UNIT – 10
TYPES OF CHEMICAL REACTIONS

$$A + B \rightarrow A B$$
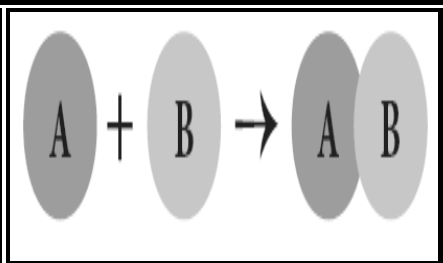
I. Choose the correct answer

1. $H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$ is a
   - a) Decomposition Reaction
   - **b) Combination Reaction**
   - c) Single Displacement Reaction
   - d) Double Displacement Reaction

2. Photolysis is a decomposition reaction caused by _____
   - a) heat
   - b) electricity
   - **c) light**
   - d) mechanical energy

3. A reaction between carbon and oxygen is represented by $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + Heat$. In which of the type(s), the above reaction can be classified?
   - (i) Combination Reaction
   - (ii) Combustion Reaction
   - (iii) Decomposition Reaction
   - (iv) Irreversible Reaction
   - a) i and ii
   - b) i and iv
   - c) i, ii and iii
   - **d) i, ii and iv**

4. The chemical equation $Na_2SO_{4(aq)} + BaCl_{2(aq)} \rightarrow BaSO_{4(s)}\downarrow + 2NaCl_{(aq)}$ represents which of the following types of reaction?
   - a) Neutralisation
   - b) Combustion
   - **c) Precipitation**
   - d) Single displacement

5. Which of the following statements are correct about a chemical equilibrium?
   - (i) It is dynamic in nature.
   - (ii) The rate of the forward and backward reactions are equal at equilibrium.
   - (iii) Irreversible reactions do not attain chemical equilibrium.
   - (iv) The concentration of reactants and products may be different.
   - **a) i, ii and iii**
   - b) i, ii and iv
   - c) ii, iii and iv
   - d) i, iii and iv

6. A single displacement reaction is represented by $X_{(s)} + 2HCl_{(aq)} \rightarrow XCl_{2(aq)} + H_{2(g)}$. Which of the following(s) could be X. (i) Zn (ii) Ag (iii) Cu (iv) Mg
   Choose the best pair.
   - a) i and ii
   - b) ii and iii
   - c) iii and iv
   - **d) i and iv**

7. Which of the following is not an "element + element → compound" type reaction? **[PTA – 3]**
   - a) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$
   - b) $2K_{(s)} + Br_{2(l)} \rightarrow 2KBr_{(s)}$
   - **c) $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$**
   - d) $4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$

8. Which of the following represents a precipitation reaction?
   - a) $A_{(s)} + B_{(s)} \rightarrow C_{(s)} + D_{(s)}$
   - b) $A_{(s)} + B_{(aq)} \rightarrow C_{(aq)} + D_{(l)}$
   - **c) $A_{(aq)} + B_{(aq)} \rightarrow C_{(s)} + D_{(aq)}$**
   - d) $A_{(aq)} + B_{(s)} \rightarrow C_{(aq)} + D_{(l)}$

9. The pH of a solution is 3. Its $[OH^-]$concentration is
   - a) 1×10^{-3} M
   - b) 3 M
   - **c) 1×10^{-11} M**
   - d) 11 M

10. Powdered $CaCO_3$ reacts more rapidly than flaky $CaCO_3$ because of _____.
    - **a) large surface area**
    - b) high pressure
    - c) high concentration
    - d) high temperature

II. Fill in the blanks

1. A reaction between an acid and a base is called **neutralization reaction**.
2. When lithium metal is placed in hydrochloric acid, **hydrogen** gas is evolved.
3. The equilibrium attained during the melting of ice is known as **physical equilibrium**.
4. The pH of a fruit juice is 5.6. If you add slaked lime to this juice, its pH **increases** (increase/decrease).
5. The value of ionic product of water at 25°C is $\mathbf{1.00\times 10^{-14}}$ **mol² dm⁻⁶**.
6. The normal pH of human blood is **7.4**.
7. Electrolysis is a type of **decomposition** reaction.
8. The number of products formed in a synthesis reaction is **one.**
9. Chemical volcano is an example for **decomposition** type of reaction.
10. The ion formed by dissolution of $\mathbf{H^+}$ in water is called **hydronium ion (or) H₃O⁺ ion**.

III. Match the following

1. Identify the types of reaction :   [PTA –2]

REACTION	TYPE	Answer
1) $NH_4OH_{(aq)} + CH_3COOH_{(aq)} \rightarrow CH_3COONH_{4(aq)} + H_2O_{(l)}$	a) Single Displacement	**1 - c**
2) $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$	b) Combustion	**2 - a**
3) $ZnCO_{3(s)} \xrightarrow{Heat} ZnO_{(s)} + CO_{2(g)}$	c) Neutralisation	**3 - d**
4) $C_2H_{4(g)} + 4O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(g)} + Heat$	d) Thermal decomposition	**4 - b**

IV. True or False: (if false give the correct statement)

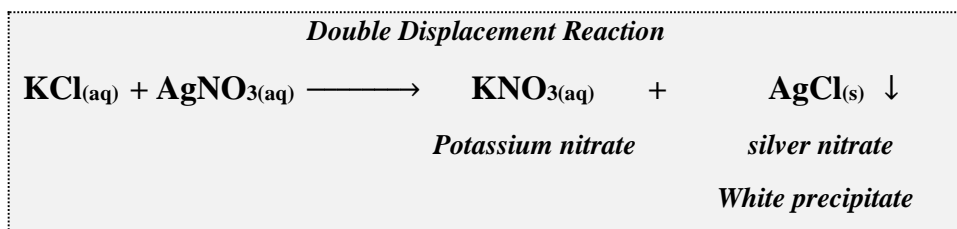1. Silver metal can displace hydrogen gas from nitric acid.   **[False]**

    ** Silver metal **does not displace** hydrogen from nitric acid.*

2. The pH of rain water containing dissolved gases like SO₃, CO₂, NO₂ will be less than 7.   **[True]**

3. At the equilibrium of a reversible reaction, the concentration of the reactants and the products will be equal.   **[True]**

4. Periodical removal of one of the products of a reversible reaction increases the yield.   **[True]**

5. On dipping a pH paper in a solution, it turns into yellow. Then the solution is basic.   **[False]**

    On dipping a pH paper in a solution, it turns into yellow. Then the solution is **acidic. (or)*
    *On dipping a pH paper in a solution, it turns into **violet**. Then the solution is basic.*

V. Short answer questions

1. When an aqueous solution of potassium chloride is added to an aqueous solution of silver nitrate, a white precipitate is formed. Give the chemical equation of this reaction.   [PTA – 6]

> *Double Displacement Reaction*
>
> $\mathbf{KCl_{(aq)} + AgNO_{3(aq)} \longrightarrow \quad KNO_{3(aq)} \quad + \quad AgCl_{(s)} \downarrow}$
>
> *Potassium nitrate   silver nitrate*
>
> *White precipitate*

2. Why does the reaction rate of a reaction increase on raising the temperature? (or) Why food kept at room temperature spoil faster than at refrigerator?   [PTA –6, MDL – 19]

❖ Raising temperature provides more energy to break more bonds (i.e) Reaction rate is increased.

❖ Thus, Food kept at room temperature spoil faster than at refrigerator, as the temperature in fridge is lower which makes the reaction rate slower.

3. Define combination reaction. Give one example for an exothermic combination reaction.

A reaction in which two or more reactants combine to form a compound is known as Combination (or) Synthesis (or) Composition reaction.

General schematic representation: $A + B \rightarrow AB$ **[MAY - 2022]**

Example for Exothermic combination reaction: $SiO_{2(s)} + CaO_{(s)} \rightarrow CaSiO_{3(s)}$

4. Differentiate reversible and irreversible reactions.   [AUG-22, MAY-22, SEP-21, PTA-1]

Reversible reaction	Irreversible reaction
1. It can be reversed under suitable condition.	1. It cannot be reversed.
2. Both forward and backward reactions take place simultaneously.	2. It proceeds only in forward direction.
3. It attains equilibrium.	3. Equilibrium is not attained.
4. It is relatively slow.	4. It is fast.

VI. Answer in detail

1. What are called thermolysis reactions?   [SEP – 2021]

❖ Reaction in which, reactant is decomposed by heat is called thermolysis reactions.

❖ They are Endothermic reactions as heat is supplied or absorbed to break bonds. **Types are,**

i. *Compound to Element / Element decomposition* $2HgO_{(S)} \xrightarrow{\text{heat}} 2Hg_{(l)} + O_{2(g)}$

**ii.** *Compound to Compound / Compound decomposition* $CaCO_{3(S)} \xrightarrow{\text{heat}} CaO_{(S)} + CO_{2(g)}$

2. Explain the types of double displacement reactions with examples.   [SEP – 2020]

Double displacement (or) metathesis reaction are reactions in which, ions of one compound is replaced by ions of another compound. Ions of identical charges alone are interchanged.
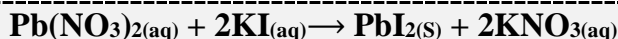
General schematic representation: $AB + CD \longrightarrow AD + CB$

***Ex:*** $Pb(NO_3)_{2s(aq)} + 2KI_{(aq)} \rightarrow PbI_{2(S)} + 2KNO_{3(aq)}$
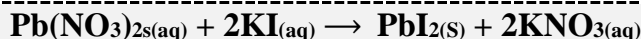
i) Precipitation reaction: When aqueous solutions of two compounds are mixed, they react to form an insoluble compound and a soluble compound.

Ex: $Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \rightarrow PbI_{2(S)} + 2KNO_{3(aq)}$

ii) Neutralization reaction: It is the reaction in which acid reacts with base to form salt and water. Here, both acid and base neutralize each other.

Ex: $NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$
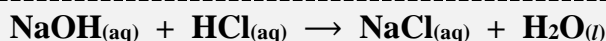
3. Explain the factors influencing the rate of a reaction. [PTA – 5]

i) *Nature of reactant:*

Ex: *Sodium reacts faster with hydrochloric acid than acetic acid.*

Because, Hydrochloric acid is stronger than acetic acid and thus more reactive.

ii) *Concentration of the reactants:*

More the concentration, more particles per volume exist in it, reaction is faster.

Ex: *Granulated zinc reacts faster with 2M hydrochloric acid than 1M Hydrochloric acid.*

iii) *Temperature:*

Most reactions are faster at higher temperature. Because adding heat provides energy to break more bonds. **Ex:** *Food at refrigerator spoil slower compared to food at outside.*

iv) *Pressure:*

If reactants are gases, increasing pressure increases the reaction rate. Because reacting particles come closer and collide frequently.

v) *Catalyst:*

Catalyst increases the reaction rate without being consumed in the reaction.

Ex: *On heating potassium chlorate, it decomposes into potassium chloride and oxygen at a slower rate. If manganese dioxide is added as catalyst, it increases the reaction rate.*

vi) *Surface area of the reactants:*

Powdered form of solid reactants reacts more readily. They have more surface area. The collision of reactant particle is increased. Thus, rate of reaction is also increased.

Ex: *Powdered calcium carbonate reacts more readily with hydrochloric acid than marble chips.*

4. How does pH play an important role in everyday life?

i) *Role of pH in human body :*

Body pH range is 7.0 to 7.8. Increases/decreases leads to disease. pH of blood is 7.4.

ii) *Role of pH in our digestive system :*

Stomach produces hydrochloric acid, which helps in digestion. During indigestion, it produces too much acid causing pain and irritation. pH of stomach fluid is 2.0.

iii) *pH changes as the cause of tooth decay :*

pH of saliva is between 6.5 to 7.5. When it falls below 5.5, enamel is weathered. Toothpastes are generally basic, it neutralizes excess acid and prevent tooth decay.

iv) *pH of soil :*

pH of soil is very important in agriculture. Citrus fruits require alkaline soil, rice requires acidic soil and sugarcane requires neutral soil.

v) *pH of rainwater :*

pH of rainwater is 7. If atmospheric air is polluted with oxides of sulphur & nitrogen, they dissolve in rainwater making its pH less than 7 causing acid rain.

5. What is a chemical equilibrium? What are its characteristics?

Chemical equilibrium: It is a state of reversible chemical reaction where there is no change in amount of reactants and products.

At equilibrium, **Rate of forward reaction = Rate of backward reaction**

Ex: $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$
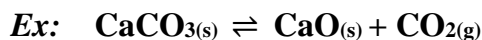
Characteristics of equilibrium: [PTA – 3]

❖ Rates of forward and backward reactions are equal.

❖ Properties like pressure, concentration, colour, density, viscosity, etc., of remain unchanged.

❖ It is a dynamic equilibrium, because both forward and backward reactions occur even though it appears static externally.

❖ In physical equilibrium, volume of all phases remain constant.

VII. HOT Questions

1. A solid compound 'A' decomposes on heating into 'B' and a gas 'C'. On passing the gas 'C' through water, it becomes acidic. Identify A, B and C.

Calcium carbonate(A) decompose to give *calcium oxide(B)* and *carbon dioxide(C)* on heating.

$$CaCO_{3(s)} \xrightarrow{heat} CaO_{(s)} + CO_{2(s)} \uparrow$$
calcium carbonate   *Calcium oxide*   *Carbon dioxide*
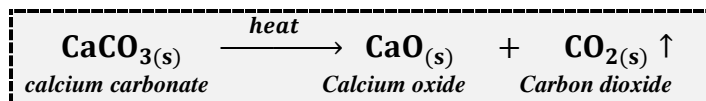
Carbon dioxide (C) is mixed with water to form carbonic acid

$$CO_{2(g)} + H_2O_{(g)} \longrightarrow H_2CO_{3(l)}$$
Carbon dioxide   *Carbonic acid*
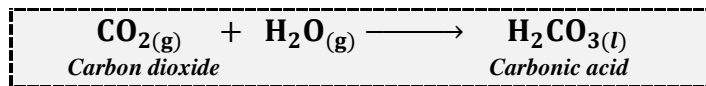
> **Compound A → CaCO₃**
> **Compound B → CaO**
> **Compound C → CO₂ gas**

2. Can a nickel spatula be used to stir copper sulphate solution? Justify your answer. [PTA – 6]

❖ Nickel spatula cannot be used to stir copper sulphate solution.

❖ Nickel is more reactive than copper. Hence, nickel displaces copper from its solution.

VIII. Solve the following problems

1. Lemon juice has a pH 2, what is the concentration of H⁺ ions?

Solution :

$$pH = -\log_{10}[H^+] = 2$$

$$Log_{10}[H^+] = -2$$

$$\Rightarrow [H^+] = 0.01 \text{ (or) } 10^{-2}$$

∴ Concentration is 1.0×10^{-2} mole litre⁻¹

2. Calculate the pH of 1.0×10^{-4} molar solution of HNO₃. [PTA – 1]

Given : $[H^+] = 1.0 \times 10^{-4} = 10^{-4}$

Solution : $pH = -\log_{10}[H^+]$

$$= -\log_{10}[10^{-4}]$$

$$= -(-4) \log_{10} 10$$

$$pH = 4(1) = 4 \ (\because \log_{10} 10 = 1)$$

∴ pH of HNO₃ is 4.

3. What is the pH of 1.0 × 10⁻⁵ molar solution of KOH? [PTA – 6]

Given : $[OH^-] = 1.0 \times 10^{-5} = 10^{-5}$

Solution : $pOH = -\log_{10}[OH^-]$

$= -\log_{10}[10^{-5}]$

$= -(-5)\log_{10} 10$

$(\because \log_{10} 10 = 1)$

$pOH = 5(1) = 5$

$\because pH + pOH = 14$

$pH = 14 - pOH = 14 - 5 = 9$

$\therefore$ pH of the solution is 9.

4. The hydroxide ion concentration of a solution is 1 × 10⁻¹¹ M. What is the pH of the solution? [PTA – 5]

Given : $[OH^-] = 1.0 \times 10^{-11} = 10^{-11}$

Solution : $pOH = -\log_{10}[OH^-]$

$= -\log_{10}[1 \times 10^{-11}]$

$= -(-11)\log_{10} 10$

$(\because \log_{10} 10 = 1)$

$pOH = 11(1) = 11$

$\because pH + pOH = 14$

$pH = 14 - pOH$

$pH = 14 - 11 = 3$

$\therefore$ pH of the solution of is 3.