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LXXXVIII. *The Motion of Electrons in Carbon Dioxide.*

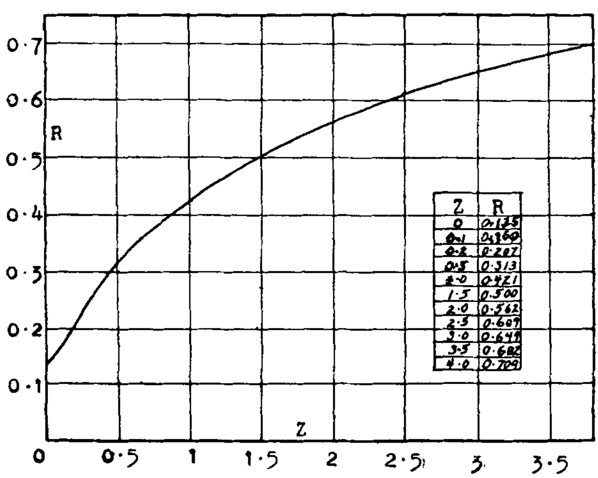
By M. F. SKINKER, *Rhodes Scholar, Exeter College, Oxford* *.

IN some recent publications of the Philosophical Magazine, Prof. J. S. Townsend and Mr. V. A. Bailey † describe their experiments on the motion of electrons in hydrogen, nitrogen, oxygen, and argon.

In this paper I wish to give the results of similar experiments with carbon dioxide and to compare the results.

The apparatus used had the same dimensions and was similar to the one described in the above papers. The electrode E_2, in fig. 1 ‡, however, was not exactly under the slit in B, but was 0·6 millimetre to the right. In order to find the velocity of agitation u it is necessary to find the normal distribution-curve when the centre of the stream is 0·6 millimetre from the centre of the electrode E_2. In this case R, the ratio of the current received by the central electrode to the total current, is given by the curve in fig. 2, Z being the electric force in volts per centimetre.

Fig. 2.



The curve differs slightly from the curve which corresponds to the case in which the centre of the stream coincides with the centre of the electrode E_2.

* Communicated by Prof. J. S. Townsend, F.R.S.

† Phil. Mag. vol. xlii. Dec. 1921, and vol. xliii. March 1922.

‡ Fig. 1, vol. xlii. p. 875.

The calculation of this curve will be explained in a future paper by Prof. J. S. Townsend and Mr. V. A. Bailey.

In order to find the velocity of the electrons in the direction of the electric force, two different magnetic forces may be used. With this eccentricity of 0·6 millimetre the stream may be deflected 1·9 millimetres to the left or 3·1 millimetres to the right. In these experiments all deflexions were to the right, as the determinations with the larger deflexions are the more accurate.

The results of the experiment are given in Table I., where

p is the pressure in millimetres of mercury,

k the factor by which the kinetic energy of the electron exceeds the kinetic energy of a molecule of a gas at 15° C.,

W the velocity of the electrons in the direction of the electric force in centimetres per second.

TABLE I.

p.	Z.	Z/p.	k.	W $\times 10^{-5}$.
20·23	4·16	0·206	1·19	—
9·82	2·08	0·222	1·283	1·18
9·82	4·16	0·444	1·29	2·41
5·06	2·08	0·411	1·277	2·45
9·82	8·33	0·888	—	4·91
5·061	4·16	0·822	1·36	4·55
2·49	2·08	0·835	1·36	4·67
5·06	8·33	1·647	—	9·42
2·49	4·16	1·67	1·72	9·81
1·26	2·08	1·66	1·64	9·47
5·06	16·67	3·30	—	22·4
2·49	8·33	3·32	2·88	23·8
1·26	4·16	3·29	2·79	23·6
·62	2·08	3·32	2·89	24·5
2·49	16·67	6·64	22·1	82·4
1·26	8·33	6·59	21·1	82·4
·63	4·16	6·64	23·1	81·4
2·49	33·33	13·4	60·6	118
1·26	16·67	13·2	60·1	124
1·26	33·33	26·4	81·3	142
·63	16·67	26·6	91	150
·63	33·33	53·2	147	202

The values of W and k are plotted against $\frac{Z}{p}$ in figs. 3–6, together with the curves for hydrogen and nitrogen.

Fig. 3.

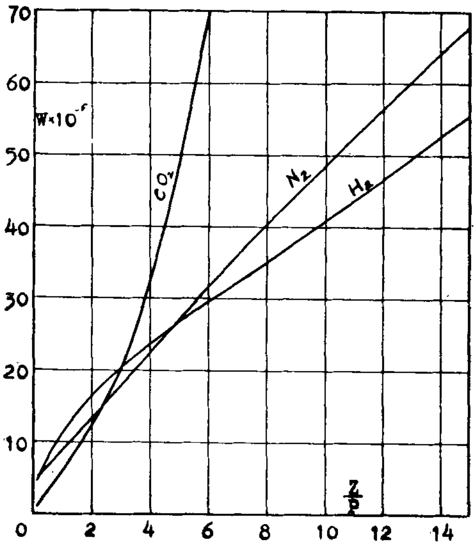


Fig. 4.

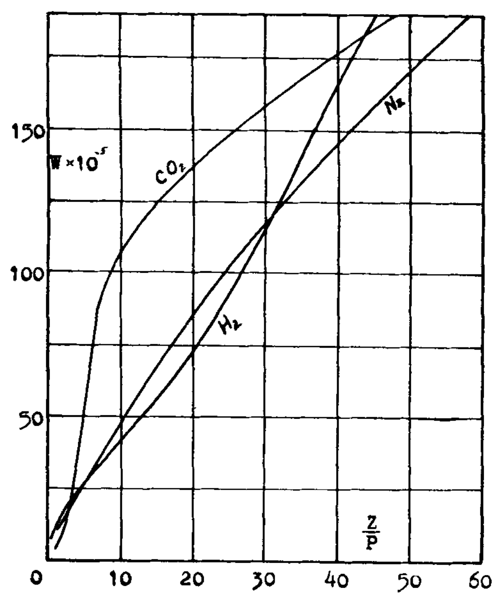


Fig. 5.

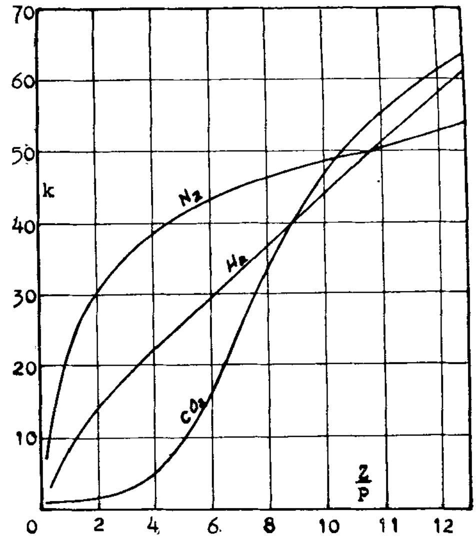
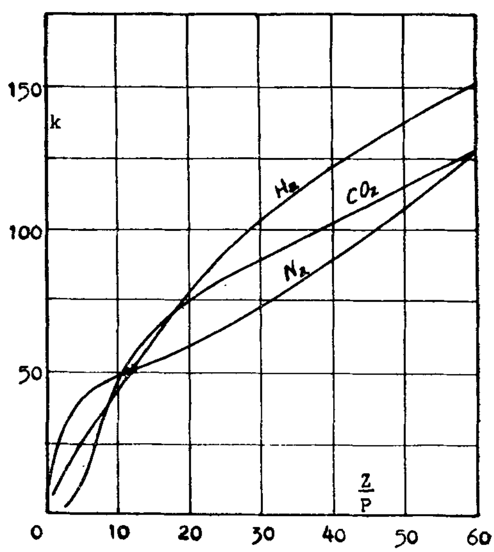

70
60
50
40
30
20
10
k
N_2
H_2
CO_2
$\frac{Z}{P}$
0
2
4
6
8
10
11
12

Fig. 6.


150
100
50
k
H_2
CO_2
N_2
$\frac{Z}{P}$
0
10
20
30
40
50
60

In the following table, u is the velocity of agitation of electrons in centimetres per second, l the mean free path of the electron in centimetres, p the pressure of the gas in millimetres of mercury, and λ the proportion of energy of the electron lost in collision with a molecule.

The formulæ connecting u, l, and λ with the quantities k and W being:—

$$u = 1{\cdot}15 \times 10^7 \times \sqrt{k},$$

$$W = \frac{Z}{p} \times \frac{e}{m} \times \frac{lp}{u} \times 0{\cdot}815,$$

$$\lambda = 2{\cdot}46 \times \frac{W^2}{u^2}.$$

TABLE II.

Z/p.	k.	$W \times 10^{-6}$.	$u \times 10^{-6}$.	$lp \times 100$.	$\lambda \times 10^4$.
50	139	19·5	135·7	3·67	506
40	117·5	17·75	124·8	3·84	497
30	96	15·9	112·8	4·15	487
20	75	13·8	99·5	4·76	472
10	47	10·8	78·9	5·91	460
6·5	20·7	7·8	52·4	4·36	543
5·0	9	5·0	34·5	2·39	516
4	4·8	3·2	25·2	1·40	397
3	2·3	2·0	17·5	·809	321
2	1·8	1·18	15·4	·630	144
1	1·5	·55	14·1	·538	37·4
0·5	1·3	·25	13·1	·454	8·95
0·25	1·2	·12	12·6	·419	2·34

In order to determine whether or not there were any ions in the stream, the magnetic force was increased, to see if the stream were completely deflected off E_1 and E_2*. This was found to be possible when using a magnetic force which was comparatively small and which would not have been sufficient to deflect ions from the plates. Also the quantity k and the velocity W were found to remain constant with different values of Z and p when $\frac{Z}{p}$ was constant; these results show that there could not have been any permanent ions formed in the gas.

* Fig. 1, vol. xlii. p. 875.

With values of $\frac{Z}{p}$ greater than 30 the loss of energy in a collision is comparatively large, so that the velocity of agitation is less than seven times W, and in these cases the formula for W in terms of l and u is not so accurate as in the cases where $\frac{Z}{p}$ is less than 30 and u comparatively large.

Table II. shows for the higher values of $\frac{Z}{p}$ that the mean free path increases with decrease of u, but for the lower values it decreases with decrease of velocity of agitation. In the other gases the mean free path increases for the smaller values of the velocity of agitation.

The values of λ show that with this gas there is a remarkable increase in the loss of energy of an electron in a collision for comparatively small increases in the velocity of agitation from the values 13×10^7 centimetres to 15×10^7 centimetres per second.

Electrical Laboratory, Oxford,
July 1922.

LXXXIX. *A Wide Angle Lens for Cloud Recording.* By W. N. Bond, *M.Sc.(Lond.), A.R.C.S., A.Inst.P., Lecturer in Physics, University College, Reading**.

[Plate VII.]

THIS paper consists of a short description of a lens that might be used for obtaining a photographic record of the clouds visible at a meteorological station at definite times, or for similar purposes, such as recording lightning flashes.

The special feature of the lens is that its field of view embraces a complete hemisphere; so that if the lens be arranged to face vertically upwards, all the clouds visible at the station at any one time can be recorded photographically on a single flat plate or film. The resultant photograph (see Pl. VII.) is circular, any clouds at the zenith being reproduced in the centre of the circle, and any near the horizon appearing near the edge of the circle. Such apparatus might, of course, be used at two stations simultaneously to obtain the altitudes of the clouds.

* Communicated by the Author.