ON THE DISSOLUTION VELOCITY OF OXYGEN INTO WATER. PART III.

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Received October 6, 1930. Published November 28, 1930.

Introduction. Sodium sulphite oxidizes at a definite velocity, quite independent of its concentration, when air is passed into the solution at uniform velocity under certain conditions(1). Following equations(2) were proposed to interprete the observed results from theoretical considerations.

$$k=\frac{v_0-v}{t-t_0} \quad \dots\dots\dots\dots \quad (1)$$

$$D=\frac{1}{4}k\times10^{-4}\ \text{moles/min.} \quad \dots\dots\dots\dots \quad (2)$$

$$D=\frac{60ap}{\sqrt{2\pi MRT}}\left(\frac{Vl}{20ru}+S_0\right)\ \text{moles/min.} \quad \dots\dots \quad (3)$$

$$k=\frac{24ap\times10^5}{\sqrt{2\pi MRT}}\left(\frac{Vl}{20ru}+S_0\right) \quad \dots\dots\dots\dots \quad (4)$$

where k=the velocity constant calculated as a zero order reaction, v_0-v being the volume of sodium thiosulphate solution of 0.1000 normal equivalent to the amount of sodium sulphite oxidized during $t-t_0$ minutes,

D=the dissolution velocity of oxygen into water when the concentration of oxygen in the surface layer is kept to be zero,

a =the ratio of the total number of the molecules of oxygen which penetrate into water and the total number of the molecules of oxygen which collide with the unit boundary surface per unit of time, the concentration of oxygen in the surface layer being kept to be zero,

p =the partial pressure of oxygen,

M=the molecular weight of oxygen,

R =the gas constant,

(1) S. Miyamoto, this Bulletin, **2** (1927), 74; *Scientific Papers of the Institute of Physical and Chemical Research*, **7** (1927), 40.

(2) S. Miyamoto and T. Kaya, this Bulletin, **5** (1930), 123; S. Miyamoto, T. Kaya and A. Nakata, ibid., **5** (1930), 229.

T =absolute temperature,
V=the volume of the gas passed per minute,
l =the depth of the center of a bubble when it just leaves the exit,
r =the radius of a bubble,
u =the ascending velocity of the bubble,
s_0=the surface area of the liquid which is in contact with the gas outside of the boundary surface of the bubbles.

If all the values in the equations 3 and 4 be kept constant except the value of the radius of the bubble, the equations can be simplified.

$$D=\frac{A}{ru}+B \quad \text{.................................} \quad (5)$$

$$k=\frac{A'}{ru}+B' \quad \text{.................................} \quad (6)$$

where A, B, A' and B' are constants.

The present research was carried out to ascertain if the equations 5 and 6 be acceptable.

Experimental. The apparatus and the method of the observation are quite the same as those described in the previous paper(1). The bubbles of various magnitude were obtained by substituting the tube through which air is passed into the solution. The radius of the bubble and the corresponding ascending velocity given in the tables were obtained in quite the same manner as in the previous case(2).

The observed result is given in Table 1.

Table 1.

Temp.=25°C. Velocity of Air Passed=86.7 c.c./min.

Radius of a bubble r cm.	Time min.	v c.c.	$v_{calc.}$ $[=v_0-k(t-t_0)]$ c.c.	$k\left[=\frac{v_0-v}{t-t_0}\right]$
0.23	3	16.16	—	0.249
	33	8.70	8.63	
	3	16.71	—	0.255
	43	6.52	6.67	
	3	44.63	—	0.253
	53	31.96	32.08	
	3	56.32	—	0.248
	53	43.90	43.77	
			Mean:	0.251

(1) S. Miyamoto, T. Kaya and A. Nakata, this Bulletin, **5** (1930), 230.
(2) S. Miyamoto and T. Kaya, this Bulletin, **5** (1930), 134.

Table 1.—(*Continued*)

Radius of a bubble r cm.	Time min.	v c.c.	$v_{calc.}$ $[=v_0-k(t-t_0)]$ c.c.	$k\left[=\frac{v_0-v}{t-t_0}\right]$
0.29	3 43	18.92 9.86	— 9.92	0.227
	3 52	23.88 12.83	— 12.85	0.226
	3 53	37.60 26.28	— 26.35	0.226
	3 53	50.86 39.74	— 39.61	0.222
	3 53	65.54 54.39	— 54.29	0.223
			Mean:	0.225
0.36	3 43	17.25 9.10	— 9.01	0.204
	3 53	23.25 12.78	— 12.95	0.209
	3 58	37.61 26.36	— 26.28	0.205
	3 53	50.51 40.12	— 40.21	0.208
	3 53	60.97 50.89	— 50.67	0.202
			Mean:	0.206
0.41	3 43	18.04 10.61	— 10.24	0.186
	3 43	18.02 10.19	— 10.22	0.196
	3 54	23.33 13.13	— 13.38	0.200
	3 53	38.01 28.24	— 28.26	0.195
	3 55	62.13 51.75	— 51.99	0.200
			Mean:	0.195

Table 1.—(*Concluded*).

Radius of a bubble r cm.	Time min.	v c.c.	$v_{calc.}$ $[=v_0-k(t-t_0)]$ c.c.	$k\left[=\frac{v_0-v}{t-t_0}\right]$
0.49	3	16.41	—	0.175
	43	9.42	9.33	
	3	23.02	—	0.175
	53	14.27	14.17	
	3	34.54	—	0.181
	53	25.49	25.72	
	3	46.55	—	0.181
	53	37.51	37.70	
	3	64.11	—	0.175
	53	55.34	55.26	
			Mean:	0.177

Table 2.

Temp. $=25°C$. Velocity of Air Passed $=86.7$ c.c./min.

r cm.	u cm./sec.	ru	$k_{obs.}$	$k_{calc.}$	$D_{obs.}$ $[=\frac{1}{4}k_{obs.}\times10^{-4}]$ moles./min.	$D_{calc.}$ moles./min.
0.23	23.7	5.451	0.251	0.252	6.28×10^{-6}	6.29×10^{-6}
0.29	23.1	6.699	0.225	0.226	5.63 ,,	5.64 ,,
0.36	23.1	8.316	0.206	0.204	5.15 ,,	5.10 ,,
0.41	23.1	9.471	0.195	0.193	4.88 ,,	4.82 ,,
0.49	23.1	11.319	0.177	0.180	4.43 ,,	4.50 ,,

The values of k and D calculated by the following equations are given in Table 2.

$$D_{\text{calc.}} = \frac{1.886 \times 10^{-5}}{ru} + 2.83 \times 10^{-6}$$

$$k_{\text{calc.}} = \frac{0.7543}{ru} + 0.1132$$

where the constants were obtained by the least square method. The observed values are plotted in Figs. 1 and 2.

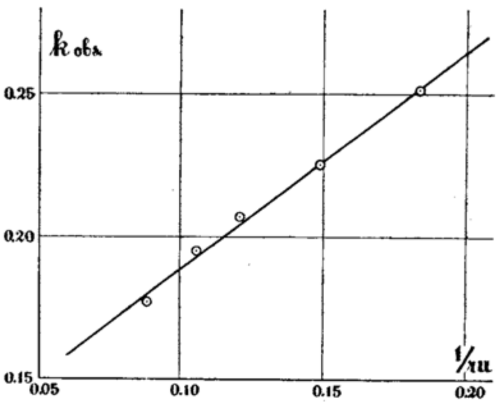

Fig. 1.

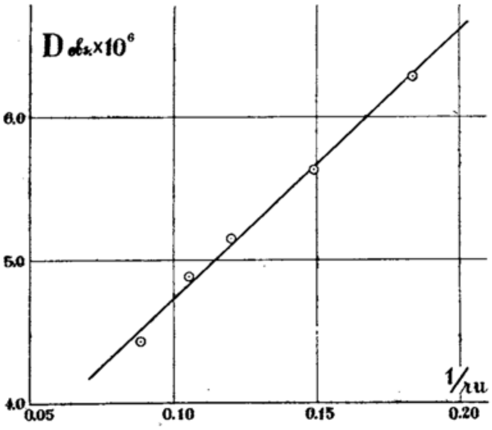

Fig. 2.

The result is thus quite favourable for the authors' considerations, as was expected.

Summary.

(1) The influence of the magnitude of the radius of the tube, through which air is passed, upon the oxidation velocity of sodium sulphite was observed.

(2) The theoretical considerations on the result was described.

The authors wish to express their appreciation for a grant from the Department of Education for the expenses of this research.

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