Physical Science 20
Chemical Reactions and Equations (6)

Chemical Reactions

- Chemical equations occur when matter reacts to form new types of matter
- In chemical reactions, the actual atoms do not change – the combination of atoms change to produce a new type of reaction.
- The net product of a reaction contains the same amount of atoms as were present in the reactants.
- This leads to the Law of Conservation of Mass:
  - *The total mass of all reactants before a chemical reaction must be the same as the total mass of the products after the chemical reaction.*
- **The only thing that changes is the bonds between the atoms.**
  - Old bonds are broken and new bonds form between atoms – atoms remain the same

Word Equation

- These are used to describe an equation on the macroscopic scale.
- Using this method, we name the reactants and products, while using addition (+) signs and "yields" (→) signs.

Ex. hydrogen + oxygen → water
(reactants) (products)

Chemical Equation

- A chemical equation displays a lot of information using symbols
- This represents events at the microscopic level.

Ex. $O_2 + H_2 \rightarrow H_20$ This is an unbalanced reaction.

- Because of the Law of Conservation of Mass, the total number of atoms of each element reacting must equal the product.
  - In our above example, there is 2 oxygen and 2 hydrogen on the reactant side, while there is 2 hydrogen and only 1 oxygen on the product side. This is NOT balanced.

- To balance chemical equations, we must only use coefficients:
  - In our example above, we need to balance the oxygens. This becomes:

    $O_2 + H_2 \rightarrow 2H_20$ We now have 2 O's as products.

  - The problem is that we now have 4 H's as products, but only 2 H's as reactants. So we must balance the H's. This becomes:

    $O_2 + 2H_2 \rightarrow 2H_20$ Now both sides are balanced.

- NOTE:
  - Products and reactants must be represented by correct formulas.
  - You CANNOT change the subscripts of a formula
  - Balance the equation using coefficients to satisfy the Law of Conservation of Mass

- We use the following symbols when balancing chemical equations:
  - + means add
  - → means yields of produces
  - (s) means solid
  - (l) means liquid
  - (g) means gas
  - (aq) means aqueous
  - N.R. means no reaction

- Two other things to remember about chemical reactions:
  - Some elements are diatomic (ex. O_2)
  - (+) ions will react chemically with (-) ions

Types of Chemical Reactions

- Synthesis or Composition
  - In this type of reaction, two or more substances combine to form a more complex substance.
  - Ex: A + B → AB
  - Ex: Na + Cl → NaCl

- Combustion
  - A reaction where a substance reacts with oxygen. (This is a special type of synthesis reaction)
  - Ex: 2 Mg (s) + O_2 (g) → 2MgO (s)

- Decomposition
  - A reaction where a substance breaks into its parts
  - Ex: AB → A + B
  - Ex: 2 $H_2$0 (l) → H_2 (g) + O_2 (g)

- Single Replacement
  - This occurs if the element which is doing the replacing is more reactive than the replaced element.
  - Ex: A + BC → AC + B
  - Ex: Zn (s) + 2 HCl (l) → $ZnCl_2$ (aq) + H_2 (g)
  - Ex: Cu (s) + $PbSO_4$ (aq) → N.R. (Will not happen because Cu will not replace Pb)

- Double Replacement
  - Elements, or ions in the reacting compounds replace each other (exchange positions)
  - Ex: AC + DE → AE + DC
  - Ex: ZnI_2 (aq) + 2 $AgNO_3$ (aq) → 2 AgI (aq) + $Zn(NO_3)_2$ (aq)

- Water Forming
  - A reaction where water is one of the products
  - This is a special case of double replacement reaction
  - Ex: HB + XOH → XB + HOH (or H_2O)
  - Ex: H_2SO_4 (aq) + 2 NaOH →Na_2SO_4 (aq) + 2H_2O (l)

Chemical Changes in a Chemical Reaction

- Chemical reactions occur because chemical bonds break and form new bonds when the atoms rearrange themselves.
- If energy is released, it means the energy given off from the new bonds is greater than the energy needed to break the bonds.

- If energy is <u>required</u>, the energy given off by the new bonds is less than the energy needed to break the old bonds.
- Reactions that give off heat (energy) are called <u>exothermic</u>.
- Reactions that require heat (energy) are called <u>endothermic</u>.
- All substances have a certain amount of heat content/energy content. This is called the substances <u>enthalpy</u>. This enthalpy is measured in joules (J).
    - A joule is the amount of energy produced when 1 Newton acts over a distance of 1 metre.
- ΔH – stands for the change in heat.
    - ΔH = heat of products – heat of reactants
    - If the ΔH is negative the products have less heat then the reactants = energy is given off (exothermic reaction)
    - If the ΔH is positive the products have more heat then the reactants = energy is absorbed (endothermic reaction)
- Often, the energy change is included in the chemical reaction:

<u>Ex #1: Octane burning (exothermic reaction)</u>

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O + \text{energy}$$

- From experiments we know that this reaction gives off 5445 kJ of energy, so we could write it as:

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O + 5445\ kJ$$

- Also, we could write the equation using the ΔH symbol:

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O \qquad \Delta H = -5445\ kJ$$

NOTE: - ΔH means exothermic reaction

<u>Ex #2: Ammonium chloride + water reaction (endothermic reaction)</u>

$$NH_4Cl\ (s) + H_2O\ (l) + \text{energy} \rightarrow NH_4Cl\ (aq)$$

- From experiments, we know that ammonium chloride dissolves 16.28 kJ of energy in this reaction.

$$NH_4Cl\ (s) + H_2O\ (l) + 16.28\ kJ \rightarrow NH_4Cl\ (aq)$$

- Also, we could write this as:

$$NH_4Cl\ (s) + H_2O\ (l) \rightarrow NH_4Cl\ (aq) \qquad \Delta H = 16.82\ kJ$$

NOTE: + ΔH means endothermic reaction