

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	2											17	18				
H 1.008												He 4.00					
3	4											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	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K 39.10	Ca 40.08	Sc 44.96	Ti 47.90	V 50.94	Cr 52.00	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69	Cu 63.55	Zn 65.39	Ga 69.72	Ge 72.59	As 74.92	Se 78.96	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 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc (98)	Ru 101.1	Rh 102.91	Pd 106.42	Ag 107.87	Cd 112.41	In 114.82	Sn 118.71	Sb 121.75	Te 127.60	I 126.91	Xe 131.29
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs 132.91	Ba 137.33	*La 138.91	Hf 178.49	Ta 180.95	W 183.85	Re 186.21	Os 190.2	Ir 192.2	Pt 195.08	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98	Po (209)	At (210)	Rn (222)
87	88	89	104	105	106	107	108	109	110	111							
Fr (223)	Ra 226.02	†Ac 227.03	Rf (261)	Db (262)	Sg (266)	Bh (264)	Hs (277)	Mt (268)	Ds (271)	Rg (272)							
*Lanthanide Series																	
58	59	60	61	62	63	64	65	66	67	68	69	70	71				
Ce 140.12	Pr 140.91	Nd 144.24	Pm (145)	Sm 150.4	Eu 151.97	Gd 157.25	Tb 158.93	Dy 162.50	Ho 164.93	Er 167.26	Tm 168.93	Yb 173.04	Lu 174.97				
90	91	92	93	94	95	96	97	98	99	100	101	102	103				
Th 232.04	Pa 231.04	U 238.03	Np (237)	Pu (244)	Am (243)	Cm (247)	Bk (247)	Cf (251)	Es (252)	Fm (257)	Md (258)	No (259)	Lr (262)				
†Actinide Series																	

STANDARD REDUCTION POTENTIALS IN AQUEOUS SOLUTION AT

Half-reaction		$E^\circ(\text{V})$
$\text{F}_2(\text{g}) + 2e^-$	$\rightarrow 2\text{F}^-$	2.87
$\text{Co}^{3+} + e^-$	$\rightarrow \text{Co}^{2+}$	1.82
$\text{Au}^{3+} + 3e^-$	$\rightarrow \text{Au}(\text{s})$	1.50
$\text{Cl}_2(\text{g}) + 2e^-$	$\rightarrow 2\text{Cl}^-$	1.36
$\text{O}_2(\text{g}) + 4\text{H}^+ + 4e^-$	$\rightarrow 2\text{H}_2\text{O}(\text{l})$	1.23
$\text{Br}_2(\text{l}) + 2e^-$	$\rightarrow 2\text{Br}^-$	1.07
$2\text{Hg}^{2+} + 2e^-$	$\rightarrow \text{Hg}_2^{2+}$	0.92
$\text{Hg}^{2+} + 2e^-$	$\rightarrow \text{Hg}(\text{l})$	0.85
$\text{Ag}^+ + e^-$	$\rightarrow \text{Ag}(\text{s})$	0.80
$\text{Hg}_2^{2+} + 2e^-$	$\rightarrow 2\text{Hg}(\text{l})$	0.79
$\text{Fe}^{3+} + e^-$	$\rightarrow \text{Fe}^{2+}$	0.77
$\text{I}_2(\text{s}) + 2e^-$	$\rightarrow 2\text{I}^-$	0.53
$\text{Cu}^+ + e^-$	$\rightarrow \text{Cu}(\text{s})$	0.52
$\text{Cu}^{2+} + 2e^-$	$\rightarrow \text{Cu}(\text{s})$	0.34
$\text{Cu}^{2+} + e^-$	$\rightarrow \text{Cu}^+$	0.15
$\text{Sn}^{4+} + 2e^-$	$\rightarrow \text{Sn}^{2+}$	0.15
$\text{S}(\text{s}) + 2\text{H}^+ + 2e^-$	$\rightarrow \text{H}_2\text{S}(\text{g})$	0.14
$2\text{H}^+ + 2e^-$	$\rightarrow \text{H}_2(\text{g})$	0.00
$\text{Pb}^{2+} + 2e^-$	$\rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+} + 2e^-$	$\rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+} + 2e^-$	$\rightarrow \text{Ni}(\text{s})$	-0.25
$\text{Co}^{2+} + 2e^-$	$\rightarrow \text{Co}(\text{s})$	-0.28
$\text{Cd}^{2+} + 2e^-$	$\rightarrow \text{Cd}(\text{s})$	-0.40
$\text{Cr}^{3+} + e^-$	$\rightarrow \text{Cr}^{2+}$	-0.41
$\text{Fe}^{2+} + 2e^-$	$\rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Cr}^{3+} + 3e^-$	$\rightarrow \text{Cr}(\text{s})$	-0.74
$\text{Zn}^{2+} + 2e^-$	$\rightarrow \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O}(\text{l}) + 2e^-$	$\rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-$	-0.83
$\text{Mn}^{2+} + 2e^-$	$\rightarrow \text{Mn}(\text{s})$	-1.18
$\text{Al}^{3+} + 3e^-$	$\rightarrow \text{Al}(\text{s})$	-1.66
$\text{Be}^{2+} + 2e^-$	$\rightarrow \text{Be}(\text{s})$	-1.70
$\text{Mg}^{2+} + 2e^-$	$\rightarrow \text{Mg}(\text{s})$	-2.37
$\text{Na}^+ + e^-$	$\rightarrow \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+} + 2e^-$	$\rightarrow \text{Ca}(\text{s})$	-2.87
$\text{Sr}^{2+} + 2e^-$	$\rightarrow \text{Sr}(\text{s})$	-2.89
$\text{Ba}^{2+} + 2e^-$	$\rightarrow \text{Ba}(\text{s})$	-2.90
$\text{Rb}^+ + e^-$	$\rightarrow \text{Rb}(\text{s})$	-2.92
$\text{K}^+ + e^-$	$\rightarrow \text{K}(\text{s})$	-2.92
$\text{Cs}^+ + e^-$	$\rightarrow \text{Cs}(\text{s})$	-2.92
$\text{Li}^+ + e^-$	$\rightarrow \text{Li}(\text{s})$	-3.05

ADVANCED PLACEMENT CHEMISTRY EQUATIONS AND CONSTANTS

ATOMIC STRUCTURE

$$E = hv \quad c = \lambda\nu$$

$$\lambda = \frac{h}{m\nu} \quad p = mv$$

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

EQUILIBRIUM

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

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

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

$$= K_a \times K_b$$

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

$$14 = \text{pH} + \text{pOH}$$

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

$$\text{pOH} = \text{p}K_b + \log \frac{[\text{HB}^+]}{[\text{B}]}$$

$$\text{p}K_a = -\log K_a, \text{p}K_b = -\log K_b$$

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

where Δn = moles product gas – moles reactant gas

THERMOCHEMISTRY/KINETICS

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

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

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

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

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

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

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

$$q = mc\Delta T$$

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

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

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

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

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, $h = 6.63 \times 10^{-34} \text{ J s}$

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

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

Equilibrium Constants

K_a (weak acid)

K_b (weak base)

K_w (water)

K_p (gas pressure)

K_c (molar concentrations)

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, $\mathcal{F} = 96,500 \text{ coulombs per mole of electrons}$

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

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

$= 62.4 \text{ L torr mol}^{-1} \text{ K}^{-1}$

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

GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

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

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

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

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

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

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

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

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

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

$$KE \text{ per mole} = \frac{3}{2}RT$$

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

molarity, M = moles solute per liter solution

molality = moles solute per kilogram solvent

$$\Delta T_f = iK_f \times \text{molality}$$

$$\Delta T_b = iK_b \times \text{molality}$$

$$\pi = iMRT$$

$$A = abc$$

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

$$Q = \frac{[C]^c [D]^d}{[A]^a [B]^b}, \text{ where } aA + bB \rightarrow cC + dD$$

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

$$E_{cell} = E_{cell}^\circ - \frac{RT}{nF} \ln Q = E_{cell}^\circ - \frac{0.0592}{n} \log Q \text{ @ } 25^\circ C$$

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

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

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

$$= 62.4 \text{ L torr mol}^{-1} \text{ K}^{-1}$$

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

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

$$K_f \text{ for H}_2\text{O} = 1.86 \text{ K kg mol}^{-1}$$

$$K_b \text{ for H}_2\text{O} = 0.512 \text{ K kg mol}^{-1}$$

$$1 \text{ atm} = 760 \text{ mm Hg}$$

$$= 760 \text{ torr}$$

$$\text{STP} = 0.00^\circ C \text{ and } 1.0 \text{ atm}$$

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