

1																	2
H 1.008																	He 4.00
3	2															9	10
Li 6.94	Be 9.01															F 19.00	Ne 20.18
11	12															17	18
Na 22.99	Mg 24.30															Cl 35.45	Ar 39.95
19	20	21	3	4	5	6	7	8	9	10	11	12					36
K 39.10	Ca 40.08	Sc 44.96	Ti 47.87	V 50.94	Cr 52.00	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69	Cu 63.55	Zn 65.38	Ga 69.72	Ge 72.63	As 74.92	Se 78.97	Br 79.90	Kr 83.80
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
85.47	87.62	88.91	91.22	92.91	95.95		101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.60	126.90	131.29
55	56			73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	57-71	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.91	137.33	*	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.2	208.98			
87	88	89-103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra	†	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La 138.91	Ce 140.12	Pr 140.91	Nd 144.24	Pm	Sm 150.36	Eu 151.97	Gd 157.25	Tb 158.93	Dy 162.50	Ho 164.93	Er 167.26	Tm 168.93	Yb 173.05	Lu 174.97
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th 232.04	Pa 231.04	U 238.03	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

*Lanthanoids

†Actinoids

Periodic Table of the Electronegativities

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1 H 2.1	3 Li 1.0	11 Na 0.9	19 K 0.8	27 V 1.6	35 Br 2.8	43 Tc 1.6	51 Sb 1.9	59 Pr 1.1	67 Ho 1.1	75 Re 1.9	83 Bi 1.9	91 Pa 1.5	99 Es 1.3	107 Uuh 1.1	115 Nh 1.7	123 Nh 1.7	131 Nh 1.7
2 He	4 Be 1.5	12 Mg 1.2	20 Ca 1.0	28 Ni 1.8	36 Kr 3.0	44 Ru 2.2	52 Te 2.1	60 Nd 1.1	68 Er 1.1	76 Os 2.2	84 Po 2.0	92 U 1.7	100 Fm 1.3	108 Uuo 1.1	116 Lv 1.8	124 Lv 1.8	132 Lv 1.8
	5 B 2.0	13 Al 1.5	21 Sc 1.3	29 Cu 1.9	37 Rb 0.8	45 Rh 2.2	53 I 2.5	61 Pm 1.1	69 Tm 1.1	77 Ir 2.2	85 At 2.2	93 Np 1.3	101 Md 1.3	109 Uue 1.1	117 Ts 2.0	125 Ts 2.0	133 Ts 2.0
	6 C 2.5	14 Si 1.8	22 Ti 1.5	30 Zn 1.6	38 Sr 1.0	46 Pd 2.2	54 Xe 2.6	72 Hf 1.3	80 Hg 1.9	88 Ra 0.9	96 Cf 1.3	104 No 1.3	112 Nh 1.3	120 Ds 1.3	128 Ds 1.3	136 Ds 1.3	144 Ds 1.3
	7 N 3.0	15 P 2.1	23 V 1.6	31 Ga 1.6	39 Y 1.2	47 Ag 1.9	55 Cs 0.7	73 Ta 1.5	81 Tl 1.8	89 Ac 1.1	97 Bk 1.3	105 Db 1.3	113 Nh 1.3	121 Nh 1.3	129 Nh 1.3	137 Nh 1.3	145 Nh 1.3
	8 O 3.5	16 S 2.5	24 Cr 1.6	32 Ge 1.8	40 Zr 1.4	48 Pt 2.2	56 Ba 0.9	74 W 1.7	82 Pb 1.8	90 Th 1.3	98 Cf 1.3	106 Lr 1.2	114 Nh 1.3	122 Nh 1.3	130 Nh 1.3	138 Nh 1.3	146 Nh 1.3
	9 F 4.0	17 Cl 3.0	25 Mn 1.5	33 As 2.0	41 Nb 1.6	49 In 1.7	57 La 1.1	75 Re 1.9	83 Bi 1.9	91 Pa 1.5	99 Es 1.3	107 Uuo 1.1	115 Nh 1.7	123 Nh 1.7	131 Nh 1.7	139 Nh 1.7	147 Nh 1.7
	10 Ne	18 Ar	26 Fe 1.8	34 Se 2.4	42 Mo 1.8	50 Sn 1.8	58 Ce 1.1	76 Os 2.2	84 Po 2.0	92 U 1.7	100 Fm 1.3	108 Uuo 1.1	116 Lv 1.8	124 Lv 1.8	132 Lv 1.8	140 Lv 1.8	148 Lv 1.8

Electro. Neg. Difference	Bond Type
0 - 0.4	nonpolar
0.5 - 1.9	polar
≥ 2.0	ionic

Lanthanide Series

Actinide Series

AP® CHEMISTRY EQUATIONS AND CONSTANTS

UNIT SYMBOLS	
gram,	g
mole,	mol
liter,	L
meter,	m
second,	s
hertz,	Hz
atmosphere,	atm
millimeter of mercury,	mm Hg
degree Celsius,	°C
kelvin,	K
joule,	J
volt,	V
coulomb,	C
ampere,	A

UNIT CONVERSIONS
1 hertz = 1 s ⁻¹
1 atm = 760 mm Hg = 760 torr
K = °C + 273.15
1 volt = $\frac{1 \text{ joule}}{1 \text{ coulomb}}$
1 ampere = $\frac{1 \text{ coulomb}}{1 \text{ second}}$

METRIC PREFIXES		
Factor	Prefix	Symbol
10 ⁹	giga	G
10 ⁶	mega	M
10 ³	kilo	k
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p

ATOMIC STRUCTURE

$$E = h\nu$$

$$c = \lambda\nu$$

$$F_{\text{coulombic}} \propto \frac{q_1 q_2}{r^2}$$

E = energy

ν = frequency

λ = wavelength

F = force

q = charge

r = separation

Planck's constant, *h* = 6.626 × 10⁻³⁴ J s

Speed of light, *c* = 2.998 × 10⁸ m s⁻¹

Avogadro's number = 6.022 × 10²³ mol⁻¹

GASES, LIQUIDS, AND SOLUTIONS

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$PV = nRT$$

$$P_A = P_{\text{total}} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{\text{total}} = P_A + P_B + P_C + \dots$$

$$n = \frac{m}{M}$$

$$D = \frac{m}{V}$$

$$KE = \frac{1}{2}mv^2$$

$$M = \frac{n_{\text{solute}}}{L_{\text{solution}}}$$

$$A = \epsilon bc$$

P = pressure

V = volume

T = temperature

n = number of moles

X = mole fraction

m = mass

M = molar mass

D = density

KE = kinetic energy

v = velocity

M = molarity

A = absorbance

ε = molar absorptivity

b = path length

c = concentration

Gas constant, *R* = 8.314 J mol⁻¹ K⁻¹

= 0.08206 L atm mol⁻¹ K⁻¹

STP = 273.15 K and 1.0 atm

Ideal gas at STP = 22.4 L mol⁻¹

KINETICS

$$[A]_t - [A]_0 = -kt$$

$$\ln[A]_t - \ln[A]_0 = -kt$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

k = rate constant

t = time

$t_{1/2}$ = half-life

EQUILIBRIUM

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}, \text{ where } a A + b B \rightleftharpoons c C + d D$$

$$K_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

$$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

$$pK_w = 14 = \text{pH} + \text{pOH at } 25^\circ\text{C}$$

$$\text{pH} = -\log[H_3O^+], \quad \text{pOH} = -\log[OH^-]$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}, \quad K_b = \frac{[OH^-][HB^+]}{[B]}$$

$$pK_a = -\log K_a, \quad pK_b = -\log K_b$$

$$K_w = K_a \times K_b, \quad pK_w = pK_a + pK_b$$

$$\text{pH} = pK_a + \log \frac{[A^-]}{[HA]}$$

Equilibrium Constants

K_c (molar concentrations)

K_p (gas pressures)

K_w (water)

K_a (acid)

K_b (base)

THERMODYNAMICS/ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$\Delta H^\circ_{\text{reaction}} = \sum \Delta H^\circ_{f \text{ products}} - \sum \Delta H^\circ_{f \text{ reactants}}$$

$$\Delta S^\circ_{\text{reaction}} = \sum S^\circ_{\text{products}} - \sum S^\circ_{\text{reactants}}$$

$$\Delta G^\circ_{\text{reaction}} = \sum \Delta G^\circ_{f \text{ products}} - \sum \Delta G^\circ_{f \text{ reactants}}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$= -RT \ln K$$

$$= -nFE^\circ$$

$$I = \frac{q}{t}$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{RT}{nF} \ln Q$$

q = heat

m = mass

c = specific heat capacity

T = temperature

S° = standard entropy

H° = standard enthalpy

G° = standard Gibbs free energy

R = gas constant

K = equilibrium constant

n = number of moles of electrons

E° = standard potential

I = current (amperes)

q = charge (coulombs)

t = time (seconds)

Q = reaction quotient

Faraday's constant, $F = 96,485 \text{ coulombs} / 1 \text{ mol } e^-$

TABLE 8.4 • Average Bond Enthalpies (kJ/mol)**Single Bonds**

C—H	413	N—H	391	O—H	463	F—F	155
C—C	348	N—N	163	O—O	146		
C—N	293	N—O	201	O—F	190	Cl—F	253
C—O	358	N—F	272	O—Cl	203	Cl—Cl	242
C—F	485	N—Cl	200	O—I	234		
C—Cl	328	N—Br	243			Br—F	237
C—Br	276			S—H	339	Br—Cl	218
C—I	240	H—H	436	S—F	327	Br—Br	193
C—S	259	H—F	567	S—Cl	253		
		H—Cl	431	S—Br	218	I—Cl	208
Si—H	323	H—Br	366	S—S	266	I—Br	175
Si—Si	226	H—I	299			I—I	151
Si—C	301						
Si—O	368						
Si—Cl	464						

Multiple Bonds

C=C	614	N=N	418	O ₂	495
C≡C	839	N≡N	941		
C=N	615	N=O	607	S=O	523
C≡N	891			S=S	418
C=O	799				
C≡O	1072				

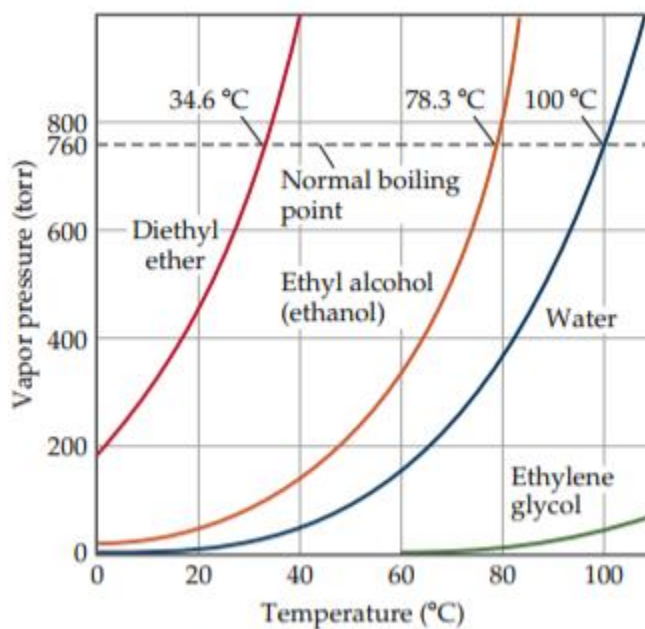
**▲ FIGURE 11.25** Vapor pressure for four liquids as a function of temperature.

TABLE 9.2 • Electron-Domain and Molecular Geometries for Two, Three, and Four Electron Domains around a Central Atom

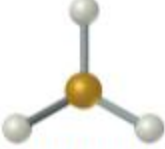
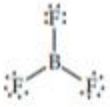
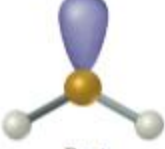
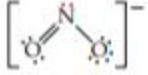
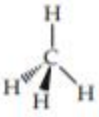
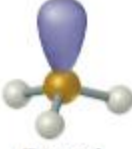
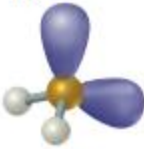
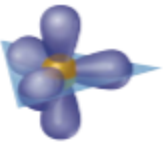
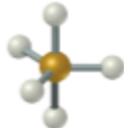
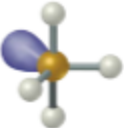
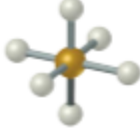
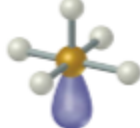
Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
2	 Linear	2	0	 Linear	$\ddot{\text{O}}=\text{C}=\ddot{\text{O}}$
3	 Trigonal planar	3	0	 Trigonal planar	
		2	1	 Bent	
4	 Tetrahedral	4	0	 Tetrahedral	
		3	1	 Trigonal pyramidal	
		2	2	 Bent	

TABLE 9.3 • Electron-Domain and Molecular Geometries for Five and Six Electron Domains around a Central Atom

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
5	 Trigonal bipyramidal	5	0	 Trigonal bipyramidal	PCl_5
		4	1	 Seesaw	SF_4
		3	2	 T-shaped	ClF_3
		2	3	 Linear	XeF_2
6	 Octahedral	6	0	 Octahedral	SF_6
		5	1	 Square pyramidal	BrF_5
		4	2	 Square planar	XeF_4