Transformation of Substance

Introduction

In a chemical process, the molecules of the reactant undergo, the molecules of the reactant undergo changes to form molecules of the products. Thus, during a chemical reaction, substances undergo chemical transformation to form new substances.

Characteristics of substances can be determined by finding their boiling point and melting point whether a given substances is pure or not. It is because that no two different pure substances can have the same melting point and boiling point.

Melting Point

The temperature at which a solid starts changing into its liquid state without any rise in temperature at the atmospheric pressure is called its melting point.

(a) Effect of impurities on the melting point of pure substances:

It has been found that the melting point of pure substances usually decreases with the addition of impurities.

e.g.

(i) Melting point of pure ice is O^{o}C If potassium nitrate is added to ice, melting point is lowered to – 3^{o}C.

If ammonium nitrate is added to ice, melting point ssis lowered to – 9^{o}C.

If common salt is added to snow it lowers the melting point below O^{o}C.

(ii) Melting point of gold is 1063^{o}C. When borax powder is added to gold its melting point is lowered considerably and it melts even over kerosene oil flame.

Boiling Point

The temperature at which a liquid changes into a gas or vapour at the atmospheric pressure is called its boiling point. We can check whether the liquid is pure or not by determining its boiling point of a substances rises if there is an impurity in substances.

Distillation.

The process of conversion of a liquid into its gaseous state by boiling and then condensing the gas into the liquid in another vessel is called distillation. Different type of distillation methods are.

(i) Simple distillation: When organic compound contains nonvolatile impurities, it is then purified by simple distillation method.

e.g. Separation of salt form water

(ii) Fractional Distillation:

The process of separation of two miscible liquids by the process of distillation by making uses of difference in their boiling points (less than 10^{o}C or between 10 to 20^{o}C) is called fractional distillation.

e.g. In nature, petroleum is found under the earth surface and is a mixture of a number of hydrocarbons. These hydrocarbons (diesel, kerosene, petrol, petroleum gas etc.) have very close boiling points. These products are separated by fractional distillation.

e.g. Methyl alcohol (65^{o}C) and acetone (56^{o}C) are separated by fractional distillation method.

(iii) vaccum distillation (Distillation at low pressure): The compounds which are decomposed at their boiling point on heating, are purified by vaccum distillation method.

e.g. Boiling point of glycerine is 290^{o}C under atmospheric condition. If the pressure is reduced to 13 mm, glycerine starts boiling at 180^{o}C and gets distillated without decomposition.

(iv) Steam distillation: The substances which are insoluble in water but volatile in steam, can be purified by steam distillation.

e.g. Nitrobenzene and aniline are purified by steam distillation method.

Chemical Reaction

When we heat sugar crystals they melt and on further heating they give steamy vapours, leaving behind brownish black mass. on cooling no sugar crystals appear. Thus change which takes place on heating sugar is a chemical change and the process which brings about this chemical change is called chemical reaction.

(i) In this reaction the substances which take part in bringing about chemical change are called reactants.

(ii) The substances which are produced as a result of chemical change are called products.

(iii) These reactions involve breaking and making of chemical bonds.

(iv) Product or products of the reaction are new substances with new manes and formulae.

(v) It is often difficult or impossible to reverse some chemical reactions.

(vi) Properties of products formed during a chemical reaction are different from those of the reactants.

(vii)Apart from heat other forms of energies are light and electricity which are also used in carrying out chemical changes.

Characteristics of Chemical Reactions

In all chemical reactions, the transformation from reactants of products is accompanied by various characteristics, which are-

(a) Evolution of gas:

Some chemical reactions are characterized by evolution of a gas.

(i) When zinc metal is treated with dilute sulphuric acid, hydrogen gas is evolved. The hydrogen gas burns with a pop sound.

$$\underset{\text{Zinc}}{Zn(g)} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_4(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

(ii) When washing soda is treated with hydrochloric acid, it gives off colourless gas with lots of effervescence.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3(aq)} + 2\underset{\text{Hydrochloric acid}}{HCl(dil)} \longrightarrow 2\underset{\text{Sodium chloride}}{NaCl(aq)} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

$$\underset{\text{Sodium carbonate}}{2NaHCO_3(s)} \longrightarrow \underset{\text{Sodium carbonate}}{Na_2CO_3(s)} + \underset{\text{Water}}{H_2O(I)} + \underset{\text{Carbon carbonate dioxide}}{CO_2(g)}$$

(b) Charge of Colour:

Certain chemical reactions are characterized by the change in colour of reacting substances.

(i) When red lead oxide is heated strongly, it forms yellow colour lead monoxide and gives off oxygen gas.

$$\underset{\text{Lead (II, IV) oxide (Red)}}{2Pb_3O_4(s)} \xrightarrow{Heat} \underset{\text{Lead (II) oxide (Yellow)}}{6PbO(s)} + \underset{\text{Oxygen}}{O_2(g)}$$

(ii) When copper carbonate (green) is heated strongly, it leaves behind a black residue.

$$\underset{\text{Copper carbonate (Green)}}{CuCO_3(s)} \xrightarrow{Heat} \underset{\text{Copper oxide}}{CuO(s)} + \underset{\text{Carbon dioxide (black)}}{CO_2(g)}$$

(iii) When lead (II) nitrate is heated strongly, it forms white solid and brown coloured gas.

$$\underset{\text{Lead (II) nitrate white}}{2Pb(NO_3)_2(s)} \longrightarrow \underset{\text{Lead (II) oxide}}{2PbO(s)} + \underset{\text{Nitrogen dioxide}}{4NO_2(g)} + \underset{\text{Oxygen (Yellow) (Brown)}}{O_2(g)}$$

(iv) When sugar is heated strongly, it is converted into black mass.

$$\underset{\text{White sugar}}{C_{12}H_{22}O_{11}(s)} \xrightarrow{Heat} 12\underset{\text{Carbon black}}{C(s)} + 11\underset{\text{Water}}{H_2O(\ell)}$$

(c) Formation of precipitate:

Some chemical reactions are characterized by the formation of precipitate.

(i) When silver nitrate solution is mixed with a solution of sodium chloride.

$$\underset{\substack{\text{Silver nitrate}\\(\text{Colourless})}}{AgNO_3(aq)} + \underset{\substack{\text{Sodium chloride}\\(\text{Colourless})}}{NaCl(aq)} \longrightarrow \underset{\substack{\text{Sodium nitrate}\\(\text{Colourless})}}{NaNO_3(aq)} + \underset{\substack{\text{Silver chloride}\\(\text{White ppt})}}{AgCl(s)}$$

(ii) **A dirty green precipitate of ferrous hydroxide** is formed when a solution of ferrous sulphate is mixed with sodium hydroxide sodium.

$$\underset{\substack{\text{Ferrous Sulphate}\\(\text{Light green solution})}}{FeSO_4(aq)} + 2\underset{\substack{\text{Sodium hydroxide}\\(\text{Colourless solution})}}{NaOH(dil)} \longrightarrow \underset{\substack{\text{Sodium Sulphate}\\(\text{Colourless solution})}}{Na_2SO_4(aq)} + \underset{\substack{\text{Ferrous hydroxide}\\(\text{Dity green ppt})}}{Fe(OH)_2(s)}$$

$$\underset{\text{Barium chloride}}{BaCl_2(aq)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\substack{\text{Barium sulphate}\\(\text{White ppt})}}{BaSO_4(s)} + 2\underset{\substack{\text{Hydrochloric}\\\text{acid}}}{HCl(dil)}$$

(d) All chemical reactions proceed either with the absorption or release of energy.

(i) Endothermic reactions: A chemical reaction in which heat energy is absorbed, is called an endothermic reaction.

e.g.

$$1)\ \underset{\text{Carbon}}{C(s)} + \underset{\text{Sulphur}}{2S(s)} \xrightarrow{Heat} \underset{\substack{\text{Carbon}\\\text{disulphide}}}{CS_2(\ell)} - Energy$$

2) Light energy in essential for biochemical reaction, photosynthesis, by which green plants prepare their food from carbon dioxide & water.

$$6CO_2(g) + 12H_2O(I) \xrightarrow[\text{ChlorophyII}]{Light} C_6H_{12}O_6(s) + 6H_2O(I) + 6O_2(g)$$

(ii) Exothermic reactions: A chemical reaction in which heat energy is released, is called an exothermic reaction.

3) When magnesium wire is heated from its tip in a Bunsen flame, it catches fire and burns with a dazzling white flame with release of heat and light energy.

$$\underset{\text{Magnesium}}{2Mg(s)} + \underset{\text{Oxygen}}{O_2(g)} \xrightarrow{Heat} \underset{\substack{\text{Magnesium}\\\text{oxide}}}{2MgO(s)} + Energy$$

4) When quick lime (calcium oxide) is placed in water, the water becomes very hot and sometime

starts boiling. It is because of release of heat energy during reaction.

$$\underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Water}}{H_2O(\ell)} \longrightarrow \underset{\text{Calciumhydroxide}}{Ca(OH)_2(aq)} + Energy$$

(e) Change of physical state:

Some chemical reactions are characterized by a change in physical state i.e. solid, liquid or gas.

(i) Two volumes of hydrogen gas react with one volume of oxygen gas to form water (liquid state).

$$\underset{\text{Hydrogen}}{2H_2(g)} + \underset{\text{Oxygen}}{O_2(g)} \longrightarrow \underset{\text{Water}}{2H_2O(\ell)}$$

or when current is pass through water, it splits into its constituent elements.

$$\underset{\text{Water}}{2H_2O(\ell)} \xrightarrow{\text{Electric current}} \underset{\text{Hydrogen}}{2H_2(g)} + \underset{\text{Oxygen}}{O_2(g)}$$

(ii) $$\underset{\text{Ammonia}}{NH_3(g)} + \underset{\text{Hydrochloric acid}}{HCl(g)} \longrightarrow \underset{\text{Ammoniumchloride}}{NH_4Cl(s)}$$

Types of Chemical Reaction

Following are the types of chemical reactions-

(a) Combination reaction:

When two or more elements or compounds combine chemically to form one new product only, it is called combination reaction.

$$A + B \longrightarrow AB$$

Combination reaction occurs in the following ways-

(i) Two elements react to form one new product.

$$\underset{\text{Magnesium}}{2Mg(s)} + \underset{\text{Oxygen}}{O_2(g)} \xrightarrow{\text{Heat}} \underset{\text{Magnesiumoxide}}{2MgO(s)}$$

$$\underset{\text{Iron}}{Fe(s)} + \underset{\text{Sulphur}}{S(s)} \xrightarrow{\text{Heat}} \underset{\text{Ferroussulphide}}{FeS(s)}$$

This type of combination reactions is also known as synthesis reaction.

(ii) An element reacts with a compound to form one new product.

$$\underset{\text{Carbon monoxide}}{2CO(g)} + \underset{\text{Oxygen}}{O_2(g)} \longrightarrow \underset{\text{Carbon dioxide}}{2CO_2(g)}$$

(iii) Two compounds react to form one new product.

$$\underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Water}}{H_2O(I)} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2(aq)} + Heat$$

(b) Decomposition reaction: When a single chemical compound decomposes on heating or by some other kind of energy, so as to form two or more new substances, it is called decomposition reaction.

Decomposition reaction occurs in the following ways-

(i) A chemical compound decomposes into two elements.

$$\underset{\text{Mercuricoxide}}{2HgO(s)} \xrightarrow{\text{Heat}} \underset{\text{Mercury}}{2Hg(\ell)} + \underset{\text{Oxygen}}{O_2(g)}$$

This type of decomposition reactions is also known as analysis reaction.

(ii) When a chemical compound decomposes into one element & one compound.

$$\underset{\text{Potassium chlorate}}{2KClO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Potassium chloride}}{2KCl(s)} + \underset{\text{Oxygen}}{3O_2(g)}$$

(iii) When a chemical compound decomposes into new compounds.

$$\underset{\text{Calciumcarbonate}}{CaCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Calciumoxide}}{CaO(s)} + \underset{\text{Carbondioxide}}{CO_2(g)}$$

(c) Displacement reaction:

When a more reactive element displaces less reactive element form its salt solution, it is called chemical displacement.

$$AB + C \longrightarrow AC + B$$

(i) Iron reacts with copper sulphate solution to displace copper.

$$\underset{\text{Iron}}{Fe(s)} + \underset{\text{Copper sulphate}}{CuSO_4(aq)} \longrightarrow \underset{\text{Ferrous sulphate}}{FeSO_4(aq)} + \underset{\text{Copper}}{Cu(s)}$$

(ii) $$\underset{\text{Potassium Bromide}}{2KBr(aq)} + \underset{\text{Chlorine}}{Cl_2(g)} \longrightarrow \underset{\text{Potassium chloride}}{2KCl(aq)} + \underset{\text{bromine}}{Br_2(g)}$$

(d) Double displacement reaction (double decomposition reaction): The reaction in which exchange of atoms or ions takes place between the reactant molecules leading to the formation of products is called double displacement reaction or double decomposition reaction.

$$BaCl_2(aq) + CuSO_4(aq) \rightarrow BaSO_4(s) + CuCl_2(aq)$$

(e) Neutralization Reactions:

When an acid reacts with a base by exchanging their radicals, such that salt and water are the only products, then the reaction is called a neutralization reaction.

$$Base + Acid \longrightarrow Salt + Water + Heat$$

(i) $$\underset{\text{Sodium hydroxide}}{2NaOH} + \underset{\text{Sulphuric acid}}{H_2SO_4(dil)} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_4} + \underset{\text{Water}}{2H_2O}$$

(ii) $$\underset{\text{Potassium hydroxide}}{KOH} + \underset{\text{Hydrochloric acid}}{HCl} \longrightarrow \underset{\text{Potassium chloride}}{KCl} + \underset{\text{Water}}{H_2O}$$

(f) Oxidation and reduction reactions:

(i) Oxidation: When a substance gains oxygen or loses hydrogen then oxidation of that substances takes place.
Oxidising Agent: The substance which supplies oxygen or gains hydrogen is called oxidising agent.
e.g.

(A) $\underset{\text{Magnesium}}{2Mg(s)} + \underset{\text{Oxygen}}{O_2(g)} \xrightarrow{Heat} \underset{\text{Magnesiumoxide}}{2MgO(s)}$

In the above reaction magnesium gains oxygen. Therefore oxidation of magnesium takes place. Oxygen molecule supplies oxygen therefore oxygen is an oxidising agent.

(B) $\underset{\text{Manganese dioxide}}{MnO_2(s)} + 4\underset{\text{Hydrogen chloride}}{HCl(dil)} \xrightarrow{Heat} \underset{\text{Manganese chloride}}{MnCl_2(aq)} + \underset{\text{Water}}{2H_2O(\ell)} + \underset{\text{Chlorine}}{Cl_2(g)}$

In the above reaction as hydrochloric acid loses hydrogen, therefore its oxidation takes place. As manganese dioxide supplies oxygen, therefore it is an oxidising agent.

(C) $\underset{\text{Copper oxide}}{CuO(s)} + \underset{\text{Hydrogen}}{H_2(g)} \longrightarrow \underset{\text{Copper}}{Cu(s)} + \underset{\text{Water}}{H_2O(\ell)}$

In the above reaction as hydrogen gains oxygen, therefore its oxidation takes place. As copper oxide supplies oxygen, therefore it is an oxidising agent.
(ii) Reduction: When a substance gains hydrogen or loses oxygen then reduction of the substance takes place.
Reducing agent: The substance that gains oxygen or loses hydrogen is called reducing agent.

(A)
$\underset{\text{Methane}}{CH_4(g)} + 2\underset{\text{Oxygen}}{O_2(g)} \xrightarrow{Heat} \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{2H_2O(\ell)}$

As oxygen gains hydrogen, therefore reduction or oxygen gas takes place. As methane loses hydrogen, therefore it is a reducing agent.

$\underset{\text{Chlorine}}{Cl_2(g)} + \underset{\text{Hydrogen sulphide}}{H_2S(g)} \longrightarrow \underset{\text{Hydrogen chloride}}{2HCl(g)} + \underset{\text{Sulphur}}{S(s)}$

As chlorine gas gains hydrogen, therefore reduction of chlorine gas takes place. As hydrogen sulphide loses hydrogen, therefore hydrogen sulphide is a reducing agent.

Redox Reaction:

A chemical reaction in which oxidation and reduction of the reactants takes place simultaneously is called redox reaction.
e.g.

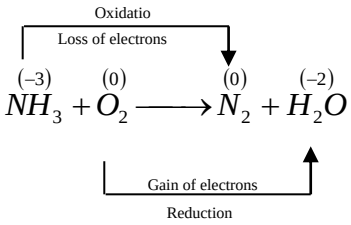
$\underset{\text{Hydrogen chloride}}{4HCl} + \underset{\text{Manganese dioxide}}{MnO_2} \longrightarrow \underset{\text{Manganese chloride}}{MnCl_2} + \underset{\text{Chlorine}}{Cl_2} + \underset{\text{Water}}{2H_2O}$ S

As hydrochloric acid gives hydrogen therefore its oxidation takes place and manganese dioxide supplies oxygen therefore its reduction takes place.

Apart from this theory, for oxidation and reduction it term of loss or gain of oxygen or hydrogen, we study a new theory for oxidation and reduction, which is explained in terms of electrons.

Some important facts:

5) Oxidation is loss of electrons and reduction is gain of electrons.
e.g.



6) An Oxidizing agent is one that removes an electron or electrons from the substance it oxidizes.
7) A reducing agent is one that adds an electron or electrons to the substance.
We can say that oxidation an reduction cannot occur alone.

e.g. $Mg(s) + CuSO_4(aq) \longrightarrow MgSO_4(aq) + Cu(s)$

Equation can be written as.
$Mg + Cu^{2+} + SO_4^{2-} \longrightarrow Mg^{2+} + SO_4^{2-} + Cu$

Magnesium loses 2 electrons so it is oxidized, copper gains 2 electrons so it is reduced.
Oxidising agent is an electron acceptor and reducing agent is an electron donor, therefore Mg is reducing agent while Cu^{++} is oxidising agent.

EXERCISE

1. Critical temperature is temperature-
(A) at which a liquid can solidified
(B) above which a gas can be liquefied.
(C) above which a gas cannot be liquefied
(D) none of these

2. $AgNO_3(aq.) + Nacl(aq.) \longrightarrow AgCl(s) + NaNO_3(aq.)$
Above reaction is a-
(A) precipitation reaction
(B) double displacement reaction
(C) combination reaction (D) (a) and (b) both

3. $CuO + H_2 \longrightarrow H_2O + CU$, *reaction is an example of –*
(A) redox reaction (B) synthesis reaction
(C) neutralisation (D) analysis reaction.

4. Rusting of iron is a chemical reaction. The reaction can be termed as-
(A) displacement (B) combination
(C) double decomposition (D) decomposition

5. Which of the following reactions depicts the neutralization reaction?
(A) $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$
(B) $MgO + H_2O \longrightarrow Mg(OH)_2$
(C) $CO_2 + H_2O \longrightarrow H_2CO3$
(D) $HCl + NaOH \longrightarrow NaCl + HO_2$

6. Redox reactions are those where _____ occur simultaneously.
(A) exothermic-endothermic reactions occur
(B) oxidation-reduction
(C) reversible-irreversible reactions
(D) composition-decomposition reactions

7. Which of the following is an endothermic reaction?
(A) N_2 (g) + $3H_2$ (g) $\rightleftharpoons$ $2NH_3$ + 22.4 Kcals.
(B) N_2 (g) + O_2 (g) $\rightleftharpoons$ 2NO (g) – 180 Kcals
(C) CO_2 (g) + H2 (g) $\rightleftharpoons$ CO (g) + H_2O(g) Energy (D) None

8. Which of the following is an exothermic reaction?
(A) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
(B) $SO_2 + O_2 \rightarrow SO_3$
(C) $PCl_5 \rightarrow 2NO_2$
(D) $N_2O_4 \rightarrow 2NO_2$

9. Double displacement reaction is-
(A) $CuO + H_2 \rightarrow Cu + H_2O$
(B) $2P + 3Cl_2 \rightarrow 2PCl_3$
(C) $BaCl_2 + CuSO_4 \rightarrow BaSO_4 + CuCl_2$
(D) $2KNO_3 \rightarrow 2KNO_2 + O_2$

10. The reaction in which substance is decomposed on heating to give its onsituent element is called-
(A) combination reaction
(B) decomposition reaction
(C) displacement reaction
(D) None of these

11. A mixture of alcohol and water can be separated by-
(A) separating funnel (B) fractional distillation
(C) simple distillation (D) crystallization

12. Boiling point of a substance-
(A) decreases with decreasing the pressure
(B) decreases with increasing the pressure
(C) increases with decreasing the pressure
(D) All of these

13. The temperature at which a liquid starts converting into solid without any rise in temperature is called-
(A) melting point (B) boiling point
(C) freezing point (D) None of these

14. Freezing point of water is-
(A) 100°C (B) O°C
(C) 273.15K (D) (b) and (c) both

15. The change of state of substance from gas to liquid is called-
(A) melting (B) boiling
(C) condensation (D) vaporization

16. Glycerol is purified by-
(A) fractional distillation method
(B) steam distillation method
(C) vaccum distillation method
(D) simple distillation method

17. Substance which has non-volatile impurity, is purified by-
(A) simple distillation (B) crystallization
(C) steam distillation (D) vaccum distillation

18. $H^+(aq) + OH^-(aq) \longrightarrow H_2O$
above reaction is an example of-
(A) neutralisation (B) addition
(C) combination (D) electrolysis

19. Purity of oxalic acid can be determined by-
(A) deterring the boiling point
(B) deterring the method point
(C) by dissolving it into water
(D) None of these

20. It water begins to boils at 15°C it shows that pressure it-
(A) lower than the atmospheric pressure
(B) greater than the atmospheric pressure
(C) equal to the atmospheric pressure
(D) None of these

21. Which of the following substance is not a compound? **(NTSE-Stage/I/Raj/2007)**

(A) Water (B) Air

(C) Glucose (D) Salt

22. Which of the following statements in false? **(NTSE-Stage/II/2007)**

(A) Melting and freezing point of a substance are the same.

(B) Vaporization of liquid takes place only at its boiling point

(C) Pure water has no taste

(D) Water allows sunlight to pass through it.

23. Some matter and their group are given in column P and Q respectively. **(NTSE-Stage/I/Raj/2008)**

(P)	**(Q)**
(a) Air	(i) Element
(b) O2	(ii) Mixture
(c) Copper sulphate	(iii) Base
(d) Sodium hydroxide	(iv) Salt

The correct option is-

(A) a (ii), b(iv), c(i), d(iii)

(B) a(iv), b(iii), c(ii), d(i)

(C) A(i), b(ii), c(iii), d(iv)

(D) a(ii), b(i), c(iv), d(iii)

ANSWER – KEY

TRANSFORMATION OF SUBSTANCES

Q.	1	2	3	4	5	6	7	8	9	10
A.	C	D	A	B	D	B	B	B	C	B
Q.	11	12	13	14	15	16	17	18	19	20
A.	B	A	C	D	C	C	A	A	B	B
Q.	21	22	23							
A.	B	B	D							