DESCRIPTION OF PLATE.

A. Solar spectrum, purposely out of focus.
B. α Aquilæ.
C. β Arietis, purposely out of focus.
D. β Arietis, in focus.

The photographs of the spectrum of α Aquilæ which have been obtained at Kensington since 1890 were nearly all taken by Messrs. Fowler, Baxandall, Shackleton, and North. Mr. Baxandall has assisted in the determination of origins.

The photographic plate has been prepared from the original negatives by Sapper Wilkie, R.E.

"The Velocity of the Ions produced in Gases by Röntgen Rays."

By John Zeleny, B.Sc., B.A., Assistant Professor of Physics, University of Minnesota. Communicated by Professor J. J. Thomson, F.R.S. Received February 15,—Read March 1, 1900.

(Abstract.)

The sum of the velocities with which the positive and the negative ions that are produced in gases by the Röntgen rays move when in a unit electric field has already been determined by an indirect method by E. Rutherford.* In the experiments here described the velocity was determined in a number of gases for the positive and negative ions separately, by comparing the ionic velocity directly with that of a stream of gas. The stream of gas was made to flow between two concentric cylinders, which were maintained at different potentials. By passing a narrow beam of Röntgen rays through the cylinders at right angles to their length, a narrow layer of ionised gas was produced. Due to the electric field between the two cylinders, the ions of this layer tended to move radially towards, or away from, the axis of the cylinders, but at the same time they were carried along by the stream of gas. Of the ions of this layer which travelled inwards, those that started from the inner surface of the outer cylinder were carried a distance X by the gas stream before they reached the surface of the inner cylinder.

This distance is dependent directly upon the mean velocity of the gas stream, and inversely upon the difference of potential between the two cylinders. For obtaining the difference of potential which must be used to allow the ions to be carried a certain distance along the tubes by the gas stream the inner cylinder was divided at some distance from the beam of rays into two parts, insulated from each

* E. Rutherford, 'Phil. Mag.,' November, 1897.

other. That one of these parts which was not traversed by the rays was connected to a pair of quadrants of an electrometer, so that it was possible to tell when any ions reached it. A series of readings was taken for the charge reaching the electrometer in a given time for different values of the potential of the outer cylinder. From this was determined the value of this potential for which the ions starting from the outer edge of the ionised layer were just able to reach the juncture in the inner cylinder.

The ionic velocity in a unit electric field is given by the equation—

$$v = \frac{U(b^2 - a^2)}{2AX} \log_e \frac{b}{a},$$

where U is the mean velocity of the gas stream between the cylinders,
b is the inner radius of the outer cylinder,
a is the outer radius of the inner cylinder,
A is the potential of the outer cylinder, corresponding to
X the distance defined above.

To avoid the presence of vortices in the gas at the place where it was exposed to the rays, a sufficiently small velocity was used, and the gas was previously passed through a long portion of the cylinder to allow the motion to assume a steady state.

The disturbing influence upon the electric field between the cylinders of the free charges formed in the gas during the conduction was diminished by using weak rays. The fall of potential at the electrodes* was also reduced by this means. For diminishing the amount of ionisation due to the secondary radiation produced at the metal surface,† the cylinders were made of aluminium, for which metal the effect is the least.

The spreading of the ions due to diffusion produces an error, the amount of which increases with the time required for the ions to travel between the two cylinders.

The value of this time is found from the equation $T = X/U$, where X and U have the same significance as above.

The experimental values obtained for the velocity decreased as T increased, and from a series of results with different values of T the velocity could be obtained corresponding to $T = O$. Since in that case the effects of diffusion and similar causes disappear, this result was taken as the desired value of the ionic velocity.

For testing the accuracy of the method, in addition to using different values of U and X, changes were also made in the intensity of the rays, in the diameter of the internal cylinder, and in the metal which formed the inner surface of the outer cylinder.

Determinations were made with the gases when dry and when satu-

* J. Zeleny, 'Camb. Phil. Soc. Proc.,' vol. 10, Part I, p. 17.

† J. Perrin. 'Comptes Rendus,' vol. 124, p. 455.

rated with aqueous vapour, as the results were found to be different in the two cases. This is in agreement with the effect of moisture upon the coefficients of diffusion of the ions, as observed by J. S. Townsend.* A summary of the results obtained is given in the following table. The results are reduced to a pressure of 76 cm. of mercury, but are not corrected for temperature, the effect of which is not known.

Ionic Velocities.

Gas.	Velocity in centimetres per second in a field of 1 volt per centimetre.		Velocity in centimetres per second in a field of 1 E.S.U. per centimetre.		Ratio of negative to positive.	Temperature.
	Positive.	Negative.	Positive.	Negative.		
Air, dry	1·36	1·87	408	561	1·375	13·5° C.
Air, moist	1·37	1·51	411	453	1·100	14
Oxygen, dry	1·36	1·80	408	540	1·320	17
Oxygen, moist	1·29	1·52	387	456	1·180	16
Carbonic acid, dry	0·76	0·81	228	243	1·070	17·5
Carbonic acid, moist	0·82	0·75	246	225	0·915	17
Hydrogen, dry	6·70	7·95	2010	2385	1·190	20
Hydrogen, moist	5·30	5·60	1590	1680	1·050	20

It is believed that in no case is the error greater than 5 per cent. while most of the observations indicate a considerably greater accuracy. It is observed that the presence of moisture always diminishes the velocity of the negative ions, and that in carbonic acid the velocity of the positive ions is at the same time markedly increased. The velocity of the negative ions is the greater in all of the cases except for moist carbonic acid. The ratios of the velocities of the ions previously determined for these gases by the writer† were between those given above for the dry and for the moist gases, as the influence of moisture was unknown at that time, and the gases had not been dried.

E. Rutherford‡ does not state whether he used dry gases in determining the sum of the velocities of the two ions produced by Röntgen rays; but his result for air (3·2 cm. per second) agrees with the sum of the values separately obtained above for the two ions in dry air, while his values for oxygen (2·8 cm. per second) and hydrogen (10·4 cm. per second) correspond to those for the moist gases. His value for carbonic acid (2·15 cm. per second) is higher than those

* J. S. Townsend, 'Phil. Trans.,' A, vol. 193, 1899.

† J. Zeleny, 'Phil. Mag.,' July, 1898.

‡ E. Rutherford, 'Phil. Mag.,' November, 1897.

here obtained. The value obtained by E. Rutherford* for the velocity of the negative ions produced in dry carbonic acid (0·78 cm. per second) by the action of ultra-violet light, is quite near to that here obtained (0·81 cm. per second) for the ions produced by Röntgen rays, but his values for dry air (1·4 cm. per second) and dry hydrogen (3·9 cm. per second) are considerably smaller.

In discharge from points, A. P. Chattock† has obtained for the velocities of the positive and negative ions in dry air 413 and 540 cm. per second respectively for a field of 1 E.S.U. per cm., which values are quite close to those obtained here for the ions produced by Röntgen rays.

J. S. Townsend‡ has shown that from the coefficients of diffusion of the ions and from their velocities it is possible to compare the charges carried by the different ions, and also to compare them with those carried by the ions in the electrolysis of liquids. By using the velocities given above with the coefficients of diffusion determined by J. S. Townsend, the values of Ne are obtained, N being the number of molecules in 1 c.c. of the gas and e the charge carried by each ion. The results thus obtained for the moist gases, air, oxygen, and hydrogen, perhaps justify the statement that the charges carried by the positive and the negative ions are equal, and that the charge is the same for the different gases, and is equal to the charge carried by the hydrogen ion in the electrolysis of liquids.

The values of Ne obtained for the positive ions in these gases when dry are considerably larger than the above, while in carbonic acid all of the results are over 20 per cent. smaller.

"Mathematical Contributions to the Theory of Evolution. VIII. On the Correlation of Characters not Quantitatively Measurable." By Karl Pearson, F.R.S. Received February 7, —Read March 1, 1900.

(From the Department of Applied Mathematics, University College, London.)

(Abstract.)

1. In August last I presented to the Society a memoir on the inheritance of coat-colour in thoroughbred horses, and of eye-colour in man. This memoir, which was read in November of last year, presented the novel feature of determining correlation between characters which were not capable *à priori* of being quantitatively measured. The theoretical

* E. Rutherford, 'Camb. Phil. Soc. Proc.,' vol. 9, Part VIII.

† A. P. Chattock, 'Phil. Mag.,' November, 1899.

‡ J. S. Townsend, 'Phil. Trans.,' A, vol. 193, 1899.