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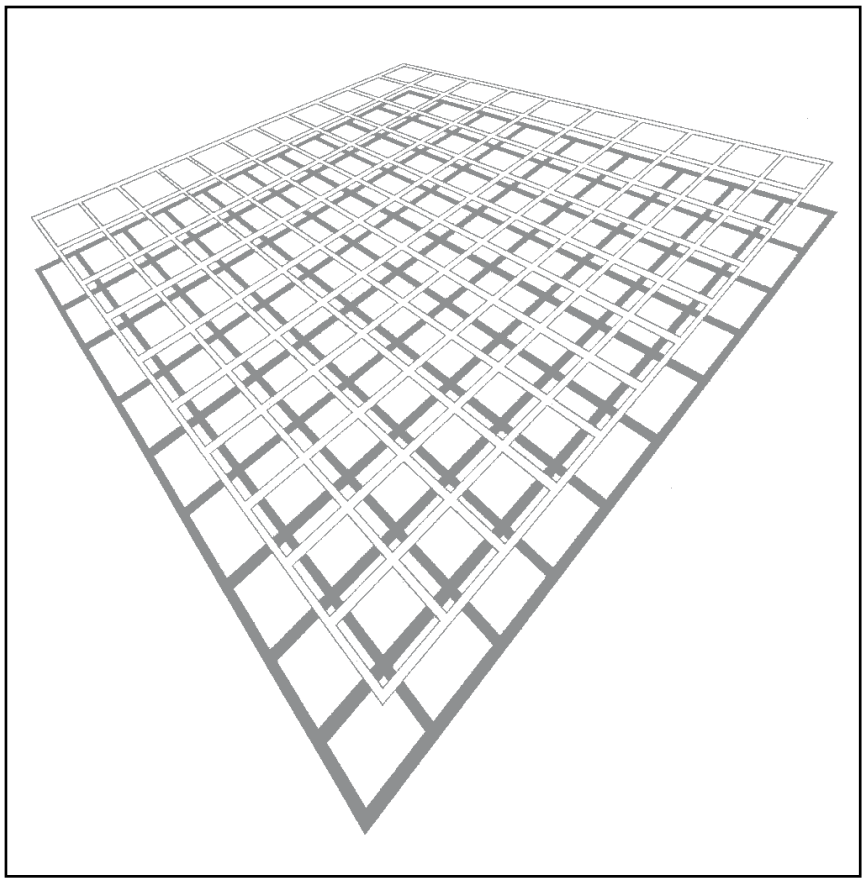
Conductance Data For Commonly Used Chemicals



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CONDUCTANCE DATA FOR COMMONLY USED CHEMICALS

From an analytical point of view, little can be done with a conductance reading, however accurate it may be, unless it can be related to chemical concentration via a table or graph. Much data has been generated in the past 100 years in this area, but a comprehensive gathering of the information in a form useful to industry has been lacking[1]. It is hoped that the following will provide a ready and reasonably accurate reference of conductance values for the majority of electrolytes encountered in industrial situations.

The information is presented in graphical form to permit rapid evaluation of response patterns and to eliminate the time consuming and often impractical (because of non-linearity) extrapolation required in tables with widely separated concentrations. This method of presentation sacrifices the precision gained by listing actual values, but the accuracy retained is more than sufficient for the great majority of industrial uses. The intent has been to provide a useful working tool more so than a scientific reference.

Most of the data presented is the result of extremely careful and accurate laboratory work conducted by various researchers over the years. It is recognized that older sources of information, notably the extensive International Critical Tables, have been found to be slightly inaccurate due to changes in the definition of basic units in recent times as well as to erroneous alignment procedures and measurement techniques. However, with the previously stated area of application in mind, these minor errors are of little significance and may safely be ignored.

A few curves are based on more casual "field condition" observations, and others are derived from data with a low degree of resolution in the original reference. Both will be marked with a single asterisk (*) in the index that follows.

All conductance values have been referenced to a single temperature of 25°C for convenience (isothermal plots are given for selected chemicals of major importance). Much of the original data was presented at this temperature, and all sources fell in the range of 15° to 25°C. Where possible, the temperature correction factor was calculated from isothermal equivalent conductances listed in the International Critical Tables. An average was taken over as wide a range as possible from .5N to 5N and 0-25°C. When such a calculation was not possible, the widely accepted "average" of 2%/°C was used. Temperature factors, of course, will vary in a non-linear manner with respect to both temperature and concentration for many chemicals, but the small size of the adjustments render this of little importance. As the majority of corrections involved differentials of only 5° or 7°C, errors introduced from this source will be small. With this in mind, the final effect of temperature correction error deserves further comment.

The relative conductance values at various concentrations would not be noticeably affected. The error could be approximately but correctly described as relating to the reference temperature rather than conductance. Too much or too little correction simply means that the curve shown is really that seen at 24° or 26° rather than the indicated 25°. It is not anticipated that errors will exceed the $\pm$1° examples given in any except the most unusual cases.

No guarantees of accuracy can be given, but most of the data should easily fall within 5% of the correct absolute value. The choice of curve shape through data points will be a factor in some cases, and it is for this reason that the points were clearly indicated. (Some were omitted in the lower portions of the scale for the sake of clarity.)

[1]An earlier and excellent series of curves was published for this purpose by Industrial Instruments Inc. It provided very detailed data for a half-dozen or so commonly used chemicals, and has been included in the list of reference sources.

NOTES:

1. Concentration is expressed as % by Weight of the anhydrous substance.

2. Conductance units are µmhos/cm.

3. Plotted data points are indicated by circles.

SOURCES OF CONDUCTANCE DATA

1. *International Critical Tables*, Vol. VI, pp. 230-258; McGraw Hill, 1929.

2. *Handbook of Chemistry and Physics*, 55th Edition: CRC Press, 1976.

3. *Lange's Handbook of Chemistry*, 10th and 11 th Editions.

4. Graphs published by Industrial Instruments, Inc.; Cedar Grove, N.J.

5. Previously unpublished laboratory measurements performed at Uniloc, Inc., Irvine, Calif. 1970-1976.

6. Miscellaneous information regarding single electrolytes obtained from various reliable industrial sources.

7. *Electrolyte Solutions*, Robinson and Stokes: Butterworths, 1959.

8. *Electrochemical Data*, Dobos: Elsevier, 1975.

9. *Electrolytic Conductance and the Conductances of the Halogen Acids in Water*, Hamer and DeWane: National Bureau of Standards Publication NSRDS-NBS 33, 1970.

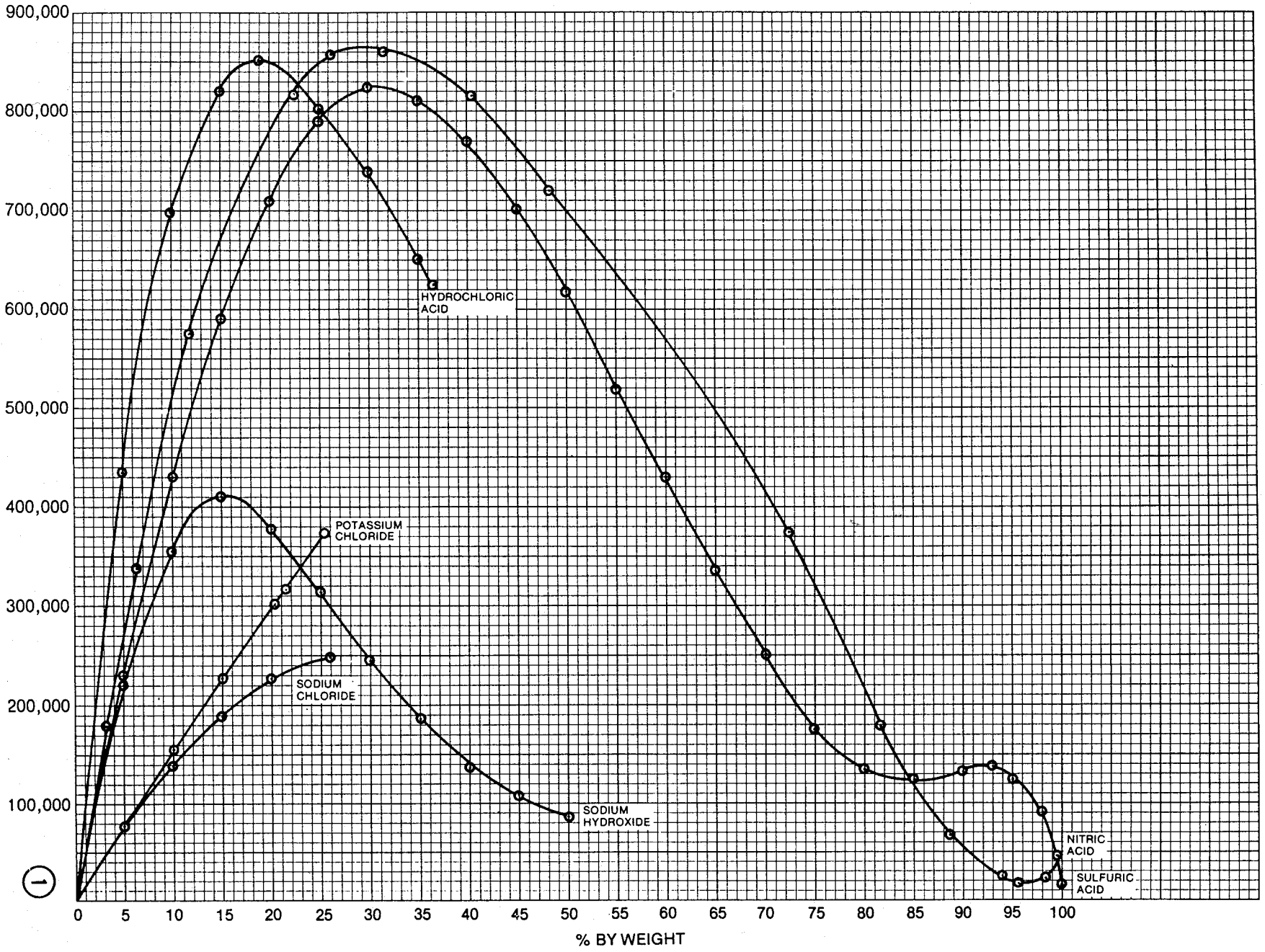
10. *Handbook of Electrochemical Constants*, Parsons: Butterworths/Academic Press, 1959.

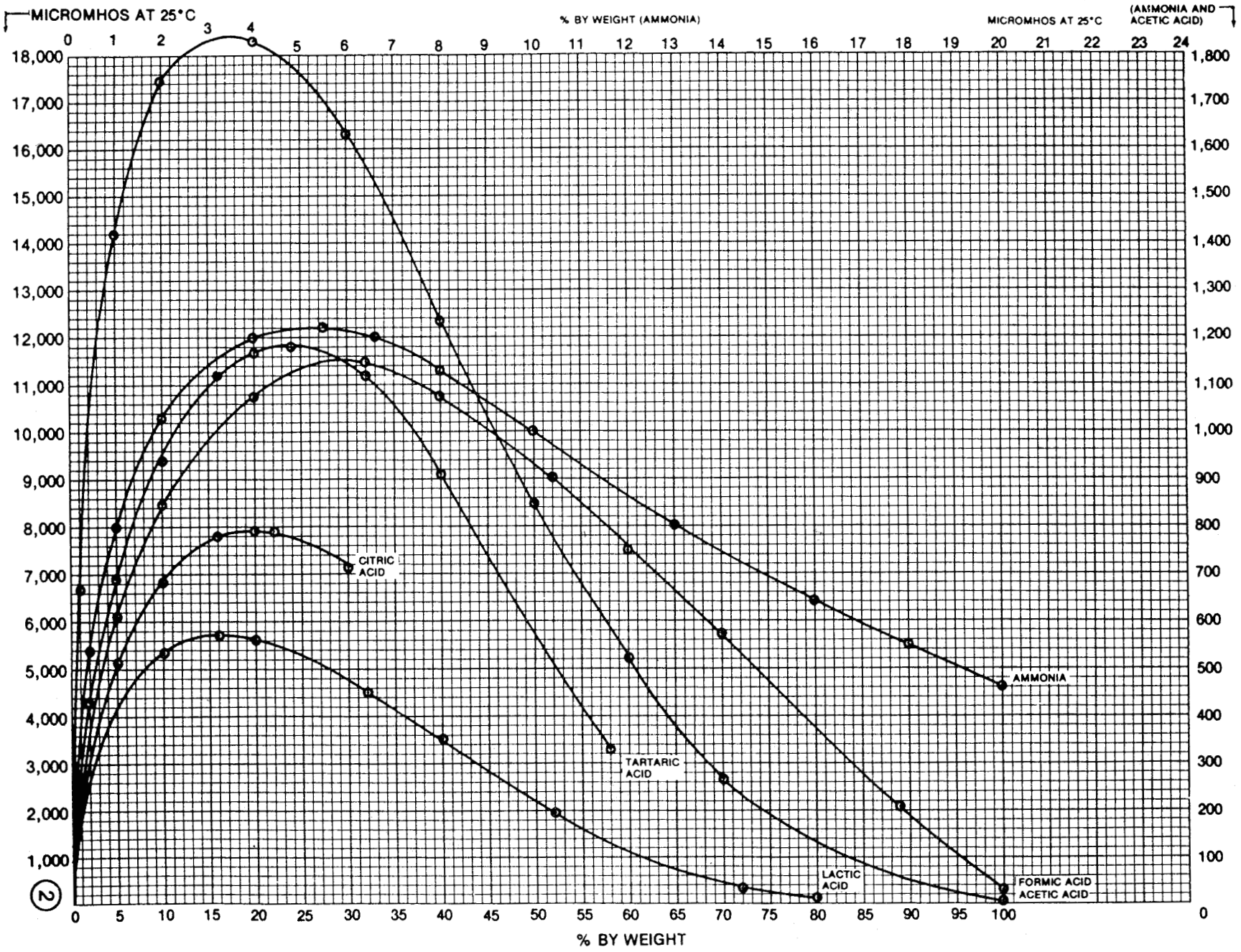
INDEX OF ELECTROLYTES

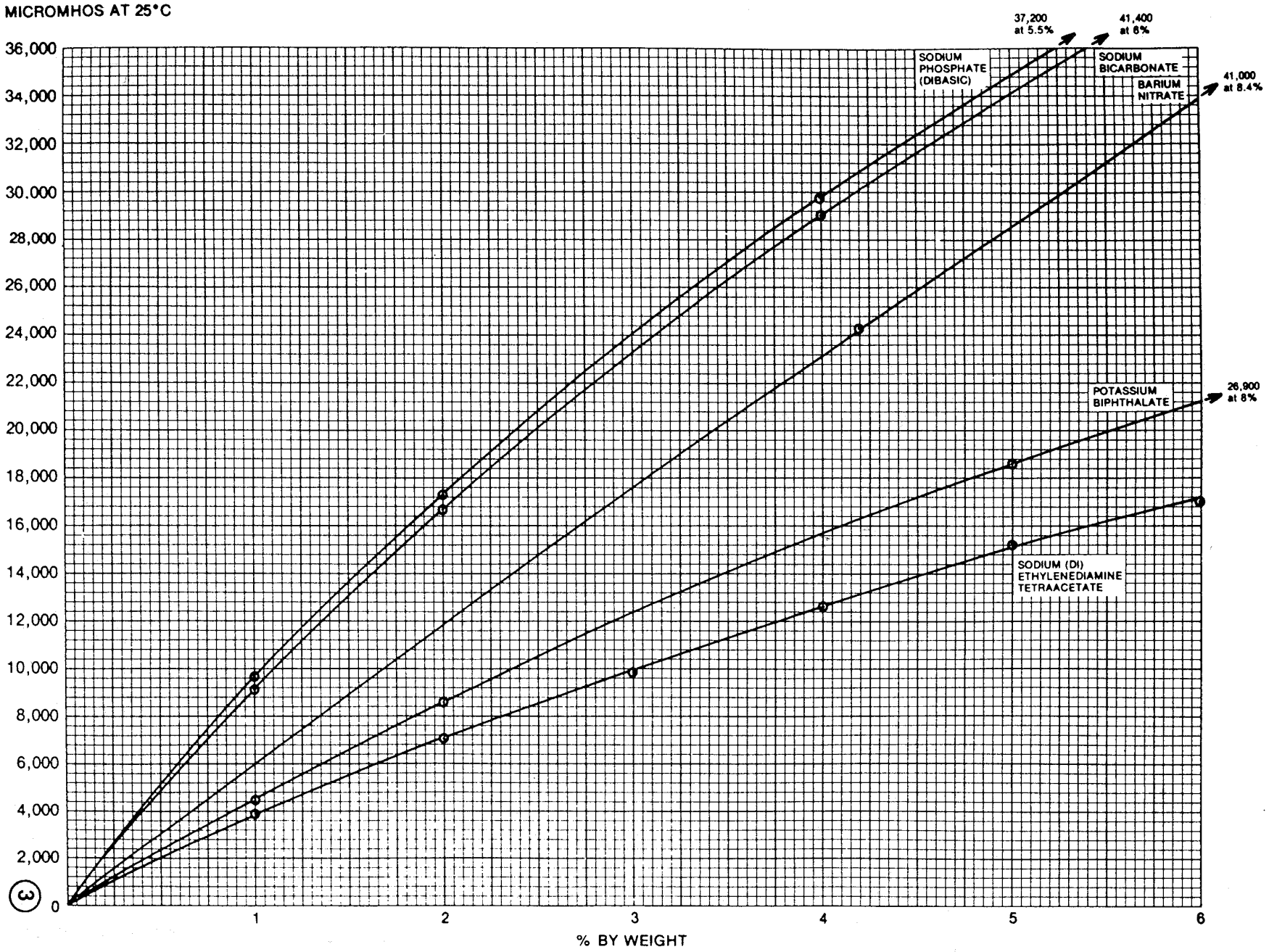
	Substance	Chemical Formula	Maximum conductance and point of inflection at 25°C [µmhos/cm/% by wt.]	Mol. Wt. (Anhydrous)	Graph No.
1.	Acetic acid	CH_3COOH	1,850/17%	60.05	2
2.	Aluminum chloride	$AlCl_3$	—	133.34	6
3.	*Ammonia/Ammonium Hydroxide	NH_3/NH_4OH	1,200/5.5%	17.03/35.05	2
4.	*Ammonium bifluoride	$NH_4F•HF$	—	57.04	7
5.	Ammonium chloride	NH_4Cl	—	53.50	13
6.	Ammonium fluoride	NH_4F	—	37.04	7
7.	Ammonium iodide	NH_4I	—	144.94	14
8.	Ammonium nitrate	NH_4NO_3	—	80.04	13
9.	Ammonium sulfate	$(NH_4)_2SO_4$	—	132.14	11
10.	Ammonium thiocyanate	NH_4SCN	—	76.12	10
11.	Barium chloride	$BaCl_2$	—	208.25	8
12.	*Barium hydroxide	$Ba(OH)_2$	—	171.39	4
13.	*Barium nitrate	$Ba(NO_3)_2$	—	261.38	3
14.	Cadmium bromide	$CdBr_2$	30,000/32%	272.24	9
15.	Cadmium chloride	$CdCl_2$	35,000/22%	183.32	5
16.	Cadmium iodide	CdI_2		366.25	9
17.	Cadmium nitrate	$Cd(NO_3)_2$	108,000/32%	164.10	9
18.	Cadmium sulfate	$CdSO_4$	51,000/27%	208.48	9
19.	Calcium chloride	$CaCl_2$	204,000/24%	110.99	11
20.	Calcium nitrate	$Ca(NO_3)_2$	122,000/25%	164.10	9
21.	Cesium chloride	$CsCl$	—	168.37	13
22.	Chromic acid	CrO_3	670,000/35%	99.99	14
23.	Citric acid	$(COOH)CH_2C(OH)(COOH)•H_2O$	7,900/20%	210.14 (Hyd.)	2
24.	Cobaltous Chloride	$COCl_2$	—	129.84	6
25.	Cupric chloride	$CuCl_2$	108,000/23%	134.45	11
26.	Cupric nitrate	$Cu(NO_3)_2$	134,000/28%	187.55	8
27.	Cupric sulfate	$CuSO_4$	—	159.61	6
28.	(Ethylenediamine) Tetraacetic acid disodium salt, EDTA sodium	$Na_2C_{10}H_{14}O_8N_2•2H_2O$	—	372.24(Hyd.)	3
29.	Ferric chloride	$FeCl_3$	96,000/16%	162.22	9
30.	Ferrous sulfate	$FeSO_4$	53,000/24%	15.94	6
31.	Formic acid	$HCOOH$	11,500/30%	46.03	2
32.	Hydrobromic acid	HBr	—	80.92	14
33.	Hydrochloric acid	HCl	850,000/19%	36.47	1
34.	Hydrofluoric acid	HF	—	20.01	13
35.	Hydroiodic acid	HI	—	127.93	14
36.	Iodic acid	HIO_3	—	175.93	12
37.	Lactic acid	$CH_3CHOH\ COOH$	5,700/15%	90.08	2
38.	Lanthanum nitrate	$La(NO_3)_3$	97,000/28%	324.93	8
39.	Lead (plumbous) nitrate	$Pb(NO_3)_2$	—	331.23	8
40.	Lithium chloride	$LiCl$	190,000/21%	42.40	11
41.	Lithium hydroxide	$LiOH$	380,000/11%	23.95	13
42.	Lithium iodide	LiI	—	133.86	7
43.	Lithium sulfate	Li_2SO_4	83,000/18%	109.95	7
44.	Magnesium chloride	$MgCl_2$	160,000/18%	95.23	11
45.	Magnesium nitrate	$Mg(NO_3)_2$	—	148.34	6
46.	Magnesium sulfate	$MgSO_4$	58,000/17%	120.37	7
47.	Manganous chloride	$MnCl_2$	130,000/20%	125.84	8
48.	Manganous sulfate	$MnSO_4$	51,500/22%	151.00	5
49.	Nickel sulfate	$NiSO_4$	—	154.78	7
50.	Nitric acid	HNO_3	865,000/29%	63.02	1
51.	Oxalic acid	HO_2CCO_2H	—	90.04	4
52.	Phosphoric acid	H_3PO_4	230,000/50%	98.00	12
53.	Potassium acetate	KCH_3CO_2	150,000/32%	98.14	12
54.	Potassium bicarbonate	$KHCO_3$	—	100.12	7

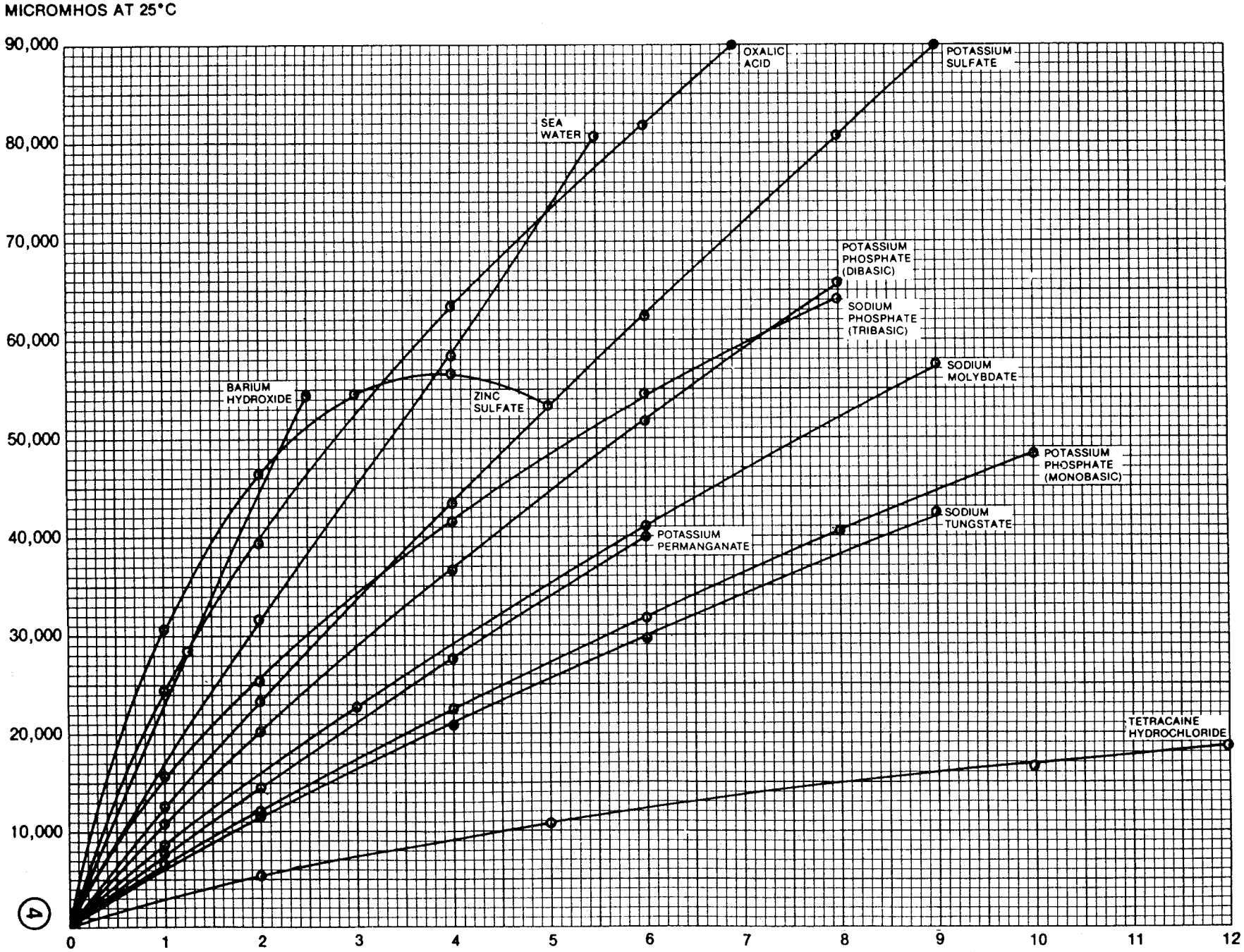
INDEX OF ELECTROLYTES (Continued)

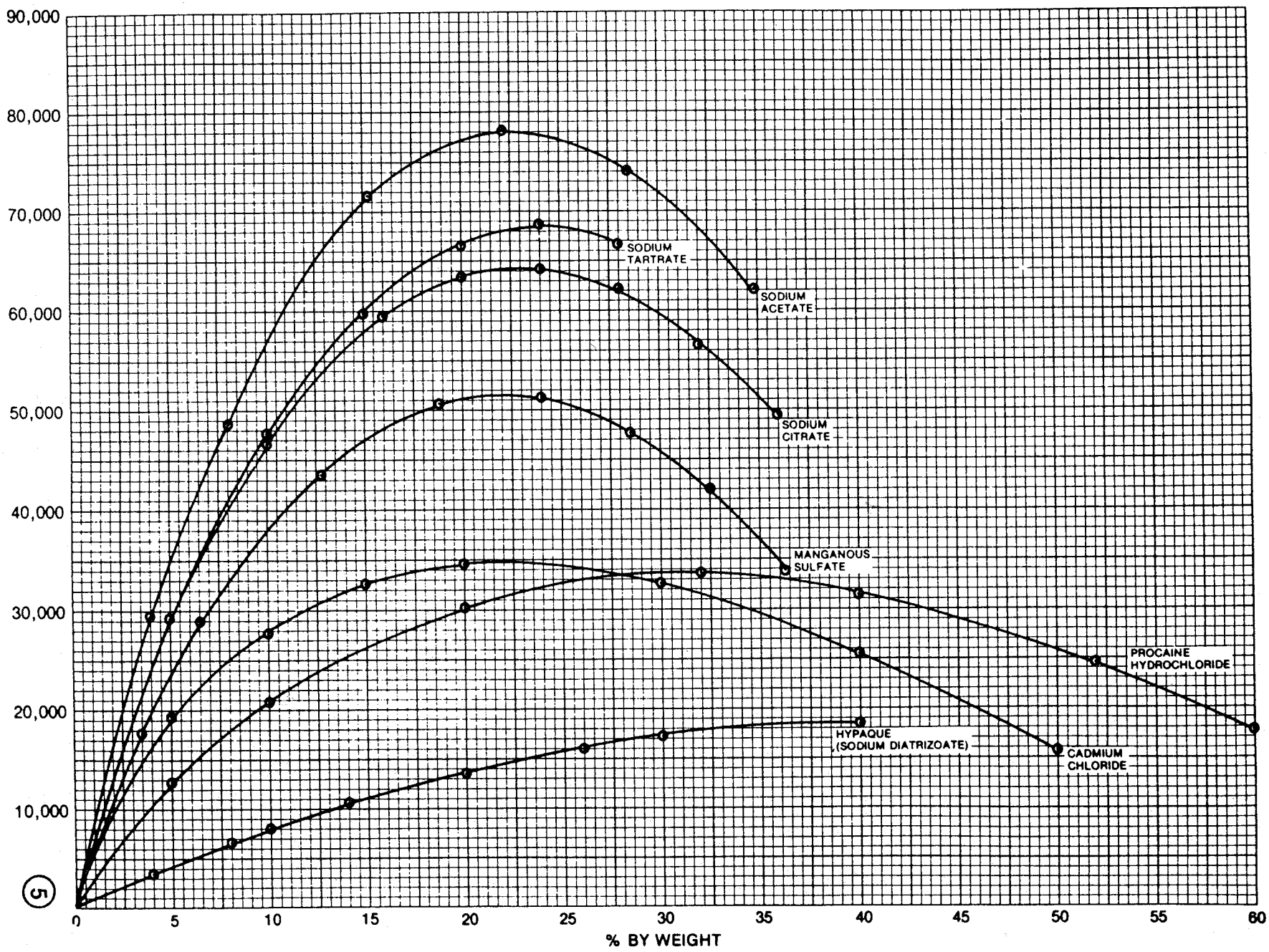
	Substance	Chemical Formula	Maximum conductance and point of inflection at 25°C [µmhos/cm/% by wt.]	Mol. Wt. (Anhydrous)	Graph No.
56.	Potassium bromide	KBr	—	119.01	13
57.	Potassium carbonate	K_2CO_3	258,000/34%	138.21	12
58.	Potassium chloride	KCl	—	74.55	1
59.	Potassium chromate	K_2CrO_4	—	194.20	10
60.	Potassium cyanide	KCN	—	65.11	6
61.	Potassium dichromate	$K_2Cr_2O_7$	—	294.21	6
62.	Potassium ferricyanide	$K_3Fe(CN)_6$	—	329.26	13
63.	Potassium ferrocyanide	$K_4Fe(CN)_6$	—	368.36	6
64.	Potassium fluoride	KF	288,000/34%	58.10	12
65.	Potassium hydroxide	KOH	625,000/26%	56.11	14
66.	Potassium iodide	KI	—	166.03	14
67.	Potassium nitrate	KNO_3	—	101.10	7
68.	Potassium oxalate	$K_2C_2O_4$	—	166.22	7
69.	Potassium permanganate	$KMnO_4$	—	158.04	4
70.	Potassium phosphate (monobasic)	KH_2PO_4	—	136.13	4
71.	Potassium phosphate (dibasic)	K_2HPO_4	—	174.18	4
72.	Potassium sulfate	K_2SO_4	—	174.26	4
73.	Potassium sulfide	K_2S	535,000/30%	110.26	14
74.	Potassium thiocyanate	KSCN	—	97.18	10
75.	Procaine hydrochloride	$C_6H_4[COOCH_2CH_2N(C_2H_5)_2](NH_2)\bullet HCl$-1,4	34,000/32%	272.78	5
76.	Sea water	—	—	—	4
77.	*Silver fluoride	AgF	—	126.88	10
78.	Silver nitrate	$AgNO_3$	—	169.89	12
79.	Sodium acetate	$NaCH_3CO_2$	78,000/22%	82.04	5
80.	Sodium bicarbonate	$NaHCO_3$	—	84.01	3
81.	Sodium bromide	NaBr	—	102.91	10
82.	Sodium carbonate	Na_2CO_3	103,000/19%	106.01	6
83.	Sodium chloride	NaCl	—	58.44	1
84.	Sodium citrate	$Na_3C_6H_5O_7$	64,500/23%	258.07	5
85.	Sodium diatrizoate (Hypaque)	$Na(CH_3CONH)_2C_6I_3CO_2$	18,500/40%	635.92	5
86.	Sodium dichromate	$Na_2Cr_2O_7$	165,000/40%	261.97	9
87.	Sodium ferrocyanide	$Na_4Fe(CN)_6$	—	303.92	10
88.	Sodium hydroxide	NaOH	410,000/15%	40.01	1
89.	Sodium molybdate	Na_2MoO_4	—	205.95	4
90.	Sodium nitrate	$NaNO_3$	—	85.01	11
91.	Sodium phosphate (monobasic)	NaH_2PO_4	60,000/28%	119.97	8
92.	Sodium phosphate (dibasic)	Na_2HPO_4	—	141.98	3
93.	Sodium phosphate (tribasic)	Na_3PO_4	—	163.96	4
94.	Sodium sulfate	Na_2SO_4	—	142.07	7
95.	Sodium sulfide	Na_2S	262,000/15%	78.06	10
96.	Sodium tartrate	$NaOOC(CHOH)_2COONa$	68,500/24%	194.07	5
97.	Sodium thiocyanate	NaSCN	206,000/34%	81.08	12
98.	Sodium thiosulfate	$Na_2S_2O_3$	152,000/29%	158.13	8
99.	Sodium tungstate	Na_2WO_4	—	293.92	4
100.	Strontium chloride	$SrCl_2$	198,000/30%	158.55	11
101.	Strontium nitrate	$Sr(NO_3)_2$	113,000/30%	211.65	8
102.	Sulfuric acid	H_2SO_4	825,000/30%	98.08	1
103.	Tartaric acid	$HO_2C(CHOH)_2CO_2H$	11,800/24%	150.09	2
104.	Tetracaine hydrochloride	$C_{l5}H_{24}N_2O_2\bullet HCl$	—	300.84	4
105.	Trichloracetic acid	CCl_3COOH	—	163.38	10
106.	Zinc chloride	$ZnCl_2$	104,000/27%	136.29	12
107.	Zinc Sulfate	$ZnSO_4$	56,500/4%	161.44	4

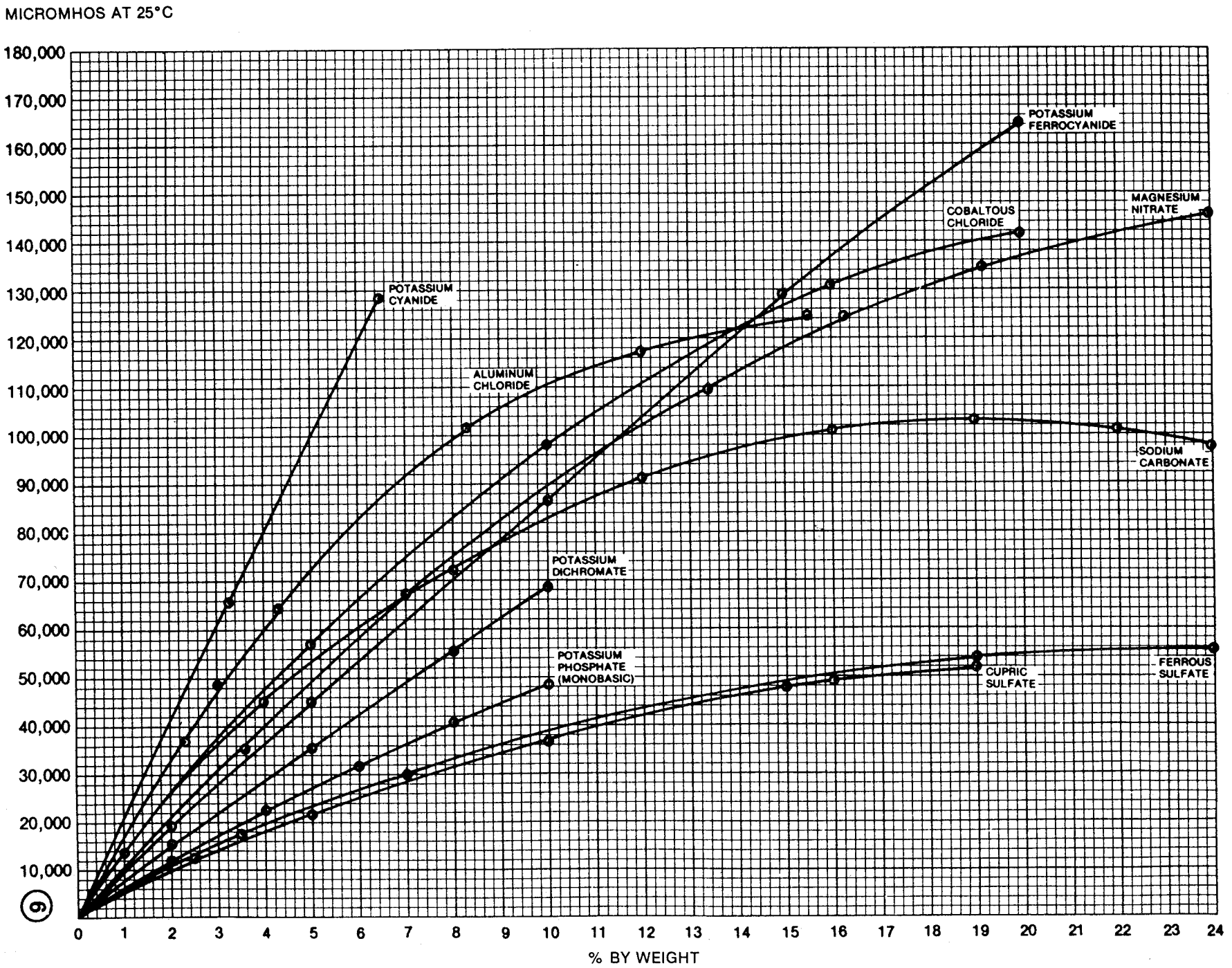

MICROMHOS AT 25°C
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
HYDROCHLORIC ACID
POTASSIUM CHLORIDE
SODIUM CHLORIDE
SODIUM HYDROXIDE
NITRIC ACID
SULFURIC ACID
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
% BY WEIGHT

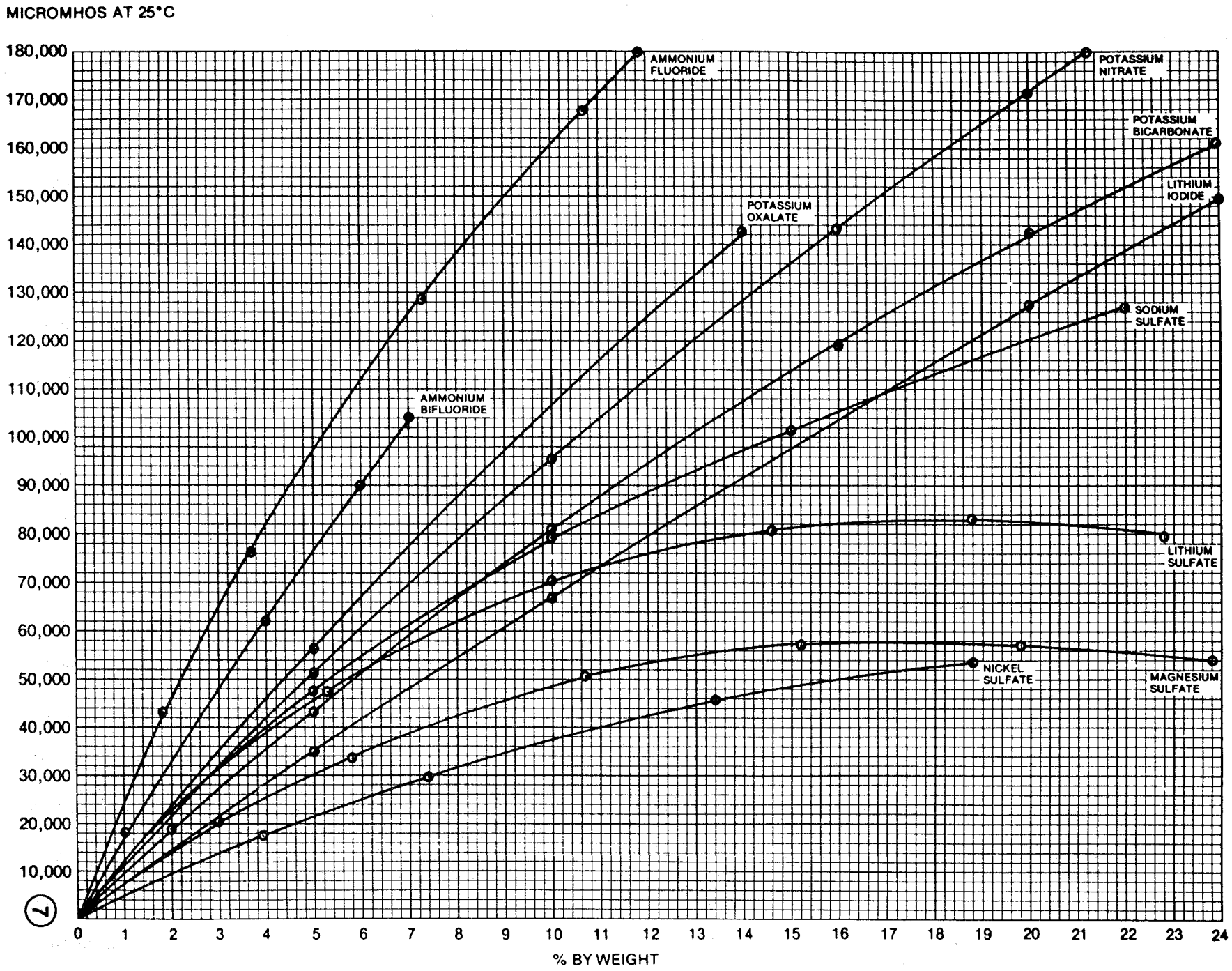

MICROMHOS AT 25°C
% BY WEIGHT (AMMONIA)
MICROMHOS AT 25°C
(AMMONIA AND ACETIC ACID)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
18,000 17,000 16,000 15,000 14,000 13,000 12,000 11,000 10,000 9,000 8,000 7,000 6,000 5,000 4,000 3,000 2,000 1,000
1,800 1,700 1,600 1,500 1,400 1,300 1,200 1,100 1,000 900 800 700 600 500 400 300 200 100 0
CITRIC ACID
TARTARIC ACID
LACTIC ACID
FORMIC ACID
ACETIC ACID
AMMONIA
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
% BY WEIGHT

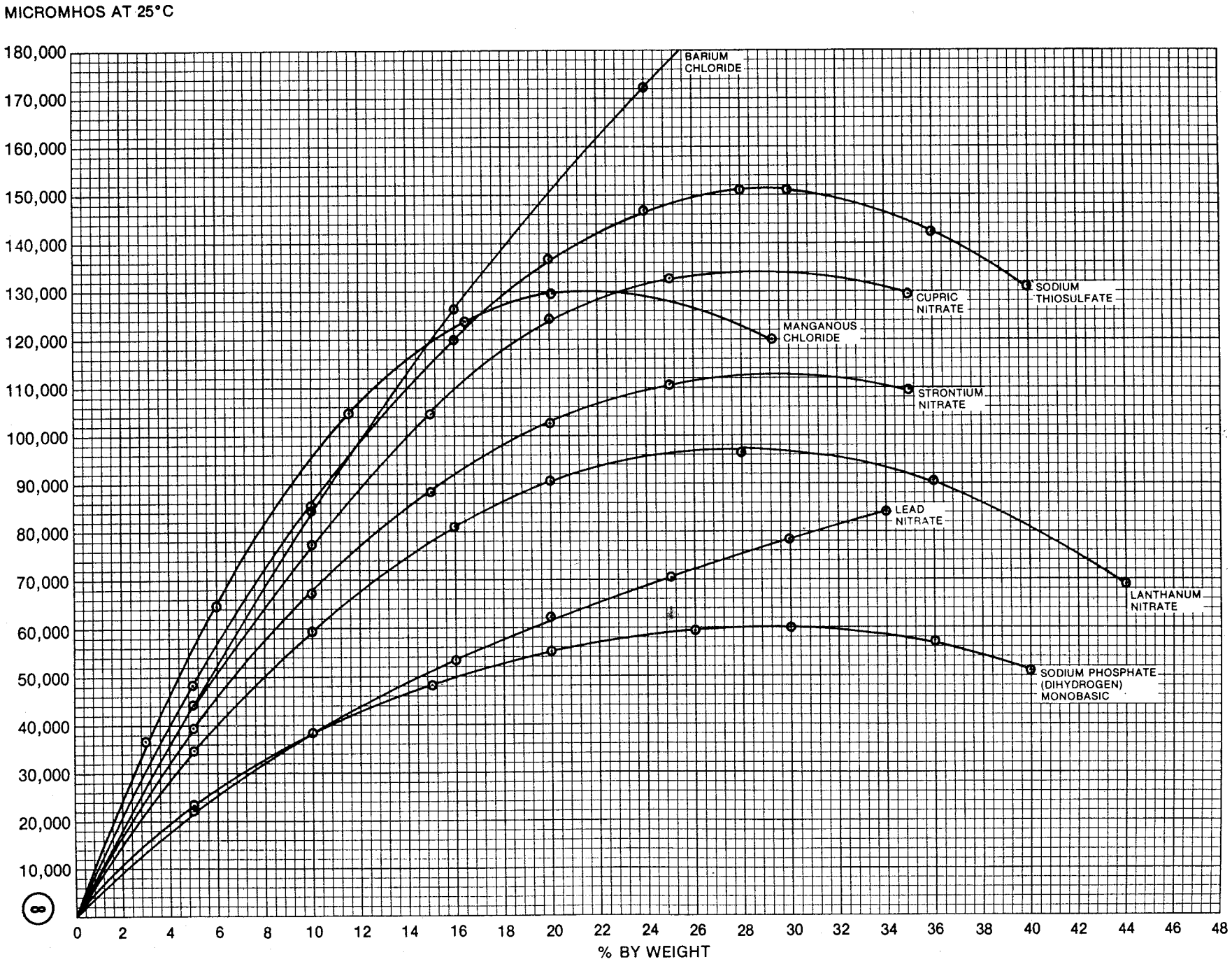

MICROMHOS AT 25°C
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1
2
3
4
5
6
% BY WEIGHT
37,200 at 5.5%
41,400 at 6%
41,000 at 8.4%
26,900 at 8%
SODIUM PHOSPHATE (DIBASIC)
SODIUM BICARBONATE
BARIUM NITRATE
POTASSIUM BIPHTHALATE
SODIUM (DI) ETHYLENEDIAMINE TETRAACETATE

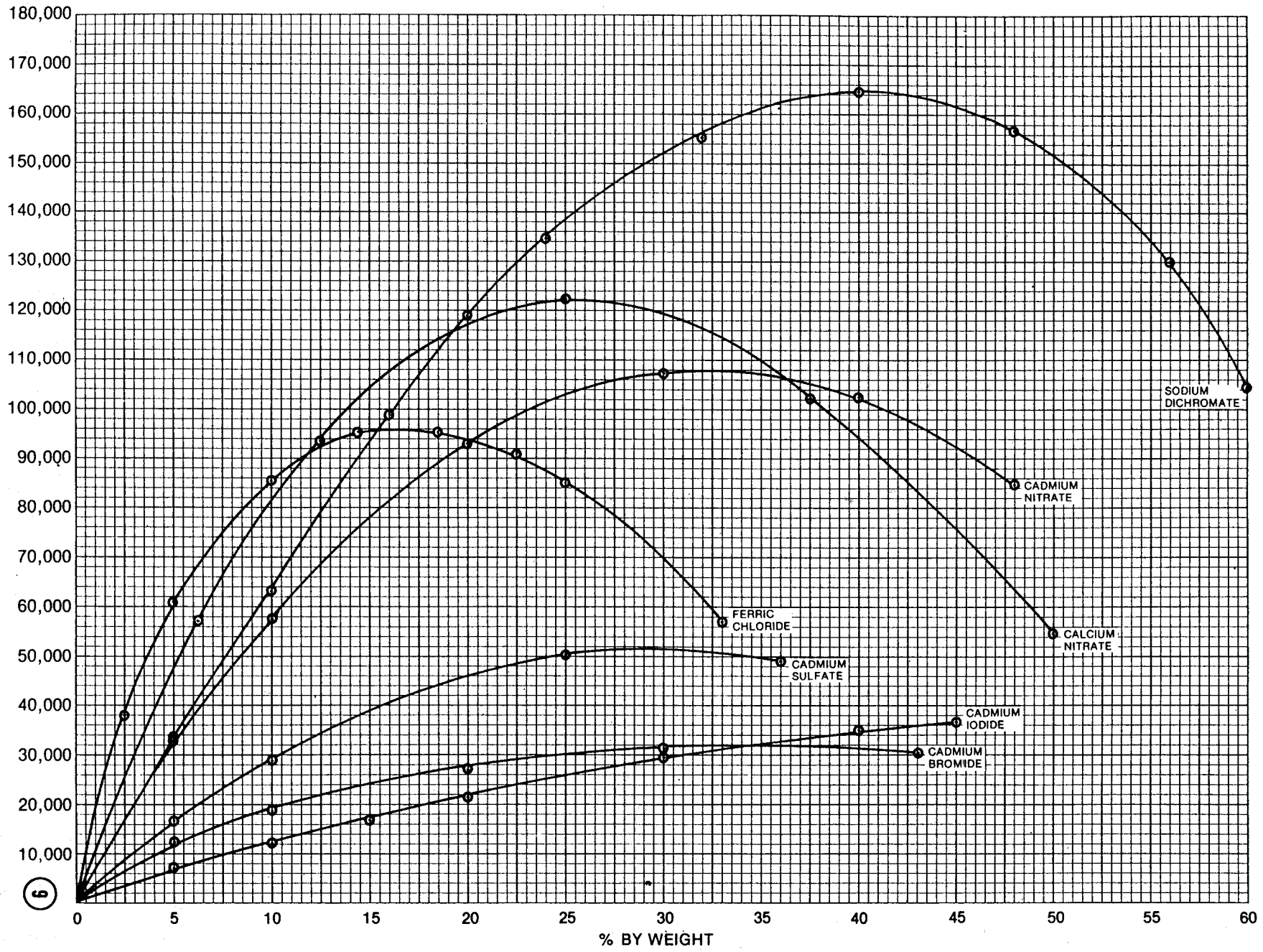

MICROMHOS AT 25°C
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1
2
3
4
5
6
7
8
9
10
11
12
OXALIC ACID
POTASSIUM SULFATE
SEA WATER
POTASSIUM PHOSPHATE (DIBASIC)
SODIUM PHOSPHATE (TRIBASIC)
SODIUM MOLYBDATE
BARIUM HYDROXIDE
ZINC SULFATE
POTASSIUM PHOSPHATE (MONOBASIC)
SODIUM TUNGSTATE
POTASSIUM PERMANGANATE
TETRACAINE HYDROCHLORIDE
4

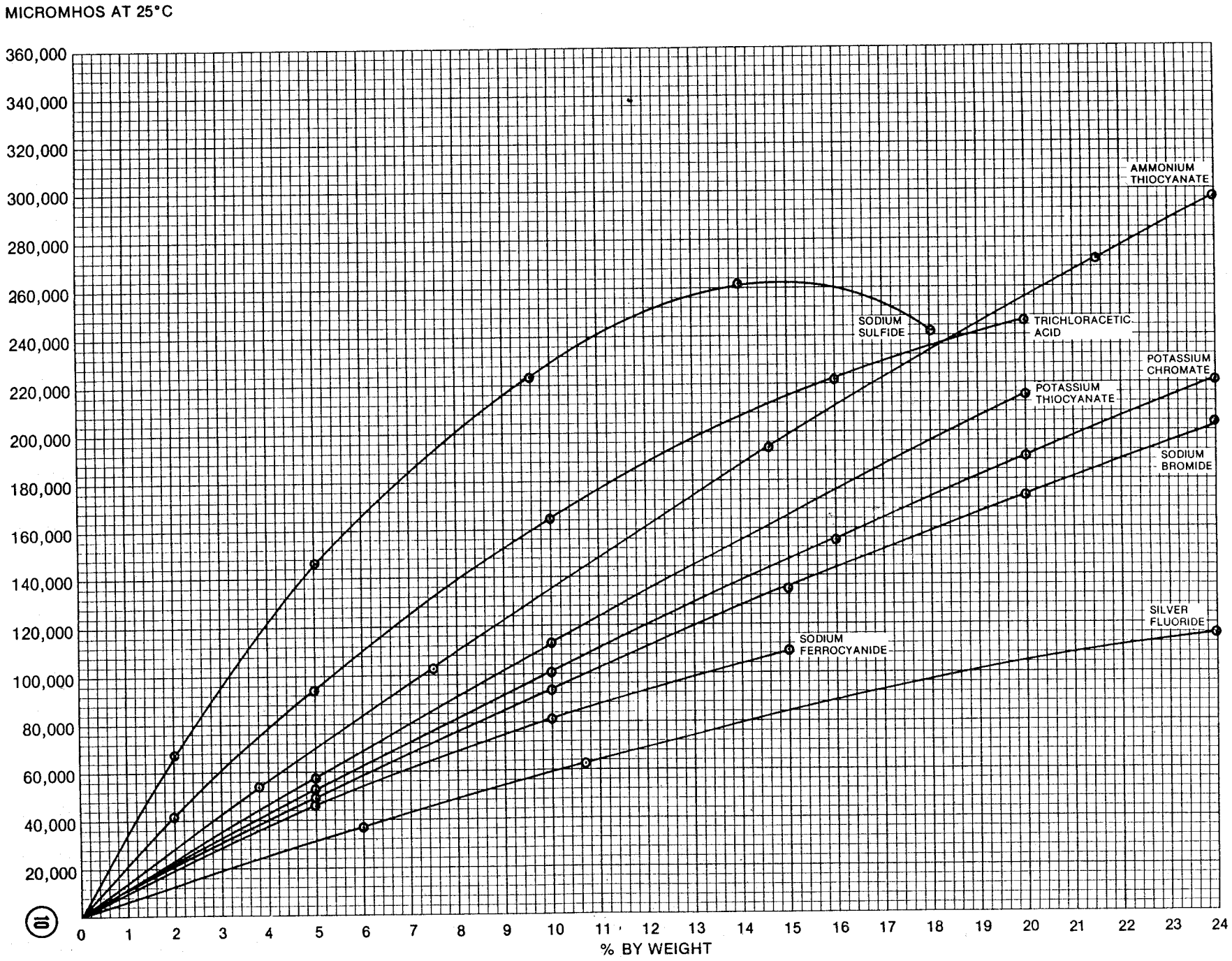

90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
5
10
15
20
25
30
35
40
45
50
55
60
% BY WEIGHT
SODIUM TARTRATE
SODIUM ACETATE
SODIUM CITRATE
MANGANOUS SULFATE
PROCAINE HYDROCHLORIDE
HYPAQUE (SODIUM DIATRIZOATE)
CADMIUM CHLORIDE
5


MICROMHOS AT 25°C
180,000
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
% BY WEIGHT
POTASSIUM FERROCYANIDE
MAGNESIUM NITRATE
COBALTOUS CHLORIDE
POTASSIUM CYANIDE
ALUMINUM CHLORIDE
SODIUM CARBONATE
POTASSIUM DICHROMATE
POTASSIUM PHOSPHATE (MONOBASIC)
CUPRIC SULFATE
FERROUS SULFATE

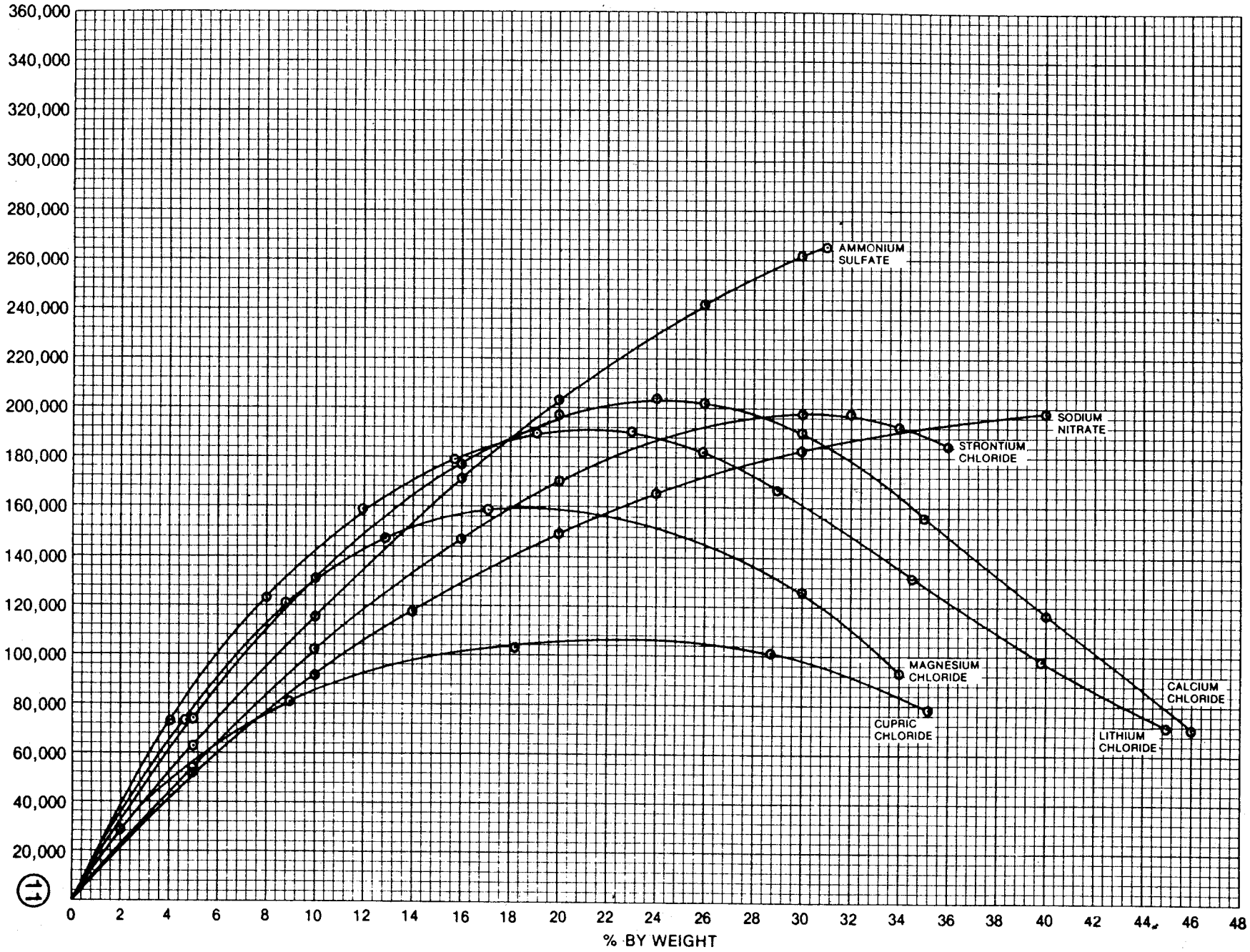

MICROMHOS AT 25°C
180,000
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
% BY WEIGHT
AMMONIUM FLUORIDE
POTASSIUM NITRATE
POTASSIUM BICARBONATE
LITHIUM IODIDE
POTASSIUM OXALATE
SODIUM SULFATE
AMMONIUM BIFLUORIDE
LITHIUM SULFATE
NICKEL SULFATE
MAGNESIUM SULFATE

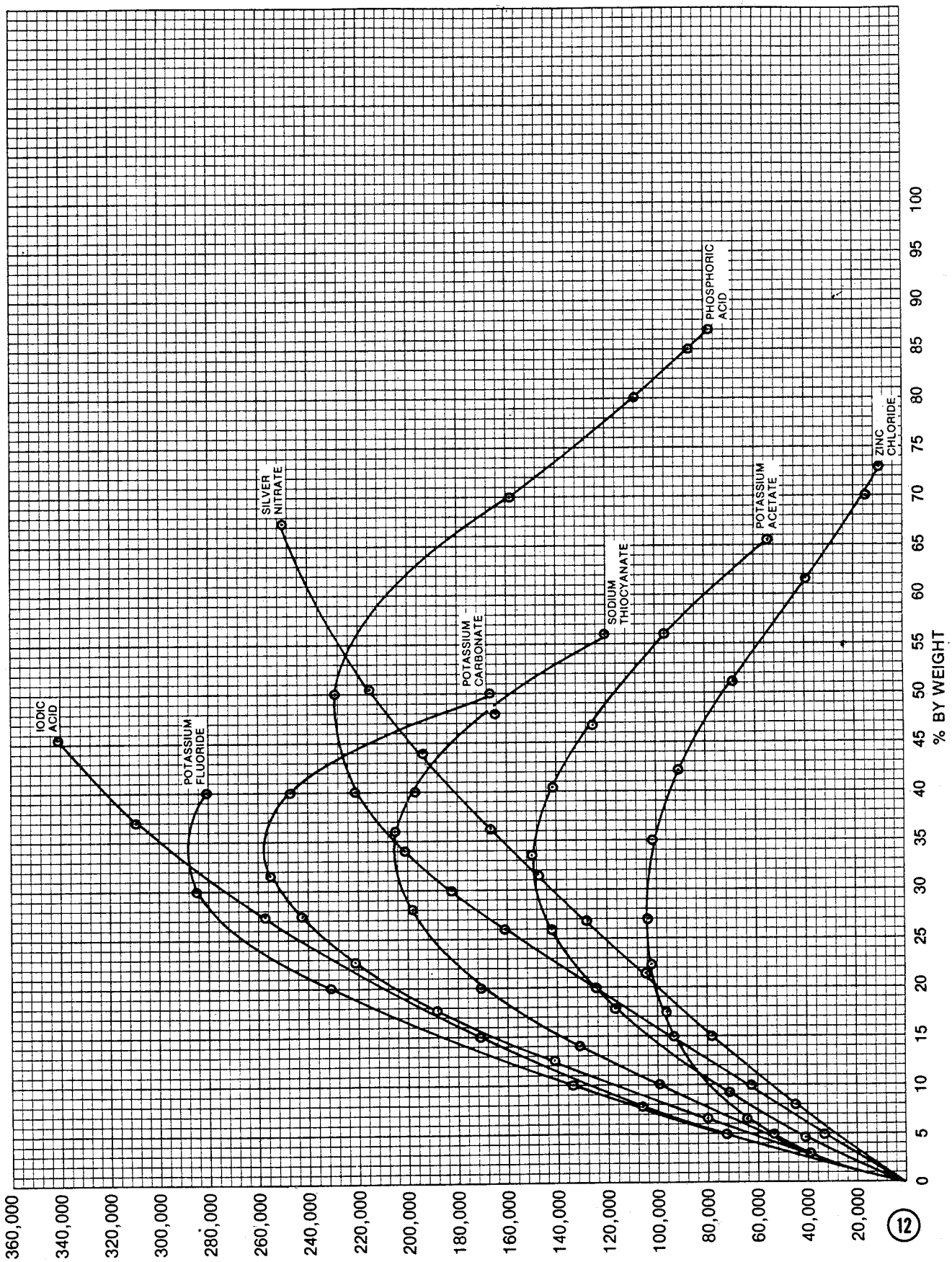

MICROMHOS AT 25°C
180,000
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
% BY WEIGHT
BARIUM CHLORIDE
SODIUM THIOSULFATE
CUPRIC NITRATE
MANGANOUS CHLORIDE
STRONTIUM NITRATE
LEAD NITRATE
LANTHANUM NITRATE
SODIUM PHOSPHATE (DIHYDROGEN) MONOBASIC

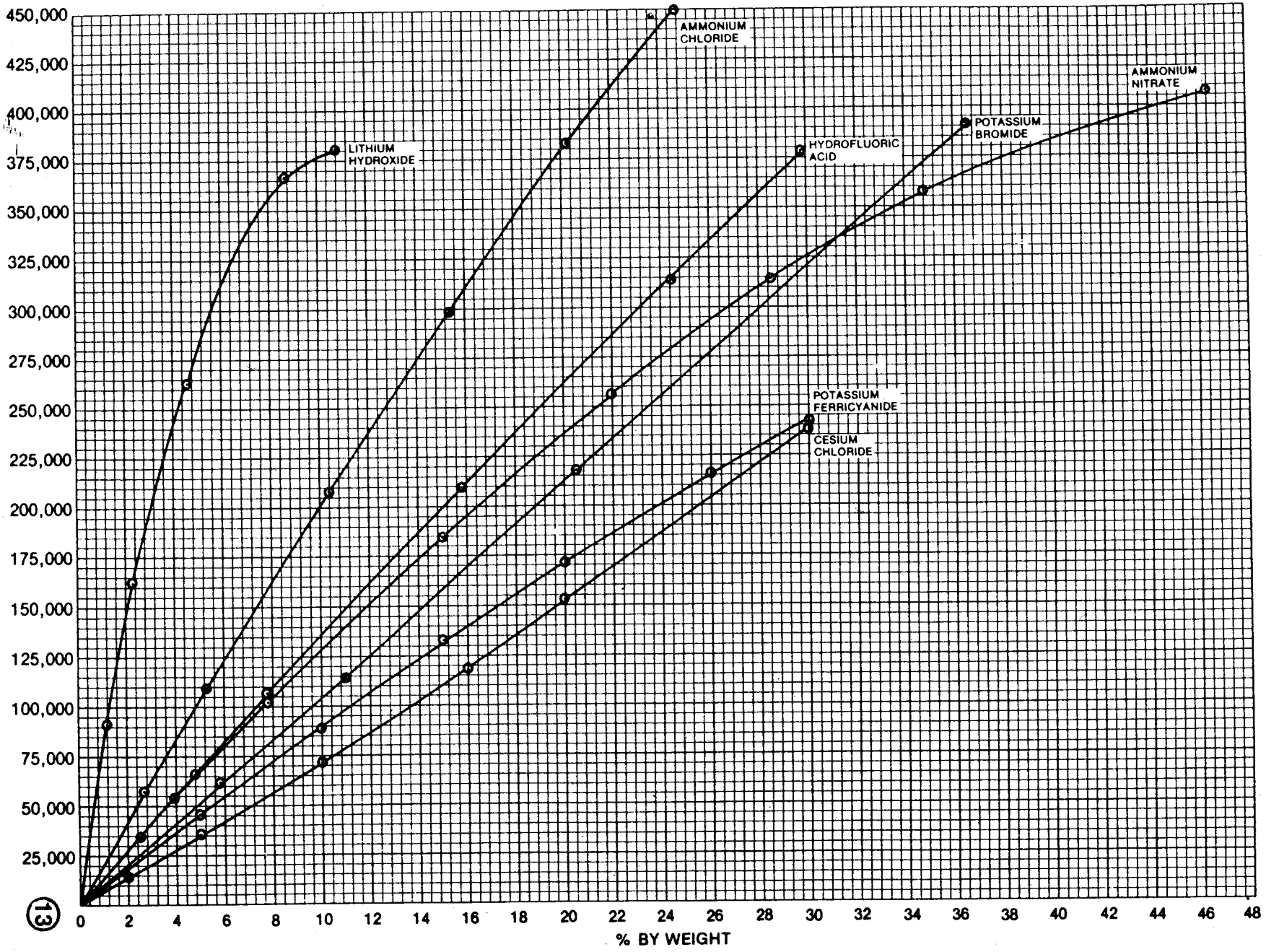

MICROMHOS AT 25°C
180,000
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
5
10
15
20
25
30
35
40
45
50
55
60
% BY WEIGHT
SODIUM DICHROMATE
CADMIUM NITRATE
CALCIUM NITRATE
FERRIC CHLORIDE
CADMIUM SULFATE
CADMIUM IODIDE
CADMIUM BROMIDE
6

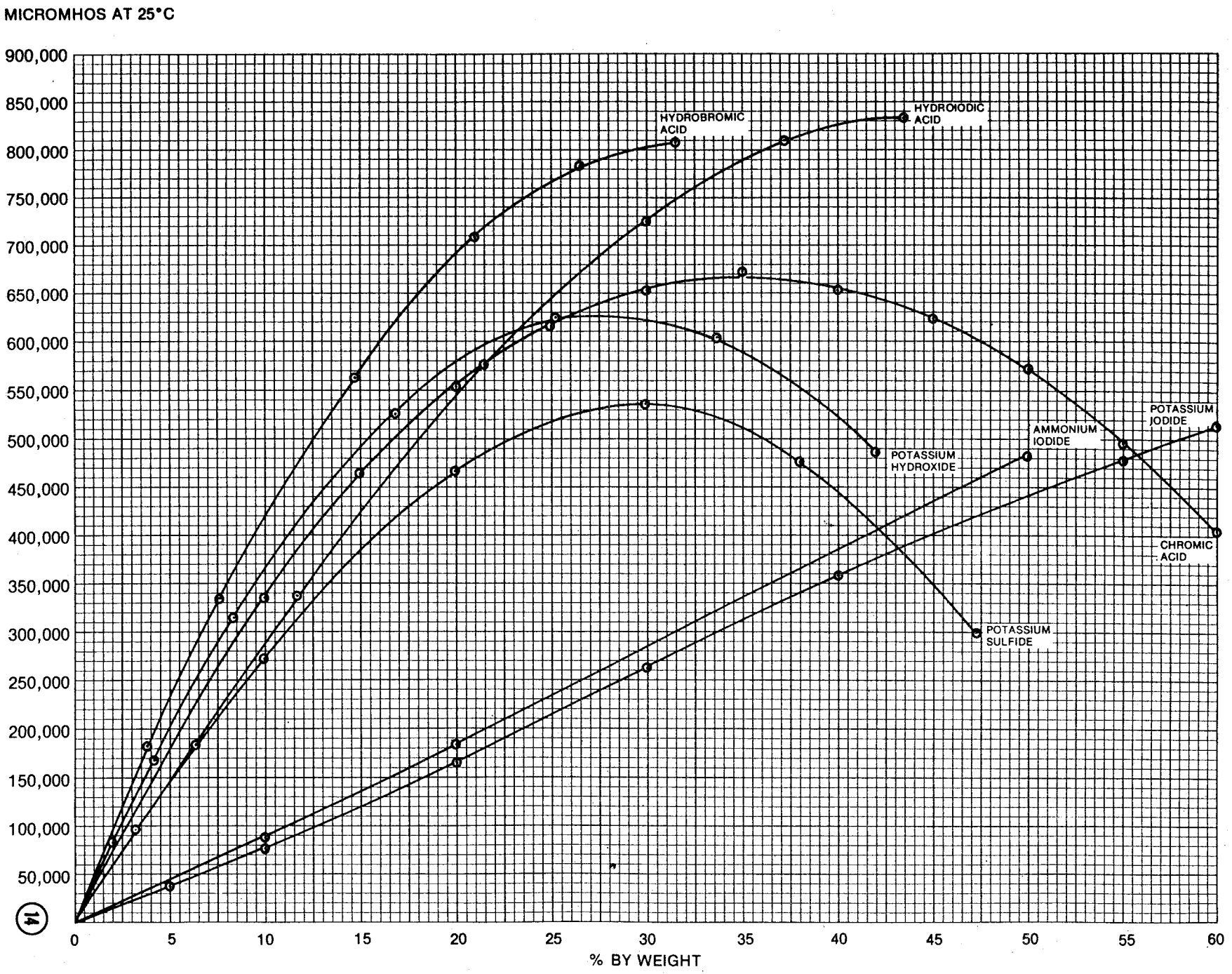

MICROMHOS AT 25°C
360,000
340,000
320,000
300,000
280,000
260,000
240,000
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
% BY WEIGHT
AMMONIUM THIOCYANATE
SODIUM SULFIDE
TRICHLORACETIC ACID
POTASSIUM CHROMATE
POTASSIUM THIOCYANATE
SODIUM BROMIDE
SILVER FLUORIDE
SODIUM FERROCYANIDE

MICROMHOS AT 25°C




MICROMHOS AT 25°C
360,000
340,000
320,000
300,000
280,000
260,000
240,000
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
% BY WEIGHT
IODIC ACID
POTASSIUM FLUORIDE
SILVER NITRATE
POTASSIUM CARBONATE
SODIUM THIOCYANATE
POTASSIUM ACETATE
PHOSPHORIC ACID
ZINC CHLORIDE
12


MICROMHOS AT 25°C
450,000
425,000
400,000
375,000
350,000
325,000
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
% BY WEIGHT
AMMONIUM CHLORIDE
LITHIUM HYDROXIDE
HYDROFLUORIC ACID
POTASSIUM BROMIDE
AMMONIUM NITRATE
POTASSIUM FERRICYANIDE
CESIUM CHLORIDE


MICROMHOS AT 25°C
900,000
850,000
800,000
750,000
700,000
650,000
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
5
10
15
20
25
30
35
40
45
50
55
60
% BY WEIGHT
HYDROBROMIC ACID
HYDROIODIC ACID
POTASSIUM HYDROXIDE
AMMONIUM IODIDE
POTASSIUM IODIDE
CHROMIC ACID
POTASSIUM SULFIDE
14

ELECTRICAL CONDUCTANCE OF SATURATED SOLUTIONS OF SLIGHTLY SOLUBLE ELECTROLYTES (SALTS ARE CORRECTED FOR CONDUCTANCE OF WATER)

(Data from *International Critical Tables,* Vol. VI)

SUBSTANCE	TEMP.°C	SOLUTION µMHOS/CM	SUBSTANCE	TEMP.°C	SOLUTION µMHOS/CM
AgBr	21.1	0.075	HgCl	24.6	2.13
$AgBrO_3$	19.9	663.24	HgI_2	18.0	0.2 (?)
$AgCH_3COC(CN)CO_2C_2H_5$	25.0	251.5	$La(IO_3)_3•3H_2O$	25.0	692
AgCl	25.0	1.794	$La2(C_2O_4)_3•10H_2O$	25.0	953
AgCN	20.0	19.0	$La_2(C_4H_4O_6)_3•3H_2O$	25.0	58.5
$Ag_2C_2O_4$	25.0	35.97	$Li_2PO_3•3.5H_2O$	25.0	274
Ag_2CrO_4	25.0	26.61	$Li_3PO_4•0.5H_2O$	25.0	937
AgI	20.8	0.002	MgC_2O_4	18.0	199.3
$AgIO_3$	25.0	101.27	$MgCO_3$	25.9	885.1
$AgONC(CN)CO_2C_2H_5$	25.0	234.6	MgF_2	27.0	270.7
$AgONC(CN)CO_2CH(CH_3)_2$	25.0	131.8	$Mn(OH)_2$	18.0	9.49
$AgOOCCH_3$	25.0	4,975	$Nd_2(C_2O_4)_3•10H_2O$	25.0	0.764
AgOH	24 9	35.944	$PbBr_2$	20.0	3,692
Ag_3PO_4	19.5	6.1	$Pb(BrO_3)_2$	19.9	4,630.4
AgSCN	20.0	0.096	$PbCO_3$	20.0	1.39
Agn-Propionate	25.0	1,924	PbC_2O_4	22.0	1.54
Agdl-Tartratc	25.0	583.4	$PbCl_2$	20.0	53,540
Ag d-Tartrate	25.0	989	PbF_2	25.0	514
Ag l-Tartrate	25.0	1009	PbI_2	20.1	338.4
Ag p-Toluate	25.0	251.7	$Pb(IO_3)_2$	25.0	8.75
Aragonite	25.0	41.0	$Pb_3(PO_4)_2$	20.0	0.14
Antipyrine Salicylate	18.0	1,000	$Pb(SCN)_2$	20.0	5,346
$BaCO_3$	18.0	25.475	$PbSO_4$	25.0	40.3
$BaCrO_4$	25.0	4.345	$Pr_2(C_2O_4)_3•10H_2O$	25.0	1.164
$BaC_2O_4•?H_2O$	25.0	91.62	$Sa_2(C_2O_4)_3$	25.0	0.82
$BaC_2O_4•2H_2O$	25.0	108.6	SrF_2	25.0	204.6
$BaC_2O_4•3.5H_2O$	18.0	94.91	SrC_2O_4	25.0	70.79
$BaSO_4$	25.0	2.923 (avg.)	$SrSO_4$	25.0	147.4
Barite	25.0	3.517	TlBr	25.0	293.8
$CaCO_3$	25.0	35.97	$TlBrO_3$	19.9	1,079.
$CaC_2O_4•H_2O$	25.0	12.37	TlCl	25.0	2,160.
CaF_2	26.1	50.55	TlC_2O_4	20.0	5,341.
CaF_2 (Fluorite)	25.0	45.81	TlI	25.0	36.64
$CaSO_4•2H_2O$	25 0	2,210	$TlIO_3$	20.0	154.1
$CdC_2O_4•3H_2O$	25.0	36.22	TlSCN	20.0	1,399
$Ce(IO_3)_3•2H_2O$	25.0	636.8	Tl_2S	20.0	216
$Ce2(C_2O_4)_3•10H_2O$	25.0	0.651	$Y_2(C_2O_4)•9H_2O$	25.0	1.74
$Ce_2(C_4H_4O_6)_3•4.5H_2O$	25.0	51.66	$Yb_2(C_2O_4)_3•10H_2O$	25.0	4.849
CuI	24.6	2.128	$ZnC_2O_4•2H_2O$	25.0	10.21
CuSCN	18.0	0.4			
Calcite	25.0	33.8			
Celestite	25.0	147.4			

ELECTRICAL CONDUCTANCE OF VARIOUS PURE LIQUIDS

(Data from *Lange's Handbook of Chemistry, 12th edition*)

LIQUID	TEMP.°C	µMHOS/CM	LIQUID	TEMP.°C	µMHOS/CM
ACETALDEHYDE	15	1.7	DIETHYL OXALATE	25	.76
ACETAMIDE	100	<43	DIETHYL SULFATE	25	.26
ACETIC ACID	25	.0112	DIETHYLAMINE	-33.5	.0022
ACETIC ANHYDRIDE	25	.48	DIMETHYL SULFATE	0	.16
ACETONE	25	.06	EPICHLOROHYDRIN	25	.034
ACETONITRILE	20	7	ETHYL ACETATE	25	< .001
ACETOPHENONE	25	.006	ETHYL ACETOACETATE	25	.04
ACETYL BROMIDE	25	2.4	ETHYL ALCOHOL	25	.00135
ACETYL CHLORIDE	25	.4	ETHYL BENZOATE	25	<.001
ALIZARIN	233	1.45 (?)	ETHYL BROMIDE	25	< .02
ALLYL ALCOHOL	25	7	ETHYL ETHER	25	$< 4x10^{-7}$
AMMONIA	-79	.13	ETHYL IODIDE	25	.02
ANILINE	25	.024	ETHYL ISOTHIOCYANATE	25	.126
ANTHRACENE	230	.0003	ETHYL NITRATE	25	.53
ARSENIC TRIBROMIDE	35	1.5	ETHYL THIOCYANATE	25	1.2
ARSENIC TRICHLORIDE	25	1.2	ETHYLAMINE	0	.4
BENZALDEHYDE	25	.15	ETHYLENE BROMIDE	19	<.0002
BENZENE	—	.076	ETHYLENE CHLORIDE	25	.03
BENZOIC ACID	125	.003	ETHYLIDENE CHLORIDE	25	<.17
BENZONITRILE	25	.05	EUGENOL	25	.17
BENZYL ALCOHOL	25	1.8	FORMAMIDE	25	4
BENZYL BENZOATE	25	<.001	FORMIC ACID	25	64
BENZYLAMINE	25	<.017	FURFURAL	25	1.5
BROMINE	17.2	1.3×10^{-7}	GALLIUM	30	36,800 mhos
BROMOBENZENE	25	<.00002			
BROMOFORM	25	<.02	GERMANIUM TETRABROMIDE	30	78
CAPRONITRILE	25	3.7	GLYCEROL	25	.064
CARBON DISULFIDE	1	7.8×10^{-12}	GLYCOL	25	.3
CARBON TETRACHLORIDE	18	4×10^{-12}	GUAIACOL	25	.28
CHLORINE	-70	$<1 \times 10^{-10}$	HEPTANE	20	$<1x10^{-7}$
CHLOROACETIC ACID	60	1.4	HEXANE	18	$<1x10^{-12}$
CHLOROFORM	25	<.02	HYDROGEN BROMIDE	-80	.008
CHLOROHYDRIN	25	.5	HYDROGEN CHLORIDE	-96	.01
CYANOGEN	-	<.007	HYDROGEN CYANIDE	0	3.3
CYMENE	25	<.02	HYDROGEN IODIDE	-35	.2
DICHLOROACETIC ACID	25	.07	HYDROGEN SULFIDE	-60	.00001
DICHLOROHYDRIN	25	12	IODINE	110	.00013
DIETHYL CARBONATE	25	.017	iso-BUTYLALCOHOL	25	.08

ELECTRICAL CONDUCTANCE OF VARIOUS PURE LIQUIDS

(Data from *Lange's Handbook of Chemistry, 12th edition*)

LIQUID	TEMP.°C	µMHOS/CM
KEROSENE	25	<.017
m-CHLOROANILINE	25	.05
m-CRESOL	25	<.017
MERCURY	0	10,629.6 mhos
METHYL ACETATE	25	3.4
METHYL ALCOHOL	18	.44
METHYL IODIDE	25	<.02
METHYL NITRATE	25	4.5
METHYL THIOCYANATE	25	1.5
METHYLETHYL KETONE	25	.1
NAPTHALENE	82	.0004
NITROBENZENE	0	.005
NITROMETHANE	18	.6
NONANE	25	<.017
o- or m- NITROTOLUENE	25‘	<.2
OLEIC ACID	15	<.0002
PENTANE	19.5	<.0002
PETROLEUM	—	3×10^{-7}
PHENETOLE	25	<.017
PHENOL	25	<.017
PHENYL ISOTHIOCYANATE	25	1.4
PHOSGENE	25	.007
PHOSPHORUS	25	.4
PHOSPHORUS OXYCHLORIDE	25	2.2
PINENE	23	<.0002
PIPERIDENE	25	< .2
PROPIONALDEHYDE	25	.85
PROPIONIC ACID	25	<.001
PROPIONITRILE	25	< .1
n-PROPYL ALCOHOL	25	.02
iso-PROPYL ALCOHOL	25	3.5
n-PROPYL BROMIDE	25	< .02
PYRIDINE	18	.053
QUINOLINE	25	.022
SALICYLALDEHYDE	25	.16
STEARIC ACID	80	$< 4 \times 10^{-7}$
SULFONYL CHLORIDE	25	2
SULFUR	115	1×10^{-6}
SULFUR	130	5×10^{-5}
SULFUR	440	.12
SULFUR DIOXIDE	35	.015
SULFURIC ACID	25	10000
SULFURYL CHLORIDE	25	.03
TOLUENE	—	$< 1 \times 10^{-8}$
o-TOLUIDINE	25	< 2
p-TOLUIDINE	100	.062
TRICHLOROACETIC ACID	25	.003
TRIMETHYLAMINE	-33.5	.00022
TURPENTINE	—	2×10^{-7}
iso-VALERIC ACID	80	$<4 \times 10^{-7}$
WATER	18	.044
XYLENE	—	1.43×10^{-11}

SUMMARY OF FORMULAE, CONVERSION DATA AND MISCELLANEOUS INFORMATION

1. To obtain the conductance at temperatures other than reference when the temperature coefficient is known:

$C_T = C_R [1 + tc (T - T_R)]$ for the general case.

$C_T = C_R [1 + tc (T - 25)]$ for 25°C reference.

T = temperature of interest — T_R = reference temperature

tc = temperature coefficient — C_T = conductivity at temperature of interest

C_R = conductivity at reference — C_{25} = conductivity at 25°C

2. To obtain the conductance at 25°C when conductance values at two other temperatures are known:

$$C_{25} = [C_{T2}(T_1 - 25) - C_{T1}(T_2 - 25)]/(T_1 - T_2)$$

3. To obtain the temperature coefficent, referenced to 25°C, when the conductance at any two temperatures is known:

$$tc = (C_{T1} - C_{T2})/[C_{T2}(T_1 - 25) - C_{T1}(T_2 - 25)]$$

4. Centigrade - Fahrenheit conversion:

$$°C = 5/9(°F - 32) \quad °F = 9/5(°C) + 32$$

A rule-of-thumb method for making the conversion is to recall the easily remembered values at freezing and boiling, and that a change of 5°C is matched by a change of 9°F. Thus, 35°C is seven "increments" above freezing. Multiply the seven by the Fahrenheit "increments" of 9 to obtain a Fahrenheit reading that is 63 degrees above freezing, or 95°F.

5. Concentration conversions:

   Multiply the original concentration value by the conversion factor shown.

6. Resistance values to simulate contacting (electrode) sensor:

$$\text{Resistance(ohms)} = \frac{\text{Cell Constant} \times 10^6}{\mu\text{mhos of solution at 25°C}}$$

7. For a 1.0 cell constant:

Conductance, µmhos	Resistance, ohms
1	1,000,000
10	100,000
100	10,000
1,000	1,000
10,000	100
100,000	10
1,000,000	1

Here is an easy way to remember it — there are always a total of six zeros in the conductance/resistance combination for the even decade values shown. So, 100 umhos, having two, will require a resistance with four, which is 10,000 ohms.

FROM	Weight Conc.	Molarity	Molality	Weight%
TO				
Weight Conc.	$\frac{\text{Grams Solute}}{\text{Liter solution}}$	Wm	$\frac{10^3 p\ Wm}{10^3 + C\ Wm}$	10p
Molarity	$\frac{1}{Wm}$	$\frac{\text{Moles solute}}{\text{Liter Solution}}$	$\frac{10^3 p}{10^3 + CWm}$	$\frac{10p}{Wm}$
Molality	$\frac{10^3}{Wm(10^3 p - Wc)}$	$\frac{10^3}{10^3 p - MWm}$	$\frac{\text{Moles Solute}}{\text{1000 Grams Solvent}}$	$\frac{10^3}{Wm(10^2 - W\%)}$
Weight %	$\frac{1}{10p}$	$\frac{Wm}{10p}$	$\frac{10^2 Wm}{10^3 + CWm}$	$\frac{\text{Grams Solute}}{\text{100 Grams Solution}}$
ppm = W% x 10^4		Normality = Molarity x Equivalents per mole		

Wm = Molecular weight of solute (g)
Wc = Weight concentration
M = Molality
p = Solution density (g/cm3)
W% = Weight %
C = Molarity

TABLE OF THE ELEMENTS

NAME	SYMBOL	ATOMIC WEIGHT
Actinium	Ac	(227)
Aluminum	Al	26.9815
Americium	Am	(243)
Antimony	Sb	121.75
Argon	Ar	39.948
Arsenic	As	74.9216
Astatine	At	(210)
Barium	Ba	137.34
Berkelium	Bk	(245)
Beryllium	Be	9.01218
Bismuth	Bi	208.9806
Boron	B	10.81
Bromine	Br	79.904
Cadmium	Cd	112.40
Calcium	Ca	40.08
Californium	Cf	(248)
Carbon	C	12.011
Cerium	Ce	140.12
Cesium	Cs	132.9055
Chlorine	Cl	35.453
Chromium	Cr	51.996
Cobalt	Co	58.9332
Copper	Cu	63.546
Curium	Cm	(247)
Dysprosium	Dy	162.50
Einsteinium	Es	(254)
Erbium	Er	167.26
Europium	Eu	151.96
Fermium	Fm	(253)
Fluorine	F	18.9984
Francium	Fr	(223)
Gadolinium	Gd	157.25
Gallium	Ga	69.72
Germanium	Ge	72.59
Gold	Au	196.9665
Hafnium	Hf	178.49
Helium	He	4.00260
Holmium	Ho	164.9303
Hydrogen	H	1.0080
Indium	In	114.82
Iodine	I	126.9045
Iridium	Ir	192.22
Iron	Fe	55.847
Krypton	Kr	83.80
Lanthanum	La	138.9055
Lawrencium	Lr	(257)
Lead	Pb	207.2
Lithium	Li	6.941
Lutetium	Lu	174.97
Magnesium	Mg	24.305
Manganese	Mn	54.9380
Mendelevium	Md	(256)

NAME	SYMBOL	ATOMIC WEIGHT
Mercury	Hg	200.59
Molybdenum	Mo	95.94
Neodymium	Nd	144.24
Neon	Ne	20.179
Neptunium	Np	237.0482
Nickel	Ni	58.71
Niobium	Nb	92.9064
Nitrogen	N	14.0067
Nobelium	No	(254)
Osmi um	Os	190.2
Oxygen	O	1 5.9994
Palladium	Po	106.4
Phosphorus	P	30.9738
Platinum	Pt	195.09
Plutonium	Pu	239.05
Polonium	Po	210
Potassium	K	39.102
Praseodymium	Pr	140.9077
Promethium	Pm	(147)
Protactinium	Pa	231.0359
Radium	Ra	226.0254
Radon	Rn	(222)
Rhenium	Re	186.2
Rhodium	Rh	102.9055
Rubidium	Rb	85.4678
Ruthenium	Ru	101.07
Samarium	Sm	150.4
Scandium	Sc	44.9559
Selenium	Se	78.96
Silicon	Si	28.086
Silver	Ag	107.868
Sodium	Na	22.9898
Strontium	Sr	87.62
Sulfur	S	32.06
Tantalum	Ta	180.9479
Technetium	Tc	98.9062
Tellurium	Te	127.60
Terbium	Tb	158.9254
Thallium	Tl	204.37
Thorium	Th	232.0381
Thulium	Tm	168.9342
Tin	Sn	118.69
Titanium	Ti	47.90
Tungsten (Wolfram)	W	183.85
Uranium	U	238.029
Vanadium	V	50.9414
Xenon	Xe	131.30
Ytterbium	Yb	173.04
Yttrium	Y	88.9059
Zinc	Zn	65.37
Zirconium	Zr	91.22

CONDUCTANCE IN DILUTE AQUEOUS SOLUTIONS

(Data obtained from *Handbook of Electrochemical, Constants,* Parsons; Academic Press/Butterworths, 1959)

Conductance values at lower concentrations can be approximately determined by use of the following formula:

Specific Conductance at 25°C $\simeq$ 1000 C Ao (1-a $\sqrt{C}$ + bC)

Ao, a and b are obtained from the tables that follow.

$$C = \text{Normality} \simeq \frac{\text{Parts Per million concentration}}{1000 \text{ X Equivalent weight}}$$

The equivalent weight may be obtained from the tables also. The formula is useful for values of C between 0.0001 and 0.1 only. No allowance was made for solution density as it will be near that of pure water at lower concentrations. However, if it is known and greater accuracy is desired, simply multiply the value already calculated for C times the density to obtain a more precise answer. If normality is known, rather than ppm or wt. %, use it directly for C.

Example 1: What is the specific conductance of a 10,000 ppm solution of silver nitrate at 25°C?

$C \simeq 10{,}000/_{(1000 \times 169.89)} = .05886$

Specific Conductance
$\simeq$ 1000 (.05886) (133.3) [(1-.68 $\sqrt{.05886}$ + .35(.05886)]
$\simeq$ 6,713 mhos/cm

How much would density correction affect the reading? The relative density at 10,000 ppm is 1.007 (at 20 C).

$C = 10{,}000\ (1.007)/_{(1000 \times 169\ 89)} =$
.05927 Corrected for density

Specific conductance
$\simeq$ 1000 (.05927) (133.3) [(1-.68 $\sqrt{.05927}$ + .35(.05886)]
$\simeq$ 6,757 mhos

The error due to no density correction was less than 1%.

Example 2: What is the specific conductance of a 0.01 N solution of KCI at 25°C?

Specific Conductance$\simeq$
1000 (.01) (149.8) [1-.63 $\sqrt{.01}$ + .64 (0.1)]
$\simeq$ 1,413 umhos/cm

Because C was given as normality, no density correction is necessary. Referring to the table of conductance values for standard KCI solutions, the measured value at 0.01N is 1411 umhos/cm. The calculated value of 1413 is, thus, in error by less than two-tenths of one percent. Not all calculations will be this close, but this approximation will be more than adequate for most industrial applications.

Specific Conductance (25°C) ≃ 1000 CAo (1-a $\sqrt{C}$ + bC) where .0001 C .1

C = Normality = ppm concentration/(1000 x equivalent weight)

(Multiply ppm x density for greater accuracy.)

Substance	Equivalent Weight	Ao(25°C)	a	b	Min./Max. ppm for use of Formula
$AgMnO_4$	226.81	122	0.72	2.0	20 - 23,000
$AgNO_3$	169.87	133.3	0.68	0.35	16 - 17,000
Ag_2SO_4	155.90	t42	1.30	-3.5	15 - 16,000
$AlBr_3$	88.90	139	1.64	2.2	8 - 9,000
$AlCl_3$	44.45	137.6	1.65	2.0	4 - 5,000
AlI_3	135.90	137.6	1.66	3.1	13 - 14,000
$Al(NO_3)_3$	71.00	129.5	1.72	2.2	7 - 8,000
$BaAc_2$	127.72	104.2	1.59	1.7	12 - 13,000
$BaBr_2$	148.58	141.1	1.28	1.78	14 - 15,000
$Ba(BrO_3)_2$	196.57	118	1.44	1.4	19 - 20,000
$BaCl_2$	104.13	139.5	1.28	1.74	10 - 11,000
BaI_2	195.58	141	1.28	2.7	19 - 20,000
$Ba(MnO_4)_2$	187.61	119	1.42	1.4	18 - 19,000
$Ba(NO_3)_2$	130.68	132	1.34	1.2	13 - 14,000
$Ba(OH)_2$	85.68	256	0.88	0.0	8 - 9,000
$CaBr_2$	99.95	133.0	1.32	2.1	9 - 10,000
$CaCl_2$	55.50	135.6	1.3	1.8	5 - 6,000
$Ca_2Fe(CN)_6$	73.03	118	5.47	11.0	7 - 8,000
$Ca_3[Fe(CN)_6]_2$	90.71	138	3.87	7.2	9 - 10,000
$Ca(NO_3)_2$	82.05	130.0	1.35	2.0	8 - 9,000
$CaSO_4$	68.07	104	2.9	3.6	6 - 7,000
$CdBr_2$	136.11	97	1.73	0.95	13 - 14,000
$CdCl_2$	91.66	104	1.65	0.9	9 - 10,000
CdI_2	183.11	77	2.02	1.38	18 - 19,000
$CdSO_4$	104.23	105	2.89	3.7	10 - 11,000
$CoAc_2$	118.04	90.1	1.74	1.4	11 - 12,000
$CoBr_2$	109.38	126	1.35	1.9	10 - 11,000
$CoCl_2$	64.92	124.5	1.37	1.2	6 - 7,000
$Co(NO_3)_2$	91.47	122.4	1.39	2 0	9 - 10,000
$CoSO_4$	77.50	100	2.07	1.65	7 - 8,000
CsCl	168.40	154.6	0.62	-0.7	16 - 17,000
CsOH	74.96	271	0.45	0.5	7 - 8,000
$CuAc_2$	90.82	60	2.36	2.2	9 - 10,000
$CuBr_2$	71.73	134	1.31	1.6	7 - 8,000
$CuCl_2$	67.22	131	1.33	1.5	6 - 7,000
$Cu(NO_3)_2$	93.78	128.8	1.38	1 7	9 - 10,000
$CuSO_4$	79.80	113	2.79	3.3	7 - 8,000
$FeCl_2$	63.38	137	1.34	1.05	6 - 7,000
$FeSO_4$	75.97	99	2.08	1.7	7 - 8,000
$GdBr_3$	132.33	139.9	1.63	3.2	13 - 14,000
$GdCl_3$	87.87	140	1.63	2.5	8 - 9,000
GdI_3	179.32	139	1.64	4.0	17 - 18,000
HBr	80.92	429.4	0.37	0.35	8 - 9,000
$HBrO_3$	128.92	408	0.37	-5.0	12 - 13,000
HCNS	59.09	404	0.38	0.37	5 - 6,000
HCl	36.46	426.0	0.37	0.38	3 - 4,000
$HClO_3$	84.46	408	0.36	0.4	8 - 9,000
$HClO_4$	100.46	417	0.37	0.4	10 - 11,000
H_2CrO_4	59.01	207	0.97	2.2	5 - 6,000
HI	127.91	428	0.37	0.42	12 - 13,000
HIO_3	175.91	391.2	0.38	-4.7	17 - 18,000
$HMnO_4$	119.95	410	0.38	0.2	11 - 12,000
HNO_3	63.01	420	0.37	0.36	6 - 7,000
KAc	98.15	115.4	0.75	1.3	9 - 10,000

Substance	Equivalent Weight	Ao(25°C)	a	b	Min./Max. ppm for use of Formula
KBr	119.01	151.7	0.62	0.62	11 - 12,000
$KBrO_3$	167.01	129.4	0.69	0.48	16 - 17,000
KCNS	97.18	140.0	0.65	0.63	9 - 10,000
KCl	74.56	149.8	0.63	0.64	7 - 8,000
$KCLO_3$	122.55	138.7	0.66	0.4	12 - 13,000
K_2CrO_4	97.10	156	1.22	1.3	9 - 10,000
KF	58.10	128	0.70	0.5	5 - 6,000
$K_4Fe(CN)_6$	92.09	169	2.48	3.6	9 - 10,000
$K_3Fe(CN)_6$	109.75	167.8	1.56	1.8	10 - 11,000
$K_2Fe(CN)_5NO$	147.07	136.4	1.32	1.9	14 - 15,000
KI	166.01	150.8	0.63	0.62	16 - 17,000
KIO_3	214.00	115	0.53	0.4	20 - 22,000
$KMnO_4$	158.04	136	0.67	0.5	15 - 16,000
KNO_3	101.11	144.5	o.64	0.36	10 - 11,000
KOH	56.11	271	0.45	0.4	5 - 6,000
K_2SO_4	87.14	151.4	1.24	1.14	8 - 9,000
LiBr	86.85	121.4	0.72	0.5	8 - 9,000
LiCl	42.39	115	0.75	0.78	4 - 5,000
$LiClO_3$	90.39	104.1	0.81	0.3	9 - 10,000
Li_2CrO_4	64.93	123.6	1.46	1.5	6 - 7,000
LiI	133.84	117.7	0.74	0.8	13 - 14,000
$LiNO_3$	68.94	111	0.77	0.45	6 - 7,000
LiOH	23.95	236.5	0.48	0.5	2 - 3,000
Li_2SO_4	54.97	119.2	1.48	1.4	5 - 6,000
$MgBr_2$	92.07	129	1.34	2.2	9 - 10,000
$MgCrO_4$	70.15	125	2.64	3.2	7 - 8,000
$Mg_2Fe(CN)_6$	65.14	172	4.75	13	6 - 7,000
$Mg(NO_3)_2$	74.16	129.0	1.35	1.8	7 - 8,000
$Mg(OH)_2$	29.17	257	0.87	2.1	2 - 3,000
$MgSO_4$	60.19	116	2.75	3.7	6 - 6,000
$MnBr_2$	107.38	128	1.34	1.7	10 - 11,000
$MnCl_2$	62.92	126	1.36	1.6	6 - 7,000
$MnSO_4$	75.50	109	2.84	3.8	7 - 8,000
NH_4Br	97.95	155	0.62	0.60	9 - 10,000
NH_4CNS	76.12	140.8	0.65	0.5	7 - 8,000
NH_4Cl	53.49	150.5	0.63	0.49	5 - 6,000
NH_4IO_3	192.94	117	0.74	0	19 - 20,000
NH4Pic	246.14	104.4	0.80	0.9	24 - 25,000
$(NH_4)_2SO_4$	66.07	149.9	1.25	1.1	6 - 7,000
NaAc	82.03	91.1	0.89	0.34	8 - 9,000
NaBr	102.90	126.0	0.70	0.5	10 - 11,000
$NaBrO_3$	150.90	106.1	0.79	0.60	15 - 16,000
NaCNS	81.07	110.5	0.77	0.75	8 - 9,000
Na_2CO_3	53.00	124.1	1.47	1.6	5 - 6,000
NaCl	58.44	126.5	0.70	0.74	5 - 6,000
$NaClO_3$	106.44	115	0.75	0.6	10 - 11,000
$NaClO_4$	122.44	110	0.77	0.6	12 - 13,000
$NaCrO_4$	161.97	132	1.38	1.5	16 - 17,000
NaF	41.99	106	0.79	0.6	4 - 5,000
$Na_4Fe(CN)_6$	75.98	155	2.74	4.7	7 - 8,000
$NaHCO_3$	84.01	96.0	0.85	0.6	8 - 9,000
NaI	149.89	127.0	0.70	0.80	14 - 15,000
$NaNO_3$	84.99	123	0.72	0.36	8 - 9,000
NaOH	40.01	246.5	0.47	0.3	4 - 4,000

Substance	Equivalent Weight	Ao(25°C)	a	b	Min./Max. ppm for use of Formula
NaPic	251.09	81.	0.97	0.7	25 - 26,000
Na_2SO_4	71.02	129.0	1.39	1.50	7 - 8,000
$Na_2S_2O_3$	79.06	135.0	1.36	1.60	7 - 8,000
$NiAc_2$	88.40	89.5	1.75	1.3	8 - 9,000
$NiBr_2$	109.27	127	1.34	1.6	10 - 11,000
$NiCl_2$	64.81	123.3	1.37	1.7	6 - 7,000
$Ni(NO_3)_2$	91.36	124.5	1.37	1.8	9 - 10,000
$NiSO_4$	77.39	100	2.7	1.6	7 - 8,000
$PbCl_2$	139.05	145.0	1.26	-7.0	13 - 14,000
$Pb(NO_3)_2$	165.60	135.7	1.32	0.89	16 - 17,000
RbBr	165.37	148	0.63	0.2	16 - 17,000
RbCl	120.92	153	0.62	0.7	12 - 13,000
RbI	212.37	145.3	0.64	0.65	21 - 22,000
RbOH	102.48	272	0.45	0.5	10 - 11,000
$SnIBr_3$	130.02	140.2	1.63	2.9	12 - 14,000
$SmCl_3$	85.57	139.8	1.64	3.0	8 - 9,000
SmI_3	177.02	138.5	1.64	3.4	17 - 18,000
$SrAC_2$	102.86	101	1.63	2.0	10 - 11,000
$SrBr_2$	123.72	136.0	1.30	1.8	12 - 13,000
$SrCl_2$	79.27	136.0	1.30	1.74	7 - 9,000
$Sr(NO_3)_2$	105.82	131.8	1.34	1.5	10 - 11,000
TlCl	239.82	150.3	0.63	-1.3	23 - 25,000
$TlClO_3$	~87.82	137.6	0.65	0.45	28 - 30,000
TlOH	221.38	276.1	0.45	0.45	22 - 23,000
YBr_3	137.59	141	1.63	2.8	13 - 14,000
YCl_3	65.09	136	1.67	3.5	6 - 7,000
YI_3	156.54	143.8	1.60	2.6	15 - 16,000
$ZnAc_2$	91.73	88	1.77	1.2	9 - 10,000
$ZnBr_2$	112.60	159	1.23	0.7	11 - 12,000
$ZnCl_2$	68.14	130	1.48	2.3	6 - 7,000
$Zn(NO_3)_2$	94.69	125	1.37	2.2	9 - 10,000
$ZnSO_4$	80.72	105	2.90	4.2	8 - 8,000
Me_3HNCl	95.56	123.6	0.71	0.76	9 - 10,000
Me_4NI	201.03	118.6	0.73	0.35	20 - 21,000
Me_4NPic	290.22	76	1.02	0.5	29 - 30,000
Et_4NI	257.15	108	0.78	–.–	25 - 26,000
Et_4NPic	346.34	63	1.18	–.–	34 - 35,000
Pr_4NI	313.27	100	0.83	–.–	31 - 32,000

Ac = Acetate
Et = Ethyl
Me = Methyl
Pic = Picrate
Pr = Propyl

CONDUCTANCE IN DILUTE NON-AQUEOUS SOLUTIONS

(Data obtained from *Handbook of Electrochemical Constants,*
Parsons; Academic Press/Butterworths, 1959)

All comments, formulae, etc. regarding aqueous solutions will apply here as well (except as noted regarding limits for C and temperature).

ACETONITRIDE AT 25°C

Solute	Ao	a	b
$AgNO_3$	150.0	2.28	1.4
KI	181.4	2.02	1.5
$1/3TlBr_3$	140.5	2.39	5.9
$1/3TlCl_3$	170.4	2.09	2.1
Pr_4NClO_4	172.3	2.08	2.4
Pr_4NI	169.6	2.10	10.0
Pr_4NPic	146.3	2.32	14.0
Am_4NI	152.0	2.26	1.0
$CPh_2(p\text{-}C_6H_4OMe)ClO_4$	160.9	2.18	4.0
$C(p\text{-}C_6H_4OMe)_3ClO_4$	156.7	2.22	5.0

METHANOL AT 25°C

Solute	Ao	a	b
HBr	192.0	1.78	2.0
HCl	188.0	1.79	2.0
HI	197.0	1.76	2.5
$KCH_3(CH_2)COO$	89.0	2.73	4.1
KI	113.3	2.34	5.1
KOH	105.8	2.45	5.5
$KOCH_3$	106.8	2.42	1.0
LiCHS	101.5	2.51	5.5
LiCl	94.2	2.53	3.0
$LiNO_3$	100.7	2.52	5.0
NaBr	101.8	2.50	4.1
NaCNS	106.9	2.43	6.0
$NaCH_3(CH_2)_3COO$	82.0	2.88	4.1
$NaC_6HCH_3(NO_2)_3O$	91.0	2.67	3.9
NaCl	98.4	2.56	4.0
NaI	107.8	2.42	4.8
NaOH	95.7	2.60	5.6
$NaOH_3$	98.4	2.55	5.0
NaPic	91.4	2.68	4.6
Et_4NI	117.6	2.30	2.0
Me_3NCH_2PhI	96.8	2-58	5.0
$(C_5H_{11})NI$	86.9	2.77	4.0
$C_3H_5H_2Pic$	102.4	2.49	2.0
$i\text{-}C_4H_9H_3NCl$	97.4	2.57	6.0
$C_5H_{12}NC_6HMc(NO_2)_3O$	94.4	2.63	2.8
$PhH_3NC_6HMc(NO_2)_3O$	82.0	2.88	3.8

FORMAMIDE AT 25°C			
Solute	**Ao**	**a**	**b**
1/2 Ba $(NO_3)_2$	30.3	1.33	1.33
1/2 Ca $(NO_3)_2$	31.6	1.29	1.00
CsCl	29.0	0.74	0.75
$CsNO_3$	29.4	0.74	0.61
KCNS	28.7	0.75	1.20
KCl	28.0	0.76	0.90
KI	27.7	0.77	1.04
$LiNO_3$	25.0	0.83	1.05
NH_4Cl	30.4	0.72	1.60
NH_4I	30.5	0.72	1.10
NH_4NO_3	33.6	0.67	0.60
NaBr	25.7	0.81	0.80
$1/2Na_2CrO_4$	26.0	1.56	1.80
NaI	25.0	0.83	1.18
$NaNO_3$	28.3	0.76	0.63
NaHCOO	25.1	o.83	0.65
NaPhCOO	20.0	0.99	0.78
NaSalicylate	20.6	0.97	0.60
$NaPhSO_3$	20.7	0.96	0.75
RbBr	28.3	0.76	1.10
RbCl	28.2	0.76	0.60
RbI	28.0	0.76	1.00
$RbNO_3$	28.6	0.75	1.00
$1/2Sr(NO_3)_2$	32.0	1.28	1.00
Me_4NCl	28.7	0.75	0.65
Me_4NI	25.0	0.83	1.10
Et_4NCl	28.7	0.75	0.65
Et_4NI	25.0	0.83	1.10

HYDROGEN CYANIDE AT 18°C b = 0		
Valid to C = 10^{-5}N.		
Solute	**Ao**	**A**
CsCl	368.2	200
KBr	363.2	248
KCNS	358.0	243
KCl	363.4	280
$KClO_4$	353-3	275
KI	363.3	235
KNO_3	353.9	253
LiBr	356.9	270
LiCNS	340.6	400
LiCl	345.4	335
$LilCO_4$	336.9	230
Lil	348.0	258
$LiNO_3$	336.6	402
NaBr	343.8	243
NaCNS	337.7	230
$NaClO_4$	335.5	235
NaI	344.9	238
$NaNO_3$	333.8	250
NaPic	266.9	195
RbCl	363.2	195
Et_4NPic	282.3	215

SULPHUR DIOXIDE AT 0°C			
Solute	**Ao**	**a**	**b**
Ph_3CCl0_4	153.6	5.03	17.0
$Ph_2C(C_6H_4Me)ClO_4$	149.8	4.93	15.0
$PhC(C_6H_4Me)_2ClO_4$	141.3	5.06	16.0
$C(C_6H_4Me)_3Cl$	168.5	4.69	15.0
$C(C_6H_4Me)_3ClO_4$	150.0	4.92	15.0
$Ph_2C(C_6H_4Ph)Cl$	78.3	6.83	16.0
$C(C_6H_4Ph)_3Cl$	5.0	5.00	12.0
$Ph_2C(p\text{-}C_6H_4OMe)Cl$	169.1	4.68	13.0
$Ph_2C(p\text{-}C_6H_4OMe)ClO_4$	148.0	4.95	17.0
$C(p\text{-}C_6H_4OMe)_3ClO_4$	144.4	5.03	16.0
$PhC(p\text{-}C_6H_4NO_2)(p\text{-}C_6H_4OMe)Cl$	90.0	5.97	20.0
$C(p\text{-}C_6H_4NO_2)2(p\text{-}C_6H_4OMe)ClO_4$	103.5	5.86	17.0
$C(p\text{-}C_6H_4NO_2)(p\text{-}C_6H_4OMe)_2ClO_4$	123.0	5.39	20.0
Me_4NCl	160.5	4.80	11.8
Me_4NBr	160.8	4.79	11.8
Me_4NI	166.0	4.72	12.0
Me_3SI	150.2	4.93	12.0

ACETONE AT 25°C			
Solute	**Ao**	**a**	**b**
NaI	161.0	3.71	6.0
Pr_4NI	152.0	3.83	6.0
C_5HI_2NPic	89.1	5.34	9.0
$CPh_2(p\text{-}C_6H_4OMe)ClO_4$	160.0	3.72	5.0
$C(p\text{-}C_6H_4OMe)_3ClO_4$	160.2	3.72	8.0

HYDRAZINE AT 0°C			
Solute	**Ao**	**a**	**b**
1/2 CdI_2	76.0	1.97	2.2
HCl	103.0	0.858	0.7
HPhCOO	85.9	0.950	0.0
HPh_3CCOO	74.8	1.03	–4.0
HCH_2NO_3	87.0	0.94	–3.0
Hm–$C_6H_4(NO_2)O$	86.4	0.95	–5.0
KCl	85.0	0.96	1.0
Nam–$C_6H_4(NO_2)O$	58.1	1.21	4.0
Et_4NI	66.6	0.87	–1.0
25°C HCl	153.9	0.90	0.6
25°C $KClO_4$	128.2	0.90	0.6
25°C KI	130.0	0.99	1.3
25°C $NaClO_4$	110.0	1.09	1 4
25°C NaI	112.5	1.07	0.8
25°C Et_4NCl	99.7	1.16	1.6

AMMONIA AT –33°C			
Solute	**Ao**	**a**	**b**
$AgNO_3$	241.7	3.92	8.0
HCl	183.8	4.48	9.0
HNO_3	245.5	3.89	7.3
KI	295.7	3.59	6.0
KNH_2	108.7	6.55	13.0
KPh_2N	230.0	4.01	8.0
KPh_3BNH_2	155.0	5.14	10.5
$LiNO_3$	225.7	4.05	8.5
NaBr	240.2	3.92	7.0
NaCl	206.9	4.22	8.0
NaI	265.1	3.76	7.2
$NaNO_3$	224.8	4.05	8.0
NaEtS	201.8	4.27	9.0
NaPhS	219.6	4.32	10.0
$NaPh_2N$	198.7	4.3	10.0
$NaMe_3Sn$	249.0	3.86	10.0
$NaPh_3BNH_2$	202.5	4.26	9 8
Et_2HNCl	183.0	4.43	8.0
Me_3SI	210.0	4.19	6.9

ETHANOL AT 25°C			
Solute	**Ao**	**a**	**b**
HBr	77.3	2.62	4.1
HCl	70.5	2.74	3.6
HI	81.4	2.57	4.5
KI	46.5	3.42	6.4
KOH	42.0	3.63	6.0
LiCl	37.0	3.90	7.0
$LiNO_3$	40.7	3.70	6.8
NH_4CCl_3COO	37.0	3.93	6.2
NH_4Cl	39.7	3.75	6.2
NH_4Pic	40.8	3.70	6.0
NaBr	39.0	3.80	10.0
$NaCCl_3COO$	34.3	4.12	6.6
NaI	46.0	3.44	7.0
NaOH	38.0	3.86	6.8
Me_3NCH_2PhI	43.4	3.56	5.8
C_5HI_2NCl	37.0	3.92	6.0
C_5HI_2NPic	37.5	3.90	5.6
$CPh_2(p\text{-}C_6H_4OMe)ClO_4$	61.4	3.02	6.0
$CPh(p\text{-}C_6H_4OMe)_2ClO_4$	60.3	2.97	7.0

FORMIC ACID AT 25°C			
Solute	**Ao**	**a**	**b**
CsHCOO	75.2	1.06	1.4
KHCOO	79.6	1.03	1.5
LiHCOO	75.7	1.06	0.7
NH_4HCOO	82.4	1.01	1.2
NaHCOO	75.7	1.06	1.4
RbHCOO	81.1	1.02	1.0
$PhNH_3HCOO$	75.8	1.06	1.2
8.50°C { KCl	35.82	1.12	0.94
8.50°C { Me_4NCl	35.70	1.12	0.94

DIMETHYL-FORMAMIDE AT 25°C b = o		
Solute	**Ao**	**A**
KBr	84.1	154
KCNS	90.2	151
$KClO_4$	82.7	137
KI	82.6	137
KNO_3	88.5	214
NaBr	83.4	165
NaCNS	89.5	171
NaI	81.9	138
$NaNO_3$	87.9	263

SPECIFIC CONDUCTANCE OF STANDARD KCl SOLUTIONS

(Data obtained from *Handbook of Electrochemical Constants,* Parsons; Academic Press/Butterworths, 1959)

Concentration	Conductance, µmhos/cm			
	0°C	**18°C**	**20°C**	**25°C**
1N KCl 71.3828 g KCl per kg solution	65,430	98,201	102,024	111,733
0.1N KCl 7.43344 g KCl per kg solution	7,154.3	11,191.9	11,667.6	12,886.2
0.01N KCl 0.746558 g KCl per kg solution	775.12	1,222.69	1,275.72	1,411.45

$10.00 U.S. Dollars

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