THE EQUATION SHEET

Constants:

Avogadro's Number (**N_A**)	6.02×10^{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 (**R_H**)	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 (**k_B**)	1.381×10^{-23} J/K
Molar Volume (**V_{mol}**)	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 (**K_W**)	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:

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

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

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

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

Conversion factors:

1 atm = 100 kPa 1atm = 760 torr = 760 mm Hg

1nm = 10^{-9} m 0°C = 273.15 K

1dm^3 = 1L= 1 x 10^{-3} m^3 = 1 x 10^3 cm^3 = 1 x 10^3 mL

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

Acid-Base Chemistry:

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

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

$$K_w = K_a \times K_b$$

$$pK_a + pK_b = pK_w$$

$$pK_a = -\log K_a$$

$$pK_b = -\log K_b$$

$$pK_b = 14 - pK_a$$

$$pH + pOH = 14$$

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

$$\left[OH^-\right] = 10^{-pOH}$$

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

Thermodynamics:

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

$q = \Delta H$ at constant pressure

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

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

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

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

$$Q = mc\Delta T$$

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

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

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

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

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

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

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:

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

$$c = \lambda\nu$$

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

$$E = hf$$

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

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:

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

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 + Hydrogen Gas
   Ex. $2HCl_{(aq)} + Zn_{(s)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$
2. Acid + Base = Salt + Water
   Ex. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$
3. Acid + Metal Carbonate = $CO_2 + H_2O$ + Salt
   Ex. $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)} + CaCl_{2(aq)}$
4. Metal Oxide + Acid → Salt + 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	HSO_4^-	*Tellurite*	TeO_3^{2-}
Hydrogen sulfite	HSO_3^-	*Thiocyanate*	SCN^-
Hydronium	H_3O^+	*Thiosulfate*	$S_2O_3^{2-}$

Periodic Table of Atomic Masses

1																	18
1 H 1.00794	2											13	14	15	16	17	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050	3	4	5	6	7	8	9	10	11	12	13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.59	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.09	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0254	103 Lr (262)	104 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 Uut (277)	114 Uuq (277)	115 Uup (277)	116 Uuh (277)		118 Uuo (277)

57 La 138.9055	58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04
89 Ac 227.0278	90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	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)