***Chemical Reactions and Chemical Equations***

**Learning Objectives:**

* **To observe chemical changes in chemical reactions.**
* **To become familiar with some of the observable signs of chemical changes.**
* **To write a balanced chemical equation and net ionic equation.**
* **To identify the reaction type as combination, decomposition, single replacement, double replacement or combustion reaction.**

**Introduction/Background Information**

Matter can undergo two kind of changes: Physical and Chemical changes. In a physical change, the composition of the substance remains the same but it changes only its physical state such as from solid to liquid (melting) or liquid to gas (vaporization) or solid to gas (sublimation). A simple of physical change is freezing of water changes water from liquid state to solid state (ice) or boiling of water changes liquid water-to-water vapors (gas) but chemical formula of water in all states remains the same as H2O. However, in a chemical change, substance changes its chemical identity as well as composition and lead to the formation of a new substance or new chemical with different physical and chemical properties. Such a change is called a chemical reaction.

**What is a chemical Reaction?**

There are several ways to answer this question.

**Definition 1**: A chemical reaction is that in which when a substance comes in contact with another substance (starting materials called *Reactants*), it loses its identity and leads to the formation of a new substance (called *Product(s)*) with different identity, different chemical formal and also have different physical and chemical properties.

In a chemical reaction the species that are on the left-hand side (LHS) are called reactants and the species on the right-hand side are called products and the two are separated by an arrow.



**Definition 2**: A chemical reaction is that in which atoms in the reactants break their old chemical bond(s) and form new substance with new chemical bond(s) meaning during the chemical reactions atoms rearranged their positions or partner atoms and produce new substances with new partner atoms. (Note: We cannot physically observe breaking and formation of bonds during a chemical change or chemical reaction).

**Definition 3**: In terms of energy diagram- A chemical reaction is that in which the substance crosses the energy barrier (threshold energy) and produces new substance.

An example of a chemical reactions is, when iron comes in contact with air and water or moisture, it changes its color from grayish black to brown and form iron oxide (simply called rust), a chemical compound with formula Fe2O3.



**How to assign a process or a reaction as a chemical change?**

During the course of an experiment there are several physical indications associated to assign a process to be a chemical change. These are as follows.

(a) *Change in color*- (formation of different color and not simply dilution of color by dilution of solution).

(b) *Formation of precipitate* (solid)- when two clear liquids/solution are mixed

(c) *Evolution of gas*- evident from formation of bubbles or smell

(d) *Change in temperature-* that happens internally and is not caused by external heating or cooling resources.

However, remember it is not necessary that every detectable change conclude to a chemical reaction. For example, after addition of milk to coffee, the color of solution changes from dark brown or black to light creamish yellow, but there is no chemical reaction between the two. With the certain process we can separate coffee and milk and get the original substance back. On the other hand, heating white sugar powder changes it color to brown is a chemical change (process is called caramelization), we cannot change the caramelized brown sugar back to normal white sugar powder.

**What is a chemical equation?**

A chemical equation is the symbolic representation of a chemical reaction. For example, a chemical reaction between mixing of sodium hydroxide and hydrochloric acid that leads to the formation of sodium chloride and water and its chemical equation is shown below:



In a chemical equation the physical states of various substances are shown as their abbreviations in parentheses. The full meaning of various commonly used abbreviations is shown below:

|  |  |
| --- | --- |
| Abbreviation | meaning |
| *s* | for solid substances that are insoluble in reaction mixture |
| *l* | for pure liquid substances |
| *g* | for gaseous substances |
| *aq* | for substances that dissolved in water to make a solution |

Also, any special reaction conditions that are used to perform a reaction are always shown above or below the arrow. For example, **Δ** is used as a symbol for heating.

**Balancing of a chemical Equation**

A chemical equation must be balanced both atomically (for molecular equations) and charge wise or electronically (for ionic equations). An atomically balanced equation must have the same number and type of atoms on the LHS of a chemical equation as they appear on the RHS of the chemical equation. To balance the number of atoms of each element on two sides of the equation you can change the coefficient in front of the formula and keep changing this for all the elements until you have a balanced equation. This method of changing the coefficients of formula to get the balanced equation is called *Hit and Trial* method. Make sure **DO NOT** change the chemical formula of a compound, but only the coefficient.





**Types of Chemical Reactions: The chemical reactions are classified into various types. The five most common reaction types are discussed below.**

|  |  |  |
| --- | --- | --- |
| **Type of Reaction** | **Discription** | **Example of Chemical Reactions** |
| **Combination or formation or Synthesis Reactions** | In a combinations reaction two or more substances join together to make one substance or one compound. A generalized combination reaction is shown below:  **A + B → AB** |  |
| **Decomposition Reactions** | In a decomposition reaction one substance break down to give two or more substances. A generalized form of a decomposition reaction is shown below:  **AB → A + B** |  |
| **Single Displacement Reaction:** | When one element displaces another element of the same kind in a compound, is called a single displacement reaction. A generalized form of a single displacement reaction is shown below:    **A + BC → AC + B**  **or M + M՛Nm → MNm + M՛**  Where M and M՛ are metal atom or metal ion respectively and Nm represent a nonmetal ion. |  |
| **Double Displacement Reaction:** | In these reactions atoms or ions in two or more different compounds exchanges positions and form new compounds. When one of the new compounds formed appears as solid, called **precipitate** then double displacement reactions also known as ***precipitation reaction***. A generalized form of a double displacement reaction is shown below.  **AB + CD → AD + CB**  **Or**  **MNm + M՛Nm՛ → MNm՛ + M՛Nm** |  |
| **Combustion Reactions:** | These are the reactions in which one of the reactant molecules is Oxygen, O2. |  |

**Type 1: Combination or formation or Synthesis Reactions**

In a combinations reaction two or more substances join together to make one substance or one compound. A generalized combination reaction is shown below.

**A + B → AB**

Here below are some specific examples of combination reactions.



**Type 2: Decomposition Reactions:** In a decomposition reaction one substance break down to give two or more substances. A generalized form of a decomposition reaction is shown below:

**AB → A + B**

Some specific examples of decompositions reactions are:



**Type 3: Single Displacement Reaction:** When one element displaces another element of the same kind in a compound, is called a single displacement reaction. A generalized form of single displacement reaction is shown below.

**A + BC → AC + B or**

**M + M՛Nm → MNm + M՛**

Where M and M՛ are metal atom or metal ion respectively and Nm represent a nonmetal ion.

Some specific examples of single displacement reactions are



**Type 4: Double Displacement Reaction:** In these reactions’ atoms or ions in two or more different compounds exchanges positions and form new compounds. When one of the new compounds formed appears as solid, called **precipitate** then double displacement reactions also known as ***precipitation reaction***. A generalized form of single displacement reaction is shown below.

**AB + CD → AD + CB or**

**MNm + M՛Nm՛ → MNm՛ + M՛Nm**

Where M and M՛ are two different metal ions and Nm and Nm՛ are two different nonmetal ions.

Some specific examples of single displacement reactions are:



**Type 5: Combustion Reactions:** These are the reactions in which one of the reactant molecules is O2. Some specific examples of combustion reactions are:



**Note: Some reactions can also be classified into more than one type. For example,**



Both of the above two reactions are classified as a combination as well as combustion reactions.

***Experimental Procedure:***

**Chemical Alert**

**(a)**

**Pre Lab questions**

**Data Sheet**

**Post Lab questions**