy's book is more likely to be regarded as a work on the calculus than anything else; as such, it will be a useful companion to such treatises as those of Lamb and Gibson. M.

Clay Modelling in Manual Training from Plan, Elevation, and Section. By F. W. Farrington. With an Introduction by J. W. T. Vinall. Pp. 47; plates xl. (London: Blackie and Son, Ltd., 1908.) Price 3s. net.

Clay Modelling in Manual Training. Scholars' Handbook. (Same publishers.) Intermediate and Senior, plates xl., price 4d. net. Junior, plates xvi., price 3d. net.

ANY practical pursuit which leads to a scientific training of the hands and eyes of young pupils should receive encouragement in the schools; and modelling in clay can, in the hands of a skilful teacher, become a very useful aid in teaching several subjects. Mr. Farrington indicates how clay modelling may assist school teaching in arithmetic and geography, but hardly develops sufficiently these and similar practical applications of this form of manual work. The books will serve to provide young teachers and pupils with helpful guidance.

Handbook to the Technical and Art Schools and Colleges of the United Kingdom. Compiled from Official Information. With an Index to Courses of Instruction. Pp. xii+140. (London: Scott, Greenwood and Son, 1909.) Price 3s. 6d. net.

THIS useful directory of some of the most important schools and colleges in the British Isles providing instruction in science, technology, and art gives information as to the governing authority, principal, and secretary of each of the institutions dealt with, and particulars as to the courses of instruction arranged at each centre. Though comprehensive, the directory is not complete, and it may be hoped that the request made by the publishers for data of schools omitted will be complied with by the respective authorities, so that the omissions may be rectified in the second edition.

LETTERS TO THE EDITOR.

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Ionisation in the Atmosphere.

THE apparatus designed by Ebert has been widely used to determine the total charges per c.c. of the positive and negative ions in the atmosphere. Except under unusual conditions, the measurement of the positive charge exceeds that of the negative charge by an amount very variable, which averages perhaps about 20 per cent. Thus the ratio of the charges has an average value not far different from the ratio of the mobilities of the ions or from the ratio of their coefficients of diffusion.

The apparatus consists of a metal cylindrical testing vessel with an insulated axial rod connected with the central system of an electroscope. Air is drawn through the testing vessel at a known speed by a small turbine driven by clockwork. The quantity of electricity received by the central charged rod is determined from a knowledge of the electrical capacity and observations of the loss of potential.

The following simple experiments by Mr. F. W. Bates and the writer led to unexpected results. A large hollow cone of cardboard was placed so that the air entering the testing vessel all passed through the cone, and the air during its passage was strongly ionised by the β and γ rays of radium, or by the γ rays alone. The instrument itself was well screened from the rays, and the radium bromide (14 mg.) was carefully sealed in a test-tube so that no emanation escaped. The position of the radium was varied, so that the number of ions detected in different experiments covered a wide range.

Assuming the value of the ionic charge to be 3.4×10^{-10} E.S.U., and supposing that every ion carried unit charge, then the values obtained, after necessary small corrections, gave the following average number of ions per c.c. :—

Series	Positive ions	Negative ions	Ratio
1 ...	37,570	34,300	1.09
2 ...	19,900	10,100	1.99
3 ...	22,320	16,820	1.33
4 ...	14,350	11,850	1.21
5 ...	7,280	5,800	1.25
			Mean 1.39
Without radium	1,280	1,050	1.22

The variation in the ratio may be due to changes in the humidity or to the presence of dust.

The main point is, however, strongly marked. Whilst the γ rays of radium produce equal quantities of positive and negative electricity when they ionise gas in a closed vessel, we find that on ionising air near Ebert's apparatus there appears to be a large excess of positive electricity.

Care has been taken in designing the apparatus to avoid an external field. Since negative ions are under almost all conditions more mobile than positive ions, we should expect the negative ions to be captured more readily than the positive in the testing vessel, unless, indeed, some of the positive ions had a double charge. Again, it is possible that a large number of the negative ions diffuse to the top and sides of the testing vessel before entering it. In that case the diffusion is unexpectedly rapid. Moreover, the ratio, positive to negative, remained unchanged when the air was drawn through an earthed wide-meshed wire cylinder, when the loss by diffusion of the negative ions might be expected to show a relative large increase.

The details require further investigation, but the main and important result seems to be well established, namely, that the Ebert apparatus, and others of like type, are misleading in indicating a large excess of positive over negative electricity in the atmosphere. Thus when observers have recorded the average ratio as 1.2 there may really have existed equality, and the apparent excess may be due to the inequality of the rate of diffusion of the two

kinds of ions, dependent on and varying with atmospheric conditions, such as humidity.

The recent interesting work of Townsend proves that under some conditions the positive ion may have a double charge, two negative ions appearing at its formation. Hence it is possible that in the atmosphere a newly generated positive ion may for a short time be the more mobile, and the apparent excess of positive electricity may not improbably be traced to this cause, as some preliminary experiments seem to indicate. Even if that is so, the fact remains that the quantities of positive and negative electricity in the atmosphere do not differ, at least not to the large extent usually recorded.

A. S. EVE.

Montreal, February 17.

The Absorption of X-Rays.

THE results of experiments that have been made by a number of investigators on the absorption of X-rays, secondary X and γ rays, are so complicated by a variety of conditions that few general conclusions can be drawn from them. It is apparent that a knowledge of the simple laws governing the absorption of X-rays, and the emission of secondary rays, would in many cases enormously simplify the explanations, and save much fruitless labour.

By the use of homogeneous beams of X-rays, and by a study of secondary X-rays, we have been enabled to arrive at the following conclusions:—

Many elements—possibly all—when subject to a suitable Röntgen radiation emit at least one homogeneous beam of X-radiation, which is characteristic simply of the substance emitting it.

When a radiation which is of more absorbable type than the radiation characteristic of a certain substance is incident on that substance, it does not appreciably excite that characteristic secondary radiation.

When the incident radiation is of more penetrating type than that characteristic of the exposed substance, that characteristic secondary radiation is excited.

The absorption of the radiation not sufficiently penetrating to excite the homogeneous secondary radiation characteristic of an absorbing element is governed by very simple laws, the ratio of the absorption coefficients in elements A and B (say) being constant. That is, λ_A/λ_B is approximately a constant for any radiation experimented upon which is not more penetrating than the radiation characteristic of A or B.

When the incident radiation is of more penetrating type, the absorption is greater than would be given by this law, additional absorption being evidently essential to the emission of the characteristic secondary radiation. As the general penetrating power of the incident radiation increases, the intensity of secondary radiation increases, and the absorption by this particular element increases, and finally for more penetrating primary rays the intensity of secondary radiation and absorption of primary rays decrease again in the ordinary way.

The beam emerging from the absorbing plate consists of a weakened primary beam proceeding in its original direction, a little scattered radiation, and a homogeneous radiation uniformly distributed (except for internal absorption). There is no evidence of any other kind of transformation—speaking purely of X-rays.

We may, therefore, by a proper choice of primary radiation and absorbing element observe any of the following:—

(1) Incident and emergent beams of identical penetrating power.

(2) Incident beam, homogeneous; emergent beam a mixture of two homogeneous beams, the ratio of the intensities of which asymptotically approaches a constant value, as the thickness of the absorber increases.

(3) Incident beam, homogeneous; emergent beam a mixture of two, the radiation of incident type ultimately vanishing and leaving a completely transformed radiation.

A homogeneous radiation from an element appears specially penetrating to that element and to elements of neighbouring atomic weight, because it is of less penetrating type, or only just more penetrating than the radiations from these elements.

The change in the character of an ordinary heterogeneous

beam of X-rays in transmission through an element is due to (1) the general selection of rays of the more absorbable type; (2) the special selection of those rays of greater general penetrating power than the radiation characteristic of the absorbing substance; (3) the emission of secondary rays, which are more generally absorbable than the radiations which produced them, but which may be more penetrating to the element emitting them.

The energy of primary radiation transformed into secondary rays is so great that the secondary X-rays proceeding from the antikathode of a Röntgen tube constitute a considerable portion of the heterogeneous beam.

Many of Mr. Kaye's experiments on so-called primary rays, for example, are obviously experiments on secondary rays, verifying our previous results. A comparison of the absorption coefficients shows the identity of the two.

A fuller treatment of the subject of absorption will shortly be published. We wish, however, to point out the great simplification that results from the application of these simple laws to many of the phenomena which have recently been described in a variety of papers on X-rays and secondary X-rays. Probably the laws may be extended to include also the γ rays.

C. G. BARKLA.
C. A. SADLER.

University of Liverpool, March 5.

The Rays of Uranium X.

IN continuation of the work published in a letter to NATURE of January 28, p. 366, I have now carried out under more favourable conditions a second series of observations designed to detect the growth, if any, of a feeble α radiation during the decay of the intense β radiation of uranium X. I used the preparations, obtained from 50 kilograms of uranyl nitrate, employed by Mr. Russell and myself in the study of the γ rays (NATURE, March 4, p. 7). The preparation was placed 1.6 cm. from the thin aluminium foil, forming the base of an electroscope, in a magnetic field of 10,800 units, so that no β rays with a value for $H\beta$ less than 8640 could enter the electroscope.

Under these conditions, although the β radiation from the preparation was sufficiently intense to show luminosity on an X-ray screen in a fully lighted room, the leak in the electroscope was small enough for accurate measurement. About one-fourth of the leak was due to γ rays, and the remainder to still undeflected β rays. Initially the leak was not measurably altered by covering the preparation with a layer of thin tin foil sufficient to absorb any α radiation. In a few hours after preparation a decided difference was noticed, pointing to a growth of α radiation from the preparation, as the considerations outlined in my previous letter had led me to expect. Instead, however, of this absorbable radiation growing with the time according to the function $1 - e^{-\lambda t}$, where λ is the radio-active constant of uranium X, contrary to all expectation the absorbable radiation very quickly reached a maximum, and has since remained constant. About one-half the maximum was reached after the lapse of one day, while after 2.5 days no further increase was observed. At this stage the absorbable radiation was about one-fifth of the total.

The observations have now been in progress for one month. These observations and the whole of those previously made indicate that this α radiation remains constant after the maximum is reached over a period of several years. This points to the existence of a new body, presumably somewhere in the uranium series, with a period of the order of one day, the product of which gives α rays, and has a very long period of life.

I have thought it well to record these observations before being in a position fully to explain them as there has just come to hand the announcement by M. Danne (*Le Radium*, February, p. 42) that, working with 20 kilograms of uranyl nitrate, he has succeeded in effecting the partial separation of the parent of uranium X, which he terms *radio-uranium*. From his description it appears that the new body is very closely allied to uranium in chemical nature. So far as can be judged, it appears improbable that in preparing the uranium X for these experiments any of the radio-uranium was separated. One may conclude at