

Reference Tables for Physical Setting/CHEMISTRY

2011 Edition

Table A
Standard Temperature and Pressure

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of H ₂ O(ℓ)	4.18 J/g•K

Table C
Selected Prefixes

Factor	Prefix	Symbol
10 ³	kilo-	k
10 ⁻¹	deci-	d
10 ⁻²	centi-	c
10 ⁻³	milli-	m
10 ⁻⁶	micro-	μ
10 ⁻⁹	nano-	n
10 ⁻¹²	pico-	p

Table D
Selected Units

Symbol	Name	Quantity
m	meter	length
g	gram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of substance
J	joule	energy, work, quantity of heat
s	second	time
min	minute	time
h	hour	time
d	day	time
y	year	time
L	liter	volume
ppm	parts per million	concentration
M	molarity	solution concentration
u	atomic mass unit	atomic mass

Table E
Selected Polyatomic Ions

Formula	Name	Formula	Name
H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	mercury(I)	$\text{Cr}_2\text{O}_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$\left. \begin{array}{l} \text{C}_2\text{H}_3\text{O}_2^- \\ \text{CH}_3\text{COO}^- \end{array} \right\}$	acetate	NO_2^-	nitrite
CN^-	cyanide	NO_3^-	nitrate
CO_3^{2-}	carbonate	O_2^{2-}	peroxide
HCO_3^-	hydrogen carbonate	OH^-	hydroxide
$\text{C}_2\text{O}_4^{2-}$	oxalate	PO_4^{3-}	phosphate
ClO^-	hypochlorite	SCN^-	thiocyanate
ClO_2^-	chlorite	SO_3^{2-}	sulfite
ClO_3^-	chlorate	SO_4^{2-}	sulfate
ClO_4^-	perchlorate	HSO_4^-	hydrogen sulfate
		$\text{S}_2\text{O}_3^{2-}$	thiosulfate

Table F
Solubility Guidelines for Aqueous Solutions

Ions That Form Soluble Compounds	Exceptions	Ions That Form Insoluble Compounds*	Exceptions
Group 1 ions (Li^+ , Na^+ , etc.)		carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
ammonium (NH_4^+)		chromate (CrO_4^{2-})	when combined with Group 1 ions, Ca^{2+} , Mg^{2+} , or ammonium (NH_4^+)
nitrate (NO_3^-)		phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
acetate ($\text{C}_2\text{H}_3\text{O}_2^-$ or CH_3COO^-)		sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydrogen carbonate (HCO_3^-)		hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+} , Ba^{2+} , Sr^{2+} , or ammonium (NH_4^+)
chlorate (ClO_3^-)			
halides (Cl^- , Br^- , I^-)	when combined with Ag^+ , Pb^{2+} , or Hg_2^{2+}		
sulfates (SO_4^{2-})	when combined with Ag^+ , Ca^{2+} , Sr^{2+} , Ba^{2+} , or Pb^{2+}		

*compounds having very low solubility in H_2O

Table G
Solubility Curves at Standard Pressure

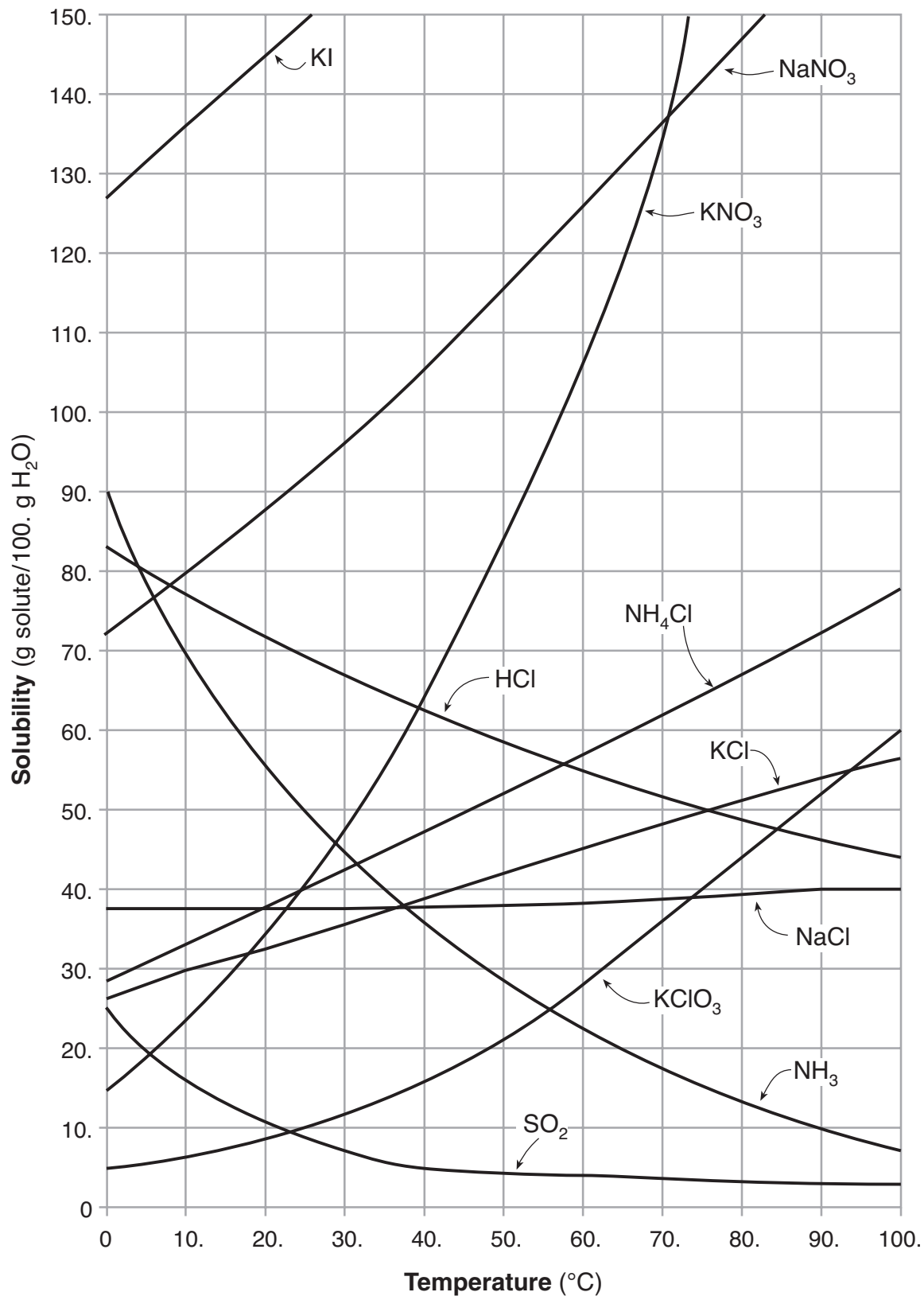


Table H
Vapor Pressure of Four Liquids

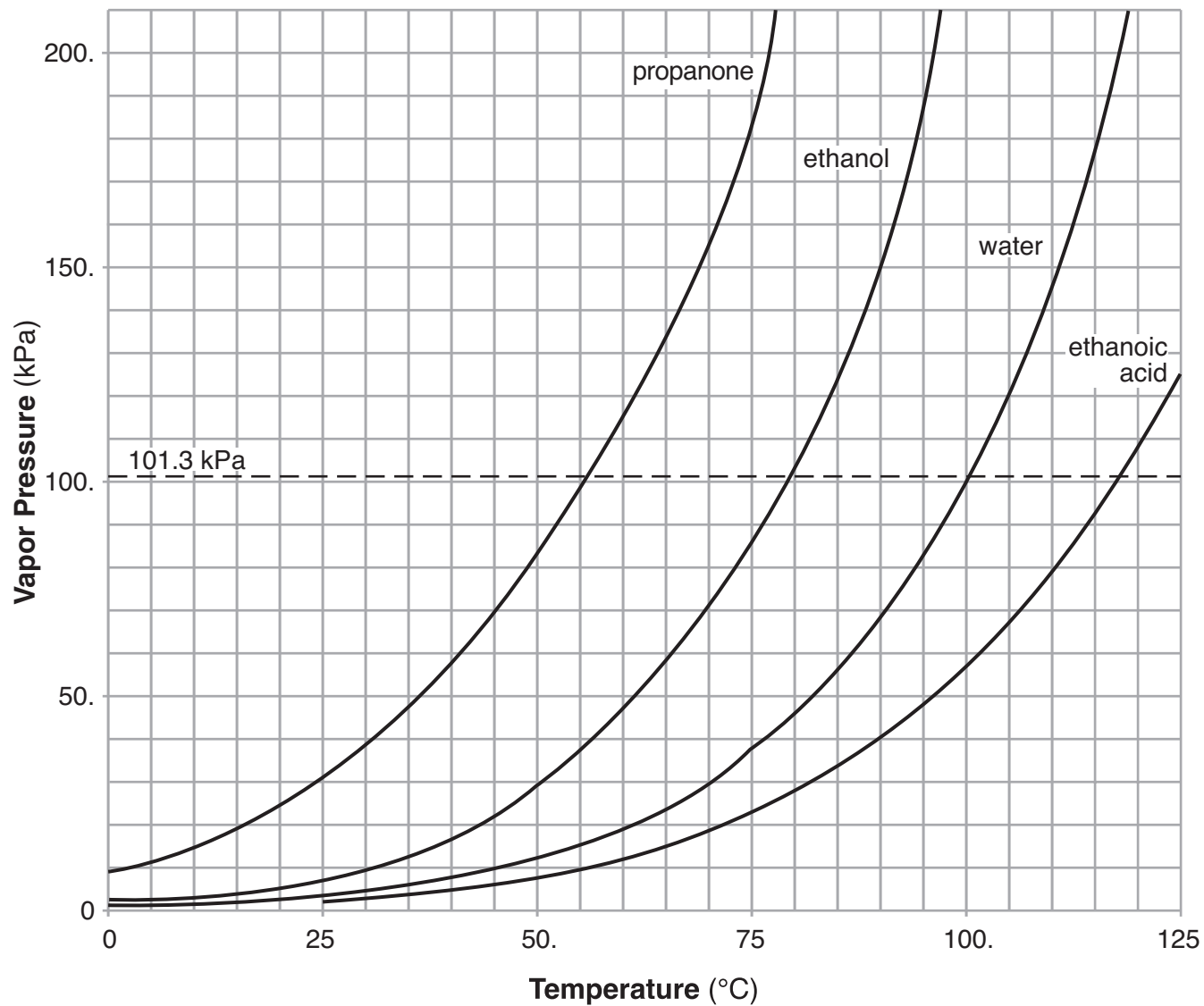


Table I
Heats of Reaction at 101.3 kPa and 298 K

Reaction	ΔH (kJ)*
$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\ell)$	-890.4
$\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \longrightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\ell)$	-2219.2
$2\text{C}_8\text{H}_{18}(\ell) + 25\text{O}_2(\text{g}) \longrightarrow 16\text{CO}_2(\text{g}) + 18\text{H}_2\text{O}(\ell)$	-10943
$2\text{CH}_3\text{OH}(\ell) + 3\text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\ell)$	-1452
$\text{C}_2\text{H}_5\text{OH}(\ell) + 3\text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\ell)$	-1367
$\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \longrightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\ell)$	-2804
$2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g})$	-566.0
$\text{C}(\text{s}) + \text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g})$	-393.5
$4\text{Al}(\text{s}) + 3\text{O}_2(\text{g}) \longrightarrow 2\text{Al}_2\text{O}_3(\text{s})$	-3351
$\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{NO}(\text{g})$	+182.6
$\text{N}_2(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow 2\text{NO}_2(\text{g})$	+66.4
$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{H}_2\text{O}(\text{g})$	-483.6
$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{H}_2\text{O}(\ell)$	-571.6
$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \longrightarrow 2\text{NH}_3(\text{g})$	-91.8
$2\text{C}(\text{s}) + 3\text{H}_2(\text{g}) \longrightarrow \text{C}_2\text{H}_6(\text{g})$	-84.0
$2\text{C}(\text{s}) + 2\text{H}_2(\text{g}) \longrightarrow \text{C}_2\text{H}_4(\text{g})$	+52.4
$2\text{C}(\text{s}) + \text{H}_2(\text{g}) \longrightarrow \text{C}_2\text{H}_2(\text{g})$	+227.4
$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \longrightarrow 2\text{HI}(\text{g})$	+53.0
$\text{KNO}_3(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{K}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$	+34.89
$\text{NaOH}(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$	-44.51
$\text{NH}_4\text{Cl}(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$	+14.78
$\text{NH}_4\text{NO}_3(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{NH}_4^+(\text{aq}) + \text{NO}_3^-(\text{aq})$	+25.69
$\text{NaCl}(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$	+3.88
$\text{LiBr}(\text{s}) \xrightarrow{\text{H}_2\text{O}} \text{Li}^+(\text{aq}) + \text{Br}^-(\text{aq})$	-48.83
$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\ell)$	-55.8

*The ΔH values are based on molar quantities represented in the equations. A minus sign indicates an exothermic reaction.

Table J
Activity Series**

Most Active	Metals	Nonmetals	Most Active
↓	Li	F ₂	↓
	Rb	Cl ₂	
	K	Br ₂	
	Cs	I ₂	
	Ba		
	Sr		
	Ca		
	Na		
	Mg		
	Al		
	Ti		
	Mn		
	Zn		
	Cr		
	Fe		
	Co		
	Ni		
	Sn		
	Pb		
H ₂			
Cu			
Ag			
Au			
Least Active			Least Active

**Activity Series is based on the hydrogen standard. H₂ is *not* a metal.

Table K
Common Acids

Formula	Name
HCl(aq)	hydrochloric acid
HNO ₂ (aq)	nitrous acid
HNO ₃ (aq)	nitric acid
H ₂ SO ₃ (aq)	sulfurous acid
H ₂ SO ₄ (aq)	sulfuric acid
H ₃ PO ₄ (aq)	phosphoric acid
H ₂ CO ₃ (aq) or CO ₂ (aq)	carbonic acid
CH ₃ COOH(aq) or HC ₂ H ₃ O ₂ (aq)	ethanoic acid (acetic acid)

Table L
Common Bases

Formula	Name
NaOH(aq)	sodium hydroxide
KOH(aq)	potassium hydroxide
Ca(OH) ₂ (aq)	calcium hydroxide
NH ₃ (aq)	aqueous ammonia

Table M
Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8–9	colorless to pink
litmus	4.5–8.3	red to blue
bromocresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

Source: *The Merck Index*, 14th ed., 2006, Merck Publishing Group

Table N
Selected Radioisotopes

Nuclide	Half-Life	Decay Mode	Nuclide Name
¹⁹⁸ Au	2.695 d	β ⁻	gold-198
¹⁴ C	5715 y	β ⁻	carbon-14
³⁷ Ca	182 ms	β ⁺	calcium-37
⁶⁰ Co	5.271 y	β ⁻	cobalt-60
¹³⁷ Cs	30.2 y	β ⁻	cesium-137
⁵³ Fe	8.51 min	β ⁺	iron-53
²²⁰ Fr	27.4 s	α	francium-220
³ H	12.31 y	β ⁻	hydrogen-3
¹³¹ I	8.021 d	β ⁻	iodine-131
³⁷ K	1.23 s	β ⁺	potassium-37
⁴² K	12.36 h	β ⁻	potassium-42
⁸⁵ Kr	10.73 y	β ⁻	krypton-85
¹⁶ N	7.13 s	β ⁻	nitrogen-16
¹⁹ Ne	17.22 s	β ⁺	neon-19
³² P	14.28 d	β ⁻	phosphorus-32
²³⁹ Pu	2.410 × 10 ⁴ y	α	plutonium-239
²²⁶ Ra	1599 y	α	radium-226
²²² Rn	3.823 d	α	radon-222
⁹⁰ Sr	29.1 y	β ⁻	strontium-90
⁹⁹ Tc	2.13 × 10 ⁵ y	β ⁻	technetium-99
²³² Th	1.40 × 10 ¹⁰ y	α	thorium-232
²³³ U	1.592 × 10 ⁵ y	α	uranium-233
²³⁵ U	7.04 × 10 ⁸ y	α	uranium-235
²³⁸ U	4.47 × 10 ⁹ y	α	uranium-238

Source: *CRC Handbook of Chemistry and Physics*, 91st ed., 2010–2011, CRC Press

Table O
Symbols Used in Nuclear Chemistry

Name	Notation	Symbol
alpha particle	${}^4_2\text{He}$ or ${}^4_2\alpha$	α
beta particle	${}^0_{-1}\text{e}$ or ${}^0_{-1}\beta$	β^-
gamma radiation	${}^0_0\gamma$	γ
neutron	${}^1_0\text{n}$	n
proton	${}^1_1\text{H}$ or ${}^1_1\text{p}$	p
positron	${}^0_{+1}\text{e}$ or ${}^0_{+1}\beta$	β^+

Table P
Organic Prefixes

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	$\text{C}_n\text{H}_{2n+2}$	ethane	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $
alkenes	C_nH_{2n}	ethene	$ \begin{array}{c} \text{H} \quad \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \quad \text{H} \end{array} $
alkynes	$\text{C}_n\text{H}_{2n-2}$	ethyne	$\text{H}-\text{C}\equiv\text{C}-\text{H}$

Note: n = number of carbon atoms

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	-F (fluoro-) -Cl (chloro-) -Br (bromo-) -I (iodo-)	$R-X$ (X represents any halogen)	$\text{CH}_3\text{CHClCH}_3$ 2-chloropropane
alcohol	-OH	$R-OH$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ 1-propanol
ether	-O-	$R-O-R'$	$\text{CH}_3\text{OCH}_2\text{CH}_3$ methyl ethyl ether
aldehyde	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{H} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{H} \end{array}$ propanal
ketone	$\begin{array}{c} \text{O} \\ \\ -\text{C}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-R' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \end{array}$ 2-pentanone
organic acid	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{OH} \end{array}$ propanoic acid
ester	$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{O}- \end{array}$	$\begin{array}{c} \text{O} \\ \\ R-\text{C}-\text{O}-R' \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{COCH}_3 \end{array}$ methyl propanoate
amine	$\begin{array}{c} \\ -\text{N}- \end{array}$	$\begin{array}{c} R' \\ \\ R-\text{N}-R'' \end{array}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ 1-propanamine
amide	$\begin{array}{c} \text{O} \quad \\ \quad \\ -\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \quad R' \\ \quad \\ R-\text{C}-\text{NH} \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3\text{CH}_2\text{C}-\text{NH}_2 \end{array}$ propanamide

Note: R represents a bonded atom or group of atoms.

Periodic Table of the Elements

1.00794 1	H 1
4.00260 2	He 2

KEY

Atomic Mass → 12.011
Symbol → **C**
Atomic Number → 6
Electron Configuration → 2-4

← Selected Oxidation States
-4
+2
+4

Relative atomic masses are based on ¹²C = 12 (exact)

Note: Numbers in parentheses are mass numbers of the most stable or common isotope.

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	Group 2		Group										Group 18						
1	1.00794 1	4 2-2	21 2-8-9-2	22 2-8-10-2	23 2-8-11-2	24 2-8-13-1	25 2-8-13-2	26 2-8-14-2	27 2-8-15-2	28 2-8-16-2	29 2-8-18-1	30 2-8-18-2	31 2-8-18-3	32 2-8-18-4	33 2-8-18-5	34 2-8-18-6	35 2-8-18-7	36 2-8-18-8	37 2-8-18-9-1
2	6.941 2-1	9.01218 2-2	22.98977 2-8-9-2	47.867 2-8-10-2	50.9415 2-8-11-2	51.996 2-8-13-1	54.9380 2-8-13-2	55.845 2-8-14-2	58.9332 2-8-15-2	58.9332 2-8-16-2	63.546 2-8-18-1	65.409 2-8-18-2	69.723 2-8-18-3	72.64 2-8-18-4	74.9216 2-8-18-5	78.96 2-8-18-6	79.904 2-8-18-7	83.798 2-8-18-8	85.468 2-8-18-9-1
3	22.98977 2-8-1	24.305 2-8-2	88.9059 2-8-9-2	88.9059 2-8-9-2	92.9064 2-8-11-2	95.94 2-8-13-1	98.906 2-8-13-2	101.07 2-8-14-2	102.906 2-8-15-2	106.42 2-8-16-2	107.868 2-8-18-1	112.41 2-8-18-2	114.818 2-8-18-3	118.71 2-8-18-4	121.760 2-8-18-5	127.60 2-8-18-6	126.904 2-8-18-7	131.29 2-8-18-8	132.905 2-8-18-9-1
4	39.0983 2-8-8-1	40.08 2-8-8-2	44.9559 2-8-9-2	47.867 2-8-10-2	50.9415 2-8-11-2	51.996 2-8-13-1	54.9380 2-8-13-2	55.845 2-8-14-2	58.9332 2-8-15-2	58.9332 2-8-16-2	63.546 2-8-18-1	65.409 2-8-18-2	69.723 2-8-18-3	72.64 2-8-18-4	74.9216 2-8-18-5	78.96 2-8-18-6	79.904 2-8-18-7	83.798 2-8-18-8	85.468 2-8-18-9-1
5	85.4678 2-8-18-8-1	87.62 2-8-18-8-2	88.9059 2-8-9-2	91.224 2-8-10-2	92.9064 2-8-11-2	95.94 2-8-13-1	98.906 2-8-13-2	101.07 2-8-14-2	102.906 2-8-15-2	106.42 2-8-16-2	107.868 2-8-18-1	112.41 2-8-18-2	114.818 2-8-18-3	118.71 2-8-18-4	121.760 2-8-18-5	127.60 2-8-18-6	126.904 2-8-18-7	131.29 2-8-18-8	132.905 2-8-18-9-1
6	132.905 2-8-18-8-1	137.33 2-8-18-8-2	138.9055 2-8-18-9-2	178.49 2-8-18-10-2	180.948 2-8-18-11-2	183.84 2-8-18-13-1	186.207 2-8-18-13-2	190.23 2-8-18-15-1	192.22 2-8-18-16-1	195.08 2-8-18-18	196.867 2-8-18-18-1	200.59 2-8-18-18-2	204.383 2-8-18-18-3	207.2 2-8-18-18-4	212.760 2-8-18-18-5	212.760 2-8-18-18-6	216.904 2-8-18-18-7	222 2-8-18-18-8	223 2-8-18-18-9-1
7	223 2-8-32-18-8-1	226 2-8-32-18-8-2	227 2-8-32-18-9-2	261 2-8-32-10-2	262 2-8-32-11-2	266 2-8-32-12-2	272 2-8-32-13-2	277 2-8-32-14-2	281 2-8-32-17-1	281 2-8-32-17-1	280 2-8-32-18-1	285 2-8-32-18-2	284 2-8-32-18-3	289 2-8-32-18-4	288 2-8-32-18-5	292 2-8-32-18-6	294 2-8-32-18-7	294 2-8-32-18-8	294 2-8-32-18-9-1

140.116 58	140.908 59	144.24 60	151.964 61	151.964 62	157.25 63	157.25 64	158.925 65	162.500 66	162.500 67	167.259 68	167.259 69	168.934 70	173.04 71	173.04 72	173.04 73	173.04 74	173.04 75	173.04 76	173.04 77	173.04 78	173.04 79	173.04 80	173.04 81	173.04 82	173.04 83	173.04 84	173.04 85	173.04 86	173.04 87	173.04 88	173.04 89	173.04 90	173.04 91	173.04 92	173.04 93	173.04 94	173.04 95	173.04 96	173.04 97	173.04 98	173.04 99	173.04 100	173.04 101	173.04 102	173.04 103	173.04 104	173.04 105	173.04 106	173.04 107	173.04 108	173.04 109	173.04 110	173.04 111	173.04 112	173.04 113	173.04 114	173.04 115	173.04 116	173.04 117	173.04 118	173.04 119	173.04 120	173.04 121	173.04 122	173.04 123	173.04 124	173.04 125	173.04 126	173.04 127	173.04 128	173.04 129	173.04 130	173.04 131	173.04 132	173.04 133	173.04 134	173.04 135	173.04 136	173.04 137	173.04 138	173.04 139	173.04 140	173.04 141	173.04 142	173.04 143	173.04 144	173.04 145	173.04 146	173.04 147	173.04 148	173.04 149	173.04 150	173.04 151	173.04 152	173.04 153	173.04 154	173.04 155	173.04 156	173.04 157	173.04 158	173.04 159	173.04 160	173.04 161	173.04 162	173.04 163	173.04 164	173.04 165	173.04 166	173.04 167	173.04 168	173.04 169	173.04 170	173.04 171	173.04 172	173.04 173	173.04 174	173.04 175	173.04 176	173.04 177	173.04 178	173.04 179	173.04 180	173.04 181	173.04 182	173.04 183	173.04 184	173.04 185	173.04 186	173.04 187	173.04 188	173.04 189	173.04 190	173.04 191	173.04 192	173.04 193	173.04 194	173.04 195	173.04 196	173.04 197	173.04 198	173.04 199	173.04 200	173.04 201	173.04 202	173.04 203	173.04 204	173.04 205	173.04 206	173.04 207	173.04 208	173.04 209	173.04 210	173.04 211	173.04 212	173.04 213	173.04 214	173.04 215	173.04 216	173.04 217	173.04 218	173.04 219	173.04 220	173.04 221	173.04 222	173.04 223	173.04 224	173.04 225	173.04 226	173.04 227	173.04 228	173.04 229	173.04 230	173.04 231	173.04 232	173.04 233	173.04 234	173.04 235	173.04 236	173.04 237	173.04 238	173.04 239	173.04 240	173.04 241	173.04 242	173.04 243	173.04 244	173.04 245	173.04 246	173.04 247	173.04 248	173.04 249	173.04 250	173.04 251	173.04 252	173.04 253	173.04 254	173.04 255	173.04 256	173.04 257	173.04 258	173.04 259	173.04 260	173.04 261	173.04 262	173.04 263	173.04 264	173.04 265	173.04 266	173.04 267	173.04 268	173.04 269	173.04 270	173.04 271	173.04 272	173.04 273	173.04 274	173.04 275	173.04 276	173.04 277	173.04 278	173.04 279	173.04 280	173.04 281	173.04 282	173.04 283	173.04 284	173.04 285	173.04 286	173.04 287	173.04 288	173.04 289	173.04 290	173.04 291	173.04 292	173.04 293	173.04 294	173.04 295	173.04 296	173.04 297	173.04 298	173.04 299	173.04 300	173.04 301	173.04 302	173.04 303	173.04 304	173.04 305	173.04 306	173.04 307	173.04 308	173.04 309	173.04 310	173.04 311	173.04 312	173.04 313	173.04 314	173.04 315	173.04 316	173.04 317	173.04 318	173.04 319	173.04 320	173.04 321	173.04 322	173.04 323	173.04 324	173.04 325	173.04 326	173.04 327	173.04 328	173.04 329	173.04 330	173.04 331	173.04 332	173.04 333	173.04 334	173.04 335	173.04 336	173.04 337	173.04 338	173.04 339	173.04 340	173.04 341	173.04 342	173.04 343	173.04 344	173.04 345	173.04 346	173.04 347	173.04 348	173.04 349	173.04 350	173.04 351	173.04 352	173.04 353	173.04 354	173.04 355	173.04 356	173.04 357	173.04 358	173.04 359	173.04 360	173.04 361	173.04 362	173.04 363	173.04 364	173.04 365	173.04 366	173.04 367	173.04 368	173.04 369	173.04 370	173.04 371	173.04 372	173.04 373	173.04 374	173.04 375	173.04 376	173.04 377	173.04 378	173.04 379	173.04 380	173.04 381	173.04 382	173.04 383	173.04 384	173.04 385	173.04 386	173.04 387	173.04 388	173.04 389	173.04 390	173.04 391	173.04 392	173.04 393	173.04 394	173.04 395	173.04 396	173.04 397	173.04 398	173.04 399	173.04 400	173.04 401	173.04 402	173.04 403	173.04 404	173.04 405	173.04 406	173.04 407	173.04 408	173.04 409	173.04 410	173.04 411	173.04 412	173.04 413	173.04 414	173.04 415	173.04 416	173.04 417	173.04 418	173.04 419	173.04 420	173.04 421	173.04 422	173.04 423	173.04 424	173.04 425	173.04 426	173.04 427	173.04 428	173.04 429	173.04 430	173.04 431	173.04 432	173.04 433	173.04 434	173.04 435	173.04 436	173.04 437	173.04 438	173.04 439	173.04 440	173.04 441	173.04 442	173.04 443	173.04 444	173.04 445	173.04 446	173.04 447	173.04 448	173.04 449	173.04 450	173.04 451	173.04 452	173.04 453	173.04 454	173.04 455	173.04 456	173.04 457	173.04 458	173.04 459	173.04 460	173.04 461	173.04 462	173.04 463	173.04 464	173.04 465	173.04 466	173.04 467	173.04 468	173.04 469	173.04 470	173.04 471	173.04 472	173.04 473	173.04 474	173.04 475	173.04 476	173.04 477	173.04 478	173.04 479	173.04 480	173.04 481	173.04 482	173.04 483	173.04 484	173.04 485	173.04 486	173.04 487	173.04 488	173.04 489	173.04 490	173.04 491	173.04 492	173.04 493	173.04 494	173.04 495	173.04 496	173.04 497	173.04 498	173.04 499	173.04 500
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*denotes the presence of (2-8-) for elements 72 and above

**The systematic names and symbols for elements of atomic numbers 113 and above will be used until the approval of trivial names by IUPAC.

Source: CRC Handbook of Chemistry and Physics, 91st ed., 2010–2011, CRC Press

Table S
Properties of Selected Elements

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm³)	Atomic Radius (pm)
1	H	hydrogen	1312	2.2	14	20.	0.000082	32
2	He	helium	2372	—	—	4	0.000164	37
3	Li	lithium	520.	1.0	454	1615	0.534	130.
4	Be	beryllium	900.	1.6	1560.	2744	1.85	99
5	B	boron	801	2.0	2348	4273	2.34	84
6	C	carbon	1086	2.6	—	—	—	75
7	N	nitrogen	1402	3.0	63	77	0.001145	71
8	O	oxygen	1314	3.4	54	90.	0.001308	64
9	F	fluorine	1681	4.0	53	85	0.001553	60.
10	Ne	neon	2081	—	24	27	0.000825	62
11	Na	sodium	496	0.9	371	1156	0.97	160.
12	Mg	magnesium	738	1.3	923	1363	1.74	140.
13	Al	aluminum	578	1.6	933	2792	2.70	124
14	Si	silicon	787	1.9	1687	3538	2.3296	114
15	P	phosphorus (white)	1012	2.2	317	554	1.823	109
16	S	sulfur (monoclinic)	1000.	2.6	388	718	2.00	104
17	Cl	chlorine	1251	3.2	172	239	0.002898	100.
18	Ar	argon	1521	—	84	87	0.001633	101
19	K	potassium	419	0.8	337	1032	0.89	200.
20	Ca	calcium	590.	1.0	1115	1757	1.54	174
21	Sc	scandium	633	1.4	1814	3109	2.99	159
22	Ti	titanium	659	1.5	1941	3560.	4.506	148
23	V	vanadium	651	1.6	2183	3680.	6.0	144
24	Cr	chromium	653	1.7	2180.	2944	7.15	130.
25	Mn	manganese	717	1.6	1519	2334	7.3	129
26	Fe	iron	762	1.8	1811	3134	7.87	124
27	Co	cobalt	760.	1.9	1768	3200.	8.86	118
28	Ni	nickel	737	1.9	1728	3186	8.90	117
29	Cu	copper	745	1.9	1358	2835	8.96	122
30	Zn	zinc	906	1.7	693	1180.	7.134	120.
31	Ga	gallium	579	1.8	303	2477	5.91	123
32	Ge	germanium	762	2.0	1211	3106	5.3234	120.
33	As	arsenic (gray)	944	2.2	1090.	—	5.75	120.
34	Se	selenium (gray)	941	2.6	494	958	4.809	118
35	Br	bromine	1140.	3.0	266	332	3.1028	117
36	Kr	krypton	1351	—	116	120.	0.003425	116
37	Rb	rubidium	403	0.8	312	961	1.53	215
38	Sr	strontium	549	1.0	1050.	1655	2.64	190.
39	Y	yttrium	600.	1.2	1795	3618	4.47	176
40	Zr	zirconium	640.	1.3	2128	4682	6.52	164

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling Point (K)	Density** (g/cm ³)	Atomic Radius (pm)
41	Nb	niobium	652	1.6	2750.	5017	8.57	156
42	Mo	molybdenum	684	2.2	2896	4912	10.2	146
43	Tc	technetium	702	2.1	2430.	4538	11	138
44	Ru	ruthenium	710.	2.2	2606	4423	12.1	136
45	Rh	rhodium	720.	2.3	2237	3968	12.4	134
46	Pd	palladium	804	2.2	1828	3236	12.0	130.
47	Ag	silver	731	1.9	1235	2435	10.5	136
48	Cd	cadmium	868	1.7	594	1040.	8.69	140.
49	In	indium	558	1.8	430.	2345	7.31	142
50	Sn	tin (white)	709	2.0	505	2875	7.287	140.
51	Sb	antimony (gray)	831	2.1	904	1860.	6.68	140.
52	Te	tellurium	869	2.1	723	1261	6.232	137
53	I	iodine	1008	2.7	387	457	4.933	136
54	Xe	xenon	1170.	2.6	161	165	0.005366	136
55	Cs	cesium	376	0.8	302	944	1.873	238
56	Ba	barium	503	0.9	1000.	2170.	3.62	206
57	La	lanthanum	538	1.1	1193	3737	6.15	194
Elements 58–71 have been omitted.								
72	Hf	hafnium	659	1.3	2506	4876	13.3	164
73	Ta	tantalum	728	1.5	3290.	5731	16.4	158
74	W	tungsten	759	1.7	3695	5828	19.3	150.
75	Re	rhenium	756	1.9	3458	5869	20.8	141
76	Os	osmium	814	2.2	3306	5285	22.587	136
77	Ir	iridium	865	2.2	2719	4701	22.562	132
78	Pt	platinum	864	2.2	2041	4098	21.5	130.
79	Au	gold	890.	2.4	1337	3129	19.3	130.
80	Hg	mercury	1007	1.9	234	630.	13.5336	132
81	Tl	thallium	589	1.8	577	1746	11.8	144
82	Pb	lead	716	1.8	600.	2022	11.3	145
83	Bi	bismuth	703	1.9	544	1837	9.79	150.
84	Po	polonium	812	2.0	527	1235	9.20	142
85	At	astatine	—	2.2	575	—	—	148
86	Rn	radon	1037	—	202	211	0.009074	146
87	Fr	francium	393	0.7	300.	—	—	242
88	Ra	radium	509	0.9	969	—	5	211
89	Ac	actinium	499	1.1	1323	3471	10.	201
Elements 90 and above have been omitted.								

* boiling point at standard pressure

** density of solids and liquids at room temperature and density of gases at 298 K and 101.3 kPa

— no data available

Source: CRC Handbook for Chemistry and Physics, 91st ed., 2010–2011, CRC Press

Table T
Important Formulas and Equations

Density	$d = \frac{m}{V}$	d = density m = mass V = volume
Mole Calculations	number of moles = $\frac{\text{given mass}}{\text{gram-formula mass}}$	
Percent Error	% error = $\frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$	
Percent Composition	% composition by mass = $\frac{\text{mass of part}}{\text{mass of whole}} \times 100$	
Concentration	parts per million = $\frac{\text{mass of solute}}{\text{mass of solution}} \times 1000000$	
	molarity = $\frac{\text{moles of solute}}{\text{liter of solution}}$	
Combined Gas Law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	P = pressure V = volume T = temperature
Titration	$M_A V_A = M_B V_B$	M_A = molarity of H ⁺ M_B = molarity of OH ⁻ V_A = volume of acid V_B = volume of base
Heat	$q = mC\Delta T$ $q = mH_f$ $q = mH_v$	q = heat m = mass C = specific heat capacity ΔT = change in temperature H_f = heat of fusion H_v = heat of vaporization
Temperature	$K = ^\circ C + 273$	K = kelvin $^\circ C$ = degree Celsius