Q.1) **Define the following terms:**

1)Electrolyte: A substance which forms a conducting solution when dissolved in water is called an electrolyte.

2) Strong electrolyte: An electrolyte which ionises to a maximum extent in dilute aqueous solutions is called a strong electrolyte.e.g HCl, NaOH, NaCl etc

3)Weak electrolyte: An electrolyte which ionizes to a less extent in dilute aqueous solutions is called a weak electrolyte.eg.CH_3COOH, NH_4OH etc.

Q.2) Distinguish between strong electrolyte and weak electrolyte

Ans:

Sr.No.	Strong electrolyte	Weak electrolyte
1	It dissociates to a maximum extent in dilute aqueous solution.	It dissociates to a less extent in dilute aqueous solution.
2	The degree of dissociation is one.	The degree of dissociation is always less than one.
3	Law of mass action is not applicable	Law of mass action is applicable.
4	Their solutions have high conducting power.	Their aqueous solutions have less conducting power.

Q.3)Define degree of dissociation. Explain the factors affecting the degree of dissociation.

Ans: Degree of dissociation: The fraction of the total number of moles of the electrolyte that dissociates into its ions at equilibrium is called degree of dissociation.

Factors affecting degree of dissociation:

a)Nature of solute or electrolyte: The degree of dissociation for strong electrolytes is considered as unity while for weak electrolytes, it is always less than one.

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b) Nature of the solvent: The degree of dissociation is directly proportional to the polarity of solvent. Higher the polarity of the solvent, more is the degree of dissociation.

c)Concentration of the solution: The degree of dissociation increases with the decrease in concentration of the solution.

d)Temperature of the solution: The degree of dissociation increases with the increase in temperature of the solution.

Q.4)Give an account of classical definition of acids and bases .

Ans : Acid : An acid can be defined as a substance whose solution in water turns blue litmus red , has sour taste and neutralises base to form salt and water.

e.g., HCl , HNO_3 , H_2CO_3

Base : A base can be defined as a substance whose solution in water turns red litmus blue, has bitter taste , neutralises acids and soapy in touch .

e.g., NaOH , NH_4OH etc.

Q.5) Discuss Arrhenius theory of acids and bases.

Ans :

Acid : An **acid** is a **compound of hydrogen** which produces H^+ **ions** in **aqueous solution.**

e.g. **HCl** $\xrightarrow{\text{water}}$ $H^+_{(aq)}$ + $Cl^-_{(aq)}$

$CH_3COOH \overset{\text{water}}{\rightleftharpoons} CH_3COO^-_{(aq)} + H^+_{(aq)}$

Base : A base is a **hydroxy compound** which produces OH^- **ions** (hydroxyl ions) when dissolved **in water**.

e.g., **NaOH** $\xrightarrow{\text{water}}$ $Na^+_{(aq)}$ + $OH^-_{(aq)}$

$NH_4OH \overset{\text{water}}{\rightleftharpoons} NH_4^+ + OH^-_{(aq)}$

Neutralisation : The reaction of the H^+ **ions of the acid** with the OH^- **ions of the base** to produce practically unionised water is called neutralisation .

e.g., $Cl_{(aq)}$ + $NaOH_{(aq)}$ ⟶ $NaC1_{(aq)}$ + H_2O

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Ionic equation $H^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl^- + H_2O$

i.e. $H^+ + OH^- \longrightarrow H_2O$

The properties of the **acid** are due to H^+ **ions** while that of base are due to OH^- **ions**.

Q.6) State the limitations of Arrhenius theory.

Ans : The limitations of the Arrhenius theory are as follows :

i) It is applicable to solutions of acids and bases prepared in water. For example, according Arrhenius theory, HCl in water is an acid but HCl in $CHC1_3$ is not an acid

ii) Basic nature of certain compounds like Na_2CO_3**, aniline** etc . were not explained even in the absence of hydroxyl ions .

iii)Acidic nature of certain compounds like $AlCl_3$ **,** $FeCl_3$ etc. were not accounted by this theory.

iv) Existance of H^+ as hydronium ion **(**H_3O^+**)** in water were not accounted by this theory.

$$H^+ + H_2O \longrightarrow H_3O^+$$

v) Neutralisation reaction in gaseous media were not explained

$$NH_{3(g)} + HCl_{(g)} \longrightarrow NH_4CL_{(s)}$$

Q.7)Discuss Lowry and Bronsted concept of acid and bases.

Ans: According to Lowry and Bronsted concept , an **acid** is a substance **which donates a proton** while a **base** is a substance **which accepts a proton**.Thus acid base reaction involves donation of a proton by an acid to the base.

e.g. Consider the following reaction

$$HCl + NH_3 \longrightarrow NH_4^+ + Cl^-$$

In this reaction, HCl donates a proton to ammonia .Therefore it acts as an acid. Ammonia accepts a proton from HCI and it acts as a base. In the reverse reaction,NH_4^+ acts as an acid as

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it donates a proton while Cl^- acts as a base as it accepts a proton.

In the above reaction, there are two acid-base pairs which differ by a proton exchangeable between them. One pair is that of HCl and Cl^- while other pair is NH_3 and NH_4^+. Such an acid-base pairs are called **conjugate acid-base pairs**. Thus according to this theory, every **strong acid** has its **weak conjugate base** and vice versa.

The strength of an acid or a base is measured in terms of the ability of the acid or the base to donate or accept a proton. HCl is a strong acid as it donates a proton readily while Cl^- is a weak base since it shows less tendency to hold a proton.

Q.8)Explain the term 'conjugate acid-base pair' with a suitable example.

Ans. An **acid-base pair** which differ by a **single proton(H^+ ion)** exchangeable between them is called conjugate acid-base pair.

For example, consider the following reaction

$$\mathbf{CO_3^{2-} + H_2O \longrightarrow HCO_3^- + OH^-}$$

In the above reaction, $\mathbf{CO_3^{2-}}$ accepts a proton from H_2O and forms HCO_3^-. Hence $\mathbf{CO_3^{2-}}$ **and** $\mathbf{HCO_3^-}$ differ by a single proton and forms a conjugate acid-base pair.Similarly, $\mathbf{H_2O}$ **and** $\mathbf{OH^-}$ forms another conjugate acid-base pair.

Thus according to Lowry- Bronsted theory, every **strong acid** has its **weak conjugate base** and vice versa.

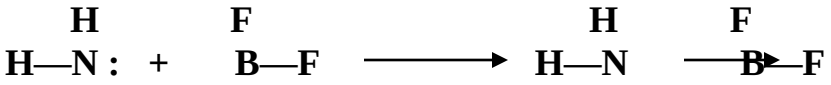
Q.9)Discuss Lewis concept of acids and bases.

Ans: According to Lewis concept, an acid is a substance (**atom, molecule or ion**) which can **accept an electron pair from a base**.

A base is a substance (**atom, ion or molecule**) **which can donate an electron pair to an acid**.

A neutralisation reaction between acid and base involves the formation of a co-ordinate bond between them.

e.g-



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H F H F

Lewis base Lewis acid Complex compound

Types of Lewis acids:

i) Neutral molecules in which the central atom possess an incomplete octets.
e.g.**BF_3, $AlCl_3$**

ii) Simple cations like Cu^{2+} ,Zn^{2+} etc.

Types of Lewis bases:

i) Molecules in which the central atom possess lone pair of electrons e.g.NH_3,H_2O

ii) Anions like OH^- , Cl^-

Another example $H^+ + : NH_3 \longrightarrow NH_4^+$

Lewis acid Lewis base

Q.10) Explain the amphoteric nature of water.

Ans :A substance which can act as an acid as well as a base is said to possess amphoteric nature. Water behaves as a base (proton acceptor) in presence of a strong acid and an acid (proton donor) in presence of a strong base. Hence it is amphoteric in nature.

e.g., $H_2O + HCl \rightleftharpoons H_3O^+ + Cl^-$

Base

$H_2O + NH_3 \rightleftharpoons NH_4^+ + OH^-$

Acid

Q.11)Write a note on ionic product of water.

Ans.Ionic product of water is defined as the product of molar concentrations of hydrogen and hydroxyl ions in pure water or in any neutral aqueous solution at a given temperature.

Pure water being a weak electrolyte, undergoes dissociation as follows :

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

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In simplified form, the above equation can be written as

$$H_2O \Longleftrightarrow H^+ + OH^-$$

By law of mass action

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

As water is in excess, $[H_2O]$ = constant

$$K(\text{ constant }) = [H^+][OH^-]$$

$K_w = [H^+][OH^-]$ where K_w is called ionic product of water

The value of K_w depends upon temperature

At 298K,the value of **K_w is 1.00×10^{-14}** since the concentrations of H_3O^+ and OH^- ions in pure water or in any neutral aqueous solution is **1×10^{-7} M**

The concept of ionic product helps in classifying aqueous solutions as neutral, acidic and basic as follows :

i) If $[H^+] > [OH^-]$ Solution is acidic.

ii) If $[H^+] < [OH^-]$ Solution is basic.

iii)If $[H^+] = [OH^-]$ Solution is neutral.

Q.12) Derive an expression for ionic product of water or ionization constant of water.
Ans.

Pure water being a weak electrolyte, undergoes dissociation as follows :

$$H_2O + H_2O \Longleftrightarrow H_3O^+ + OH^-$$

In simplified form, the above equation can be written as

$$H_2O \Longleftrightarrow H^+ + OH^-$$

By law of mass action

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

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As water is in excess, $[H_2O]$ = constant

$K(\text{ constant }) = [H^+]\,[OH^-]$

$K_w = [H^+]\,[OH^-]$ where K_w is called ionic product of water

Q.13) Define pH and pOH. Obtain a relation between them.

Ans. pH : It is defined as the **negative logarithm** to the **base10** of the **hydrogen ion concentration**

pOH: It is defined as the **negative logarithm** to the **base 10** of the **hydroxyl ion concentration.**

By definition, **$pH = -\log_{10}[H^+]$** and **$pOH = -\log_{10}[OH^-]$**

The ionic product of water K_w is given by

$K_w = [H^+]\,[OH^-]$

At 298K **$K_w = 1 \times 10^{-14}$**

$\therefore$ **$1 \times 10^{-14} = [H^+][OH^-]$**

Taking $\log_{10}$ on both sides, we get

$\log_{10}(1 \times 10^{-14}) = \log_{10}[H^+] + \log_{10}[OH^-]$

Introducing negative sign on both sides, we get

$-\log_{10}(1 \times 10^{-14}) = (-\log_{10}[H^+]) + (-\log_{10}[OH^-])$

$-(-14\log_{10}10) = pH + pOH$

$\therefore$ **$14 = pH + pOH$**

Q.14) Give examples of following types of salts

a) Salt of strong base and weak acid

b) Salt of strong acid and weak base

c) Salt of weak acid and weak base.

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Ans.

SALT	EXAMPLES
a) Salt of S .A & W.B.	a) $FeCl_3$, $CuSO_4$,$Pb(NO_3)_2$ etc.
b) Salt of S . B & W.A .	b) CH_3COONa,KCN,Na_2CO_3 etc.
c) Salt of W. A . & W.B	c) CH_3COONH_4 , NH_4CN etc.

Q.15) Give reasons for the following :

a)Aqueous solution of $FeCl_3$ is acidic in nature.

b)Aqueous solution of Na_2CO_3 is alkaline in nature.

c**)Salt of strong acid and strong base do not undergo hydrolysis.**

d)A few drops of concentrated sulphuric acid are added to an aqueous solution of copper sulphate.

Ans.

a)**Aqueous solution of $FeC1_3$ is acidic in nature** : Ferric chloride is a salt of strong acid (HCl) and weak base [$Fe(OH)_3$] . It hydrolyses as follows:

$$\mathbf{FeCl_3 + 3H_2O \rightleftharpoons Fe(OH)_3 + 3HCl}$$

Ionic equation: $\mathbf{Fe^{3+} + 3CI^- + 3H_2O \rightleftharpoons Fe(OH)_3 + 3H^+ + 3CI^-}$

$$\mathbf{Fe^{3+} + 3H_2O \rightleftharpoons Fe(OH)_3 + 3H^+}$$

Thus the resulting aqueous solution contains **excess of free H^+ ions.**Hence the solution of $FeCl_3$ is acidic in nature .

b) Aqueous solution of Na_2CO_3 is alkaline in nature : Sodium carbonate Na_2CO_3 is a salt of strong base (NaOH) and weak acid (H_2CO_3) . It hydrolyses as follows:

$$\mathbf{Na_2CO_3 + 2H_2O \rightleftharpoons H_2CO_3 + 2NaOH}$$

Ionic equation $\mathbf{2Na^+ + CO_3^{2-} + 2H_2O \rightleftharpoons H_2CO_3 + 2Na^+ + 2OH^-}$

$$\mathbf{CO_3^{2-} + 2H_2O \rightleftharpoons H_2CO_3 + 2OH-}$$

Thus the resulting aqueous solution of Na_2CO_3 conrtains **excess of free OH^- ions**.Hence it is basic in nature.

c) Salt of strong acid and strong base do not undergo hydrolysis : Consider a salt BA of strong acid [HA] and strong base [BOH]. It dissociates in water as follows

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$$BA + H_2O \rightleftharpoons BOH + HA$$

Ionic equation; $B^+ + A^- + H_2O \rightleftharpoons B^+ + OH^- + H^+ + A^-$

$$H_2O \rightleftharpoons H^+ + OH^-$$

Thus neither B^+ nor A^- of the salt react with water producing acidity or basicity in the solution. The resulting solution is neutral as $[H^+] = [OH^-]$. Therefore the salt BA does not undergo hydrolysis.

d) A few drops of concentrated sulphuric acid are added to an aqueous solution of copper sulphate.

Ans: Copper sulphate is a salt of strong acid and weak base. On hydrolysis, it forms insoluble copper hydroxide which makes the solution turbid.

$$CuSO_4 + 2H_2O \rightleftharpoons Cu(OH)_2 + H_2SO_4$$

Addition of few drops of concentrated sulphuric acid favours the backward reaction. As a result, the precipitate of $Cu(OH)_2$ dissolves and a clear solution of $CuSO_4$ is obtained. Thus sulphuric acid **prevents hydrolysis** of the $CuSO_4$ solution.

Q.16) Define pK_a , pK_b and pK_w

Ans: i) **pK_a** is define as the negative logarithm of dissociation constant of the acid.

$$pK_a = -\log_{10} K_a = \log_{10} \frac{1}{K_a}$$

ii) **pK_b** is define as the negative logarithm of dissociation constant of the base.

$$pK_b = -\log_{10} K_b = \log_{10} \frac{1}{K_b}$$

iii) **pK_w** is define as the negative logarithm of ionisation constant of water.

$$pK_w = -\log_{10} K_w = \log_{10} \frac{1}{K_w}$$

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