

The Physical Properties of Bromine and Hydrogen Bromide

Table 1

	Bromine	Hydrogen bromide
Molecular weight	159.832	80.924
Colour	Dark reddish-brown	Colourless
State	Volatile liquid	Non-flammable gas
Density	3.12 (20°C)	3.50 (0°C)
Melting point	-7.3°C	-88.5°C
Boiling point	57.78°C	-67.0°C

Table 2 The concentration of aqueous solution of bromine¹⁾

°C	-0.3	0	5.84	10
%	2.28	2.30	3.18	3.74

°C	20	30	40	50
%	3.53	3.44	3.45	3.53

Table 3 The concentration of aqueous solution of hydrogen bromide¹⁾

	Ice			
°C	-10	-20	-40	-60
%	12.5	21.3	30.1	35.3

	HBr·4H ₂ O			
°C	-80	-80	-60	-56.8
%	39.5	42.8	49.7	52.9

	HBr·3H ₂ O		HBr·2H ₂ O	
°C	-57	-48	-48.2	-20
%	54.8	60.0	60.2	64.2

	HBr·H ₂ O			
°C	-11.3	-15.5	-10	-3.3
%	69.2	73.3	74.7	78.9

Table 4 The viscosity of bromine vapour²⁾

$\eta \times 10^4$	t °K	$\eta \times 10^4$	t °K	$\eta \times 10^4$	t °K
1.526	292.0	2.097	411.0	3.476	683.0
1.574	292.2	2.369	463.0	3.525	693.6
1.542	293.5	2.500	484.0	3.591	712.0
1.535	294.0	2.626	515.0	3.967	789.1
1.530	296.5	2.698	524.2	4.106	808.0
1.528	298.0	2.999	589.0	4.300	861.0
1.921	369.0	3.163	622.5	4.292	867.0

The viscosity of liquid bromine²⁾

(-4.3° to +32°C).

$$\eta_t = \eta_0 / (1 + 1.2257 \times 10^{-2}t + 2.721 \times 10^{-6}t^2)$$

Viscosity at 0°C is 0.01241 c. g. s. units; that at the b. p., obtained by extrapolation, is 0.00717 c. g. s. units.

Table 5 The viscosity of aqueous solution of hydrogen bromide²⁾

(relative to $\eta_{H_2O} = 1$ at 25°C)

M	0.01	0.02	0.05	0.1
η	1.0003	1.0007	1.0016	1.0033

M	0.5	1	1.009	1.997
η	1.0165	1.0327	1.035	1.072

M	4.021	5.994	8.759
η	1.172	1.324	1.613

η_2 25°C, = 0.8937 c. p.

Table 6 The density of bromine²⁾

t (°C)	25.15	30.15	34.45	39.85
d	3.1006	3.0836	3.0689	3.0499

t (°C)	44.35	47.85	51.55
d	3.0345	3.0227	3.0033

Table 7 The vapour density of bromine at 1 atm²⁾

t (°C)	87.7	89.2	91.4	91.7	98.8
d_t (g/l)	5.480	5.406	5.322	5.333	5.217
PV ($\ell \cdot \text{atm.}$)	28.85	29.03	29.48	29.49	30.08

t (°C)	99.6	101.2	110.9	111.4	112.4
d_t (g/l)	5.196	5.168	5.045	5.084	5.038
PV ($\ell \cdot \text{atm.}$)	30.27	30.32	31.09	30.94	31.11

Table 8 The density of liquid hydrogen bromide²⁾

t (°C)	-67.1	-60.0	-46.0
d (g.cc ⁻¹)	2.717	2.238	2.174

Table 9 The density of aqueous solution of hydrogen bromide³⁾

%	1	2	4	6	8
D_4^{25}	1.0041	1.0111	1.0255	1.0402	1.0552

%	10	12	14	16	18
D_4^{25}	1.0707	1.0867	1.1032	1.1202	1.1377

%	20	22	24	26	28
D_4^{25}	1.1557	1.1743	1.1935	1.2134	1.2340

%	30	35	40	45	50
D_4^{25}	1.2552	1.3118	1.3736	1.4405	1.5127

%	55	60	65
D_4^{25}	1.5902	1.6731	1.7613

Table 10 The specific heat of bromine at low temperatures²⁾

T (°K)	14.9	17.3	23.3	29.9
C_p (g-cal mole ⁻¹)	1.83	2.36	3.82	5.18

T (°K)	48.6	65.5	88.1	93.5
C_p (g-cal mole ⁻¹)	7.96	9.38	10.06	10.30

T (°K)	98.5	116.5	152.7	175.4
C_p (g-cal mole ⁻¹)	10.38	10.94	11.80	12.26

T (°K)	183.0	209.3	217.8	244.2
C_p (g-cal mole ⁻¹)	12.54	13.12	13.24	14.02

T (°K)	250.6	252.4
C_p (g-cal mole ⁻¹)	14.24	14.36

$$C_p = 8.4228 + 0.974 \times 10^{-3}T - 3.555 \times 10^{-7}T^2$$

(300~1,500°K)

Table 11 The values of C_p (g-cal mole⁻¹) for hydrogen bromide²⁾

T (°K)	15.72	30.16	57.80	80.03
C_p	1.831	3.955	6.171	9.368

T (°K)	89.23	89.39	89.49	89.50
C_p	29.08	114	268	483

T (°K)	89.59	90.01	90.91	111.47
C_p	187	17.02	9.87	12.58

T (°K)	113.31	113.37	114.13	115.76
C_p	135	1290	19.32	13.06

T (°K)	116.76	116.86	118.99	172.86
C _p	239	860	10.79	11.91

T (°K)	186.24	189.93	205.11	206.38
C _p	m. p.	14.20	14.31	b. p.

Table 12 The specific heat of aqueous solution of hydrogen bromide³⁾

[H ₂ O]/[HBr] mole ratio	C _p g-cal mole ⁻¹	[H ₂ O]/[HBr] mole ratio	C _p g-cal mole ⁻¹
200	0.9688	4.85	0.4694
100	0.9402	4.65	0.4640
50	0.8876	4.013	0.4340
20.12	0.7641	2.92	0.3742
10	0.6154	2.72	0.3608
7.01	0.5397	2.48	0.3524
5.69	0.5005	2.0	0.3553
4.92	0.4711	1.84	0.3827

Table 13 Partial pressure(p) of bromine as a function of liquid composition at 20°C⁴⁾

C × 10 ³	p(exp) × 10 ⁴	p(calc) × 10 ⁴	C × 10 ³	p(exp)	p(calc)
			0.84	7.2	7.4
0.33	2.4	2.4	0.90	8.3	7.8
0.38	2.6	2.9	1.03	8.3	9.2
0.43	3.6	3.4	1.21	9.5	11.0
0.56	3.9	4.6	1.36	12.3	12.5
0.82	7.6	7.1	1.48	14.5	13.7

C is the overall bromine concentration in the liquid and is expressed in g moles bromine/litre water. p is expressed in atmospheres.

Table 14 Extinction coefficients vs. wave length of bromine⁵⁾

Wave length, (mμ)	Extinction coefficients (mole ⁻¹ l. cm ⁻¹)	Wave length, (mμ)	Extinction coefficients (mole ⁻¹ l. cm ⁻¹)	Wave length, (mμ)	Extinction coefficients (mole ⁻¹ l. cm ⁻¹)
310	410	165.0	510	70.7
320	0.2	420	165.5	520	46.2
330	0.8	430	155.5	530	33.5
340	2.9	440	140.8	540	26.3
350	10.0	450	127.4	550	20.7
360	23.3	460	117.1	560	16.1
370	47.6	470	108.4	570	11.9
380	81.4	480	101.5	580	8.8
390	119.0	490	93.2	590	6.1
400	148.9	500	82.9	600

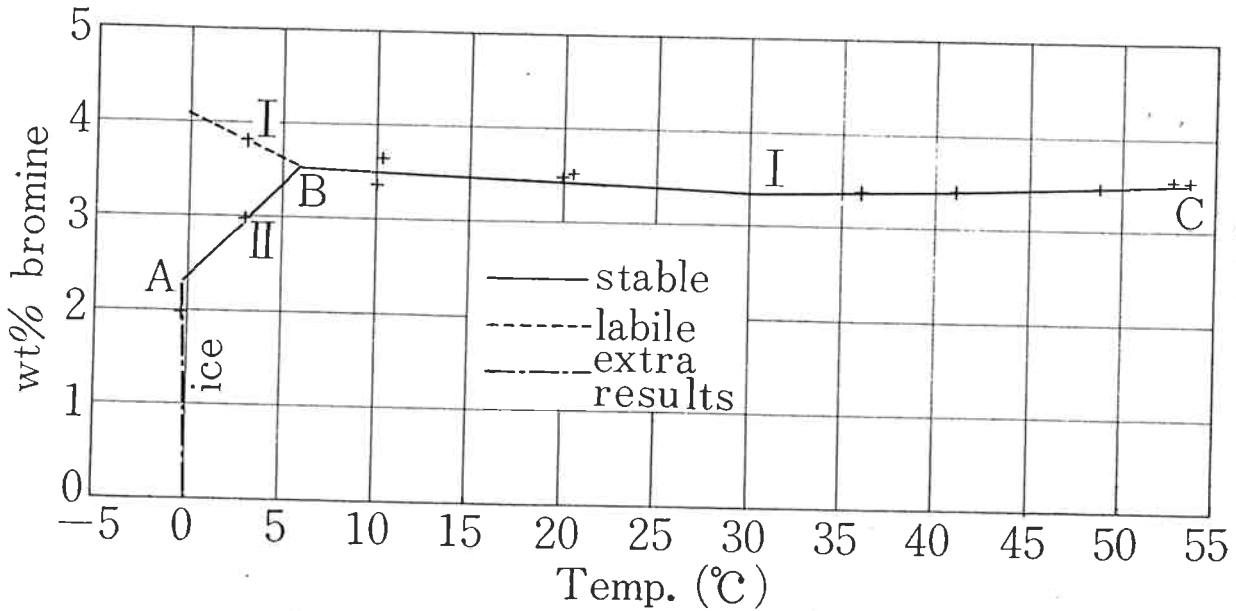


Fig. 1³⁾ Curve I : Br-conc. on liquid bromine as the bottom-substance
 Curve II : Br-conc. of aqueous solution on bromine hydrate as the bottom-substance. The concentration of bromine in water

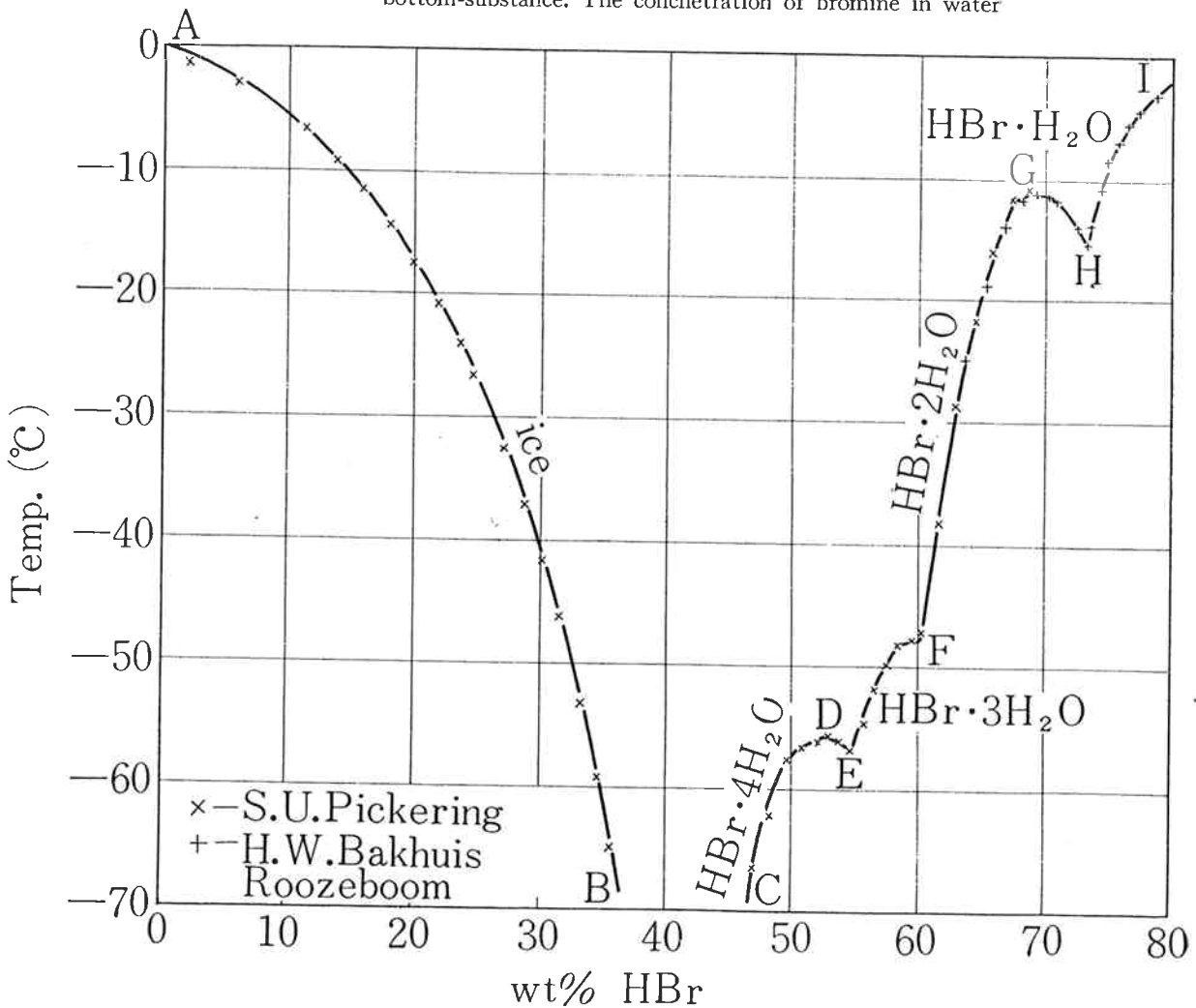


Fig. 2³⁾ The system HBr-H₂O below 0°

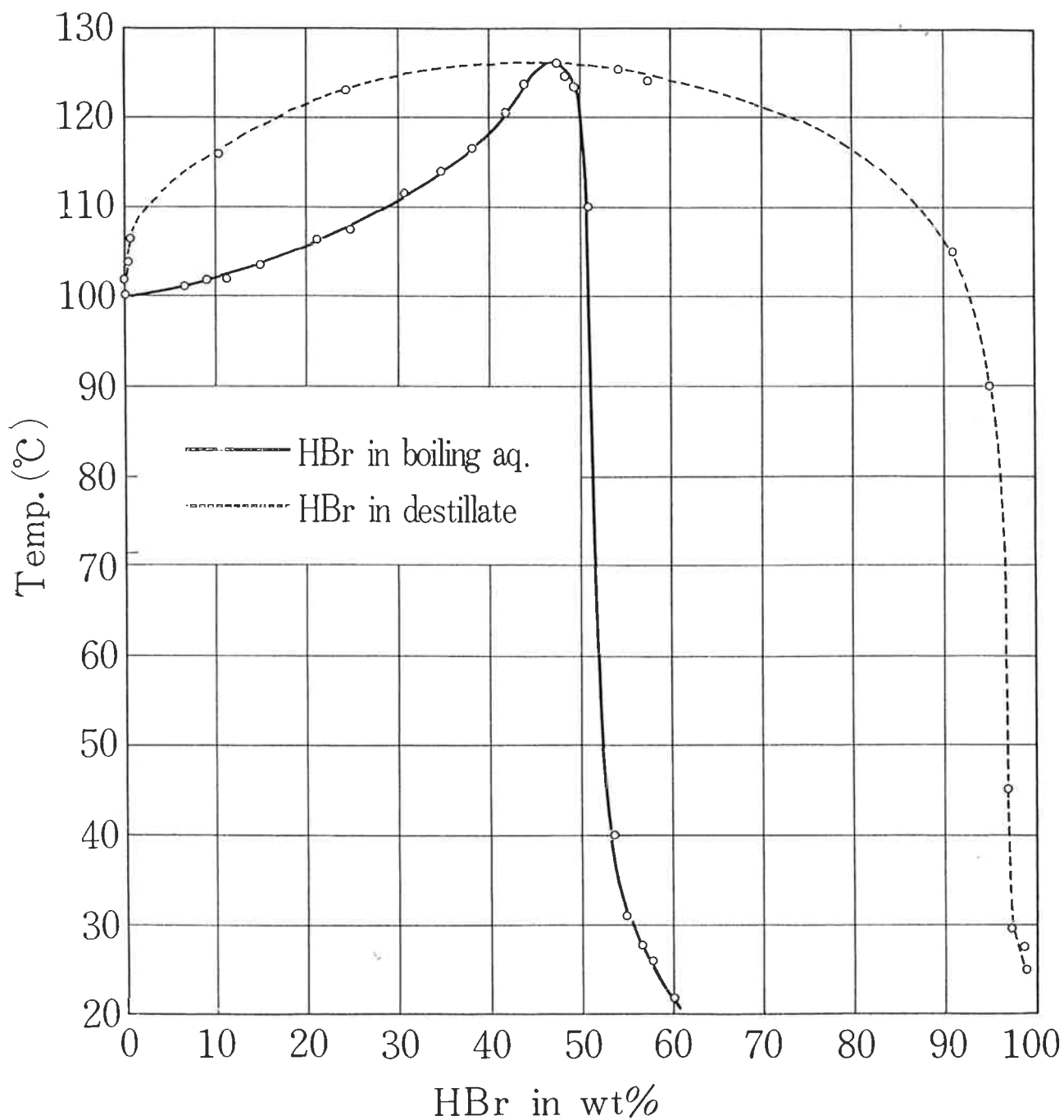


Fig. 3³⁾ HBr-content of boiling aq. solution, and of distillate at various boiling temp. under 760 mm-Hg

文 献

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