BALANCING EQUATIONS

All chemical equations must be **balanced**, that is, they must have the same total number of each type of atom or ion on each side of the arrow.

To balance equations we use **coefficients** in front of each formula until there are equal numbers of atoms or ions on each side of the equation. **We can change coefficients but we cannot change the subscripts of the formulas.**

Balancing is a **trial and error process**, but here are some hints to help you:

1. Balance polyatomic ions together, for example, treat SO_4 as one sulfate, rather than one S and four O.

2. Begin with the atom or ion present in the largest number if you don't know where to begin.

3. When you put a coefficient in front of a compound, it affects **all** parts of the compound. For example **2**H_2O means **4** H and **2** O

4. If the balancing is not working out correctly, **recheck your formulas!**

5. Leave any diatomic elements (the ones that go in pairs) to balance last.

Practice balancing these equations:

1. __Al (s) +__ N_2 (g) → __ AlN (s)

2. _ NaCl (aq) + __ H_2SO_4 (aq) → __ Na_2SO_4 (aq) + __HCl (aq)

3. __Al (s) + __ $CuSO_4$ (aq) → __ $Al_2(SO_4)_3$ (aq) + __ Cu (s)

4. __P_4 (s) + __O_2 (g) → __ P_4O_{10} (s)

5. _ $Fe(OH)_3$ → _ Fe_2O_3 (s) + _ H_2O (l)

CLASSIFYING CHEMICAL REACTIONS

There are **six major types of chemical reactions**. Once we know the types, we use their patterns to help us predict the products or reactants, since each follows a particular pattern. **YOU MUST MEMORIZE THE PATTERNS FOR EACH TYPE!!!!**

1. **SIMPLE COMPOSITION (also known as synthesis or formation)**

This type occurs when elements combine to form one compound
Pattern: **element + element → compound**

Examples: $2\ Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)$

$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$

2. **SIMPLE DECOMPOSITION**

Occurs when one compound breaks into the elements that make it up
Pattern: **compound → element + element**

Examples: $2\ HgO\ (s) \rightarrow 2\ Hg\ (l) + O_2\ (g)$

$2\ H_3BO_3\ (aq) \rightarrow 3H_2\ (g) + 3\ O_2\ (g) + 2\ B\ (s)$

3. **SINGLE REPLACEMENT (also called substitution)**

- Occurs when an element and a compound react to form a different element and a new compound.
- These reactions usually involve an element reacting with an ionic compound.
- The **element can only replace the part of the compound that forms the same type of ion that the element forms** : a **metallic element** will replace the **positive** part of the compound and a **non-metal** will replace the **negative** part.
- When doing reactions involving water, write water as HOH not H_2O

Pattern: **element + compound → element + compound**

(Note that you can reverse the order, compound + element → compound + element)
Examples: $2\ NaCl\ (aq) + Br_2\ (l) \rightarrow 2\ NaBr\ (aq) + Cl_2\ (g)$

$2\ Na\ (s) + 2\ HOH\ (l) \rightarrow 2\ NaOH\ (aq) + H_2\ (g)$

4. **DOUBLE REPLACEMENT (also called exchange)**

Occurs when compounds swap partners.
Usually occurs with ionic compounds or acids

Pattern: **Compound + compound → compound + compound**

- Remember the ions can only swap positions with the part of the other compound that forms the same type of ion**, positive swap with positive, negative swap with negative**

- When the new compounds are formed, you will need to re-balance the charges to come up with the formulas for the new compounds.

Examples: $2\ AgBr\ (aq) + ZnCl_2\ (aq) \rightarrow ZnBr_2\ (aq) + 2\ AgCl\ (s)$

$K_2Cr_2O_7(aq) + BaCl_2\ (aq) \rightarrow BaCr_2O_7\ (s) + 2\ KCl\ (aq)$

(In this example, the K^+ ions that started out in the potassium dichromate, will switch positions with the Ba^{2+} ions in the barium chloride to form the new compound of potassium chloride. The K^+ ions cannot form a new compound with the Ba^{2+} ions because they are both positive.)

5. **COMBUSTION (hydrocarbon combustion)**

Occurs when a compound reacts (burns) with oxygen gas.
The type that we can predict is called **hydrocarbon combustion**.

- Hydrocarbons contain only carbon and hydrogen general form $\mathbf{C_xH_y}$
- They burn in oxygen completely to always produce the same two products: carbon dioxide and water vapour

Pattern: $\mathbf{C_xH_y + O_2 \rightarrow CO_2\ (g) + H_2O\ (g)}$

Examples: $CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ (g)$

$2C_4H_{10}\ (g) + 13\ O_2\ (g) \rightarrow 8\ CO_2\ (g) + 10\ H_2O\ (g)$

(Hydrocarbon combustion reactions can be hard to balance. If you have trouble, put a coefficient of 2 in front of your hydrocarbon and proceed from there)

There are times, however, that hydrocarbons do not combust completely; this is called incomplete combustion and the products are slightly different. You would always be told if the reaction was compete or incomplete, if nothing is said, assume it is complete combustion

Incomplete combustion gives the products of carbon dioxide and water vapour, the same as complete combustion, but also gives C (s) , which is soot, and CO, which is carbon monoxide.

Pattern: $\mathbf{C_xH_y + O_2 \rightarrow CO_2\ (g) + H_2O\ (g) + CO\ (g) + C\ (s)}$

Examples $6CH_4\ (g) + 9\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 12H_2O\ (g) + 2C\ (s) + 2CO$