THE EQUATION SHEET

Constants:

Avogadro's Number (***NA***)	6.022×10^{23}
Universal Gas Constant (***R***)	8.314 J/mol·K or 0.0821 L·atm/mol·K
Planck's constant (***h***)	6.626×10^{-34} J·s
Rydberg Constant (**RH**)	2.18×10^{-18} J
Speed of Light (***c***)	3.00×10^{8} m/s
Charge of an Electron (***q***)	1.602×10^{-19}
Boltzmann Constant (***kB***)	1.381×10^{-23} J/K
Molar Volume (***Vmol***)	22.7 L/mol
Mass of Earth	5.97 x 10^{24} kg
Specific Heat Capacity of Water (***C***)	4.18 J/gK or 4.18 kJ/kgK
Ionic Product Constant of Water (***Kw***)	1.00×10^{-14} (mol/L)^2 at 298 K (25°C)
Faraday's constant (***F***)	96 500 C/mol
STP conditions /SATP	273 K and 100 kPa / 298 K and 100 kPa

Basic Equations:

$n = \frac{m}{M_R}$ $\quad n = cV$ $\quad PV = nRT$

$Order\ of\ reaction = m + n$ $\quad c_1V_1 = c_2V_2$

$n_{gas} = \frac{V}{22.7 mol/L}$ $\quad K_{SP} = K_c$ (Aqueous)

$\%\ atom\ ecomony = \frac{molar\ mass\ of\ desired\ product}{molar\ mass\ of\ all\ reactants} \times 100\%$

Conversion factors:

1 atm = 101.325 kPa 1atm = 760 torr = 760 mm Hg

$1nm = 10^{-9}$ m 0°C = 273.15 K

$1dm^3 = 1L = 1 \times 10^{-3}\ m^3 = 1 \times 10^{3}\ cm^3 = 1 \times 10^{3}$ mL

1 amu = 1.66 x 10^{-27} kg

Acid-Base Chemistry:

$pH = -\log[H_3O^+]$

$[H_3O^+] = 10^{-pH}$

$K_w = K_a \times K_b$

$pK_a + pK_b = pK_w$

$pK_a = -\log K_a$

$pK_b = -\log K_b$

$pK_b = 14 - pK_a$

$pH + pOH = 14$

$pOH = -\log[OH^-]$

$[OH^-] = 10^{-pOH}$

$pH_{Buffer} = pKa - \log\left(\frac{[HA]}{[A^-]}\right)$

Thermodynamics:

$\Delta H_{rxn} = H_P - H_R$

$q = \Delta H$ at constant pressure

$\Delta H^o = \frac{-Q}{\#mol}$

$M_{Enthalpy} = \sum(E_k + E_p)$

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

$C = \frac{Q}{\Delta T}$

$Q = mc\Delta T$

$\Delta H^o_{rxn} = \sum[\Delta H^o_{f(P)}] - \sum[\Delta H^o_{F(R)}]$

$\Delta H^o_{rxn} = \sum D(broken) - \sum D(formed)$

$\Delta S = k \ln W = \frac{q}{T} = \frac{\Delta H}{T} = S_{System} + S_{Surrounding}$

$\Delta S^o_{rxn} = \sum S^o_{(P)} - \sum S^o_{(R)}$

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

$\Delta G^o_{rxn} = \sum \Delta G^o_{(P)} - \sum \Delta G^o_{(R)}$

Chemical Kinetics & Equilibrium:

$Rate_{Reaction} = \frac{\Delta c}{\Delta t}$

$Rate_{Reaction} = k[A]^m[B]^n$

$E_A = -RT\ln\left(\frac{k}{A}\right)$

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

$t_{1/2} = \frac{1}{k[A]_o}$

$k = Ae^{-Ea/RT}$

$[A]_t = -kt + [A]_o$

$\ln[A]_t = -kt + \ln[A]_o$

$\ln\frac{k_1}{k_2} = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$K_C = \frac{[Products]^{nB}}{[Reactants]^{nA}}$

$K_P = K_C(RT)^{\Delta n}$

$\Delta G^o = -RT\ln K$

Quantum Mechanics:

$\Delta E = \frac{hc}{\lambda}$

$c = \lambda v$

$\Delta E = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$E = hf$

$n\lambda = 2d\sin\theta$

Nuclear Chemistry:

$E = mc^2$

$^{238}_{92}U = {}^{234}_{+0}Th + {}^{4}_{2}He$

$^{1}_{0}n \rightarrow {}^{1}_{1}H + {}^{0}_{-1}e$

Gas:

$PV = nRT$ $\quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\quad \frac{Rate_1}{Rate_2} = \sqrt{\frac{M_2}{M_1}}$

STP conditions= 273 K and 100 kPa

SATP conditions= 298 K and 100 kPa

$n_{gas} = \frac{V}{22.7 mol/L}$

Redox:

$Charge = Current \times Time$

$E^o_{cell} = E^o_{cathode} - E^o_{Anode}$

$\Delta G^o = -nFE^o$

Extras

Solubility:

Q_c	K_c	Q	K_{sp} (Precipitate)
<	Prod Fav	<	No
=	EQ	=	No
>	React Fav	>	Yes (Super Saturated)

Aufbau Principle: Build up electrons one by one.

1K(2)2L(8)3M(18)4N(32)5O(50)6P(72)7Q(98)

Formations:

1. Acid + Metal = Salt (aq) + Hydrogen Gas
   Ex. $2HCl_{(aq)} + Zn_{(s)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$
2. Acid + Base = Salt (aq) + Water
   Ex. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$
3. Acid + Metal Carbonate = CO_2 + H_2O + Salt (aq)
   Ex. $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)} + CaCl_{2(aq)}$
4. Metal Oxide + Acid → Salt (aq) + Water
   Ex. $MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_2O_{(l)}$

Periodic Table of Electronegativities

H 2.20																	He n.a.
Li 0.98	Be 1.57											B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	Ne n.a.
Na 0.93	Mg 1.31											Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16	Ar n.a.
K 0.82	Ca 1.00	Sc 1.36	Ti 1.54	V 1.63	Cr 1.66	Mn 1.55	Fe 1.83	Co 1.88	Ni 1.91	Cu 1.90	Zn 1.65	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96	Kr 3.00
Rb 0.82	Sr 0.95	Y 1.22	Zr 1.33	Nb 1.60	Mo 2.16	Tc 1.90	Ru 2.20	Rh 2.28	Pd 2.20	Ag 1.93	Cd 1.69	In 1.78	Sn 1.96	Sb 2.05	Te 2.10	I 2.66	Xe 2.60
Cs 0.79	Ba 0.89	La 1.10	Hf 1.30	Ta 1.50	W 2.36	Re 1.90	Os 2.20	Ir 2.20	Pt 2.28	Au 2.54	Hg 2.00	Tl 1.62	Pb 2.33	Bi 2.02	Po 2.00	At 2.20	Rn n.a.
Fr 0.70	Ra 0.89	Ac 1.10	Rf n.a.	Db n.a.	Sg n.a.	Bh n.a.	Hs n.a.	Mt n.a.	Ds n.a.	Rg n.a.	Uub n.a.	—	Uuq n.a.	—	—	—	—

Polyatomic Ions:

Acetate	CH_3COO^- or $C_2H_3O_2^-$	*Hydroxide*	OH^-
Aluminate	AlO_2^-, $Al_2O_4^{2-}$	*Hypobromite*	BrO^-
Amide	NH_2^-	*Hypochlorite*	ClO^-
Ammonium	NH_4^+	*Hypoiodite*	IO^-
Antimonate	SbO_4^{3-}	*Hypophosphite*	PO_2^{3-}
Antimonite	SbO_3^{3-}	*Hyposulfite*	SO_2^{2-}
Arsenate	AsO_4^{3-}	*Iodate*	IO_3^-
Arsenite	AsO_3^{3-}	*Iodite*	IO_2^-
Bicarbonate (hydrogen carbonate)	HCO_3^-	*Manganate*	MnO_4^{2-}
Bromate	BrO_3^-	*Nitrate*	NO_3^-
Bromite	BrO_2^-	*Nitrite*	NO_2^-
Carbide	C_2^{2-}	*Oxalate*	$C_2O_4^{2-}$
Carbonate	CO_3^{2-}	*Ozonide*	O_3^-
Chlorate	ClO_3^-	*Perbromate*	BrO_4^-
Chlorite	ClO_2^-	*Perchlorate*	ClO_4^-
Chromate	CrO_4^{2-}	*Periodate*	IO_4^-
Chromite	CrO_2^-	*Permanganate*	MnO_4^-
Cyanate	OCN^-	*Peroxide*	O_2^{2-}
Cyanide	CN^-	*Phosphate*	PO_4^{3-}
Dichromate	$Cr_2O_7^{2-}$	*Phosphite*	PO_3^{3-}
Dihydrogen arsenate	$H_2AsO_4^-$	*Plumbate*	PbO_3^{2-}
Dihydrogen phosphate	$H_2PO_4^-$	*Plumbite*	PbO_2^{2-}
Dihydrogen phosphite	$H_2PO_3^-$	*Stannate*	SnO_3^{2-}
Disulfide	S_2^{2-}	*Stannite*	SnO_2^{2-}
Ferrate	FeO_4^{2-}	*Sulfate*	SO_4^{2-}
Hydrogen carbonate (bicarbonate)	HCO_3^-	*Sulfite*	SO_3^{2-}
Hydrogen arsenate	$HAsO_4^{2-}$	*Superoxide*	O_2^-
Hydrogen phosphate	HPO_4^{2-}	*Tartrate*	$(CH(OH)COO)_2^{2-}$
Hydrogen phosphite	HPO_3^{2-}	*Tellurate*	TeO_4^{2-}
Hydrogen sulfate (bisulphate)	HSO_4^-	*Tellurite*	TeO_3^{2-}
Hydrogen sulfite (bisulphite)	HSO_3^-	*Thiocyanate*	SCN^-
Hydronium	H_3O^+	*Thiosulfate*	$S_2O_3^{2-}$

Periodic Table of Atomic Masses and Charges

1	2											13	14	15	16	17	18
1 +1 H 1.00794																	2 0 He 4.002602
3 +1 Li 6.941	4 +2 Be 9.012182											5 +3 B 10.811	6 +4, -4 C 12.0107	7 +5, -3 N 14.00674	8 -2 O 15.9994	9 -1 F 18.9984032	10 0 Ne 20.1797
11 +1 Na 22.989770	12 +2 Mg 24.3050	3	4	5	6	7	8	9	10	11	12	13 +3 Al 26.981538	14 +4 Si 28.0855	15 +5, +3, -3 P 30.973761	16 +6, -2 S 32.066	17 -1 Cl 35.4527	18 0 Ar 39.948
19 +1 K 39.0983	20 +2 Ca 40.078	21 +3 Sc 44.955910	22 +4 Ti 47.867	23 +5, +4, +3 V 50.9415	24 +6, +3, +2 Cr 51.9961	25 +7, +4, +2 Mn 54.938049	26 +3, +2 Fe 55.845	27 +3, +2 Co 58.933200	28 +2 Ni 58.6934	29 +2, +1 Cu 63.545	30 +2 Zn 65.39	31 +3 Ga 69.723	32 +4 Ge 72.63	33 +5, +3 As 74.92160	34 +4, -2 Se 78.96	35 +5, -1 Br 79.904	36 0 Kr 83.80
37 +1 Rb 85.4678	38 +2 Sr 87.62	39 +3 Y 88.90585	40 +4 Zr 91.224	41 +5 Nb 92.90638	42 +6, +4 Mo 95.94	43 +7, +4 Tc (98)	44 +4, +3 Ru 101.07	45 +3 Rh 102.90550	46 +4, +2 Pd 106.42	47 +1 Ag 107.8682	48 +2 Cd 112.411	49 +3 In 114.818	50 +2, +4 Sn 118.710	51 +3, +5 Sb 121.760	52 +4 Te 127.60	53 +5, -1 I 126.90447	54 0 Xe 131.29
55 +1 Cs 132.90545	56 +2 Ba 137.327	71 +3 Lu 174.967	72 +4 Hf 178.49	73 +5 Ta 180.9479	74 +6, +4 W 183.84	75 +5, +4, +3 Re 186.207	76 +4 Os 190.23	77 +4, +3 Ir 192.217	78 +4, +2 Pt 195.09	79 +3, +1 Au 196.96655	80 +2, +1 Hg 200.59	81 +3, +1 Tl 204.3833	82 +2, +4 Pb 207.2	83 +3 Bi 208.98038	84 +4 Po (209)	85 -1 At (210)	86 0 Rn (222)
87 +1 Fr (223)	88 +2 Ra 226.0254	103 +3 Lr (262)	104 +4 Rf (261)	105 ? Db (262)	106 ? Sg (263)	107 ? Bh (262)	108 ? Hs (265)	109 ? Mt (266)	110 ? Ds (269)	111 ? Rg (272)	112 ? Cn (277)	113 ? Nh (286)	114 ? Fl (289)	115 ? Mc (290)	116 ? Lv (293)	117 ? Ts (294)	118 ? Og (294)

57 +3 La 138.9055	58 +3 Ce 140.116	59 +3 Pr 140.90765	60 +3 Nd 144.24	61 +3 Pm (145)	62 +3 Sm 150.36	63 +3 Eu 151.964	64 +3 Gd 157.25	65 +3 Tb 158.92534	66 +3 Dy 162.50	67 +3 Ho 164.93032	68 +3 Er 167.26	69 +3 Tm 168.93421	70 +3 Yb 173.04
89 +3 Ac 227.0278	90 +4 Th 232.0381	91 +5 Pa 231.035888	92 +6 U 238.0289	93 +7 Np (237)	94 +7, +4 Pu (244)	95 +3 Am (243)	96 +3 Cm (247)	97 +3 Bk (247)	98 +3 Cf (251)	99 +3 Es (252)	100 +3 Fm (257)	101 +2 Md (258)	102 +3 No (259)