CHEMICAL EQUATIONS:

- shorthand expression showing the changes that take place as the result of a chemical change

chemical equation : **Reactants → Products**

coefficients in a balanced equation = give the relative number of moles of reactants and product in that equation.

GENERAL CLASSES OF REACTIONS: (for prediction of products)

1. **Direct Combination** **A + B → AB**
   a. metal + nonmetal
   $2Na + Cl_2 \rightarrow 2NaCl$ $2Ca + O_2 \rightarrow 2CaO$
   b. nonmetal + oxygen -> nonmetallic oxide
   $2C + O_2 \rightarrow 2CO$ $S + O_2 \rightarrow SO_2$
   c. metal oxide + water -> metallic hydroxide
   $CaO + H_2O \rightarrow Ca(OH)_2$ $Na_2O + H_2O \rightarrow 2NaOH$
   metal oxide = basic oxide = basic anhydride
   d. nonmetallic oxide + water -> acid
   $SO_3 + H_2O \rightarrow H_2SO_4$ $CO_2 + H_2O \rightarrow H_2CO_3$
   nonmetallic oxide = acid oxide = acid anhydride
   e. nonmetallic oxide + Metallic oxide -> salt
   $SO_2 + CaO \rightarrow CaSO_3$

2. **Decomposition** **AB → A + B**
   a. hydrates → anhydrous salt + water
   $CuSO_4 \bullet 5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$
   b. chlorates → chlorides + oxygen
   $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$
   c. (some) metallic oxides → metal + O_2
   $2HgO \xrightarrow{\Delta} 2Hg + O_2$
   d. carbonates → CO_2 + oxides
   $CaCO_3 \xrightarrow{\Delta} CO_2 + CaO$
   e. bicarbonates → carbonates + H_2O + CO_2
   $NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$
   f. water → H_2 + O_2
   (electrolysis)

3. Single Displacement (Replacement)

$A + CD \rightarrow D + CA$ if A is a nonmetal

$A + CD \rightarrow C + AD$ if A is a metal

Principle: ***The more active (non)metallic element replaces the less active (non)metallic element***.

activity series (EMF) series for metals (decreasing activity): **Mnemonic device**

Li K Ba Ca Na Mg Al Mn Zn Cr Fe Ni Sn Pb

Little Peter Barry Carl Saw Magnito A Manzy Zebra Carrying Iron Nails To Liverpool.

(H) Cu Bi Sb Hg Ag Pt Au

He caught Billy A Mexican Silver Plated Goat

Halogens: **$F_2 > Cl_2 > Br_2 > I_2$**

Examples:

$Zn + Pb(NO_3)_2 \rightarrow Pb + Zn(NO_3)_2$

$Cu + SnSO_4 \rightarrow$ NVR

$Cl_2 + NaBr \rightarrow NaCl + Br_2$

$I_2 + NaF \rightarrow$ NVR

4. **Double Displacement (Metathesis)** **$AB + CD \rightarrow AD + CB$**

- may result in the formation of an insoluble compound
- know the solubility rules

a. all Na^+, K^+, NH_4^+ compounds are soluble
b. all NO_3^- , CH_3COO^-, ClO_3^- compounds are soluble
c. all Cl^- , Br^- , I^- compounds (except Ag^++, $Hg2^+$+, $Pb2^+$+) are soluble
d. all SO_4^{2-} (except Ba^{2+}, Sr^{2+}, Pb^{2+}, Ca^{2+}, Ag^+) are soluble
e. most O^{2-}, OH^-, CO_3^{2-}, S^{2-}, PO_4^{3-} (except Na^+ , K^+, NH_4^+) are insoluble

Examples:

a) Neutralization of Acid and Base

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + water$

acid + base → salt + water

b) Formation of an insoluble ppt

$BaCl_2(aq) + AgNO_3(aq) \rightarrow AgCl(s) + Ba(NO_3)_2$ (aq)

ppt

c) Metal oxide + acid → salt + water

$CaO(s) + 2HCl(aq) \rightarrow CaCl_2$ (aq) + H_2O

d) Formation of a gas

$2HCl(aq) + ZnS(s) \rightarrow ZnCl_2(aq) + H_2S(g)$

Combustion reactions of hydrocarbons

- rapid reactions that produce a flame. It involves O_2 in air as the oxidant. When hydrocarbons are combusted completely in air, they react with O_2 to form gaseous CO_2 and H_2O vapor. Balancing combustion reactions may follow the following general equation:

$$C_nH_{2m} + [(2n + m) \div 2]\, O_2 \rightarrow nCO_2 + mH_2O$$

-where n = subscript no. of carbon and
m = subscript of hydrogen divided by 2

Example: $C_3H_{8\,(g)} + 5\, O_{2\,(g)} \rightarrow 3CO_{2\,(g)} + 4H_2O_{\,(g)}$

$C_3H_{2(4)} + [(2x3 + 4) \div 2]\, O_{2\,(g)} \rightarrow 3CO_{2\,(g)} + 4H_2O_{\,(g)}$

- coefficients in oxygen may be accepted in fraction form:

$C_4H_{10\,(g)} + 13/2\, O_{2\,(g)} \rightarrow 4CO_{2\,(g)} + 5H_2O_{\,(g)}$

$C_4H_{2(5)} + [(2x4) + 5) \div 2]\, O_2 \rightarrow 4CO_2 + 5H_2O$

Oxidation Nos. - are charges assigned to the atoms of a compound according to some arbitrary rules; to some degree it reflects the positive or negative character of that atom

Rules in assigning oxidation numbers :

1. Any uncombined atom or an atom in its elemental state is assigned an oxidation number of zero.
2. The sum of the oxidation numbers of the atoms in a compound is zero, since compounds are electrically neutral.
3. The oxidation number of a monoatomic ion is the same as the charge on the ion. In their compounds, group IA metals always have oxidation numbers of +1, group IIA elements always have oxidation numbers of +2.
4. The sum of the oxidation numbers of the atoms that constitute a polyatomic ion equals the charge on the ion.
5. The oxidation number of fluorine, the most electronegative element, is -1 in all fluorine-containing compounds.
6. In most oxygen-containing compounds, the oxidation number of oxygen is -2.

   Few exceptions :
   a. In peroxides each oxygen has an oxidation number of -1.
   b. In the superoxide ion (i.e. KO_2), each oxygen has an oxidation number of -1/2.
   c. In OF_2 the oxygen has an oxidation number of +2.

7. The oxidation number of hydrogen is +1 in all its compounds except the metallic hydrides, in which hydrogen is in the -1 oxidation state.
8. In a combination of two nonmetals the oxidation number of the more electronegative element is negative and equal to the charge of the common monoatomic ion of that element.