# THE EQUATION SHEET

## Constants:

| | |
|---|---|
| Avogadro's Number ($N_A$) | $6.02 \times 10^{23}$ |
| Universal Gas Constant (R) | 8.314 J/mol·K or 0.0821 L·atm/mol·K |
| Planck's constant (h) | $6.626 \times 10^{-34}$ J·s |
| Rydberg Constant ($R_H$) | $2.18 \times 10^{-18}$ J |
| Speed of Light (c) | $3.00 \times 10^{8}$ m/s |
| Charge of an Electron (q) | $1.602 \times 10^{-19}$ |
| Boltzmann Constant ($k_B$) | $1.381 \times 10^{-23}$ J/K |
| Molar Volume ($V_{mol}$) | 22.7 L/mol |
| Mass of Earth | $5.97 \times 10^{24}$ kg |
| Specific Heat Capacity of Water (C) | 4.18 J/gK or 4.18 kJ/kgK |
| Ionic Product Constant of Water (Kw) | $1.00 \times 10^{-14}$ (mol/L)$^2$ at 298 K (25°C) |
| Faraday's constant (F) | 96 500 C/mol |
| STP conditions | 273 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)

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

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:

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

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

$K_w = K_a \times K_b$

$pK_a + pK_b = pK_w$

$pK_a = -\log K_a$

$pK_b = -\log K_b$

$pK_b = 14 - pK_a$

$pH + pOH = 14$

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

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

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

## 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:

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

$c = l\nu$

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

$E = hf$

n? = 2dsin?

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

## 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 | Ra | Ac | Rf | Db | Sg | Bh | Hs | Mt | Ds | Rg | Uub | | Uuq | | | | |

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* | $S_2O_3^{2-}$ |