INFORMATION IN THE TABLE BELOW AND IN THE TABLES ON PAGES 3-5 MAY BE USEFUL IN ANSWERING THE QUESTIONS IN THIS SECTION OF THE EXAMINATION.

DO NOT DETACH FROM BOOK.

PERIODIC TABLE OF THE ELEMENTS

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 16.00	9 F 19.00	10 Ne 20.179
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.938	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.91	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.02	89 †Ac 227.03	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 § (269)	111 § (272)	112 § (277)						

§Not yet named

*Lanthanide Series	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
†Actinide Series	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

STANDARD REDUCTION POTENTIALS IN AQUEOUS SOLUTION AT 25°C

Half-reaction			$E°$(V)
$F_2(g) + 2e^-$	→	$2F^-$	2.87
$Co^{3+} + e^-$	→	Co^{2+}	1.82
$Au^{3+} + 3e^-$	→	$Au(s)$	1.50
$Cl_2(g) + 2e^-$	→	$2Cl^-$	1.36
$O_2(g) + 4H^+ + 4e^-$	→	$2H_2O(l)$	1.23
$Br_2(l) + 2e^-$	→	$2Br^-$	1.07
$2Hg^{2+} + 2e^-$	→	$Hg_2{}^{2+}$	0.92
$Hg^{2+} + 2e^-$	→	$Hg(l)$	0.85
$Ag^+ + e^-$	→	$Ag(s)$	0.80
$Hg_2{}^{2+} + 2e^-$	→	$2Hg(l)$	0.79
$Fe^{3+} + e^-$	→	Fe^{2+}	0.77
$I_2(s) + 2e^-$	→	$2I^-$	0.53
$Cu^+ + e^-$	→	$Cu(s)$	0.52
$Cu^{2+} + 2e^-$	→	$Cu(s)$	0.34
$Cu^{2+} + e^-$	→	Cu^+	0.15
$Sn^{4+} + 2e^-$	→	Sn^{2+}	0.15
$S(s) + 2H^+ + 2e^-$	→	$H_2S(g)$	0.14
$2H^+ + 2e^-$	→	$H_2(g)$	0.00
$Pb^{2+} + 2e^-$	→	$Pb(s)$	−0.13
$Sn^{2+} + 2e^-$	→	$Sn(s)$	−0.14
$Ni^{2+} + 2e^-$	→	$Ni(s)$	−0.25
$Co^{2+} + 2e^-$	→	$Co(s)$	−0.28
$Cd^{2+} + 2e^-$	→	$Cd(s)$	−0.40
$Cr^{3+} + e^-$	→	Cr^{2+}	−0.41
$Fe^{2+} + 2e^-$	→	$Fe(s)$	−0.44
$Cr^{3+} + 3e^-$	→	$Cr(s)$	−0.74
$Zn^{2+} + 2e^-$	→	$Zn(s)$	−0.76
$2H_2O(l) + 2e^-$	→	$H_2(g) + 2OH^-$	−0.83
$Mn^{2+} + 2e^-$	→	$Mn(s)$	−1.18
$Al^{3+} + 3e^-$	→	$Al(s)$	−1.66
$Be^{2+} + 2e^-$	→	$Be(s)$	−1.70
$Mg^{2+} + 2e^-$	→	$Mg(s)$	−2.37
$Na^+ + e^-$	→	$Na(s)$	−2.71
$Ca^{2+} + 2e^-$	→	$Ca(s)$	−2.87
$Sr^{2+} + 2e^-$	→	$Sr(s)$	−2.89
$Ba^{2+} + 2e^-$	→	$Ba(s)$	−2.90
$Rb^+ + e^-$	→	$Rb(s)$	−2.92
$K^+ + e^-$	→	$K(s)$	−2.92
$Cs^+ + e^-$	→	$Cs(s)$	−2.92
$Li^+ + e^-$	→	$Li(s)$	−3.05

ADVANCED PLACEMENT CHEMISTRY EQUATIONS AND CONSTANTS

ATOMIC STRUCTURE

$E = h\nu \qquad c = \lambda\nu$

$\lambda = \dfrac{h}{mv} \qquad p = mv$

$E_n = \dfrac{-2.178 \times 10^{-18}}{n^2}$ joule

E = energy, v = velocity
ν = frequency, n = principal quantum number
λ = wavelength, m = mass
p = momentum

Speed of light, $c = 3.0 \times 10^{8}\ \text{m s}^{-1}$

Planck's constant, $h = 6.63 \times 10^{-34}$ J s

Boltzmann's constant, $k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$

Avogadro's number $= 6.022 \times 10^{23}\ \text{mol}^{-1}$

Electron charge, $e = -1.602 \times 10^{-19}$ coulomb

1 electron volt per atom $= 96.5\ \text{kJ mol}^{-1}$

EQUILIBRIUM

$K_a = \dfrac{[H^+][A^-]}{[HA]}$

$K_b = \dfrac{[OH^-][HB^+]}{[B]}$

$K_w = [OH^-][H^+] = 1.0 \times 10^{-14}$ @ 25°C

$= K_a \times K_b$

$pH = -\log[H^+],\ pOH = -\log[OH^-]$

$14 = pH + pOH$

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

$pOH = pK_b + \log\dfrac{[HB^+]}{[B]}$

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

$K_p = K_c(RT)^{\Delta n}$,

where Δn = moles product gas − moles reactant gas

Equilibrium Constants

K_a (weak acid)
K_b (weak base)
K_w (water)
K_p (gas pressure)
K_c (molar concentrations)

THERMOCHEMISTRY/KINETICS

$\Delta S^\circ = \sum S^\circ$ products $- \sum S^\circ$ reactants

$\Delta H^\circ = \sum \Delta H_f^\circ$ products $- \sum \Delta H_f^\circ$ reactants

$\Delta G^\circ = \sum \Delta G_f^\circ$ products $- \sum \Delta G_f^\circ$ reactants

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

$= -RT \ln K = -2.303\, RT \log K$

$= -n\mathcal{F}E^\circ$

$\Delta G = \Delta G^\circ + RT \ln Q = \Delta G^\circ + 2.303\, RT \log Q$

$q = mc\Delta T$

$C_p = \dfrac{\Delta H}{\Delta T}$

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

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

$\ln k = \dfrac{-E_a}{R}\left(\dfrac{1}{T}\right) + \ln A$

S° = standard entropy
H° = standard enthalpy
G° = standard free energy
E° = standard reduction potential
T = temperature
n = moles
m = mass
q = heat
c = specific heat capacity
C_p = molar heat capacity at constant pressure
E_a = activation energy
k = rate constant
A = frequency factor

Faraday's constant, $\mathcal{F}$ = 96,500 coulombs per mole of electrons

Gas constant, $R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$

$= 0.0821\ \text{L atm mol}^{-1}\ \text{K}^{-1}$

$= 8.31\ \text{volt coulomb mol}^{-1}\ \text{K}^{-1}$

GASES, LIQUIDS, AND SOLUTIONS

$PV = nRT$

$\left(P + \dfrac{n^2a}{V^2}\right)(V - nb) = nRT$

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

$P_{total} = P_A + P_B + P_C + \ldots$

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

$K = {}^\circ C + 273$

$\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$

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

$u_{rms} = \sqrt{\dfrac{3kT}{m}} = \sqrt{\dfrac{3RT}{M}}$

KE per molecule $= \dfrac{1}{2}mv^2$

KE per mole $= \dfrac{3}{2}RT$

$\dfrac{r_1}{r_2} = \sqrt{\dfrac{M_2}{M_1}}$

molarity, M = moles solute per liter solution

molality = moles solute per kilogram solvent

$\Delta T_f = iK_f \times$ molality

$\Delta T_b = iK_b \times$ molality

$\pi = iMRT$

$A = abc$

P = pressure
V = volume
T = temperature
n = number of moles
D = density
m = mass
v = velocity

u_{rms} = root-mean-square speed
KE = kinetic energy
r = rate of effusion
M = molar mass
π = osmotic pressure
i = van't Hoff factor
K_f = molal freezing-point depression constant
K_b = molal boiling-point elevation constant
A = absorbance
a = molar absorptivity
b = path length
c = concentration
Q = reaction quotient
I = current (amperes)
q = charge (coulombs)
t = time (seconds)
E° = standard reduction potential
K = equilibrium constant

OXIDATION-REDUCTION; ELECTROCHEMISTRY

$Q = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$, where $a\,A + b\,B \rightarrow c\,C + d\,D$

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

$E_{cell} = E^\circ_{cell} - \dfrac{RT}{n\mathcal{F}}\ln Q = E^\circ_{cell} - \dfrac{0.0592}{n}\log Q$ @ 25°C

$\log K = \dfrac{nE^\circ}{0.0592}$

Gas constant, $R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$

$= 0.0821\ \text{L atm mol}^{-1}\ \text{K}^{-1}$

$= 8.31\ \text{volt coulomb mol}^{-1}\ \text{K}^{-1}$

Boltzmann's constant, $k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$

K_f for $H_2O = 1.86\ \text{K kg mol}^{-1}$

K_b for $H_2O = 0.512\ \text{K kg mol}^{-1}$

1 atm = 760 mm Hg

= 760 torr

STP = 0.000°C and 1.000 atm

Faraday's constant, $\mathcal{F}$ = 96,500 coulombs per mole of electrons