

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. $O_2 + H_2 \rightarrow H_2O$ 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:

$O_2 + H_2 \rightarrow 2H_2O$ 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:

$O_2 + 2H_2 \rightarrow 2H_2O$ 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 or 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. O₂)
 - (+) 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: $A + B \rightarrow AB$
 - Ex: $Na + Cl \rightarrow NaCl$
- **Combustion**
 - A reaction where a substance reacts with oxygen. (This is a special type of synthesis reaction)
 - Ex: $2 Mg (s) + O_2 (g) \rightarrow 2MgO (s)$
- **Decomposition**
 - A reaction where a substance breaks into its parts
 - Ex: $AB \rightarrow A + B$
 - Ex: $2 H_2O (l) \rightarrow H_2 (g) + O_2 (g)$
- **Single Replacement**
 - This occurs if the element which is doing the replacing is more reactive than the replaced element.
 - Ex: $A + BC \rightarrow AC + B$
 - Ex: $Zn (s) + 2 HCl (l) \rightarrow ZnCl_2 (aq) + H_2 (g)$
 - Ex: $Cu (s) + PbSO_4 (aq) \rightarrow N.R.$ (Will not happen because Cu will not replace Pb)
- **Double Replacement**
 - Elements, or ions in the reacting compounds replace each other (exchange positions)
 - Ex: $AC + DE \rightarrow AE + DC$
 - Ex: $ZnI_2 (aq) + 2 AgNO_3 (aq) \rightarrow 2 AgI (aq) + Zn(NO_3)_2 (aq)$
- **Water Forming**
 - A reaction where water is one of the products
 - This is a special case of double replacement reaction
 - Ex: $HB + XOH \rightarrow XB + HOH$ (or H₂O)
 - Ex: $H_2SO_4 (aq) + 2 NaOH \rightarrow Na_2SO_4 (aq) + 2H_2O (l)$

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 required, 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 exothermic.
- Reactions that require heat (energy) are called endothermic.
- All substances have a certain amount of heat content/energy content. This is called the substances enthalpy. 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 than the reactants = energy is given off (exothermic reaction)
 - If the ΔH is positive the products have more heat than the reactants = energy is absorbed (endothermic reaction)
- Often, the energy change is included in the chemical reaction:

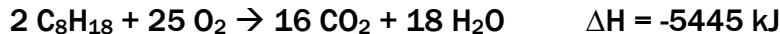
Ex #1: Octane burning (exothermic reaction)



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

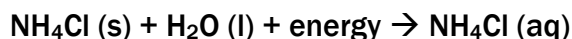


- Also, we could write the equation using the ΔH symbol:

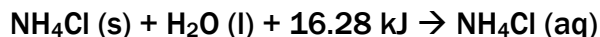


NOTE: - ΔH means exothermic reaction

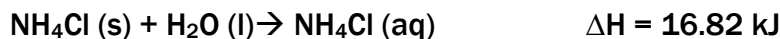
Ex #2: Ammonium chloride + water reaction (endothermic reaction)



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



- Also, we could write this as:



NOTE: + ΔH means endothermic reaction