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XXI. *Atomic Conductivities of the Ions.*

By PHILIP BLACKMAN*.

THE fact that there exists a definite quantitative relation between molecular conductivities (Phil. Mag. 1906, xi. p. 416; Ostwald's *Lehrbuch der Alg. Chemie*, II. i. p. 672) seems to indicate unmistakably that molecular conductivities are additive properties, *i. e.*, that the molecular conductivity of any substance (in aqueous solution) is equal to the sum of the atomic conductivities of its constituent ions. No such regularity apparently exists between the molecular conductivities of the acids, but if the assumption be made that the atomic conductivity of the H^+ ion is a function of the relative strengths of acids, then it is possible to calculate its value, and consequently those of other ions.

It was shown (Phil. Mag. 1906, xi. p. 417) that in the general equation

$$\mu v_{HX} + \mu v_{M_1OH} - \mu v_{M_1X} = K,$$

the disappearance of molecular conductivity was equivalent to that required by the equation $H^+ + OH' = H.OH$ for the particular acid in question. Then, according to the preceding argument, the atomic conductivity (μv_H) of the H^+ ion may be determined from the equations

$$Rv_{HX} \cdot \mu v_H + \mu v_{OH} = K,$$

$$Rv_{HX_1} \cdot \mu v_H + \mu v_{OH} = K_1,$$

$$Rv_{HX_2} \cdot \mu v_H + \mu v_{OH} = K_2,$$

$$\dots\dots\dots = \dots$$

(in which Rv_{HX} , Rv_{HX_1} , Rv_{HX_2} , etc., represent, respectively, the relative strengths of the acids HX , HX_1 , HX_2 , etc., all measured at the same concentration, v , and at the same temperature).

The calculations effected by means of these equations are so fairly consistent that the assumptions made above may very reasonably be taken as correct.

As an example, the atomic conductivities of the ions H^+ , OH' , K^+ , and Cl' , at 18° and at concentration $v=500$, are worked out in full.

$$R_{HCl}, R_{HNO_3}, R_{\frac{1}{2}H_2SO_4}, R_{\frac{1}{2}H_2C_2O_4}, \text{ and } R_{CH_3CO_2H}$$

* Communicated by the Author.

are respectively 1.0, 0.9946, 0.94, 0.46, and 0.08 ;

are respectively 474, 472, 456, 285, and 163.

$$\text{Hence } 1.0\mu_{\text{H}} + \mu_{\text{OH}} = 474, \quad 0.9946\mu_{\text{H}} + \mu_{\text{OH}} = 472,$$

$$0.94\mu_{\text{H}} + \mu_{\text{OH}} = 456, \quad 0.46\mu_{\text{H}} + \mu_{\text{OH}} = 285,$$

$$\text{and} \quad 0.08\mu_{\text{H}} + \mu_{\text{OH}} = 163.$$

By adding all the equations together and solving the resulting equation $4.749\mu_{\text{H}} = 1618$, it is found that $\mu_{\text{H}} = 340$.

$$\mu_{\text{OH}} = \mu_{\text{HOH}} - \mu_{\text{H}} \cdot R_{\text{HCl}} = 474 - 337 = 137 ;$$

$$\mu_{\text{Cl}} = \mu_{\text{HCl}} - R_{\text{HCl}} \cdot \mu_{\text{H}} = 376 - 1.0 \times 337 = 39 ;$$

$$\mu_{\text{K}} = \mu_{\text{KCl}} - \mu_{\text{Cl}} = 126 - 39 = 87 ;$$

$$\text{or } \mu_{\text{K}} = \mu_{\text{KOH}} - \mu_{\text{OH}} = 233 - 137 = 96, \text{ etc.}$$

v (at 18°)=	1000	500	200	100	50	20	10	2	1
H	337	336	333	330	329	323	313	291	270
Rb	90	89	87	85	85	81	77	...	71
Cs	91	89	87	85	...	...	76	...	...
K	89	89	88	86	83	80	78	67	63
NH ₄	85	84	82	80	78	75	72	64	63
Li	85	85	82	77	76	76	76	...	...
$\frac{1}{2}$ Ba	75	75	69	66	65	57	52	40	36
$\frac{1}{2}$ Pb	76	73	69	63	59	49	41	19	14
$\frac{1}{2}$ Sr	74	70	67	62	61	55	54	36	30
Ag	73	72	70	67	...	62	58	43	40
$\frac{1}{2}$ Ca	69	66	64	60	60	54	44	34	29
Na	66	65	64	61	60	59	58	41	38
$\frac{1}{2}$ Mg	64	60	56	52	47	42	34	32	28
$\frac{1}{2}$ Zn	64	60	56	50	45	40	35	29	19
$\frac{1}{2}$ Cd	...	...	55	46	38	32	26	22	15
$\frac{1}{2}$ Cu	62	55	48	40	33	27	22	...	13
Li	56	54	53	52	51	48	45	40	34
OH	143	140	140	139	138	135	127	122	109
$\frac{1}{2}$ CO ₃	45	41	36	32	27	21	15	12	7
Cl	40	40	40	40	38	37	37	36	31
NO ₃	40	40	40	40	38	37	36	34	28
Br	40	39	38	38	38	37	36	36	...
I	39	38	37	37	37	37	36	36	36
$\frac{1}{2}$ SO ₄	37	37	33	32	29	24	22	21	13
SCN	30	29	28	28	28	28	26	25	24
ClO ₃	28	27	26	26	26	24	21	18	...
F	21	20	20	20	20	18	16	16	16
$\frac{1}{2}$ C ₂ O ₄	12	12	11	11	9	8	7	6	5
$\frac{1}{2}$ PO ₄	11	11	11	9	7	6	5	3	2
IO ₃	8	8	7	7	7	5	2	...	...
CH ₃ CO ₂ ..	7	6	6	6	5	4	2	1	0.8

The letter μ (strictly speaking denoting "molecular conductivity") has been retained, for the sake of simplicity, to represent also "atomic conductivity." The table has been entirely constructed from the data in Landolt-Börnstein's *Physikalisch-Chemische Tabellen* (latest, 1905, edition). In all cases, the atomic conductivities given are the means of those obtained by all the possible calculations. To calculate the molecular conductivity of any salt, base, or acid, respectively, the equation $\mu v_M + \mu v_X$, $\mu v_M + \mu v_{OH}$, or $Rv_{HX} \cdot \mu v_H + \mu v_X$, should be employed.

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XXII. *Distribution of the Intensity of the Radiation from Radioactive Sources.* By E. RUTHERFORD, F.R.S., *Macdonald Professor of Physics, McGill University, Montreal*.*

[Plate II.]

IN the course of my experiments on the magnetic deflexion of the α rays emitted by the active deposit of radium, a very peculiar photographic effect was observed. The experimental arrangement was similar to that described in a previous paper (Phil. Mag. July 1905). The rays from a wire about 1.5 cms. long and 0.5 mm. in diameter, made strongly active by exposure in the radium emanation, passed through a slit and fell on a photographic plate placed some distance above the slit. The whole apparatus was exhausted of air, and a strong magnetic field applied so as to bend the pencil of α rays. With a broad slit, comparable in width to the diameter of the active wire, the photographic trace of the α rays on the plate is shown by a black band with sharply defined edges; and the intensity of the photographic impression is approximately uniform over its cross section. With a very narrow slit, however, the photographic trace of the rays has a very different appearance.

Fig. 1 A, Pl. II., shows a magnified drawing of such a trace. The outside edges of the band are sharply defined, and the photographic impression falls off rapidly from the outside to the centre, but is most intense at the extreme edges. The trace, at first sight, appears as if it consisted of two dark

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