

ION COLORS			
Ion	Solution Color	Ion	Flame Color
Groups 1, 2, 17	colorless	Li <sup>+</sup>	bright red
Cr <sup>2+</sup>	blue	Na <sup>+</sup>	yellow
Cr <sup>3+</sup>	green	K <sup>+</sup>	violet
Ca <sup>2+</sup>	pink		
Cu <sup>+</sup>	green	Ca <sup>2+</sup>	yellow-red
Cu <sup>2+</sup>	blue	Sr <sup>2+</sup>	bright red
Fe <sup>2+</sup>	pale green	Ba <sup>2+</sup>	yellow-green
Fe <sup>3+</sup>	yellow-brown		
Mn <sup>2+</sup>	pale pink	Cu <sup>2+</sup>	blue (halides) green (others)
Ni <sup>2+</sup>	green		
CrO <sub>4</sub> <sup>2-</sup>	yellow		
Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup>	orange	Pb <sup>2+</sup>	light blue-grey
MnO <sub>4</sub> <sup>-</sup>	purple	Zn <sup>2+</sup>	whitish green

### SPECIFIC HEAT CAPACITIES OF PURE SUBSTANCES

Substance	Specific Heat Capacity* (J/(g · °C))	Substance	Specific Heat Capacity* (J/(g · °C))
aluminum	0.900	nickel	0.444
calcium	0.653	potassium	0.753
copper	0.385	silver	0.237
gold	0.129	sodium	1.226
hydrogen	14.267	sulfur	0.732
iron	0.444	tin	0.213
lead	0.159	zinc	0.388
lithium	3.556	ice, H <sub>2</sub> O <sub>(s)</sub>	2.01
magnesium	1.017	water, H <sub>2</sub> O <sub>(l)</sub>	4.19
mercury	0.138	steam, H <sub>2</sub> O <sub>(g)</sub>	2.01

\*Elements at SATP state.

### CONCENTRATED (SATURATED) REAGENTS

Reagent (• strong acids)	Formula	Concentration (mol/L)	Concentration (mass %)
acetic acid	CH <sub>3</sub> COOH <sub>(aq)</sub>	17.4	99.5
ammonia	NH <sub>3(aq)</sub>	14.8	28
carbonic acid	H <sub>2</sub> CO <sub>3(aq)</sub>	0.039	0.17
• hydrochloric acid	HCl <sub>(aq)</sub>	11.6	36
• nitric acid	HNO <sub>3(aq)</sub>	15.4	69
phosphoric acid	H <sub>3</sub> PO <sub>4(aq)</sub>	14.6	85
sodium hydroxide	NaOH <sub>(aq)</sub>	19.1	50
sulfurous acid	H <sub>2</sub> SO <sub>3(aq)</sub>	0.73	6
• sulfuric acid	H <sub>2</sub> SO <sub>4(aq)</sub>	17.8	95

### SI PREFIXES

Prefix	Symbol	Factor
giga	G	10 <sup>9</sup>
mega	M	10 <sup>6</sup>
kilo	k	10 <sup>3</sup>
milli	m	10 <sup>-3</sup>
micro	μ	10 <sup>-6</sup>
nano	n	10 <sup>-9</sup>

### DEFINED (EXACT) QUANTITIES

1 t	=	1000 kg = 1 Mg
STP	=	0°C and 101.325 kPa (use 0°C and 101 kPa)
SATP	=	25°C and 100 kPa
0°C	=	273.15 K (use 273 K)
1 atm	=	101.325 kPa (use 101 kPa)

### MEASURED (UNCERTAIN) QUANTITIES

N <sub>A</sub>	=	6.02 × 10 <sup>23</sup> /mol
R	=	8.31 kPa · L/(mol · K)
F	=	9.65 × 10 <sup>4</sup> C/mol
K <sub>w</sub>	=	1.0 × 10 <sup>-14</sup> (mol/L) <sup>2</sup>
H <sub>fusion</sub> <sub>H<sub>2</sub>O</sub>	=	+6.03 kJ/mol
H <sub>vap</sub> <sub>H<sub>2</sub>O</sub>	=	+40.8 kJ/mol
c	=	3.00 × 10 <sup>8</sup> m/s
V <sub>STP</sub>	=	22.4 L/mol
V <sub>SATP</sub>	=	24.8 L/mol
d <sub>H<sub>2</sub>O</sub>	=	1.00 g/mL

### VOLUMETRIC HEAT CAPACITIES

Substance	Volumetric Heat Capacity (MJ)/(m <sup>3</sup> · °C)
air	0.0012
brick/rock	1.9
concrete	2.1
ethylene	3.7
glycol (50%)	
water	4.19

### POLYATOMIC IONS – THEORETICAL SUMMARY

1 <sup>-</sup> ions	1 <sup>-</sup> ions	2 <sup>-</sup> ions	3 <sup>-</sup> ions
• acetate CH <sub>3</sub> COO <sup>-</sup>	hydrogen sulfide (bisulfide) HS <sup>-</sup>	• carbonate CO <sub>3</sub> <sup>2-</sup>	borate BO <sub>3</sub> <sup>3-</sup>
benzoate C <sub>6</sub> H <sub>5</sub> COO <sup>-</sup>	hydrogen sulfite (bisulfite) HSO <sub>3</sub> <sup>-</sup>	chromate CrO <sub>4</sub> <sup>2-</sup>	citrate C <sub>6</sub> H <sub>5</sub> OH(COO) <sub>3</sub> <sup>3-</sup>
chlorate* ClO <sub>3</sub> <sup>-</sup>	• hydroxide OH <sup>-</sup>	• dichromate Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup>	• phosphate PO <sub>4</sub> <sup>3-</sup>
chlorite ClO <sub>2</sub> <sup>-</sup>	• hypochlorite ClO <sup>-</sup> ; OCl <sup>-</sup>	hydrogen phosphate HPO <sub>4</sub> <sup>2-</sup>	5 <sup>-</sup> ion
cyanide CN <sup>-</sup>	• nitrate NO <sub>3</sub> <sup>-</sup>	oxalate O <sup>2-</sup>	tripolyphosphate P <sub>3</sub> O <sub>10</sub> <sup>5-</sup>
dihydrogen phosphate H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>	nitrite NO <sub>2</sub> <sup>-</sup>	silicate SiO <sub>3</sub> <sup>2-</sup>	1 <sup>+</sup> ions
glutamate C <sub>5</sub> H <sub>9</sub> NO <sub>4</sub> <sup>-</sup>	perchlorate* ClO <sub>4</sub> <sup>-</sup>	• sulfate SO <sub>4</sub> <sup>2-</sup>	• ammonium NH <sub>4</sub> <sup>+</sup>
• hydrogen carbonate (bicarbonate) HCO <sub>3</sub> <sup>-</sup>	permanganate MnO <sub>4</sub> <sup>-</sup>	sulfite SO <sub>3</sub> <sup>2-</sup>	hydronium H <sub>3</sub> O <sup>+</sup>
hydrogen oxalate HOOCCOO <sup>-</sup>	stearate C <sub>17</sub> H <sub>35</sub> COO <sup>-</sup>	tetraborate B <sub>4</sub> O <sub>7</sub> <sup>2-</sup>	2 <sup>+</sup> ion
• hydrogen sulfate (bisulfate) HSO <sub>4</sub> <sup>-</sup>	thiocyanate SCN <sup>-</sup>	thiosulfate S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	mercury(II) Hg <sub>2</sub> <sup>2+</sup>

\*There are also corresponding ions containing Br and I instead of Cl. • Frequently used ions

### SOLUBILITY OF IONIC COMPOUNDS AT SATP – GENERALIZATIONS

Anion	Cl <sup>-</sup> , Br <sup>-</sup> , I <sup>-</sup>	S <sup>2-</sup>	OH <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	CO <sub>3</sub> <sup>2-</sup> , PO <sub>4</sub> <sup>3-</sup> , SO <sub>3</sub> <sup>2-</sup>	CH <sub>3</sub> COO <sup>-</sup>	NO <sub>3</sub> <sup>-</sup>
High Solubility (aq) ≥ 0.1 mol/L (at SATP)	most	Group 1, NH <sub>4</sub> <sup>+</sup> Group 2	Group 1, NH <sub>4</sub> <sup>+</sup> Sr <sup>2+</sup> , Ba <sup>2+</sup> , Tl <sup>+</sup>	most	Group 1, NH <sub>4</sub> <sup>+</sup>	most	all
Low Solubility (s) < 0.1 mol/L (at SATP)	Ag <sup>+</sup> , Pb <sup>2+</sup> , Tl <sup>+</sup> , Hg <sub>2</sub> <sup>2+</sup> (Hg <sup>+</sup> ), Cu <sup>+</sup>	most	most	Ag <sup>+</sup> , Pb <sup>2+</sup> , Ca <sup>2+</sup> , Ba <sup>2+</sup> , Sr <sup>2+</sup> , Ra <sup>2+</sup>	most	Ag <sup>+</sup>	none

All Group 1 compounds, including acids, and all ammonium compounds are assumed to have high solubility in water.

### ACID-BASE INDICATORS

Common Name of Indicator	Suggested Symbol	Color of HIn <sub>(aq)</sub>	Approximate pH Range	Color of In <sub>(aq)</sub>	Temperature (°C)	Vapor Pressure (kPa)
methyl violet	HMv	yellow	0.0 – 1.6	blue	15	1.70
thymol blue*	H <sub>2</sub> Tb	red	1.2 – 2.8	yellow	16	1.82
orange IV	HO <sub>r</sub>	red	1.4 – 2.8	yellow	17	1.94
benzopurpurine-4B	HBp	violet	2.2 – 4.2	red	18	2.06
congo red	HCr	blue	3.0 – 5.0	red	19	2.20
methyl orange	HMo	red	3.2 – 4.4	yellow	20	2.34
bromocresol green	HBg	yellow	3.8 – 5.4	blue	21	2.49
methyl red	HMr	red	4.8 – 6.0	yellow	22	2.64
chlorophenol red	HCh	yellow	5.2 – 6.8	red	23	2.81
bromothymol blue	HBb	yellow	6.0 – 7.6	blue	24	2.98
litmus	HLi	red	6.0 – 8.0	blue	25	3.17
phenol red	HPr	yellow	6.6 – 8.0	red	26	3.36
metacresol purple	HMp	yellow	7.4 – 9.0	purple	27	3.57
thymol blue*	HTb	yellow	8.0 – 9.6	blue	28	3.78
phenolphthalein	HPh	colorless	8.2 – 10.0	red	29	4.01
thymolphthalein	HTh	colorless	9.4 – 10.6	blue	30	4.24
alizarin yellow R	HAY	yellow	10.1 – 12.0	red	31	4.49
indigo carmine	HIC	blue	11.4 – 13.0	yellow	32	4.75
1,3,5-trinitrobenzene	HNB	colorless	12.0 – 14.0	orange		

### VAPOR PRESSURE OF WATER