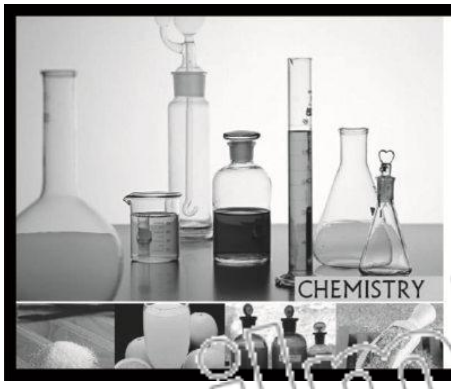


CHAPTER 10

ACIDS, BASES & SALTS

INTRODUCTION

SHORT QUESTIONS

Q.1 What was the contribution of Jabir Bin Haiyan towards acids? *(Knowledge Base)*

Ans:

CONTRIBUTION OF JABIR BIN HAIYAN

A famous Muslim Chemist Jabir Bin Hayan prepared:

- Nitric acid (HNO_3)
- Hydrochloric acid (HCl)
- Sulphuric acid (H_2SO_4)

Q.2 What was the contribution of Lavoisier towards acids? *(Knowledge Base)*

Ans:

CONTRIBUTION OF LAVOISIER

In 1787, Lavoisier named binary compounds of oxygen such as CO_2 and SO_2 as acids which on dissolution in water gave acidic solutions.

Q.3 Give the work of Sir Humphrey Davy towards acids. *(Knowledge Base)*

Ans:

WORK OF SIR HUMPHREY DAVY

In 1815, Sir Humphrey Davy gave the following countributions:

- He discovered that there are certain acids which are without oxygen. For example, HCl.
- He proved the presence of hydrogen as the main constituent of all acids.

Q.4 Which acid is present in stomach and how is stomach acidity treated? (*Understanding+Application Base)*

Ans:

ACID PRESENT IN STOMACH

We all have little concentration of hydrochloric acid in our stomach, which helps to break down the food. Sometimes the amount of stomach acid becomes too much, which causes acidity.

Treatment of Stomach Acidity:

Stomach acidity is easily treated by taking an alkaline medicine. The alkali neutralizes the acid, producing a harmless chemical called a salt.

MULTIPLE CHOICE QUESTIONS

1. Nitric acid was prepared by: *(K.B)*

(A) Bu Ali Sina (B) Jabir Bin Hayan
(C) Laviosier (D) Humphrey

2. The first acid known to man was: *(K.B)* **(SWL 2017)**

(A) Hydrochloric acid (B) Sulphuric acid
(C) Nitric acid (D) Acetic acid

3. The word acid is derived from: *(K.B)*

(A) Acidic (B) Acidus
(C) Acetic (D) Acetate

4. Humphrey Davy proved that main constituent of all acids is: *(K.B)*

(A) Nitrogen (B) Oxygen
(C) Hydrogen (D) Chlorine

5. CO_2 and SO_2 are: *(K.B)*

(A) Base (B) Acid
(C) Amphoteric compounds (D) Neutral compounds

6. Which one gives acidic solution? ***(K.B)***

(A) CO_2 (B) SO_2

(C) Both A and B (D) MgO

7. Hydrochloric acid was prepared by: ***(K.B)*** **(SGD 2016 G-II)**

(A) Alkhawarzmi (B) Ibnehashim

(C) Jabir Bin Hayan (D) Bu Ali Sina

8. The meaning of Latin word acidus is: ***(K.B)*** **(DGK 2016 G-II)**

(A) Sweet (B) Tasteless

(C) Sour (D) Salty

10.1 CONCEPTS OF ACIDS AND BASES

10.1.1 ARRHENIUS CONCEPT OF ACIDS AND BASES

LONG QUESTIONS

Q.1 What is the comparison between acids and bases? ***(Knowledge Base)*** **(DGK 2016 G-I)**

OR

Write down characteristic properties of acids and bases.

Ans: **COMPARISON BETWEEN ACIDS AND BASES**

Following are characteristics properties of acids and bases:

Acids	Bases
Taste	
• Acids have **sour** taste. e.g. unripe citrus fruits or lemon juice	• Bases have **bitter** taste and feel slippery. e.g. soap is slippery to touch
Effect on Litmus	
• They turn **blue litmus red**	• They turn **red litmus blue**
Nature	
• They are **corrosive** in concentrated form	• They are **non-corrosive** except concentrated forms of NaOH and KOH
Electrical Conductivity	
• Their aqueous solutions conduct electric current	• Their aqueous solutions conduct electric current
Examples	
• HCl, H_2SO_4,HNO_3 etc	• NaOH, KOH, $Ca(OH)_2$ etc

Q.2 Write in detail Arrhenius concept of acids and bases. ***(Knowledge + Understanding Base)***

(LHR 2020, MTN 2016 G-II, 17, SGD 2016 G-II, 17, FSD 2016 G-I, 17)

Ans: **ARRHENIUS CONCEPT**

This concept was given by Arrhenius in 1787.

Acid:

"Acid is a substance which ***dissociates*** *in* ***aqueous solution*** *to give* ***hydrogen ions****".*

Examples:

- Hydrochloric acid **(HCl)**
- Nitric acid **(HNO_3)**

- Sulphuric acid **(H_2SO_4)**
- Phosphoric acid **(H_3PO_4)**

General Reaction:

In general the ionization of acids, takes place as follows.

$$HA \rightleftharpoons H^+ + A^-$$

Explanation:

$$HCl \xrightleftharpoons{water} H^+ + Cl^-$$

$$HNO_3 \xrightleftharpoons{water} H^+ + NO_3^-$$

$$CH_3COOH \xrightleftharpoons{water} H^+ + CH_3COO^-$$

Base: **(BWP 2017)**

*"Base is a substance which **dissociates** in **aqueous solution** to give **hydroxide ions**".*

Examples:

- Sodium hydroxide **(NaOH)**
- Potassium hydroxide **(KOH)**
- Calcium hydroxide **[$Ca(OH)_2$]**
- Aluminium hydroxide **[$Al(OH)_3$]**

General Reaction:

The general ionization of bases takes place as follows;

Explanation:

$$BOH \xrightleftharpoons{water} B^+ + {}^-OH$$

$$NaOH \xrightleftharpoons{water} Na^+ + OH^-$$

Conclusion:

Thus, according to Arrhenius Concept:

Acid gives H^+ in water and base gives OH^- in water.

Limitations: **(LHR 2014, 2015, 2019, 2020)**

- **Aqueous medium:**

  This concept is applicable only in aqueous medium and **does not explain** nature of acids and bases in **non-aqueous medium**.

- **Nature of compounds:**

  According to this concept, acids and bases are only those compounds which contain hydrogen (H^+) and hydroxide (OH^-) ions, respectively. It **can't explain** the **nature** of compounds like **CO_2, NH_3** etc., which are acid and base, respectively. Although this concept has limited scope yet, it led to the development of more general theories of acid-base behaviour.

10.1 CONCEPTS OF ACIDS AND BASES

10.1.1 ARRHENIUS CONCEPT OF ACIDS AND BASES

SHORT QUESTIONS

Q.1 What are physical (characteristic) properties of acids? *(Knowledge Base)* **(GRW 2014, 2016, DG. KHAN 2017, BWP 2016 G-II)**

Ans:

PHYSICAL PROPERTIES OF ACIDS

The physical properties of acids are as follows:

- Acids have **sour taste**. e.g. Unripe citrus fruits or lemon juices.
- They turn **blue litmus red.**
- They are **corrosive** in concentrated form.
- Their aqueous solutions conduct electric current.

Examples:

- Hydrochloric acid **(HCl)**
- Sulphuric acid **(H_2SO_4)**
- Nitric Acid **(HNO_3)**

Q.2 What are physical (characteristic) properties of bases? *(Knowledge Base)* **(GRW 2013, LHR 2015, BWP 2017)**

Ans:

PHYSICAL PROPERTIES OF BASES

The physical properties of acids are as follows:

- Bases have **bitter taste** and feel slippery. e.g. Soap is slippery to touch.
- They turn **red litmus blue**.
- They are **non-corrosive except** concentrated forms of **NaOH and KOH**.
- Their aqueous solutions conduct electric current.

Examples:

- Sodium hydroxide **(NaOH)**
- Potassium Hydroxide **(KOH)**
- Calcium hydroxide **[$Ca(OH)_2$]**

Q.3 What are limitations of Arrhenius concept of acids and bases? *(Understanding Base)* **(GRW 2014, 15, DGK 2016 G-II, 17, MTN 2017, RWP 2017, FSD 2016 G-II)**

Ans: *Answer given on Page # 43 (**limitations**)*

10.1.1 MULTIPLE CHOICE QUESTIONS

1. Formula of phosphoric acid is: *(K.B)*

(A) H_2PO_3 (B) H_4PO_3

(C) HPO_4 (D) H_3PO_4

2. $Al(OH)_3$ is: *(K.B)*

(A) An acid (B) A base

(C) A salt (D) A non-metallic oxide

3. The final product of Arrhenius concept is: *(U.B)*

(A) Salt +H_2O (B) An adduct

(C) A conjugate acid base pair (D) A salt only

4. Base turn red litmus to: ***(K.B)***

(A) Blue (B) Red

(C) White (D) Yellow

5. Arrhenius concept was presented in: ***(K.B)*** **(BWP 2017)**

(A) 1234 (B) 1456

(C) 1787 (D) 1987

6. It is a substance which provides hydrogen ions: ***(K.B)***

(A) Acid (B) Base

(C) Salt (D) Adduct

7. It is a substance which provides hydroxide ions: ***(K.B)***

(A) Acid (B) Base

(C) Salt (D) Adduct

10.1.2 BRONSTED LOWRY CONCEPT

LONG QUESTIONS

Q.1 Explain Bronsted-Lowry Concept. Give its limitations. ***(Knowledge + Understanding Base)*** **(Ex-Q.1)(LHR 2019, FSD 2017)**

OR

Define an acid a base according to Bronsted-Lowry concept and justify with examples that water is an amphoteric compound.

Ans:

BRONSTED-LOWRY CONCEPT

Introduction:

In 1923, the Danish Chemist Bronsted and the English Chemist Lowry independently presented their theories of acids and bases on the basis of proton transfer.

Acid:

"An acid is a ***substance*** *(molecule or ion) that can* ***donate a proton*** ***(H^+)*** *to another substance."*

Examples:

- Hydrocholoric acid **(HCl)**
- Acetic acid **(CH_3COOH)**
- Nitric acid **(HNO_3)**

Base:

"A base is a ***substance*** *that can* ***accept a proton*** ***(H^+)*** *from another substance."*

Examples:

- Ammonia **(NH_3)**
- Hydroxide **(OH^-)**

Explanation:

HCl acts as an acid while NH_3 acts as a base

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

Acid + Base Conjugate acid + Conjugate base

Water as an Amphoteric Substance: (TEST YOURSELF 10.1 q iii)

(Understanding Base)

"*A substance that can act as an **acid** as **well as a base** is called amphoteric specie".*

- **Water as a Base:**

  When HCl dissolves in water; HCl acts as an acid and H_2O as a base.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

Acid + Base Conjugate acid + Conjugate base

- **Water as an acid:**

  When ammonia dissolves in water, H_2O acts as an acid and ammonia as a base.

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

Acid + Base Conjugate acid + Conjugate base

Explanation:

It is a **reversible reaction**. In the forward reaction **HCl** is an acid as it **donates a proton**, whereas **H_2O** is a **base** as it **accepts a proton**. In the **reverse reaction Cl^- ion** is a base as it **accepts a proton** from acid **H_3O^+ ion**. Cl^- ion is called a conjugate base of acid HCl and **H_3O^+ ion is called a conjugate acid of base H_2O**. It means every acid produces a conjugate base and every base produces a conjugate acid such that there is conjugate acid-base pair.

Conjugate Acid:

"*A conjugate acid is a **specie** formed by **accepting** a **proton** by a **base**".*

Conjugate Base:

"*A conjugate base is a **specie** formed by **donating** a **proton** by an **acid**".*

Examples:

- Conjugate means joined together as pair.

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$$

Acid Base Conjugate acid Conjugate base

Condition:

According to Bronsted-Lowry concept, acid and base always, work together. That means, a substance can act as an acid (proton donor) only when another substance simultaneously behaves as a base (proton acceptor).

Limitations:

It has been observed that there are certain substances which behave as acids though they **do not** have the **ability** to **donate a proton**, e.g., **SO_3**. Similarly, **CaO behaves as a base but it cannot accept a proton**. These observations prove the limitations of Bronsted-Lowry concept of acids and bases.

Table 10.2 Conjugate Acid-Base Pairs of Common Species

Acid		Base		Conjugate Acid		Conjugate Base
$HNO_{3(aq)}$	+	$H_2O_{(l)}$	⇌	$H_3O^+_{(aq)}$	+	$NO_3^-{}_{(aq)}$
$H_2SO_{4(aq)}$	+	$H_2O_{(l)}$	⇌	$H_3O^+_{(aq)}$	+	$HSO_4^-{}_{(aq)}$
$HCN_{(aq)}$	+	$H_2O_{(l)}$	⇌	$H_3O^+_{(aq)}$	+	$CN^-_{(aq)}$
$CH_3COOH_{(aq)}$	+	$H_2O_{(l)}$	⇌	$H_3O^+_{(aq)}$	+	$CH_3COO_{(aq)}$
$H_2O_{(l)}$	+	$NH_{3(aq)}$	⇌	$NH_4^+{}_{(aq)}$	+	$OH^-_{(aq)}$
$H_2O_{(l)}$	+	$CO_3^{2-}{}_{(aq)}$	⇌	$HCO_3^-{}_{(aq)}$	+	$OH^-_{(aq)}$
$HCl_{(l)}$	+	$HCO_3^-{}_{(aq)}$	⇌	$H_2CO_{3(aq)}$	+	$Cl^-_{(aq)}$

PROBLEM 10.1

(Understanding + Application Base)

(a) What are conjugate bases of each of the following? **(DGK 2017, SWL 2017)**

$$HS^-, H_3O^+, H_2PO_4^-, HSO_4^-, HF, CH_3COOH, \left[Al(H_2O)_6\right]^{3+}$$

(b) Give the conjugate acids of the following?

$$OH^-, HCO_3^-, HPO_4^{2-}, CH_3NH_2, CO_3^{2-}, CH_3COOH\,.$$

(c) Which of the following behave both as Bronsted acids and Bronsted bases?

$$H_2O, HCO_3^-, H_2SO_4, H_3PO_4, HS^-\,.$$

NUMERICAL EXAMPLE

Solution:

(a) Conjugate Bases:

Species	Conjugate Bases
HS^-	S^{2-}
H_3O^+	H_2O
$H_2PO_4^-$	HPO_4^{2-}
HSO_4^-	SO_4^{2-}
HF	F^-
CH_3COOH	CH_3COO^-
$\left[Al(H_2O)_6\right]^{3+}$	$\left[Al(H_2O)_5OH\right]^{2+}$

(b) Conjugate Acids:

Species	Conjugate Acids
OH^-	H_2O
HCO_3^-	H_2CO_3
HPO_4^{2-}	$H_2PO_4^-$
CH_3NH_2	$CH_3NH_3^+$
CO_3^{2-}	HCO_3^-
CH_3COOH	$CH_3COOH_2^+$.

(c) Bronsted Acids as Well as Bases:

- H_2O
- HCO_3^-
- HS^-

10.1.2 BRONSTED LOWRY CONCEPT SHORT QUESTIONS

Q.1 What is conjugate acid and conjugate base? *(Knowledge Base + Understanding Base)* (GRW 2013,2014,2015)

Ans: **CONJUGATE ACID AND CONJUGATE BASE**

Conjugate Acid:

"*A conjugate acid is a **specie** formed by **accepting** a **proton** by a **base**".*

Conjugate Base:

"*A conjugate base is a **specie** formed by **donating** a proton by an **acid**".*

Examples:

- Conjugate means joined together as pair.

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

Acid + Base Conjugate acid + Conjugate base

Q.2 What are limitations of Bronsted-Lowry concept of acids and bases? *(Knowledge Base)*

Ans: *Answer given on Page # 46* ***(limitations)***

10.1.2 BRONSTED LOWRY CONCEPT MULTIPLE CHOICE QUESTIONS

1. Which one is amphoteric: *(U.B)*

(A) HCl (B) NH_3

(C) NaOH (D) H_2O

2. Bronsted Lowry acid: *(K.B)*

(A) Gives H^+ (B) Is an electron pair acceptor

(C) Donates OH^- (D) Is an electron pair

3. All Bronsted acids are: *(U.B)*

(A) Arrhenius acids (B) Lewis acids

(C) Lewis bases (D) Bronsted acids

4. Conjugate base of sulphuric acid is: ***(U.B)*** **(LHR 2014, BWP 2017)**

(A) SO_3^{2-} (B) SO^{2-}

(C) HSO_3^- (D) HSO_4^-

5. Acid is a substance that can donate a: ***(K.B)***

(A) Proton (B) Electron

(C) Neutron (D) Positron

6. Bronsted-Lowry concept was presented in: ***(K.B)*** **(SWL 2017)**

(A) 1923 (B) 1787

(C) 1823 (D) 1943

7. Bronsted-Lowry concept is based on transfer of: ***(K.B)***

(A) Proton (B) Electron

(C) Neutron (D) Positron

8. Base is a substance that can accept a: ***(K.B)***

(A) Proton (B) Electron

(C) Neutron (D) Positron

9. Substances that can behave as acid as well as base are called: ***(K.B)***

(A) Bases (B) Acids

(C) Amphoteric compounds (D) Salts

10. Which one is not an acid? ***(K.B)*** **(MTN 2016 G-II)**

(A) HCl (B) NH_3

(C) H_2CO_3 (D) H_2SO_4

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES

LONG QUESTIONS

Q.1 Explain Lewis Concept of acids and bases with suitable examples. ***(Knowledge Base + Understanding Base)*** **(Ex-Q.2)**

(LHR 2013, 2014, 2019 GRW 2013, MTN 2016 G-I, 17, SGD 2017, BWP 2016 G-II)

Ans:

LEWIS CONCEPT OF ACIDS AND BASES

Introduction:

The Arrhenius and Bronsted-Lowry concepts of acids and bases are limited to substances which contain protons. G.N. Lewis (1923) proposed a more general and broader concept of acids and bases. According to this concept:

Acid:

"An acid is a substance (molecule or ion) which can ***accept a pair of electrons****"*

Examples:

- Boron trifluoride **(BF_3)**
- Hydrogen ion **(H^+)**
- Sodium ion **(Na^+)**

- Aluminium trichloride **($AlCl_3$)**

Base:

*"A base is a substance (molecule or ion) which can **donate a pair of electrons**."*

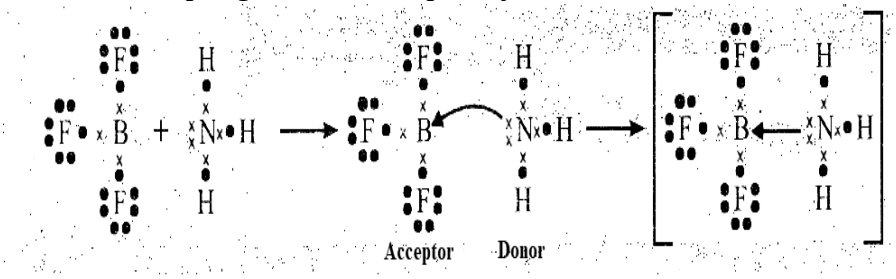
Examples:

- Ammonia **(NH_3)**
- Fluoride ion **(F^-)**
- Cyanide ion **(CN^-)**
- Alcohols **(ROH)**

Example 1:

(Reaction between Boron Trifluoride and Ammonia):

A reaction between ammonia and boron trifluoride takes place by forming a coordinate covalent bond between ammonia and boron trifluoride by donating an electron pair of ammonia and accepting that electron pair by boron trifluoride.

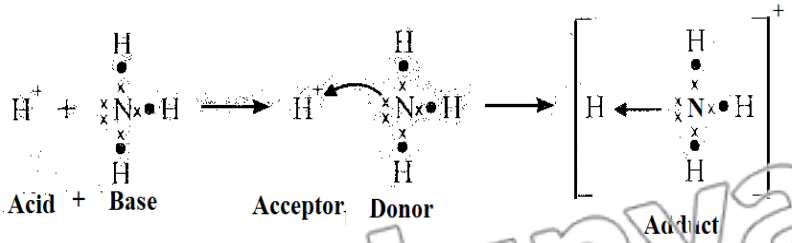


Boron trifluoride + Ammonia → Ammonia boron trifluoride (adduct)

Examples 2:

(Reaction between H^+ and Ammonia):

The cations (proton itself or metal ions) act as Lewis acids. For example, a reaction between H^+ and NH_3 where H^+ acts as an acid and ammonia as a base:



Adduct:

*"The **product** of any **Lewis acid-base** reaction is a **single specie**, called an adduct".*

Neutralization Reaction:

A **neutralization reaction** according to Lewis concept is **donation** and **acceptance** of an **electron pair** to **form** a **coordinate covalent bond** in an adduct.

Characteristics of Lewis Acids:

According to Lewis concept, the following species can act as Lewis acids:

(i) Central Atom With Incomplete Octet:

Molecules in which the **central atom** has **incomplete octet** are **Lewis acid**. The central atom has only six electrons around it, therefore, these can accept an electron pair.

Examples:

- BF_3
- $AlCl_3$
- $FeCl_3$

(ii) Simple Cations:

Simple cations can act as Lewis acids. All cations act as Lewis acids since they are deficient in electrons.

Little Tendency to Accept Electrons:

Some cataions have a very little tendency to accept electrons like:

- Na^+
- K^+
- Ca^{2+} etc.

Greater Tendency to Accept Electrons:

Some cataions have a greater tendency to accept electrons like:

- H^+
- Ag^+ etc.

Characteristics of Lewis Bases:

According to Lewis concept, the following species can act as Lewis bases:

(i) Electron Rich Species:

Neutral species having at least one lone pair of electrons act as Lewis bases because they contain a lone pair of electrons

Examples:

- Ammonia $\ddot{N}H_3$
- Aamines $R\text{-}\ddot{N}H_2$
- Alcohols $R\text{-}\ddot{O}\text{-}H$
- Water $H\text{-}\ddot{O}\text{-}H$.

(ii) Anions:

Negatively charged species or anions act as Lewis bases:

Examples:

- Chloride Cl^-
- Cyanide CN^{-1}
- Hydroxide ion OH^-

Q.2 Give brief idea about three concepts of acids and bases. ***(Knowledge Base)***

Ans: **CONCEPTS OF ACIDS AND BASES**

A summary of three concepts of acids and bases is as follows:

Concept	Acid	Base	Product
• Arrhenius	It gives H^+ ion	It gives OH^-	Salt + H_2O
• Brousted Lowry	It donates H^+	It accepts H^+	Conjugate acid base pair.
• Lewis	It is electron pair acceptor	It is electron pair donor	Adduct.

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES SHORT QUESTIONS

Q.1 What are types of Lewis bases? *(Knowledge Base)*

Ans:

TYPES OF LEWIS BASES

According to Lewis concept, the following species can act as Lewis bases:

(i) Electron Rich Species:

Neutral species having at least one lone pair of electrons act as Lewis bases because they contain a lone pair of electrons.

Examples:

- Ammonia $\ddot{N}H_3$
- Amines R-$\ddot{N}H_2$
- Alcohols R-$\ddot{O}$-H
- Water H-$\ddot{O}$-H.
- Ethers R-$\ddot{O}$-R

(ii) Anions:

Negatively charged species or anions act as Lewis bases:

Examples:

- Chloride Cl^-
- Cyanide CN^{-1}
- Hydroxide ion OH^-

Q.2 What is an adduct? *(Knowledge Base)* **(SWL 2016 G-I, II)**

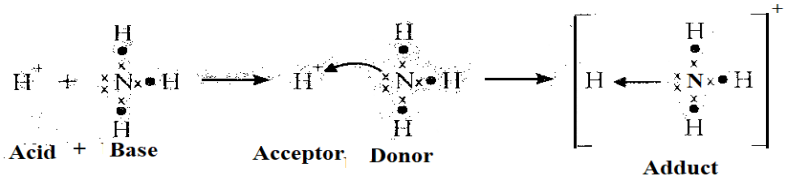
Ans:

ADDUCT

Definition:

*"The **product** of any **Lewis acid-base reaction** is a **single specie**, called an **adduct**".*

Example:



Q.3 All Bronsted bases are Lewis bases but all Bronsted acids are not Lewis acids. Justify. (*Understanding Base*) **(Do you know Pg. # 26)**

Ans:

JUSTIFICATION

It may be noted that all Bronsted bases are also Lewis bases but all Bronsted acids are not Lewis acids.

Justification:

According to Bronsted concept, a base is a substance which can accept a proton, while according to Lewis concept, a base is a substance which can donate a pair of electrons. Lewis bases generally contain one or more lone pair of electrons and, therefore, they can also accept a proton (Bronsted base). Thus, all Lewis bases are also Bronsted bases. On the other hand, Bronsted acids are those which can give a proton. For example, HCl, H_2SO_4 are not capable of accepting a pair of electrons. Hence, all Bronsted acids are not Lewis acids.

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES MULTIPLE CHOICE QUESTIONS

1. The product of any Lewis acid base reaction is a single specie called: *(K.B)* (MTN 2017)
(A) A salt (B) An adduct
(C) Salt $+H_2O$ (D) Conjugate acid-base pair

2. In a reaction between ammonia & borontrifloride, BF_3 is: *(U.B)*
(A) An acid (B) A base
(C) A conjugate base (D) An adduct

3. These can act as Lewis acids: *(K.B)*
(A) Anions (B) Radicals
(C) Cations (D) Molecule

4. These can act as lewis bases: *(K.B)*
(A) Cations (B) Anions
(C) Cations & anions (D) Radicals

5. Which is a Lewis base? *(K.B)* **(GRW 2014, LHR 2015, 2016, DGK 2017)**
(A) $AlCl_3$ (B) H^+
(C) BF_3 (D) NH_3

6. Molecules in which central atom has incomplete octet is called: *(U.B)*
(A) Lewis base (B) Lewis acid
(C) Amphoteric (D) Salt

7. Substance which has unshared pair of electons act as: *(U.B)*
(A) Lewis base (B) Lewis acid
(C) Amphoteric (D) Salt

8. Substances which have empty orbital that can accommodate an electron pair are called: *(U.B)*
(A) Lewis base (B) Lewis acid
(C) Amphoteric comopuds (D) Adduct

9. Simple cations can act as: *(U.B)*
(A) Lewis base (B) Lewis acid
(C) Amphoteric (D) Adduct

10. Ammonia, amines and alcohols are examples of: *(K.B)*
(A) Lewis base (B) Lewis acid
(C) Amphoteric (D) Arrhenius acid

10.1 TEST YOURSELF

i. What is the difference between Arrhenius base and Bronsted-Lowry base?
(*Understanding Base*)

Ans: **DIFFERENTIATION**

The differences between Arrhenius base and Bronsted-Lowry base are as follows:

Arrhenius Base	Bronsted-Lowry Base
Definition	
• A base is a substance which dissociates in aqueous solution to give hydroxide ions (OH^-).	*A base is a substance that can accept a proton (H+) from another substance.*
Examples	
• NaOH • $Ca(OH)_2$ $NaOH \xrightarrow{H_2O} Na^+ + OH^-$	• NH_3 • $AlCl_3$ $HCl + NH_3 \rightarrow NH_4^+ + Cl^-$ Acid Base

ii. What do you mean by neutralization reaction according to Arrhenius acid-base concept?
(*Understanding Base*)

Ans: **NEUTRALIZATION**

According to Arrhenius acid base concept, during neutralization reaction hydrogen ions (H^+) combine with the equal number of hydroxide ions and both neutralize each other to form water.

$$HCl \rightarrow H^+ + Cl^-$$

$$NaOH \rightarrow Na^+ + OH^-$$

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

$$HCl + NaOH \xrightarrow{In\ H_2O} NaCl + H_2O$$

iii. Prove that water is an amphoteric specie. (*Understanding Base)*

Ans: *Answer given on Page # 46*

iv. How can you justify that NH_3 is Bronsted-Lowry base but not Arrhenius base? (*Understanding Base)*

Ans: **NH_3 AS BRONSTED-LOWRY BASE**

Ammonia (NH_3) is Bronsted –Lowry base because it has the ability to accept a proton (H^+ ion) but not Arrhenius base because it does not produce hydroxide ions (OH^-) in aqueous solution.

Example:

NH_3 accepts a proton from water

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

Base	Acid	Conjugate acid	Conjugate base

v. State and explain the neutralization reaction according to Lewis concept. *(Knowledge Base)*

Ans: **NEUTRALIZATION REACTION**

Definition:

"*A neutralization reaction according to Lewis concept is donation and acceptance of a electron pair to form a coordinate covalent bond in an adduct".*

Example:

$$BF_3 + :NH_3 \longrightarrow [BF_3 \leftarrow NH_3]$$

Electron pair Acceptor (acid)	Electron pair Donor (base)	Adduct (Salt)

vi. Define and give the characteristics of Lewis acid. (*Understanding Base)*

Ans: **LEWIS ACID**

Definition:

"*An acid is a substance (molecule or ion) which can accept a pair of electrons".*

Examples:

- Boron trifluoride (BF_3)
- Hydrogen ion (H^+)
- Sodium ion (Na^+)

- Aluminium trichloride ($AlCl_3$)

Characteristics of Lewis Acids:

According to Lewis concept, the following species can act as Lewis acids:

(i) Central Atom With Incomplete Octet:

Molecules in which the central atom has incomplete octet are Lewis acid. The central atom as only six electrons around it, therefore, these can accept an electron pair.

Examples:

- BF_3
- $AlCl_3$
- $FeCl_3$

(ii) Simple Cations:

Simple cations can act as Lewis acids. All cations act as Lewis acids since they are deficient in electrons.

Little Tentdency to Accept Electrons:

Some cataions have a very little tendency to accept electrons like:

- Na^+
- K^+
- Ca^{2+} etc.

Greater Tendency to Accept Electrons:

Some cataions have a greater tendency to accept electrons like:

- H^+
- Ag^+ etc.

vii. What is an amphoteric specie according to Bronsted-Lowry concept? What is its nature according to Lewis concept? ***(Knowledge Base + Understanding Base)***

Ans:

AMPHOTERIC SPECIE

Water is amphoteric specie according to Bronsted-Lowery concept because it behaves as an acid as well as base.

NATURE OF AMPHOTERIC SPEICE

According to Lewis concept water acts only as Lewis base because it has the ability to donate electron pair.

$$H_2\ddot{O}: + H^+ \longrightarrow \left(H_2\ddot{O}\longrightarrow H\right)^+$$

Base Acid Adduct

10.1.4 GENERAL PROPERTIES OF ACIDS

LONG QUESTIONS

Q.1 Explain the chemical properties of acids? ***(Understanding + Application Base)***

(LHR 2016, GRW 2014,2017, DGK 2017)

Ans:

CHEMICAL PROPERTIES OF ACIDS

The chemical properties of acids are as follows:

(i) Reaction with Metals: **(LHR 2014)**

Acids react explosively with metals like sodium, potassium and calcium. However, dilute acids (HCl, H_2SO_4) react moderately with reactive metals like, Mg, Zn, Fe and Al form respective salts and **evolve hydrogen gas.**

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_4 + H_{2(g)} \uparrow$$

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)} \uparrow$$

(ii) Reaction with Carbonates and Bicarbonates: ***(Test Yourself 10.2 q i)***

Acids react with carbonates and bicarbonates to form corresponding salts and **evolve carbon dioxide gas.**

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 \uparrow + H_2O$$

(Calcium carbonate)

$$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2CO_2 \uparrow + 2H_2O$$

(Sodium Bicarbonate)

(iii) Reaction with Bases:

Acids react with bases (oxides and hydroxides of metal and ammonium hydroxide) to form **salts and water.** This process is called **neutralization.**

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

$$CuO_{(aq)} + H_2SO_{4(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}$$

(iv) Reaction with Sulphites and Bisulphites: ***(Test Yourself 10.2 q ii)***

Acids react with sulphites and bisulphites to form salts with liberation of **sulphur dioxide gas.**

$$CaSO_{3(aq)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + SO_{2(g)} \uparrow + H_2O_{(l)}$$

(Calcium Sulphite)

$$NaHSO_{3(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + SO_{2(g)} \uparrow + H_2O_{(l)}$$

(Sodium Bisulphite)

(v) Reaction with Sulphides:

Acids react with metal sulphides to liberate **hydrogen sulphide gas.**

$$FeS_{(aq)} + H_2SO_{4(aq)} \longrightarrow FeSO_{4(aq)} + H_2S_{(g)} \uparrow$$

Q.2 Write down uses of acids. Give some naturally occuring acids and their sources.

(Knowledge Base) **(Do you know Pg. # 29) (FSD 2016 G-I, BWP 2016 G-I, GRW 2017)**

Ans:

USES OF ACIDS

Following are the uses of some important acids:

Sulphuric Acid (H_2SO_4): ***(Test Yourself 10.2 q iii)***

It is used to manufacture fertilizers, ammonium sulphate, calcium superphosphate, explosives, paints, dyes, drugs. It is also used as an electrolyte in **lead storage batteries.**

Nitric Acid (HNO_3):

It is used in manufacturing of fertilizer (ammonium nitrate), explosives, paints, drugs and **etching designs on copper plates.**

Hydrochloric Acid (HCl):

It is used for cleaning metals, tanning and in printing industries.

Benzoic Acid (C_6H_5COOH):

It is used in preservation of food.

Acetic Acid (CH_3COOH):

It is used in food preservation & flavouring of food. It is also used to **treat stings of wasps.**

SOME NATURAL ACIDS AND THEIR SOURCES

Naturally accruing acid		
Sr. No.	**Acid**	**Source**
(i)	Citric acid	Citrus fruits i.e., lemon, orange
(ii)	Lactic acid	Sour milk
(iii)	Formic acid	Stings of bees and ants
(iv)	Butyric acid	Rancid butter
(v)	Tartaric acid	Tamarind, grapes, apples
(vi)	Maleic acid	Apples
(vii)	Uric acid	Urine
(viii)	Stearic acid	Fats

10.1.4 GENERAL PROPERTIES OF ACIDS

SHORT QUESTIONS

Q.1 What are mineral acids? *(Knowledge Base)*
(Do you know Pg. # 28)(GRW 2015)

OR

Write down the names and formulae of three mineral acids.
(GRW 2015, DGK 2017, RWP 2017)

Ans: **MINERAL ACIDS**

Definitions:
*"Acids having **inorganic origin** are called mineral acids".*

Examples:

- Hydrochloric acid (HCl)
- Sulphuric acid (H_2SO_4)
- Nitric acid (HNO_3)

Q.2 How do acids react with metals? *(Application Base)* **(LHR 2014)**

Ans: **REACTION BETWEEN ACIDS AND METALS**

Acids react explosively with metals like sodium, potassium and calcium. However, dilute acids (HCl, H_2SO_4) react moderately with reactive metals like, Mg, Zn, Fe and Al to form respective salts and evolve hydrogen gas.

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_4 + H_{2(g)}$$

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$

Q.3 Write down uses of hydrochloric acid. *(Knowledge Base)*
(GRW 2013) (DGK 2017, RWP 2017)

Ans: **USES OF HYDROCHLORIC ACID**

It is used:

- For cleaning metals
- For tanning
- In printing industries.

Q.4 Write down sources of Maleic acid and Stearic acid. ***(Knowledge Base)***

Ans:

SOURCES OF ACIDS

Following are the sources of acids:

- Maleic acid : Apple
- Stearic acid : Fats

Q.5 Write sources of citric acid and lactic acid. ***(Knowledge Base)*** **(LHR 2014,2015)**

Ans:

SOURCES OF ACIDS

The sources of citric acid and lactic acid are as follows:

- Citric acid : Citrus fruits i.e. lemon, orange.
- Lactic acid : Sour milk.

Q.6 Give the uses of sulphuric acid. ***(Knowledge Base)*** **(MTN 2016 G-I)**

Ans:

USES OF SULPHURIC ACID

Sulphuric acid (H_2SO_4) is used:

- To manufacture fertilizers, ammonium sulphate, calcium superphosphate, etc.
- To prepare explosives, paints, dyes, drugs.
- As an electrolyte in lead storage batteries.

Q.7 Write down any two uses of acetic acid. ***(Knowledge Base)*** **(SWL 2016 G-I)**

Ans:

USES OF ACETIC ACID

Acetic acid is used:

- In food preservation, flavouring of food.
- To treat stings of wasps.

Q.8 Give four uses of nitric acid. ***(Knowledge Base)*** **(DGK 2016 G-II)**

Ans:

USES OF NITRIC ACID

It is used:

- In manufacturing of fertilizer (ammonium nitrate)
- In the manutectueing of explosives,
- To prepare of paints and drugs
- For etching designs on copper plates.

Q.9 Write the name of acid present in (a) Vinegar (b) Ant sting. ***(Knowledge Base)*** **(DGK 2016 G-I)**

Ans:

NAMES OF ACIDS

The names of acids present in vinegar ant sting are:

- Vinegar : Acetic acid
- Ant Sting : Formic acid

10.1.4 GENERAL PROPERTIES OF ACIDS

MULTIPLE CHOICE QUESTIONS

1. Neutralization is reaction of: ***(U.B)***

(A) Acids with metals (B) Acids with sulphides
(C) Bases with acids (D) None of these

2. Acid used for food preservation is: ***(K.B)***

(A) Nitric acid (B) Benzoic acid
(C) Acetic acid (D) Both B and C

3. Maleic acid is found from: ***(K.B)***

(A) Apples (B) Grapes
(C) Sour milk (D) Fats

4. Acid reacts with metal sulphides to liberate: ***(U.B)***

(A) Hydrogen gas (B) Carbon dioxide
(C) Ammonia gas (D) Hydrogen sulphide gas

5. Formula of acetic acid is: ***(K.B)***

(A) CH_3COOH (B) CH_2O
(C) NaOH (D) CH_3OH

6. Which one is found in stings of bee's and ants? ***(K.B)***

(A) Lactic acid (B) Maleic acid
(C) Butyric acid (D) Formic acid

7. It is used to cure sting of wasps: ***(K.B)***

(A) Acetic acid (B) Benzoic acid
(C) Nitric acid (D) Sulphuric acid

8. When acids react with carbonates and bicarbonates, which gas evolves out? ***(U.B)***
(LHR 2013,14, GRW 2014, SWL 2017)

(A) H_2S (B) CO_3
(C) CO_2 (D) CO

9. Uric acid is present in: ***(K.B)*** **(FSD 2016 G-I, SGD 2016 G-I)**

(A) Fats (B) Citrus fruits
(C) Apples (D) Urine

10. When Na reacts with HCl the salt produced is: ***(U.B)***

(A) NaCl (B) NaOH
(C) H_2O (D) NH_3

11. Citric acid is found in: ***(K.B)*** **(BWP 2017, FSD 2016 G-II)**

(A) Urine (B) Fast
(C) Lemon (D) Sour milk

12. Acid present in sour milk is: ***(K.B)*** **(DGK 2016 G-I, 17)**

(A) Lactic acid (B) Formic acid
(C) Tartaric acid (D) Uric acid

13. Name the acid used in lead storage batteries: ***(K.B)*** **(MTN 2017, SGD 2017)**

(A) CH_3COOH (B) HCl
(C) HNO_3 (D) H_2SO_4

14. Lactic acid is found in: ***(K.B)*** **(GRW 2013, SWL 2017)**

(A) Citrus fruits (B) Sour milk
(C) Rancid butter (D) Apple

10.1.5 GENERAL PROPERTIES OF BASES

LONG QUESTIONS

Q.1 Describe the chemical properties of bases. ***(Understanding + Application Base)***
(GRW 2014)

Ans:

CHEMICAL PROPERTIES OF BASES

The chemical properties of bases are as follows:

(i) Reaction with Acids:

Bases react with acids to form salt and water. It is a **neutralization reaction.**

$$2KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$$

(ii) Reaction with Ammonium Salts:

Alkalies react with ammonium salts to liberate ammonia gas.

$$NH_4Cl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + NH_{3(g)} \uparrow + H_2O_{(l)}$$

$$(NH_4)_2SO_{4(aq)} + Ca(OH)_{2(aq)} \longrightarrow CaSO_{4(aq)} + 2NH_{3(g)} \uparrow + 2H_2O_{(l)}$$

(iii) Precipitation of Hydroxides (Reaction with Heavy Metal Salts): **(LHR 2013, 2020)**

Alkalies precipitate insoluble hydroxides when added to solutions of salts of heavy metals such as copper, iron, zinc, lead and calcium.

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Cu(OH)_{2(s)} + Na_2SO_{4(aq)}$$

Blue ppt.

$$ZnCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Zn(OH)_{2(s)} + 2NaCl_{(aq)}$$

White ppt.

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

Brown ppt.

$$Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Pb(OH)_{2(s)} + 2NaNO_{3(aq)}$$

White ppt.

$$CaCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Ca(OH)_{2(s)} + 2NaCl_{(aq)}$$

White ppt.

$$FeSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Fe(OH)_{2(s)} + Na_2SO_{4(aq)}$$

Dirty Green ppt.

Q.2 Write down the uses of bases. ***(Knowledge Base)***

(LHR 2013, 2015, 2017, 2018, 2020, GRW 2014, 2015, BWP 2017 MTN 2017, DGK 2017, SWL 2016 G-I)

Ans: **USES OF BASES**

Following are the uses of some important bases:

Sodium Hydroxide (NaOH):

It is used for **manufacturing** of **soap**.

Calcium Hydroxide $Ca(OH)_2$:

It is used for manufacturing of **bleaching powder,** softening of hard water and **neutralizing acidic** soil and lakes due to acid rain.

Potassium Hydroxide (KOH):

It is used in alkaline batteries.

Magnesium Hydroxide $Mg(OH)_2$: **(LHR 2020)**

It is used as a base to **neutralize acidity in stomach.** It is also used for the **treatment of bee's stings.**

Aluminium Hydroxide $Al(OH)_3$:

It is used as foaming agent in **fire extinguishers.**

Ammonium Hydroxide (NH_4OH):

It is used to **remove grease** stains from clothes. **(BWP 2017)**

10.1.5 GENERAL PROPERTIES OF BASES SHORT QUESTIONS

Q.1 What are the uses of magnesium hydroxide? ***(Knowledge Base)*** **(BWP 2016 G-I)**

Ans: **USES OF MAGNESIUM HYDROXIDE**

Magnesium hydroxide is used

- As a base to neutralize acidity in stomach
- For the treatment of bee's stings

Q.2 Write down four uses of bases. ***(Knowledge Base)*** **(LHR 2013) (GRW 2014,2015, MTN 2017)**

Ans: **USES OF BASES**

Bases are used for a number of purposes. The important uses of bases are:

- Potassium hydroxide is used in alkaline batteries and shaving creams.
- Magnesium hydroxide is used as a base to neutralize acidity in the stomach.
- Aluminum hydroxide is used as foaming agent in fire extinguishers.
- Ammonium Hydroxide (NH_4OH) is used to remove grease stains from clothes.

10.1.5 GENERAL PROPERTIES OF BASES MULTIPLE CHOICE QUESTIONS

1. $Fe(OH)_3$ is: ***(K.B)***

(A) An acid (B) A base
(C) A salt (D) A non-metallic oxide

2. It is used to treat bee's sting: ***(K.B)***

(A) $Mg(OH)_2$ (B) $Ca(OH)_2$
(C) NaOH (D) KOH

3. Which is found in alkaline batteries? ***(K.B)*** **(SWL 2016 G-II)**

(A) $Mg(OH)_2$ (B) KOH
(C) NaOH (D) $Ca(OH)_2$

4. Alkalies react with ammonium salts to liberate which gas? ***(K.B)***

(A) Hydrogen (B) Sulphur dioxide
(C) Carbon dioxide (D) Ammonia

5. Alkalies precipitate insoluble: ***(K.B)***

(A) Oxides (B) Hydroxides
(C) Solvents (D) Salts

6. Which is used as foaming agent in fire extinguishers. ***(K.B)***

(A) Aluminium Hydroxide (B) Ammonium Hydroxide
(C) Potassium Hydroxide (D) Sodium Hydroxide

10.2 TEST YOURSELF

i. When acids react with carbonates and bicarbonates, which gas evolves out? *(Understanding + Application Base)*

Ans: *Answer given on Page # 56*

ii. Which types of salts produce SO_2 gas on reacting with acids? *(Understanding + Application Base)*

Ans: *Answer given on Page # 56*

iii. Give the uses of sulphuric acid. *(Knowledge Base)*

Ans: *Answer given on Page # 56*

iv. Write down the colours of the precipitates formed by reaction of aqueous caustic soda with solutions of copper, zinc and ferric salts. *(Knowledge Base)*

Ans:

COLOURS OF PRECIPITATES

When caustic soda (NaOH) reacts with copper salt, it gives blue precipitate of cupric hydroxide.

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Cu(OH)_2 + Na_2SO_{4(aq)}$$

(Blue ppt.)

When caustic soda (NaOH) reacts with zinc salt, it gives white precipitate of zinc hydroxide.

$$ZnCl_2 + 2NaOH_{(aq)} \longrightarrow Zn(OH)_2 + 2NaCl_{(aq)}$$

(White ppt.)

When caustic soda (NaOH) reacts with ferric salt, it gives brown precipitate of ferric hydroxide.

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

(Brown ppt.)

v. Name an alkali used in alkaline batteries. *(Knowledge Base)*

Ans:

ALKALI USED IN ALKALINE BATTERIES

Potassium hydroxide (KOH) is an alkali used in alkaline batteries.

Science, Technology and Society (STOMACH ACIDITY)

LONG QUESTION

Q.1 Write a detailed note on stomach acidity. *(Knowledge Base)*

(Science, Technology and Society Pg. # 31)

Ans:

STOMACH ACIDITY

Definition:

"Sometimes stomach produces too much acid. It causes stomach acidity also called hyperacidity."

Composition of Stomach Secretions:

Stomach secretes chemicals in a regular way to digest food. These chemicals mainly consist of hydrochloric acid along with other salts.

Protection of Stomach from HCl:

Although hydrochloric acid is highly corrosive, but stomach is protected from its effect because it is lined with cells that produce a base. The base neutralizes stomach acid.

Functions of Acid:

- The important function of this acid is to breakdown chemical bonds of foods in the digestion process. Thus big molecules of food are converted into small ones.
- It also kills the harmful bacteria of certain foods and drinks.

Symptoms of Hyperacidity:

- Feeling burning sensation throughout the gastro intestinal tract.
- The feelings of burning sensation sometimes extend towards the chest that is called heart burning.

Prevention of Hyperacidity:

The best prevention from hyperacidity is as follows:

- Avoiding over eating and staying away from the fatty acids and spicy foods.
- Simple and regular eating.
- Remaining in an upright position for 45 minutes after taking a meal
- Keeping the head elevated while sleeping.

Science, Technology and Society (STOMACH ACIDITY)

SHORT QUESTIONS

Q.1 How we can prevent hyperacidity? ***(Knowledge Base)*** **(SWL 2017)**

Ans: **PREVENTION OF HYPERACIDITY**

Hyperacidity can be prevented:

- Avoiding over eating and staying away from the fatty acids and spicy foods.
- Simple and regular eating.
- Remaining in an upright position for 45 minutes after taking a meal
- Keeping the head elevated while sleeping.

Q.2 What is hyperacidity? ***(Knowledge Base)*** **(DGK 2017)**

Ans: **HYPERACIDITY**

Definition:

"Sometimes stomach produces too much acid. It causes stomach acidity also called hyperacidity."

Symptoms of Hyperacidity:

- Feeling burning sensation throughout the gastro intestinal tract
- The feelings of burning sensation sometimes extend towards the chest that is called heart burning.

Q.3 Describe the process of etching in art and industry. ***(Knowledge Base)***

(Science, Technology and Society Pg. # 32)

Ans: **ETCHING IN ART AND INDUSTRY**

The process of etching on glass is carried out by using a wax stencil.

Function Stencil:

Stencil is placed on areas of glass or mirror that are to be saved from acid.

Method of Etching:

Stencil is placed on the areas of glass or mirror. The glass or mirror is dipped into hydrofluoric acid. The acid dissolves the exposed part of the glass thus ething it.

Drawback:

This process has been very dangerous because the acid would damage the skin and tissues of artist's body.

Advantage:

Athough it is dangerous to deal with acid, yet aching done with acid is very attractive as compared to using other chemicals.

Science, Technology and Society (STOMACH ACIDITY)

MULTIPLE CHOICE QUESTIONS

1. **It is used in etching designs on copper plates:** ***(K.B)*** **(LHR 2013)**
   (A) Sulphuric acid (B) Acetic acid
   (C) Hydrochloric acid (D) Nitric acid
2. **In etching process, the glass or mirror is dipped into:** ***(K.B)***
   (A) Hydrochloric acid (B) Sulphuric acid
   (C) Nitric acid (D) Hydrofluoric acid
3. **Stomach acidity is also called:** ***(K.B)***
   (A) Acidity (B) Basicity
   (C) Hyperacidity (D) Hypoacidity

10.2 pH SCALE

LONG QUESTIONS

Q.1 What is autoionization of water? How it is used to establish the pH of water? ***(Knowledge + Understanding +Application Base)*** **(Ex-Q.3)**

OR

Write a note on pH scale.

Ans:

pH SCALE

Definition:

"A logarithmic scale which is used to determine the pH of a solution is called pH scale". pH is the negative logarithm of molar concentration of the hydrogen ions".

Basis of pH Scale:

Concentration of hydrogen ions $[H^+]$ in pure water is the basis for pH scale.

pH:

"*pH is the **negative logarithm** of molar concentration of the **hydrogen ions**".*

$$pH = -\log [H^+]$$

Autoionization or Self Ionization:

*"Water is a **weak electrolyte** because it ionizes **very slightly** into ions in a process called autoionization or self ionization."*

DERIVATION OF DISSOCIATION CONSTANT OF WATER:

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

The equilibrium expression of this reaction may be written as.

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

As concentration of water (H_2O) is almost constant the above equation may be written as,

$$K_c [H_2O] = [H^+][OH^-]$$

A new equilibrium constant known as ionic product constant of water 'K_w' is used instead

of product of equilibrium constant and $[H_2O]$. Therefore,

$$K_w = [H^+][OH^-] = \mathbf{1.0 \times 10^{-14}\ at\ 25°C}$$

As we know, one molecule of water produces one H^+ ion and one OH^- ion on dissociation. Therefore,

$$[H^+] = [OH^-] \quad Or \Rightarrow [H^+]^2 = [H^+][OH^-]$$

$$[H^+]^2 = (1.0 \times 10^{-14})^{1/2}$$

Taking square root on both sides

$$[H^+] = 1.0 \times 10^{-7}\ M \quad at\ 25°C$$

Thus in pure water

$$[H^+] = 1.0 \times 10^{-7}\ M$$
$$[OH^-] = 1.0 \times 10^{-7} M$$

Conversion of Figures With Negative Exponents into Positive:

As it is difficult to deal with such small figures having negative exponents, so it is convenient to convert these figures into a positive using a numerical system. It is taking the common (base-10) logarithm of the figure and multiplying it with –1.

Meaning of 'p':

'p' before a symbol means' negative logarithm of the symbol. So 'p' before H means negative logarithm of H^+.

Therefore, pH is the negative logarithm of molar concentration of the hydrogen ions. That is,

$$\mathbf{pH = -log\ [H^+]}$$

Range of pH Scale:

With reference to above equation, a scale develops according to the molar concentration of H^+ ions that is called pH scale. It ranges from 0 to 14.

To Prove That pH + pOH = 14:

According to this scale, pH of water is calculated as:

$$\mathbf{pH = -log\ [H^+]}$$
$$\mathbf{pH = -log\ (1.0 \times 10^{-7}) = 7}$$

Similarly,

$$pOH = -\log [OH^-]$$
$$pOH = -\log (1.0 \times 10^{-7}) = 7$$

pH value normally varies from 0 to 14.

Therefore:

The sum of pH and pOH of the solution is always 14 at 25°C.

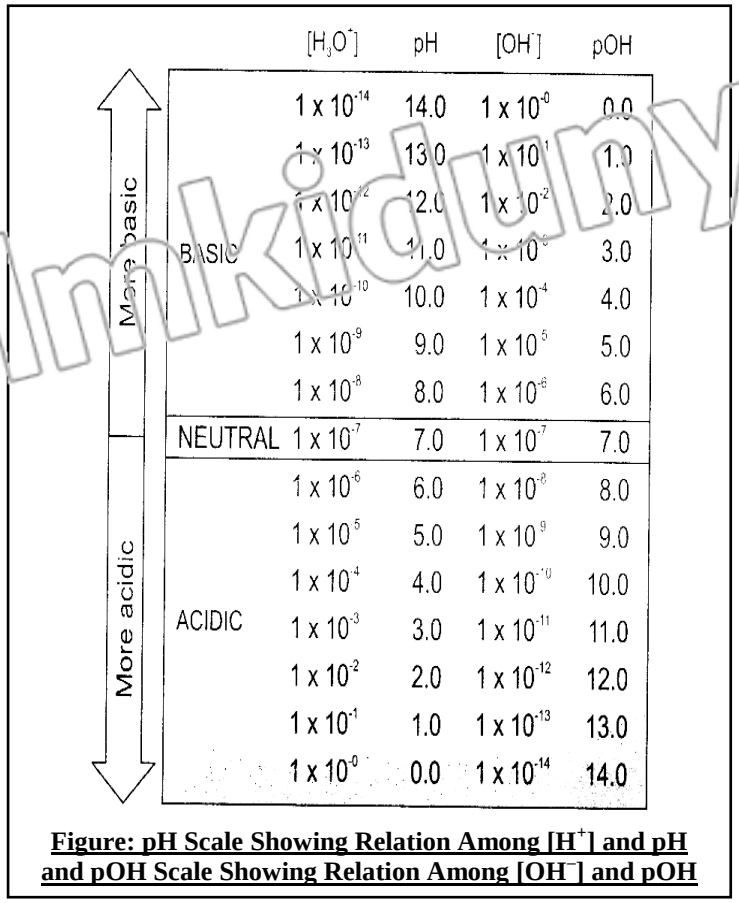
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pOH	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Identification of Acids and Bases by pH-Scale:

pH scale can be used to identify the nature of solutions as acid and base. A solution of a compound of pH 7 or pOH 7 is considered a neutral solution. Solutions of pH less than 7 are acidic and more than 7 are basic.

Conclusions:

- pH of a neutral solution is always 7.
- Acidic solutions have pH less than 7.
- Basic solutions have pH value greater than 7.
- pH and pOH values range from 0 to 14.



	$[H_3O^+]$	pH	$[OH^-]$	pOH
BASIC	1×10^{-14}	14.0	1×10^{0}	0.0
	1×10^{-13}	13.0	1×10^{-1}	1.0
	1×10^{-12}	12.0	1×10^{-2}	2.0
	1×10^{-11}	11.0	1×10^{-3}	3.0
	1×10^{-10}	10.0	1×10^{-4}	4.0
	1×10^{-9}	9.0	1×10^{-5}	5.0
	1×10^{-8}	8.0	1×10^{-6}	6.0
NEUTRAL	1×10^{-7}	7.0	1×10^{-7}	7.0
ACIDIC	1×10^{-6}	6.0	1×10^{-8}	8.0
	1×10^{-5}	5.0	1×10^{-9}	9.0
	1×10^{-4}	4.0	1×10^{-10}	10.0
	1×10^{-3}	3.0	1×10^{-11}	11.0
	1×10^{-2}	2.0	1×10^{-12}	12.0
	1×10^{-1}	1.0	1×10^{-13}	13.0
	1×10^{0}	0.0	1×10^{-14}	14.0

Figure: pH Scale Showing Relation Among $[H^+]$ and pH and pOH Scale Showing Relation Among $[OH^-]$ and pOH

10.2 pH SCALE

SHORT QUESTIONS

Q.1 What are uses of pH? ***(Knowledge Base)*** **(GRW 2017, SWL 2016 G-II, 17)**

Ans:

USES OF pH

pH is used to:

- Determine acidic or basic nature of a solution.
- Produce medicines, culture at a microbiological particular concentration of H^+ ion.
- Prepare solutions of required concentrations necessary for certain biological reactions.

Q.2 What is pH scale? Give pH of pure water. ***(Knowledge Base)*** **(RWP 2016 G-II, 17)**

Ans:

pH SCALE

Definition:

"A logarithmic scale which is used to determine the pH of a solution is called pH scale".

"pH is the negative logarithm of molar concentration of the hydrogen ions".

Basis of pH Scale:

Concentration of hydrogen ions $[H^+]$ in pure water is the basis for the pH scale.

pH of pure water:

pH of pure water is 7.

10.2 pH SCALE

MULTIPLE CHOICE QUESTIONS

1. Concentration of _____ in pure water is the basis for pH scale. *(K.B)*

(A) Hydrogen ion (B) Sodium ion
(C) Potassium ion (D) Hydroxide ion

2. Water is:

(A) Weak electrolyte (B) Strong electrolyte
(C) Non-electrolyte (D) None of these

3. Water ionizes slightly into ions in a process called: *(K.B)*

(A) Neutralization (B) Auto ionization
(C) Self ionization (D) Both B & C

4. "K_w" is known as: *(K.B)*

(A) Equilibrium constant (B) Ionic product constant
(C) Specific rate constant (D) All of these

5. The negative logarithm of molar concentration of hydrogen ions is: *(K.B)*

(A) pOH (B) p
(C) pH (D) None of these

6. The range of pH scale is from: *(K.B)*

(A) 10-14 (B) 1-14
(C) 0-14 (D) 14-0

7. The sum of pH and pOH is always: *(K.B)* **(LHR 2014, GRW 2014, DGK 2016 G-II)**

(A) 14 at 26ºC (B) 14 at 25 ºC
(C) 13 at 25 ºC (D) 7 at 25 ºC

8. A solution of a compound of pH 7 or pOH 7 is considered a/an: *(U.B)*

(A) Basic solution (B) Neutral solution
(C) Acidic solution (D) None of these

9. Solution of pH less than _____ is acidic. *(K.B)* **(RWP 2016 G-I)**

(A) 7 (B) 14
(C) 6 (D) 9

10. Solution of pH more than 7 is: *(K.B)*

(A) Acidic (B) Neutral
(C) Basic (D) Strong acidic

11. pH =_____:*(K.B)*

(A) $-\log[OH^-]$ (B) $-\log[H^+]$
(C) $\log[H^+]$ (D) Both B & C

12. A solution of pH = 1 has _____ times higher concentration of H^+ than a solution of pH = 2: *(U.B)*

(A) 14 times (B) 100 times
(C) 10 times (D) 20 times

13. pH of a neutral solution is always: *(K.B)* **(MTN 2017, SWL 2017)**

(A) 14 (B) 0
(C) 7 (D) 1

10.2.1 INDICATORS

LONG QUESTIONS

Q.1 Write a detailed note on the following. ***(Knowledge + Understanding Base)***
(LHR 2015, SGD 2014)

a. Indicators b. Measuring pH of a solution

Ans:

a. INDICATORS

Definition:

*"The **substances** which indicate the **completion of a chemical reaction** due to change in colour are called indicators".*

Properties of Indicators:

Indicators are the organic compounds. They have different colours in acidic and alkaline solutions.

Importance:

Indicators help in determining the acidic, basic and neutral nature of solutions.

Types of Indicators:

There are different types of indicators. Some of the indicators are given below:

(i) Litmus
(ii) Phenolphthalein
(iii) Methyl orange

(i) Litmus:

- Blue litmus turns red in acidic solution.
- Red litmus turns blue in alkaline solution.

(ii) Phenolphthalein:

- It is colourless in strongly acidic solution.
- It is red in strongly alkaline solution.
- It changes colour at pH about 9.
- Phenolphthalein is colourless in solution with pH less than 9.
- If the pH is above 9 then it gives pink colour.

(iii) Methyl Orange:

- It gives red colour at pH <4.
- It gives yellow colour from pH >4.

So, each indicator has a specific colour in acidic medium which changes at a specific pH to another colour in basic medium.

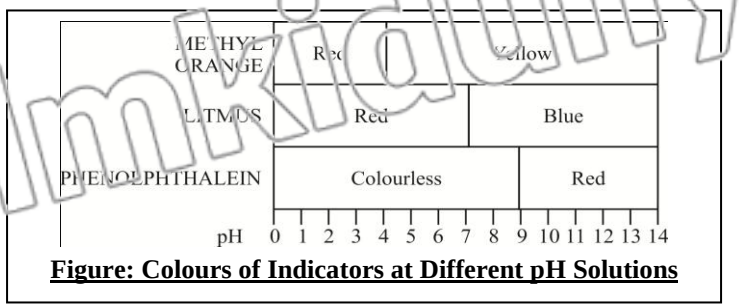


Figure: Colours of Indicators at Different pH Solutions

A few commonly used indicators in titrations are given in table 10.3.

Table: 10.3 Few Important Indicators

Indicator	Colour in Strongly Acidic Solution	pH at Which Colour Changes	Colour in Strongly Alkaline Solution
Methyl orange	Red	4	Yellow
Litmus	Red	7	Blue
Phenolphthalein	Colourless	9	Red

b. MEASURING pH OF A SOLUTION

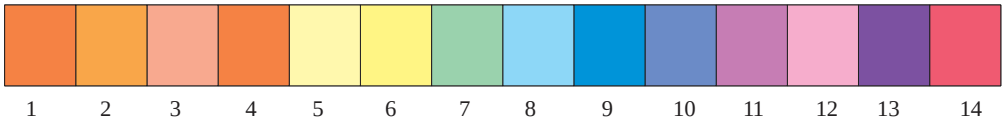
(i) Universal Indicator (pH indicator):

"The mixture of indicators which gives different colours at different pH values is called universal indicator or pH indicator".

It is used to measure the pH of a solution.

Procedure:

The pH of solution can be measured by dipping a piece of Universal Indicator paper in the solution. The pH is then found by comparing the colour obtained with a colour chart.



(ii) The pH Meter:

"A pH meter is an instrument which is used to measure the pH of a solution".

Construction:

It consists of a pH electrode connected to a meter.

Procedure:

The electrode is dipped into the solution and the meter shows the pH either on a scale or digitally.

Comparison with Universal Indicator:

It is much more reliable and accurate method of measuring pH than Universal Indicator paper, though the latter is often more convenient.

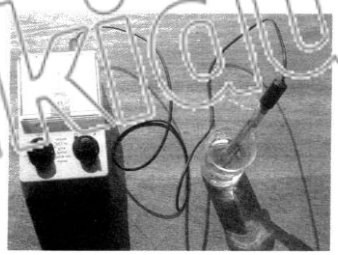


Figure: pH Meter

NUMERICAL EXAMPLE

PROBLEM 10.2 *(U.B+A.B)*

A solution of hydrochloric acid is 0.01M. What is its pH value?

Solution:

Given Data:

Molarity of HCl Solution = 0.01M

To Find:

pH of solution = ?

Calculations:

Hydrochloric acid is a strong acid so it ionizes completely that is:

$$HCl_{(aq)} \longrightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$$

So, its solution also contains 0.01M H^+ ions, i.e. 10^{-2} M.

$$pH = -\log\left[H^+\right]$$

By putting the values of H^+ ions in the above equation

$$pH = -\log 10^{-2}$$

$$pH = 2$$

Result:

Thus, pH of H_2SO_4 solution is 2.

PROBLEM 10.3 *(U.B+A.B)*

Find out the pH and pOH of 0.001M solution of KOH.

Solution:

Given Data:

Molarity of KOH solution = 0.001 M

To Find:

pH of solution = ?

pOH of solution = ?

Calculations:

Potassium hydroxide solution is a strong base. It ionizes completely such that one mole of KOH gives one mole of OH^- ions.

$$KOH_{(aq)} \longrightarrow K^{+}_{(aq)} + OH^{-}_{(aq)}$$

Therefore, 0.001 M or 10^{-3} M

$$\left[OH^-\right] = 10^{-3}\,M$$

$$pOH = -\log 10^{-3} = 3$$

$$pH = 14 - 3$$

$$pH = 11$$

$$pOH = 3$$

Result:

Thus pH and pOH of given solution are 11 and 3 respectively.

PROBLEM 10.4 *(U.B+A.B)*

Find the pH of 0.01M sulphuric acid.

Solution:

Given Data:

Sulphuric acid is a strong **dibasic acid**. It ionizes completely and its one mole produces 2 moles of hydrogen ions as presented in equation.

$$H_2SO_{4_{(eq)}} \longrightarrow 2H^{+}_{(aq)} + SO_4^{2-}$$

Therefore; 0.01M sulphuric acid will produce $2 \times 0.01M$ hydrogen ions.

To Find:

pH of solution = ?

Calculations:

Hence hydrogen ions concentration is:

$$\left[H^+\right] = 2\times 10^{-2}\text{M}$$

$$pH = -\log\left(2\times 10^{-2}\right)$$

$$= -\left(\log 2 + \log 10^{-2}\right)$$

$$= -\log 2 - \log 10^{-2}$$

Where, $\left(-\log^{-2}10 = 2\right)$

Thus

$$pH = -\log 2 + 2$$

$$= 2 - \log 2$$

$$= 1.7$$

Result:

Thus pH of given solution is 1.7.

10.2.1 INDICATORS
SHORT QUESTIONS

Q.1 What are indicators? Write names of of any two indicators. *(Knowledge Base)*
(DCK 2017, LHR 2015, RWP 2017)

Ans: *Answer given on Page # 68*

Q.2 What are universal indicators? *(Knowledge Base)*

Ans: *Answer given on Page # 69*

Q.3 What are the areas of work for analytical chemists? *(Knowledge Base)*
(Science and Technology Page#38)

Ans:

ANALYTICAL CHEMISTS

Analytical chemist examines substances qualitatively and quantitatively.

Areas of work:

- They identify substances and evaluate their properties.
- They have a wide area for working ranging from basic research in laboratories to analytical research in industries.
- They work in almost all industries including manufacturing, pharmaceuticals, healthcare, forensics and public protection where they test air, water, industrial waste, drugs and food to make sure they are safe.
- They ensure the quality of the products in industry.

10.2.1 INDICATORS
MULTIPLE CHOICE QUESTIONS

1. Indicators are: *(K.B)*
(A) Inorganic compounds (B) Hydrocarbons
(C) Organic compounds (D) Salts

2. in acidic or basic solution indicators have colour: *(K.B)*
(A) Same (B) Different
(C) Light (D) Green

3. It is a common indicator: *(K.B)*
(A) Litmus (B) pH meter
(C) pH scale (D) Both A and B

4. In strong acidic solution litmus is: *(K.B)* **(DCK 2017, BWP 2016 G-I)**
(A) Blue (B) Normal
(C) Red (D) Orange

5. In strong alkaline solution litmus is: *(K.B)* **(SGD 2016 G-II)**
(A) Red (B) Blue
(C) Yellow (D) Orange

6. Colour of Phenolphthalein in acidic solution is: *(K.B)*
(A) Red (B) Blue
(C) Yellow (D) Colorless

7. In alkaline solution methyl orange is: *(K.B)*
(A) Red (B) Blue
(C) Yellow (D) Orange

8. At which pH methyl orange changes color?
(A) 7 (B) 14
(C) 9 (D) 4

9. At which pH phenolphthalein changes color? *(K.B)*
(A) 7 (B) 4
(C) 9 (D) 0

10. pH meter consists of: *(K.B)*
(A) pH electrode (B) Positive electrode
(C) Negative electrode (D) None of these

11. It is much more reliable and accurate method of measuring pH: *(K.B)*
(A) Universal indicator (B) pH meter
(C) pH scale (D) Litmus

12. A solution of HCl is 0.001 M, what is its pH value? *(U.B)*
(A) 3 (B) 12
(C) 2 (D) 14

13. What is pOH value of 0.001 M solution of KOH? *(U.B)*
(A) 14 (B) 13
(C) 11 (D) 3

14. What is pH value of 0.01 M sulphuric acid? *(U.B)*
(A) 7.1 (B) 1.7
(C) 1.0 (D) 0.3

15. Ionic product constant depends on: *(K.B)*
(A) Temperature (B) Pressure
(C) Both (D) None of these

10.3 TEST YOURSELF

i. Why pure water is not a strong electrolyte? *(Understanding Base)*

(SGD 2016 G-II, RWP 2016 G-I)

Ans:

PURE WATER AS ELECTROLYTE

Pure water is not a strong electrolyte because it ionizes very slightly into ions in a process called auto-ionization or self ionization.

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

The concentration of ions is very small i.e.

$$[H^+] = [OH^-] = 1.0 \times 10^{-7} M .$$

ii. HCl and H_2SO_4 are strong acids. While their solutions are equimolar, they have different pH values as calculated in problem 10.2 and 10.4. Why they have different pH values? *(Understanding Base)*

Ans:

pH VALUES OF HCl AND H_2SO_4

Equimolar solutions of HCl and H_2SO_4 have different pH values because when HCl ionized it produces one H^+ ion, it is monobasic acid.
While H_2SO_4 is dibasic acid it produces two H^+ ions.

$$HCl \rightleftharpoons H^+ + Cl^-$$

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

pH of HCl = – log $[H^+]$

pH of H_2SO_4 = – log $[2 \times H^+]$

iii. Why ionic-product constant of water is temperature dependent?

(Understanding Base)

Ans: **IONIC-PRODUCT CONSTANT OF WATER**

K_w is the ionic product constant of water.

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25°C

Temperature dependence:

It is temperature dependent because it increases with the rise of temperature and vice versa.

iv. Differentiate between "p" and "pH". ***(Understanding Base)***

Ans: **DIFFERENTIATION**

The difference between "p" and "pH" is as follows:

"p"	"pH"
"p" before the symbol means negative logarithm of the symbol. So 'p' before H means negative logarithm of H^+ (hydrogen ion).	pH is the negative logarithm of molar concentration of the hydrogen ions. $pH = -\log [H^+]$

10.3 SALTS

10.3.1 PREPARATION OF SALTS

LONG QUESTIONS

Q.1 What are the salts? Write down characteristic properties of salt. ***(Knowledge + Understanding Base)*** **(Ex-Q.4)**

(GRW 2013, BWP 2017 DGK 2017, RWP 2017)

Ans: **SALTS**

Definition:

*"Salts are **ionic compounds** generally **formed** by the **neutralization** of an **acid** with a **base**".*

Composition of Salts:

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

Salts are made up of positive ions (cations) and negative ions (anions).

Basic Radical:

*"A **cation** is **metallic ion derived** from a **base**, therefore, it is called basic radical".*

Acid Radical:

*"An **anion** is **non-metallic ion derived** from **acid**, therefore, it is called acid radical".*

Salts are named from the name of the metal and the respective acid. **(SGD 2017)**

Nomenclature:

A salt gets its name from the name of the metal and the acid as shown in the following.

Metal	Acid	Salt Name
• **Sodium (Na)** • **Potassium (K)** • **Zinc (Zn)** • **Calcium (Ca)** • **Silver (Ag)**	Hydrochloric acid (HCl) Nitric Acid (HNO_3) Sulphuric acid (H_2SO_4) Phosphoric acid (H_3PO_4) Acetic acid (CH_3COOH)	Sodium Chloride (NaCl) Potassium nitrate (KNO_3) Zinc sulphate ($ZnSO_4$) Calcium phosphate $Ca_3(PO_4)_2$ Silver acetate (CH_3COOAg)

Characteristic Properties of Salts: **(DGK 2016 G-I)**

The characteristic properties of salts are as follows:

Ionic Compounds:

Salts are ionic compounds found in crystalline form.

Melting and Boiling Points:

They have high melting and boiling points.

Water of Crystallization:

Most of the salts contain water of crystallization which is **responsible** for the **shape of the crystals**. The number of molecules of water is specific for each salt and they are written with the chemical formula of a salt.

Example:

Copper sulphate **$CuSO_4.5H_2O$;** Calcium sulphate **$CaSO_4.2H_2O$**

(Gypsum)

Neutral Compound: ***(Test Yourself 10.4 q iii)***

Salts are neutral compounds. Although, they **do not** compose of equal **number** of **positive** and **negative ions,** but have **equal number** of **positive** and **negative charges.**

$$NaCl \longrightarrow Na^+ + Cl^-$$

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$$

Q.2 Explain with examples that how soluble salts are prepared? Describe preparation of insoluble salts as well. ***(Understanding Base + Application Base)***

(Ex-Q.5) (SGD 2014, LHR 2021)

Ans:

PREPARATION OF SOLUBLE SALTS

Salts may be water soluble or insoluble. The methods used for the preparation of salts are based on their solubility in water.

General Methods for the Preparation of Salts:

There are five general methods for the preparation of salts. Four methods make soluble salts but one prepares insoluble salts.

(i) Preparation of Soluble Salts:

Soluble salts are often prepared in water. Therefore, they are **recovered** by **evaporation** or **crystallization.**

(a) By the Reaction of an Acid and a Metal (Direct Displacement Method):

This is direct displacement method in which hydrogen ion of acid is replaced by a reactive metal such as calcium, magnesium, zinc and iron

Examples:

$$\text{Acid + Metal} \longrightarrow \text{Salt + Hydrogen gas}$$

$$HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

(b) By the Reaction of An Acid And a Base (Neutralization Method):

It is a neutralization reaction in which acid and base react to produce a salt and water.

Example:

$$\text{Acid + Base} \longrightarrow \text{Salt + Water}$$

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

(c) By the Reaction of an Acid and Metallic Oxide:

Mostly the insoluble metallic oxides react with dilute acids to form salt and water.

$$\text{Acid + Metallic oxide} \longrightarrow \text{Salt + water}$$

$$H_2SO_{49aq)} + CuO_{(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(aq)}$$

(d) By the Reaction of an Acid and a Carbonate:

Dilute acids react with metallic carbonates to produce salts, water and carbon dioxide gas.

$$2HNO_{3(aq)} + Na_2CO_{3(aq)} \longrightarrow NaNO_{3(aq)} + H_2O_{(l)} + CO_2 \uparrow_{(g)}$$

(ii) Preparation of Insoluble Salts:

In this method, usually **solutions of soluble salts** are mixed. During the reaction exchange of ionic radicals (i.e., metallic radicals exchange with acidic radicals) takes place to produce two new salts. **One of the salts is insoluble and the other is soluble.** The insoluble salt precipitates (solidify in solution).

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow \mathbf{AgCl_{(s)}} + NaNO_{3(aq)}$$

$$Na_2CO_{3(aq)} + CuSO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + \mathbf{CuCO_{3(s)}}$$

10.3 SALTS

SHORT QUESTIONS

Q.1 Write names of any two methods for the preparation of salts. *(Knowledge Base)* **(LHR 2014)**

Ans:

PREPARATION OF SALTS

Two important methods for the preparation of salts are as follows:

- Direct displacement method
- Neutralization method

Q.2 Complete and balance the equation. *(Understanding Base)* **(LHR 2013)**

$$Al + HCl \longrightarrow$$

Ans:

COMPLETE AND BALANCED EQUATION

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(s)} + 3H_{2(g)}$$

10.3 SALTS

MULTIPLE CHOICE QUESTIONS

1. Salts are: ***(K.B)***
(A) Organic compounds (B) Inorganic compounds
(C) Ionic compounds (D) Polar compounds

2. A cation is derived from: ***(K.B)***
(A) Acid (B) Base
(C) Molecule (D) Compound

3. Metallic oxides are: ***(K.B)***
(A) Bases (B) Acids
(C) Salts (D) Organic compounds

4. An anion is derived from: ***(K.B)***
(A) Acid (B) Base
(C) Molecule (D) All of these

5. When K reacts with HCl the salt produced is: ***(K.B)***
(A) KCl (B) NaOH
(C) H_2O (D) NH_3

6. Salts have: ***(K.B)***
(A) High M.P and low B.P (B) High M.P and B.P
(C) Low M.P and low B.P (D) Low M.P and high B.P

7. Copper sulphate has water of crystallization: ***(K.B)***
(A) 5 (B) 2
(C) 6 (D) 24

8. Calcium sulphate has water of crystallization: ***(K.B)***
(A) 5 (B) 2
(C) 6 (D) 24

9. Salts may be: ***(K.B)***
(A) Water soluble (B) Water insoluble
(C) Both A and B (D) None of these

10. Reaction of acid and a metal is called reaction: ***(K.B)***
(A) Partial displacement (B) Direct displacement
(C) Incomplete displacement (D) All of these

11. Mostly soluble metallic oxides form salt and water when they are treated with: ***(K.B)***
(A) Dilute acids (B) Concentrated acids
(C) Dilute bases (D) None of these

12. In preparation of insoluble salts which are mixed? ***(K.B)***
(A) Insoluble salts (B) Soluble salts
(C) Insoluble and soluble salts (D) None of these

13. When Mg reacts with HCl the salt produced is: ***(K.B)***
(A) $MgCl_2$ (B) NaOH
(C) H_2O (D) NH_3

14. Soluble salts are recovered by: ***(K.B)***
(A) Evaporation (B) Crystallization
(C) Both 'A' and 'B' (D) Boiling

15. There are _____ general methods for preparation of salts. ***(K.B)***
(A) 5 (B) 4
(C) 3 (D) 2

10.4 TEST YOURSELF

i. How the salts are named? ***(Understanding Base)***

Ans:

NOMENCLATURE OF SALTS

A salt gets its name from the names of the metal and the acid from which they are made of.

Examples:

Metal	Acid	Salt Name
Sodium (Na)	Hydrochloric acid (HCl)	Sodium chloride (NaCl)
Potassium (K)	Nitric acid (HNO_3)	Potassium nitrate (KNO_3)

ii. Name the salts which are formed when Zn metal reacts with following acids.

(Understanding Base)

(A) Nitric acid (B) Phosphoric acid (C) Acetic acid

Ans:

NAMES OF SALTS

$$Zn + \text{nitric acid} \longrightarrow \text{Zinc nitrate}$$

$$Zn + \text{phosphoric acid} \longrightarrow \text{Zinc phosphate}$$

$$\text{Zinc} + \text{acetic acid} \longrightarrow \text{Zinc acetate}$$

iii. How will you justify salts are neutral compounds? ***(Understanding Base)***

Ans: *Answer given on page 74.*

iv. How many water of crystallization are present in $CuSO_4.5H_2O$ and $CaSO_4.2H_2O$?

(Understanding Base)

Ans:

WATER OF CRYSTALLIZATION

In $CuSO_4.5H_2O$, there are 5 water molecules and in $CuSO_4.2H_2O$ there are 2 water molecules attached with $CuSO_4$ and $CaSO_4$, respectively as water of crystallization.

v. Name the type of reaction that takes place between an acid and a metal. Which gas would evolve in the reaction? Explain with an example. ***(Understanding Base)***

Ans:

REACTION BETWEEN ACID AND METAL

When acid reacts with metal, salt and hydrogen gas are produced. This type of reaction is called direct displacement reaction.

Representation:

$$\text{Acid} + \text{Metal} \longrightarrow \text{Salt} + \text{Hydrogen gas}$$

Gas Evolved:

The gas produced due to reaction between acid and metal will be hydrogen gas.

Example:

$$2HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)} \uparrow$$

10.3.2 TYPES OF SALTS

LONG QUESTIONS

Q.1 Name the classes of salts? Explain them with the help of examples.
(Knowledge + Understanding + Application Base) **(RWP 2017)**

Ans: **TYPES OF SALTS**

The main classes of salts are as follows:

(i) Normal salts
(ii) Basic salt
(iii) Mixed salts
(iv) Acidic salts
(v) Double salts
(vi) Complex salts

(i) Normal or Neutral Salts: **(LHR 2015)**

*"A salt formed by the **total replacement of ionizable H^+** ions of an acid by a **positive metal ion or NH_4^+** ions, is called normal or neutral salt".*

Examples:

$$HCl_{(aq)} + KOH \longrightarrow KCl + H_2O_{(l)}$$
$$H_2SO_4 + ZnO \longrightarrow ZnSO_4 + H_2O_{(l)}$$
$$H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O_{(l)}$$
$$HNO_3 + NH_4OH \longrightarrow NH_4NO_3 + H_2O_{(l)}$$

Properties:

Normal salts are neutral to litmus and have no effect on blue or red litmus paper.

(ii) Acidic Salts: **(LHR 2015, 2016, MTN 2017)**

*"These salts are formed by **partial replacement of a replaceable H^+** ions of an acid, **by a positive metal ion".***

$$H_2SO_4 + KOH \longrightarrow KHSO_4 + H_2O$$
$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$

Properties:

Aqueous solutions of these salts turn blue litmus red.
Acidic salts react with bases to form normal salts.

$$KHSO_{4(aq)} + KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$
$$NaH_2PO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_3PO_{4(aq)} + 2H_2O_{(l)}$$

(iii) Basic Salts: **(LHR 2016, DGK 2016 G-II)**

*"Basic salts are formed by the **incomplete neutralization** of a **polyhydroxy base** by an **acid**".*

$$Al(OH)_3 + HCl \longrightarrow Al(OH)_2Cl + H_2O$$
$$Pb(OH)_2 + CH_3COOH \longrightarrow Pb(OH)CH_3COO + H_2O$$
$$Zn(OH)_2 + HNO_3 \longrightarrow Zn(OH)NO_3 + H_2O$$

Properties:

Aqueous solutions of these salts turn red litmus blue.

These salts further react with acids to form normal salts.

$$Al(OH)_2Cl + HCl \longrightarrow Al(OH)Cl_2 + HCl$$

$$Al(OH)Cl_2 + H_2O \longrightarrow AlCl_3 + H_2O$$

$$Pb(OH)CH_3COO + CH_3COOH \longrightarrow Pb(CH_3CCO)_2 + H_2O$$

$$Zn(OH)NO_3 + H_2O \longrightarrow Zn(NO_3)_2 + HNO_3$$

(iv) Double Salts:

*"Double salts are formed by **two normal salts** when they are **crystallized** from a mixture of **equimolar saturated solutions**".*

Properties:

The individual salt components retain their properties. The anions and cations give their respective tests.

Examples:

- Mohr's salt $FeSO_4 \cdot (NH_4)_2SO_4.6H_2O$
- Potash alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$
- Ferric alum $K_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$

(v) Mixed Salts:

"Mixed salts contain more than one basic or acid radicals".

Example:

- Bleaching powder Ca(OCl)Cl

(vi) Complex Salts:

*"Complex salts on dissociation provide a **simple cation and a complex anion** or vice versa".*

Only the simple ions yield the characteristic test for cation or anion.

Example:

- Potassium ferrocyanide $K_4[Fe(CN)_6]$ gives on ionization, a simple cation (K^+) and complex anion $[Fe(CN)_6]^{-4}$.

10.3.2 TYPES OF SALTS

SHORT QUESTIONS

Q.1 What are normal salts? *(Knowledge Base)* **(GRW 2017, MTN 2016 G-II, 17)**

Ans:

NORMAL OR NEUTRAL SALTS

"A salt formed by the total replacement of ionizable H^+ ions of an acid by a positive metal ion or NH_4^+ ions, is called normal or neutral salt".

Examples:

$$HCl_{(aq)} + KOH \longrightarrow KCl + H_2O_{(l)}$$

$$H_2SO_4 + ZnO \longrightarrow ZnSO_4 + H_2O_{(l)}$$

Q.2 Define acidic salts? Write one chemical equation of their reaction with bases. ***(Understanding Base)***

(GRW 2015) (LHR 2015)

Ans: **ACIDIC SALTS**

These salts are formed by partial replacement of H^+ ions of an acid by a positive metal ion.

Examples:

- Potassium hydrogen sulphate : $KHSO_4$
- Sodium hydrogen sulphate : $NaHSO_4$

Chemical Equation:

Acidic salts react with bases to form normal salts.

$$KHSO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O_{(i)}$$

Q.3 Define double salts. Give two examples. ***(Knowledge Base)*** **(GRW 2013)**

Ans: **DOUBLE SALTS**

Definition:

"Double salts are formed by two normal salts when they are crystallized from a mixture of equimolar saturated solutions."

Examples:

- Mohr's salt $FeSO_4.(NH_4)_2SO_4.6H_2O$
- Potash Alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$

Q.4 Give formulas of potash alum and ferric alum. ***(Knowledge Base)*** **(SWL 2017)**

Ans: **FORMULAS OF SALTS**

The formulas of potash alum and ferric alum are as follows:

- Potash alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$
- Ferric alum $K_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$

Q.5 Name any four types of slats. ***(Knowledge Base)*** **(SWL 2016 G-I)**

Ans: **FOUR TYPES OF SALTS**

Following are the four types of salts:

(i) Normal salts
(ii) Basic salt
(iii) Mixed salts
(iv) Acidic salts

10.3.2 TYPES OF SALTS

MULTIPLE CHOICE QUESTIONS

1. $HCl + KOH \longrightarrow KCl + H_2O$ is an example of: ***(U.B)***

(A) Neutral salt (B) Acidic salt
(C) Basic salt (D) Complex salt

2. $H_3PO_4 + 2NaOH \longrightarrow Na_2HPO_4 + 2H_2O$ is an example of: ***(U.B)***

(A) Acidic salt (B) Basic salt
(C) Double salt (D) Normal salt

3. Which litmus turns into red in acidic salts? *(K.B)*

(A) Blue (B) Orange
(C) Yellow (D) Green

4. $FeSO_4.(NH_4)_2\ SO_4.6H_2O$ is: *(K.B)*

(A) Mohr's salt (B) Potash alum
(C) Ferric alum (D) Chrome alum

5. Double salts are formed by two: *(K.B)*

(A) Acidic salts (B) Neutral salts
(C) Basic salts (D) Mixed salts

6. The formula of bleaching powder is: *(K.B)*

(A) CaCl (B) Ca(OCl)Cl
(C) $CaCl_2$ (D) Ca(OCl)

7. Washing soda has water of crystallization: *(K.B)*

(A) 24 (B) 6
(C) 5 (D) 10

8. There are how many types of salts? *(K.B)*

(A) 4 (B) 6
(C) 5 (D) 7

9. $HBr + KOH \longrightarrow KBr + H_2O$ is an example of formation of: *(K.B)*

(A) Neutral salt (B) Acidic salt
(C) Basic salt (D) Complex salt

10. Which litmus turn into blue in basic salts? *(K.B)*

(A) Blue (B) Orange
(C) Yellow (D) Red

11. $K_2SO_4.Fe_2(SO_4)_3.24H_2O$ is: *(K.B)*

(A) Mohr's salt (B) Potash alum
(C) Ferric alum (D) Chrome alum

12. A neutral salt is not composed of: *(K.B)* **(GRW 2015)**

(A) A metallic cation (B) Non-metallic anion
(C) An anion of a base (D) An anion of an acid

13. Which one of the following is acidic salt? *(K.B)* **(GRW 2016)**

(A) $KHSO_4$ (B) $Al(OH)_2Cl$
(C) NaCl (D) Ca(OCl)Cl

14. Bleaching powder is an example of: *(K.B)* **(MTN 2017)**

(A) Mixed Salt (B) Acidic Salt
(C) Double Salt (D) None of these

15. Ca(OCl)Cl is an example of: *(K.B)* **(FSD 2017 G-I)**

(A) Normal salts (B) Double salts
(C) Mixed salts (D) Complex salts

10.3.3 USES OF SALTS

LONG QUESTIONS

Q.1 Write down the uses of salts. ***(Knowledge Base)***

Ans:

USES OF SALTS

Salts have vast applications in industries and in our daily life. Some common salts and their uses are given below:

Name of Salts	Common and Industrial Uses
Sodium chloride (NaCl) (GRW 2017)	It is commonly used as a table salt and for **cooking purposes**. It is also used for **de-icing roads** in winter and for the **manufacture of sodium metal**, caustic soda, washing soda.
Sodium carbonate(Na_2CO_3) Soda ash	It is used for the manufacture of glass, detergents, pulp, paper and other chemicals.
Sodium carbonate ($Na_2CO_3.10H_2O$) Washing soda	It is used as cleaning agent for domestic and commercial purposes, for **softening of water**, in **manufacture** of chemicals like **caustic soda (NaOH),** borax, glass, soap and paper.
Sodium sulphate (Na_2SO_4)	It is used for the manufacture of glass, paper and detergents
Sodium silicate (Na_2SiO_3)	It is used for the manufacture of detergents, cleaning agents and adhesives.
Sodium chlorate ($NaClO_3$)	It is used for manufacture of explosives, plastics and other chemicals.
Sodium tetraborate ($Na_2B_4O_7.10H_2O$)	It is used for manufacture of **heat resistance glass (pyrex),** glazes and enamels, in leather industry for soaking and cleaning hides.
Calcium chloride ($CaCl_2$)	It is used for **de-icing roads in winter**, as a **drying agent of chemical reagents** and as freezing agent.
Calcium oxide (CaO) Quick lime	It is used as drying agent for gases and alcohol and in steel making, water treatment and other chemicals like slaked lime, bleaching powder, calcium carbide. **Soda Lime:** For purification of sugar, a mixture of CaO and NaOH called soda lime is used to remove carbon dioxide and water vapours from air.
Calcium sulphate ($CaSO_4.2H_2O$)	**Gypsum** is used as fertilizer, to **prepare plaster of Paris** which is used for making statues, casts, etc.
Potassium Nitrate (KNO_3)	It is used as fertilizer and for the manufacture of flint glass.

Q.2 What are neutralization reactions? *(Knowledge Base)* **(RWP 2016 G-I, 2017)**

Ans: **NEUTRALIZATION REACITONS**

Definition:

*"A reaction between an **acid** and a **base** is called a **neutralization** reaction. It produces a **salt and water**."*

Examples:

A few balanced chemical reactions are given here:

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

$$H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_{4_{(aq)}} + 2H_2O_{(l)}$$

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$$

10.3.3 USES OF SALTS

SHORT QUESTIONS

Q.1 What are uses of calcium sulphate? *(Knowledge Base)* **(RWP 2017)**

Ans: **USES OF CALCIUM SULPHATE**

Calcium sulphate (Gypsum) is used:

- As fertilizer
- To prepare Plaster of Paris which is used for making statues, casts, etc.

Q.2 What are uses of washing soda? *(Knowledge Base)*

Ans: **USES OF WASHING SODA**

Washing soda ($Na_2CO_3.10H_2O$) also called sodium carbonate is used:

- As cleaning agent for domestic and commercial purposes
- For softening of water
- In manufacture of chemicals like caustic soda (NaOH), borax, glass, soap and paper.

Q.3 Write down the use of sodium chlorate ($NaClO_3$). *(Knowledge Base)* **(LHR 2014)**

Ans: **USES OF SODIUM CHLORATE**

It is used for manufacture of:

- Explosives
- Plastics and other chemicals.

Q.4 Give the uses of calcium chloride ($CaCl_2$). *(Knowledge Base)* **(GRW 2013)**

Ans: **USES OF CALCIUM CHLORIDE**

It is used:

- For deicing roads in winter
- As a drying agent of chemical reagents
- As freezing agent

Q.5 Write uses of CaO. *(Knowledge Base)* **(SWL 2017, RWP 2017, SGD 2017)**

Ans: **USES OF CaO**

The four uses of CaO are as follows:

(i) As drying agent for gases and alcohol

(ii) In steel making, after treatment and other chemicals like slaked lime, bleaching powder, calcium carbide.

(iii) For preparation of bleaching powder

Q.6 Write down the use of sodium chloride. ***(Knowledge Base)*** **(SGD, 2016 G-I)**

Ans:

USES OF SODIUM CHLORIDE

It is commonly used:

- As a table salt and for cooking purposes
- It is also used for de-icing roads in winter
- For the manufacture of sodium metal, caustic soda, washing soda.

Q.7 How acid rain is formed? Give effects of acid rain. ***(Knowledge Base)***

(Science and Technology Page#44)

Ans.

FORMATION OF ACID RAIN

Acid rain is formed by dissoving acidic air pollutants like oxides of sulphur and nitrogen by rain water.

Effects:

- pH of the rain water decreases and it becomes too acidic.
- When this acid rain falls down, it damages animals, plants, buildings, water bodies and even soil.

10.3.3 USES OF SALTS

MULTIPLE CHOICE QUESTIONS

1. Which salt is used to dry the gas: ***(K.B)*** **(LHR 2014, 2015, BWP 2017)**

(A) $CaCl_2$ (B) NaCl

(C) CaO (D) Na_2SiO_3

2. Gypsum is also known as: ***(K.B)***

(A) Calcium carbonate (B) Calcium chloride

(C) Calcium sulphate (D) Calcium bi-carbonate

3. $Na_2CO_3.10H_2O$ is called: ***(K.B)***

(A) Baking soda (B) Washing soda

(C) Detergent (D) Soda ash

4. Na_2CO_3 is called: ***(K.B)***

(A) Baking soda (B) Washing soda

(C) Detergent (D) Soda ash

5. It is used as fertilizer and for the manufacture of flint glass: ***(K.B)***

(A) Potassium nitrate (B) Sodium silicate

(C) Calcium chloride (D) Soda ash

6. A reacton between an acid and a base is called: ***(K.B)***

(A) Displacement (B) Decomposition

(C) Hydrolysis (D) Neutralization

7. Soda lime is a mixture of: ***(K.B)***

(A) $CaCl_2$, KOH (B) NaOH, CaO

(C) NaCl, CaO (D) $Ca(OH)_2$, CaO

10.5 TEST YOURSELF

i. Name the types of salts. ***(Knowledge Base)*** **(DGK 2016 G-I)**

Ans: **TYPES OF SALTS**

Following are the main types of salts:

- Normal salts
- Basic salt
- Mixed salts
- Acidic salts
- Double salts
- Complex salts

ii. H_3PO_4 is a weak acid but its salt (Na_3PO_4) with strong base NaOH is neutral. Explain it. ***(Understanding Base)***

Ans: **NEUTRAL SALT OF H_3PO_4**

Three moles of strong base (NaOH) release 3 OH^- ions that neutralize acid H_3PO_4. So neutral salt is obtained.

$$\underset{(\text{weak acid})}{H_3PO_{4(aq)}} + \underset{(\text{strong base})}{3NaOH_{(aq)}} \longrightarrow \underset{(\text{Neutral salt})}{Na_3PO_{4(aq)}} + \underset{(\text{water})}{3H_2O_{(l)}}$$

iii. How the basic salts turn into normal salts? Explain with an example. ***(Understanding Base)***

Ans: **BASIC SALTS FORM NORMAL SALTS**

Basic salts turn into normal salt by the removal of OH group when they are treated with acid.

Example:

$$\underset{(\text{Basic salt})}{Zn(OH)NO_3} + \underset{(\text{Acid})}{HNO_3} \longrightarrow \underset{(\text{Normal salt})}{Zn(NO_3)_2} + \underset{(\text{Water})}{H_2O}$$

iv. What are complex salts? ***(Knowledge Base)*** **(SGD 2017)**

Ans: **COMPLEX SALTS**

Definition:

"*Complex salts on dissociation produce a simple cation and a complex anion or visa versa.*"

These are the simple ions which give characteristic test for cation or anion.

Example:

Potassium ferrocyanide, $K_4[Fe(CN)_6]$ gives on ionization, a simple cation (K^+) and complex anion $(Fe(CN)_6]^{-4}$

v. Na_2SO_4 is a neutral salt. What are its uses? ***(Knowledge.Base)***

Ans: **USES OF Na_2SO_4**

Na_2SO_4 is used for the manufacture of:

- Glass
- Paper
- Detergents

Science, Technology and Society (PRESERVATIVES IN FOOD)

LONG QUESTIONS

Q.1 What are preservatives? Why preservatives are used in food? *(Knowledge Base)*

(Science, Technology and Society Pg. # 44)

Ans:

FOOD PRESERVATIVES

*"Those chemicals which are used to **prevent food spoilage** are called preservatives."*

Cause of Food Spoilage:

Food spoiling may be due to **microbial actions** or chemical reactions.

Principle of preservatives:

Preservatives serve as **anti-microbial or antioxidants.**

Uses.

The important uses of preservatives are as follows:

- Manufacturers add preservatives to prevent spoilage during transportation and storage of foods for a long period of time.
- Natural food preservatives efficiently control the growth of bacteria in food. They are used to preserve meat and fish. Natural preservatives include salts, sugar, alcohol, vinegar.

Science, Technology and Society (PRESERVATIVES IN FOOD

SHORT QUESTIONS

Q.1 Why tears, perspiration and blood taste salty? *(Knowledge Base)*

(Interesting Information Pg. # 43)

Ans:

TASTE OF TEARS, PERSPIRATION AND BLOOD

There are many kinds of salt solutions inside our body, which come from the food we eat as a result of chemical reactions. So, tears, perspiration and blood are salty because they contain slat in solution.

MULTIPLE CHOICE QUESTIONS

1. The substances used to preserve food are called: *(K.B)*

(A) Preservatives (B) Oxidants
(C) Microbial (D) Degradative

2. Natural food preservatives added to food efficiently control the growth of: *(K.B)*

(A) Bacteria (B) Plants
(C) Algae (D) Vertebrates

3. Tears, perspiration and blood taste salty because of: *(K.B)*

(A) Hydrochloric acid (B) Sodium chloride and other salts
(C) Sulphuric acid (D) Sugar

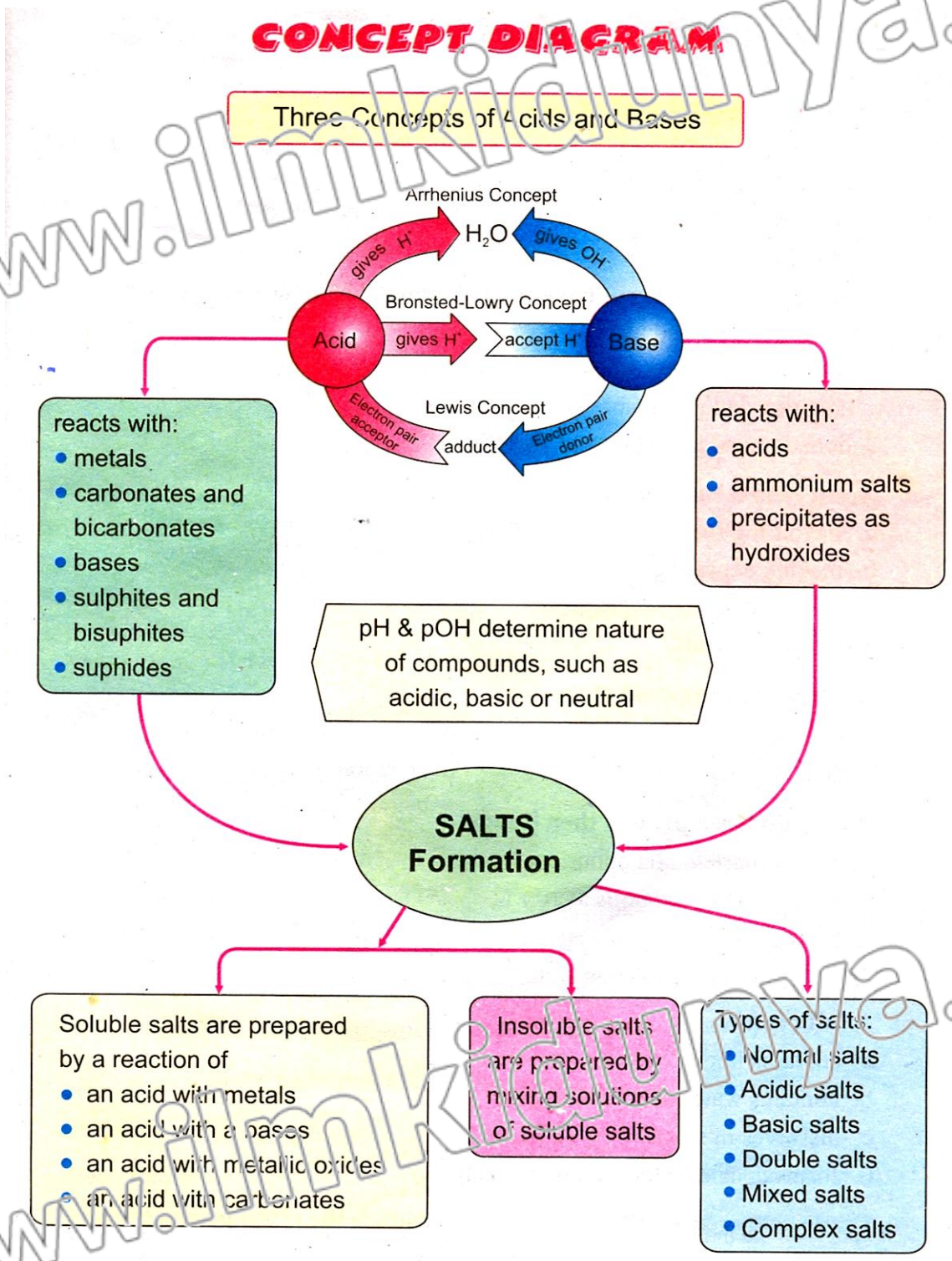
4. Which pollutants decrease the pH of rain water? *(K.B)*

(A) Basic oxides (B) Normal oxides
(C) Acidic oxides (D) None of these

5. Preservatives serve as: *(K.B)*

(A) Oxidants (B) Anti-oxidants
(C) Anti-microbial (D) Both B and C

CONCEPT DIAGRAM



ANSWER KEY

MULTIPLE CHOICE QUESTIONS

INTRODUCTION

1	B	6	C
2	D	7	C
3	B	8	C
4	C		
5	B		

10.1.1 ARRHENIUS CONCEPT OF ACIDS AND BASES

1	D	6	A
2	B	7	B
3	A		
4	A		
5	C		

10.1.2 BRONSTED LOWRY CONCEPT

1	D	6	A
2	A	7	A
3	A	8	A
4	D	9	C
5	A	10	B

10.1.3 LEWIS CONCEPT OF ACIDS AND BASES

1	B	6	B
2	A	7	A
3	C	8	B
4	B	9	B
5	D	10	A

10.1.4 GENERAL PROPERTIES OF ACIDS

1	C	6	D	11	C
2	D	7	A	12	A
3	A	8	C	13	D
4	D	9	D	14	B
5	A	10	A		

10.1.5 GENERAL PROPERTIES OF BASES

1	B	6	A
2	A		
3	B		
4	D		
5	B		

STOMACH ACIDITY

1	D
2	D
3	C

10.2 pH SCALE

1	A	6	C	11	B
2	A	7	B	12	C
3	D	8	B	13	C
4	B	9	A		
5	C	10	C		

10.2.1 INDICATORS

1	C	6	D	11	B
2	B	7	C	12	A
3	A	8	D	13	D
4	C	9	C	14	B
5	B	10	A	15	A

10.3 SALTS

10.3.1 PREPARATION OF SALTS

1	C	6	A	11	A
2	B	7	A	12	B
3	A	8	B	13	A
4	A	9	C	14	C
5	A	10	B	15	A

10.3.2 TYPES OF SALTS

1	A	6	B	11	C
2	B	7	D	12	C
3	A	8	C	13	A
4	A	9	A	14	A
5	B	10	D	15	C

10.3.3 USES OF SALTS

1	C	6	D
2	C	7	B
3	B		
4	C		
5	A		

PRESERVATIVES IN FOOD

1	A
2	A
3	B
4	C
5	D

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. A base is a substance which neutralizes an acid. Which of these substances is not a base? *(K.B)* **(GRW 2015, RWP 2017, mtn 2016 G-I)**

(a) Aqueous ammonia (b) Sodium chloride
(c) Sodium carbonate (d) Calcium oxide

2. Lewis acid-base concept has the following characteristics except: *(K.B)*

(a) Formation of an adduct (b) Formation of a co-ordinate covalent bond
(c) Donation and acceptance of an electron pair (d) Donation and acceptance of a proton

3. Acetic acid is used for: *(K.B)* **(RWP 2016 G-I, 17, FSD 2016 G-I, BWP 2016 G-I)**

(a) Flavouring food (b) Making explosive
(c) Etching designs (d) Cleaning metals

4. A salt is not composed of: *(K.B)*

(a) A metallic cation (b) Non-metallic anion
(c) An anion of a base (d) An anion of an acid

5. If a liquid has a pH of 7 then it must: **(RWP 2016 G-II, GRW 2015)**

(a) Be a colourless and odourless liquid (b) Freeze at 0^oC and boil at 100^oC
(c) Be neutral (d) Be a solution containing water

6. A salt always: *(K.B)*

(a) Contains ions (b) Contains water of crystallization
(c) Dissolves in water (d) Forms crystals which conduct electricity

7. Dilute acids react with carbonates to produce the given products except: *(K.B)* **(LHR 2013, GRW 2013, DGK 2017, MTN 2016 G-II)**

(a) Salt (b) Water
(c) Carbon dioxide (d) Hydrogen

8. In the preparation of insoluble salts, which one of the facts is incorrect? *(U.B)*

(a) Two soluble salts are mixed (b) Two soluble salts are produced
(c) One of the salts produced is insoluble (d) Both of the salts produced are insoluble

9. A reaction between an acid and base produces: *(K.B)* **(SGD 2014, RWP 2017, FSD 2017 G-I)**

(a) Salt and water (b) Salt and gas
(c) Salt and an acid (d) Salt and a base

10. The conjugate acid of HPO_4^{-2} is: *(U.B)* **(LHR 2015,2017)**

(a) PO_4^{-3} (b) H_2PO^-
(c) $H_2PO_4^-$ (d) H_3PO_4

11. What is the pOH of 0.02 M $Ca(OH)_2$? *(U.B)* **(GRW 2014)**

(a) 1.698 (b) 1.397
(c) 12.31 (d) 12.61

12. Which one of the following species is not amphoteric? *(U.B)* **(LHR 2013, FSD 2016 G-II)**

(a) H_2O (b) NH_3

(c) HCO_3^- (d) SO_4^{2-}

13. The product of Lewis acid-base reaction is called adduct. The bond between the adduct specie is: ***(K.B)***

(a) Ionic (b) Covalent

(c) Metallic (d) Coordinate covalent

14. The water of crystallization is responsible for the: ***(K.B)***

(a) Melting points of crystals (b) Boiling points of crystals

(c) Shapes of crystals (d) Transition point of crystals

15. You want to dry a gas which one of the following salt you will use: ***(K.B)***

(LHR 2013, 14, 15, BWP 2016 G-I, 17, FSD 2017 G-II, SWL 2016 G-I, MTN 2016 G-I, DGK 2016 G-I)

(a) $CaCl_2$ (b) NaCl

(c) CaO (d) Na_2SiO_3

16. Ferric hydroxide $Fe(OH)_3$ is precipitated out of solution when aqueous sodium hydroxide solution is added to ferric chloride ($FeCl_3$): ***(K.B)***

$$FeCl_{3\,(aq)} + 3NaOH_{\,(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

Colour of the precipitate is:

(a) Green (b) Blue

(c) Dirty green (d) Brown

17. Which ion is the conjugate base of sulphuric acid? ***(K.B)***

(LHR 2014, BWP 2016 G-I, 2017, SWL 2016 G-I, II)

(a) SO_3^{-2} (b) S^{-2}

(c) HSO_3^{-1} (d) HSO_4^{-1}

18. Which one of the following is a Lewis base? ***(K.B)***

(GRW 2014, LHR 2015, SGD 2014, 16 G-I RWP 2017, SWL 2016 G-II, FSD 2017 G-II)

(a) NH_3 (b) BF_3

(c) H^+ (d) $AlCl_3$

19. According to the Lewis concept, acid is a substance which can: ***(K.B)*** **(LHR 2014)**

(a) Donate a proton (b) Donate a pair of electron

(c) Accept a proton (d) Accept a pair of electron

20. Given $K_c = [H^+]\,[OH^-] = 1.0 \times 10^{-14}$ at 25°C. What is the concentration of H^+ in pure water at 25°C? ***(K.B)*** **(SGD 2017)**

(a) 1×10^{-7} mol dm^{-3} (b) 1×10^{7} mol dm^{-3}

(c) 1×10^{-14} mol dm^{-3} (d) 1×10^{14} mol dm^{-3}

ANSWER KEY

1	b	**6**	a	**11**	b	**16**	d
2	d	**7**	d	**12**	d	**17**	d
3	a	**8**	b	**13**	d	**18**	a
4	c	**9**	a	**14**	c	**19**	d
5	c	**10**	c	**15**	c	**20**	a

EXERCISE SHORT QUESTIONS

1. Name three common household substances having *(Knowledge Base)*
(a) pH value greater than
(b) pH value less than 7
(c) pH value equal to 7

Ans: **COMMON HOUSEHOLD SUBSTANCES**

(a) pH Value Greater Than 7:
White wash, soap, shampoo, detergent etc
(b) pH Value Less Than 7:
Vinegar, citrus fruits, butter, apple etc
(c) pH Value Equal to 7:
Water, sodium chloride, sugar etc

2. Define a base and explain all alkalies are bases, but all bases are not alkalies.
(Understanding Base)

Ans: **BASE**

Definition:
*"A base is a substance that can **release OH^-** ions in **aqueous solution**, **accepts a proton** or **donates an electron pair** is called base".*

Examples:
- Sodium hydroxide : NaOH
- Potassium hydroxide : KOH

All Alkalies are Bases but All Bases are not Alkalies:
Water soluble base is called an alkali but some bases are not soluble in water, so all alkalies are bases but all bases are not alkalies.

3. Define Bronsted-Lowry base and explain with an example that water is a Bronsted Lowry base. *(Knowledge Base)* **(SGD 2017, FSD 2017)**

Ans: **BRONSTED-LOWRY BASE**

Definition:
"Bronsted Lowry base is a substance that can accept a proton (H^+) from another substance".

Water as Bronsted-Lowry Base:
When HCl dissolves in water HCl acts as an acid and H_2O as a base because it takes proton from HCl. In this reaction water is a base.

$$HCl_{(aq)} + H_2O_{(aq)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

4. How can you justify that Bronsted-Lowry concept of acid and base is applicable to non-aqueous solutions? *(Application Base)*

Ans: **APPLICATION OF BRONSTED-LOWRY CONCEPT**

According to Bronsted-Lowry concept

Acids:
"An acid is a substance that can donate a proton (H^+)".

Base:
"A base is substance that can accept a proton (H^+)".

This concept does not require an aqueous medium for an acid and base to ionize. This concept requires only two substances. One acts as an acid and the other acts as a base. It means an acid and base work together to transfer a proton.

$$HCl_{(aq)} + NH_{3(aq)} \rightarrow NH^+_{4(aq)} + Cl^-_{(aq)}$$

5. Which kind of a bond forms between a Lewis acid and a base? ***(Understanding Base)***

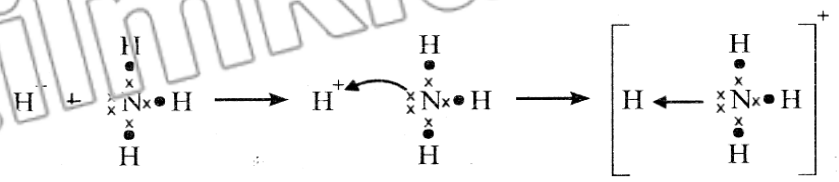
Ans:

KIND OF BOND

Coordinate covalent bond is formed between Lewis acid and base to form an adduct.

In this case **Lewis base donates** an **electron pair** and **Lewis acid accepts** that **electron pair.**

Example:



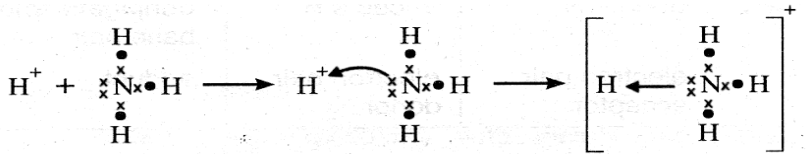
Lewis acid Lewis base Adduct

6. Why H^+ ion acts as a Lewis acid? ***(Understanding Base)*** **(SGD 2017, MTN 2016 G-II)**

Ans:

H^+ ION ACTS AS A LEWIS ACID

H^+ ion acts as a Lewis acid because it has an **empty orbital** that can accommodate a **pair of electron.**



Lewis acid Lewis base Adduct

7. Name two acids used in the manufacture of fertilizers. ***(Knowledge Base)***

(FSD 2016 G-II, SGD 2016 G-I)

Ans:

ACIDS TO MANUFACTURE OF FERTILIZERS

Acids used in the manufacture of fertilizers are:

(i) Nitric acid HNO_3

(ii) Sulphuric acid H_2SO_4

8. Define pH. What is the pH of pure water? ***(Knowledge Base)***

(LHR 2013, BWP 2017, SGD 2017, FSD 2017, MTN 2016 G-I, II)

Ans:

pH

Definition:

"pH is the negative logarithm of molar concentration of the hydrogen ions".

Mathematically,

$$pH = -\log[H^+]$$

pH of Pure Water:

The pH of pure water is 7

9. How many times a solution of pH = 1 will be stronger than that of a solution having pH = 2? ***(Understanding Base)*** **(LHR 2013)**

Ans:

STRENGTH OF SOLUTION

A solution of pH = 1 will be stronger than that of a solution having pH = 2 because the pH scale is logarithmic. A solution of pH = 1 has 10 times higher concentration of $[H^+]$ than that of a solution of pH =2.

10. Define the following: ***(Knowledge Base)*** **(LHR 2013)**

i. Normal salt ii. Basic salt

Ans: **DEFINITIONS**

(i) Normal Salt:

"A salt formed by the ***total replacement of ionizable*** H^+ *ions of an acid by a* ***positive metal ion*** *or* NH_4^+ *ion is called normal or neutral salt".*

These salts have no effect on litmus paper.

Example:

$$HCl_{aq} + KOH_{aq} \longrightarrow KCl_{aq} + H_2O$$

Acid Base Salt Water

(ii) Basic Salt:

"*A salt formed by the* ***incomplete neutralization*** *of a* ***polyhydroxy base*** *by an* ***acid.****"*

Example:

$$Al(OH)_{3(aq)} + HCl_{aq} \longrightarrow Al(OH)_2Cl_{(aq)} + H_2O$$

Base Acid Salt Water

11. Na_2SO_4 **is a neutral salt while** $NaHSO_4$ **is an acid salt. Justify.** ***(Understanding Base)***

Ans: **NEUTRAL SALT AND ACIDIC SALT**

Justification:

Na_2SO_4 is a neutral salt because it is formed by complete replacement of H^+ ions from an acid while $NaHSO_4$ is an acidic salt because it has one H^+ ion and is formed by the partial replacement of H^+ ions from an acid.

12. Give a few characteristic properties of salts. ***(Knowledge Base)***

(BWP 2016 G-II, DGK 2016 G-I)

Ans: **PROPERTIES OF SALTS**

The characteristic properties of salts are as follows:

Ionic Compounds:

Salts are ionic compounds found in crystalline form.

Melting and Boiling Points:

They have high melting and boiling points.

Water of Crystallization:

Most of the salts contain water of crystallization which is **responsible** for the **shape of the crystals**. The number of molecules of water is specific for each salt and they are written with the chemical formula of a salt.

Examples:

Copper sulphate $CuSO_4.5H_2O$; Calcium sulphate $CaSO_4.2H_2O$

13. How the soluble salts are recovered from water? ***(Understanding Base)***

Ans: **RECOVERY OF SOLUBLE SALTS**

The soluble salts are **recovered** from water by **evaporation** and **crystallization.** When salt solution is evaporated, water vaporizes leaving behind salt.

14. How the insoluble salts are prepared? ***(Knowledge Base)***
(SGD 2017, FSD 2016 G-II, BWP 2016 G-I)

Ans: **PREPARATION OF INSOLUBLE SALTS**

Insoluble slats are prepared by mixing **solutions of soluble salts**. During reaction exchange of ionic radicals takes place to produce **two new salts**. One of the salt is insoluble and other is soluble. The insoluble salt precipitates (solidifies in solution).

Example:

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow \mathbf{AgCl_{(s)}} + NaNO_{3(aq)}$$

15. Why a salt is neutral, explain with an example? ***(Understanding Base)*** **(FSD 2016 G-I)**

Ans: **SALT IS NEUTRAL**

Salts are neutral compounds although they do not contain equal member of positive and negative ions but they have positive and negative charges e.g.

$$NaCl \longrightarrow Na^{+} + Cl^{-}$$

$$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^{-}$$

16. Name an acid used in the preservation of food. ***(Knowledge Base)*** **(SGD 2017, FSD 2016 G-I)**

Ans: **ACID TO PRESERVE FOOD**

These are the acids used in preservation of food.

- Benzoic acid is used for food preservation
- Acetic acid is also used for preservation of food i.e. in pickles.

17. Name the acids present in: ***(Knowledge Base)*** **(FSD 2017, SGD 2017 G-I)**

i. Vinegar ii. Ant sting iii. Citrus fruit iv. Sour milk

Ans: **SOURCES OF ACIDS**

Following are the sources of acids:

Sr.No.	Source	Acid
(i)	Vinegar	Acetic acid
(ii)	Ant sting	Formic acid
(iii)	Citrus fruit	Citric acid
(iv)	Sour milk	Lactic acid

18. How can you justify that $Pb(OH)NO_3$ is a basic salt? ***(Application Base)*** **(SGD 2016 G-1)**

Ans: **$Pb(OH)NO_3$ IS A BASIC SALT**

$Pb(OH)NO_3$ is a basic slat because it is formed by the incomplete neutralization of a polyhydroxy base by an acid and it contains replaceable OH^{-1} ions.

Examples:

$$Pb(OH)_{2(aq)} + HNO_{3(aq)} \longrightarrow Pb(OH)NO_3 + H_2O$$

$$Pb(OH)NO_3 + HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$$

19. You are in a need of an acidic salt. How can you prepare it? ***(Application Base)***

Ans: **PREPARATION OF AN ACIDIC SALT**

An acidic salt is formed by partial replacement of replaceable H^{+} ions of an acid by a positive metal ion.

Examples:

$$H_2SO_{4(aq)} + KOH_{(aq)} \longrightarrow KHSO_{4(aq)} + H_2O_{(l)}$$

$$H_3PO_{4(aq)} + NaOH_{(aq)} \longrightarrow NaH_2PO_{4(aq)} + H_2O_{(l)}$$

20. Which salt is used to prepare Plaster of Paris? ***(Knowledge Base)***
(SGD 2016 G-II, 17, FSD 2016 G-I, 17)

Ans: **SALT USED FOR PLASTER OF PARIS**

Calcium sulphate or gypsum ($CaSO_4.2H_2O$) is used to prepare plaster of paris.

EXERCISE LONG QUESTIONS

Q.1 Define an acid and a base according to Bronsted-Lowry concept and justify with examples that water is an amphoteric compound.

Ans: See the LQ.1 (Topic 10.1.2)

Q.2 Explain the Lewis concept of acids and bases

Ans: See the LQ.1 (Topic 10.1.3)

Q.3 What is auto-ionization of water? How is it used to establish the pH of water?

Ans: See the LQ.1 (Topic 10.2)

Q.4 Define a salt and give the characteristic properties of salts.

Ans: See the LQ.1 (Topic 10.3)

Q.5 Explain with examples that how soluble salts are prepared?

Ans: See the LQ.2 (Topic 10.3.1)

Q.6 Give the characteristics of an acidic salt.

Ans: See the LQ.1 (Topic 10.3.2)

Q.7 Give four uses of calcium oxide.

Ans: See the SQ.1 (Topic 10.3.3)

Q.8 You are having a strong acid (HNO_3) and strong base (NaOH) on mixing

a. What type of salt you will have?

b. What type of this reaction will be?

c. Will it be soluble or insoluble?

d. If it is soluble, how it will be recovered?

Ans: **a.** When strong acid (HNO_3) and strong base (NaOH) react together normal or neutral slat is formed.

$$HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$$

b. This reaction will be neutralization reaction.

c. It will be a soluble salt.

d. This salt can be recovered by evaporation and crystallization process.

Q.9 Explain why:

a. HCl forms only one series of salts.

b. H_2SO_4 from two series of salts.

c. H_3PO_4 form three series of slats.

Give necessary equations.

Ans: **a.** HCl forms only one series of salts because it contains one ionizeable hydrogen ion.

$$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-$$

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

b. H_2SO_4 forms two series of salts because it contains two ionizeable hydrogen ions.

$$H_2SO_{4(aq)} \longrightarrow H^+_{(aq)} + HSO^-_{4(aq)}$$

$$HSO^-_{4(aq)} \longrightarrow H^+_{(aq)} + SO^{-2}_{4(aq)}$$

Examples:

$$KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow KHSO_{4(aq)} + H_2O_{(l)}$$

$$KHSO_{4(aq)} + KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$

c. HCl forms only one series of salts because it contains one ionizeable hydrogen ion.

$$H_2PO_{4(aq)} \longrightarrow H^+_{(aq)} + H_2PO^-_{4(aq)}$$

$$H_2PO^-_{4(aq)} \longrightarrow H^+_{(aq)} + HPO^{-2}_{4(aq)}$$

$$HPO^{-2}_{4(aq)} \longrightarrow H^+_{(aq)} + PO^{-3}_{4(aq)}$$

Examples:

$$NaOH_{(aq)} + H_3PO_{4(aq)} \longrightarrow NaH_2PO_{4(aq)} + H_2O_{(l)}$$

$$NaH_2PO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_2HPO_{4(aq)} + H_2O_{(l)}$$

$$Na_2HPO_{4(aq)} + NaOH_{(aq)} \longrightarrow Na_3PO_{4(aq)} + H_2O_{(aq)} + H_2O_{(l)}$$

Q.10 Classify the following salts as soluble or insoluble salts:
(i) Sodium chloride (ii) Silver nitrate (iii) Lead chloride (iv) Copper sulphate
(v) Barium sulphate (vi) Ammonium chloride
(vii) Sodium carbonate (viii) Calcium carbonate
(ix) Ferric chloride (x) Magnesium sulphate

Ans:

Sr. No.	Name of Salt	Solubility in Water
(i)	Sodium chloride	Soluble
(ii)	Silver nitrate	Soluble
(iii)	Lead chloride	Insoluble
(iv)	Copper sulphate	Soluble
(v)	Barium sulphate	Insoluble
(vi)	Ammonium chloride	Soluble
(vii)	Sodium carbonate	Soluble
(viii)	Calcium carbonate	Insoluble
(ix)	Ferric chloride	Soluble
(x)	Magnesium sulphate	Soluble

Q.11 Complete and balance the following equations:

- **Aluminium + Hydrochloric acid. ⟶ Aluminium chloride + Hydrogen gas**
- **Copper oxide + Sulphuric acid. ⟶ Copper sulphate + water**
- **Iron sulphide + Sulphuric acid. ⟶ Iron sulphate + hydrogen sulphide**
- **Ammonium chloride + Sodium hydroxide. ⟶ Sodium chloride + water + ammonia gas**
- **Ferric chloride + Sodium hydroxide. ⟶ Ferric hydroxide + sodium chloride**

Ans:

- Aluminium + Hydrochloric acid. ⟶ Aluminium chloride + Hydrogen gas
  $2Al + 2HCl \longrightarrow 2AlCl_3 + H_2\uparrow$
- Copper oxide + Sulphuric acid ⟶ Copper sulphate + water
  $CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$
- Iron sulphide + Sulphuric acid ⟶ Iron sulphate + hydrogen sulphide
  $FeS + H_2SO_4 \longrightarrow FeSO_4 + H_2S\uparrow$
- Ammonium chloride + Sodium hydroxide ⟶ Sodium chloride + water + ammonia gas
  $NH_4Cl + NaOH \longrightarrow NaCl + NH_3\uparrow + H_2O$
- Ferric chloride + Sodium hydroxide ⟶ Ferric hydroxide + sodium chloride
  $FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_3 + 3NaCl_{(aq)}$

EXERCISE NUMERICALS

(i) Calculate the pH and pOH of 0.2 M H_2SO_4.

Solution:

Given Data:

Molarity of H_2SO_4 solution = 0.2M

To Find:

pH of H_2SO_4 solution = ?

pOH of H_2SO_4 solution = ?

Calculations:

Ionization of H_2SO_4 in aqueous solution is as:

$$H_2SO_{4(aq)} \longrightarrow 2H^+_{(aq)} + SO^{-2}_{4\,(aq)}$$

1M 2M 2M

Therefore, 0.2 M sulphuric acid will produce 2× 0.02 M hydrogen ions.

Hence molar concentration of H^+ ions,

$= [H^+]$

$= 2\times 0.2$ M

$= 2\times 2 \times 10^{-1}$M

$= 4\times 10^{-1}$M

To find pH

$pH = -\log [H^+]$

$= -\log 4\times 10^{-1}$

$= -\log 4 + \log 10^{-1}$

$= -\log 4 - \log^{-1} 10$

$= -\log 4 + 1$

$= 1 - 0.602$

$pH = 0.398$

To find pOH

$pH + pOH = 14$

$pOH = 14 - PH$

$= 14 - 0.398$

$pOH = 13.602$

Result:

Thus pH and pOH of solution are 0.398 and 13.602 respectively.

(ii) Calculate the pH of 0.1 M KOH?

Solution:

Given Data:

Molarity of KOH solution = 0.1M

To find:

pH = ?

Calculations:

Ionization of KOH in aqueous solution is as follows.

$$KOH \longrightarrow K^+ + OH^{-1}$$

1M 1M 1M

Concentration of KOH = 0.1M

Concentration of OH^{-1} = 0.1M

$= 1\times 10^{-1}$M

In case of alkali or base first we have to calculate pOH of solution and then we calculate pH of solution.

$pOH = -\log [OH^-]$

$= -\log 1\times 10^{-1}(0.1)$

$= -\log 10^{-1}$

$pOH = -(-1) \log 10$

$pOH = 1$

To find pH

$pH + pOH = 14$

$pH = 14 - pOH$

$pH = 14 - 1$

$pH = 13$

Result:

Thus pH of solution is 13.

(iii) Calculate the pOH of 0.004 M HNO_3

Solution:

Given Data:

Molarity of HNO_3 solution = 0.004M

To find:

pOH = ?

Calculations:

Ionization of HNO_3 in aqueous solution is as follows:

$$HNO_3 \longrightarrow H^+ + NO_3^{-1}$$

1M 1M 1M

Therefore, 0.004 M HNO_3 will produce $1\times0.004M$ H^+ ions.

$[HNO_3]$ = 0.004 M

$= 4 \times 10^{-3}$ M

$[H^+]$ = 0.004M or

$= 4 \times 10^{-3}$ M

In case of an acid first we have to calculate the pH of solution.

$pH = -\log [H^+]$

$= -\log [4 \times 10^{-3}]$

$= -(\log 4 + \log 10^{-3})$

$= -\log 4 - \log 10^{-3}$

$= -\log 4 + 3 \log^{10}$

$= -\log 4 + 3$

$= 3 - \log 4$

$= 3 - 0.602$

pH = 2.398

To find pOH

pH + pOH = 14

pOH = 14 – PH

= 14 – 2.398

pOH = 11.602

Result:

Thus pOH of solution is 11.602.

(iv) Complete the following table.

Sr. No	Solution concentration	$[H^+]$	$[OH^-]$	pH	pOH
(i)	0.15 M HI	——	——	——	——
(ii)	0.040 M KOH	——	——	——	——
(iii)	0.020 M $Ba(OH)_2$	——	——	——	——
(iv)	0.00030 M $HClO_4$	——	——	——	——
(v)	0.55 M NaOH	——	——	——	——
(vi)	0.055 M HCl	——	——	——	——
(vii)	0.055 M $Ca(OH)_2$	——	——	——	——

Ans:

(i) 0.15 M HI:

Solution:

Given Data:

Molarity of HI solution = 0.15M

To find:

[H^+] = ?

pH = ?

pOH = ?

Calculations:

Ionization of HI in aqueous solution as follows.

$$HI \longrightarrow H^+ + I^-$$

1M 1M 1M

Hydrogen iodide produce one H+ ion.

To find $[H^+]$

$[H^+]$ = 0.15M

$= 15 \times 10^{-2}$M

To find pH

$pH = -\log [H^+]$

$= -\log [15\times10^{-2}]$

$= -(\log 15 + \log 10^{-2})$

$= -\log 15 - \log 10^{-2}$

$= -\log 15 + 2 \log 10$

$= \log 15 + 2$

$= 2 - \log 15$

pH = 2 – 1.18

pH = 0.82

To find pOH

pH + pOH = 14

pOH = 14 – POH

= 14 – 0.82

pOH = 13.12

Result:

Thus $[H^+]$ is 15×10^{-2}M and its pH and pOH values are 0.82 and 13.12, respectively.

(ii) 0.040 M KOH

Solution:

Given Data:

Molarity of KOH solution = 0.040M

To find:

$[H^+]$ = ?

$[OH^-]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of KOH in aqueous solution is as follows.

$KOH \rightarrow K^+ + OH^-$

1M 1M 1M

Therefore 0.040 M KOH produces 1×0.040M OH^- ions

To find $[OH^{-1}]$

[KOH] = 0.040M

$[OH^{-1}] = 0.040M$ or 4.0×10^{-2} M

To find pOH

$pOH = -\log [OH^-]$

$= -\log [4 \times 10^{-2}]$

$= -(\log 4 + \log 10^{-2})$

$= -\log 4 - \log 10^{-2}$

$= -\log 4 + 2$

$2 - \log 4$

pOH = 2 – 0.602

pOH = 1.40

To find pH

pH + pOH = 14

pH = 14 – pOH

= 14 – 1.40

pH = 12.60

Result:

Thus $[OH^{-1}]$ 0.040M or 4.0×10^{-2} M and its pH and pOH values are 12.60 and 1.40, respectively.

(iii) 0.020 M $Ba(OH)_2$:

Solution:

Given Data:

Molarity of $Ba(OH)_2$ solution = 0.020M

To find:

$[OH^-]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of $Ba(OH)_2$ in aqueous solution is as follows.

$Ba(OH)_2 \rightarrow Ba^{2+} + OH^-$

Therefore 0.020 M $Ba(OH)_2$ produces 1×0.020M OH^- ions.

To find $[OH^-]$

$[Ba(OH)_2] = 0.020$ M

$[OH^-] = 2 \times 2.0 \times 10^{-2}$

$= 4 \times 10^{-2}$

To find pOH

$pOH = -\log [OH^-]$

$= -\log [4 \times 10^{-2}]$

$= -(\log 4 + \log 10^{-2})$

$= -\log 4 - \log 10^{-2}$

$= -\log 4 + 2$

$= 2 - \log 4$

pOH = 2 – 0.602

pOH = 1.40

To find pH

pH + pOH = 14

pH = 14 – pOH

= 14 – 1.40

pH = 12.60

Result:

Thus $[OH^{-1}]$ is 4×10^{-2} M and its pH and pOH values are 12.60 and 1.40, respectively.

(iv) 0.00030 M $HClO_4$:

Solution:

Given Data:

Molarity of $HClO_4$ solution = 0.00030M

To find:

$[H^+]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of $HClO_4$ in aqueous solution is as follows.

$HClO_4 \rightarrow H^+ + ClO_4^-$

1M 1M 1M

Therefore 0.00030 M $HClO_4$ produces $1\times0.00030M$ H^+ ions

To find $[H^+]$

$[H^+] = 0.00030$ M

$= 3 \times 10^{-4}$ M

To find pOH

$pH = -\log [H^+]$

$= -\log [3\times10^{-4}]$

$= -(\log 3 + \log 10^{-4})$

$= -\log 3 - \log 10^{-4}$

$= -\log 3 + 4 \log 10$

$= \log 3 + 4$

$= 4 - 0.4771$

$pH = 3.5229$

To find pOH

$pH + pOH = 14$

$pOH = 14 - pH$

$pOH = 14 - 3.5229$

$pOH = 10.4771$

Result:

Thus $[H^+]$ is 0.00030 M or 3×10^{-4} M and its pH and pOH values are 3.5229 and 10.4771, respectively.

(v) 0.55 M NaOH:

Solution:

Given Data:

Molarity of NaOH solution = 0.55M

To find:

$[OH^-]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of NaOH in aqueous solution is as follows.

$NaOH \rightarrow Na^+ + OH^-$

Therefore 0.55 M NaOH produces 0.55 M OH^- ions

To find $[OH^-]$

$[OH^-] = 0.55$ M

$OH^- = 0.55 \times 10^{-2}$

To find pOH

$pOH = -\log [OH^-]$

$= -\log [55 \times 10^{-2}]$

$= -(\log 55 + \log 10^{-2})$

$= -\log 55 - \log 10^{-2}$

$= -\log 55 + 2$

$= 2 - \log 55$

$pOH = 2 - 1.74$

$pOH = 0.26$

To find pH

$pH + pOH = 14$

$pH = 14 - pOH$

$= 14 - .26$

$pH = 13.74$

Result:

Thus $[OH^-]$ of solution is 0.55×10^{-2} M and its pH and pOH values are 13.74 and 0.26, respectively.

(vi) 0.055 M HCl:

Solution:

Given Data:

Molarity of HCl solution = 0.055M

Fo Find:

$[H^+]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of HCl in aqueous solution is as follows.

$HCl \rightarrow H^+ + Cl^-$

1M 1M 1M

Therefore 0.055 M HCl produces 0.055 M H^+ ions

Hydrochloric acid produces one H+ ion.

To find $[H^+]$

$[H^+] = 0.055$ M

$= 5.5 \times 10^{-2}$ M

To find pH

$pH = -\log [H^+]$

$= -\log [5.5 \times 10^{-2}]$

$= -(\log 5.5 + \log 10^{-2})$

$= -\log 5.5 - \log 10^{-2}$

$= -\log 5.5 + 2 \log 10$

$= \log 5.5 + 2$

$= 2 - 0.74$

$pH = 1.26$

$pH = 1.26$

To find pOH

$pH + pOH = 14$

$pOH = 14 - pH$

$pOH = 14 - 1.26$

$pOH = 12.74$

Result:

Thus $[OH^-]$ of solution is 0.55×10^{-2} M and its pH and pOH values are 1.26 and 12.74, respectively.

(vii) 0.055M $Ca(OH)_2$:

Solution:

Given Data:

Molarity of $Ca(OH)_2$ solution = 0.055M

To find:

$[OH^-]$ = ?

pH = ?

pOH = ?

Calculations:

Ionization of $Ca(OH)_2$ in aqueous solution is as follows.

$Ca(OH)_2 \rightarrow Ca^{2+} + OH^-$

Therefore 0.055 M $Ca(OH)_2$ produces 0.055 M OH^- ions

To find $[OH^-]$

$[Ca(OH)_2] = 0.055$ M

$[OH^-] = 2 \times 5.5 \times 10^{-2}$

$= 11 \times 10^{-2}$ M

To find pOH

$pOH = -\log [OH^-]$

$= -\log (11 \times 10^{-2})$

$= -(\log 11 + \log 10^{-2})$

$= -\log 11 - \log 10^{-2}$

$= -\log 11 + 2$

$= 2 - \log 11$

$pOH = 2 - 1.04$

$pOH = 0.96$

To find pH

$pH + pOH = 14$

$pH = 14 - pOH$

$= 14 - 0.96$

$pH = 13.04$

Result:

Thus $[OH^-]$ of solution is 11×10^{-2} and its pH and pOH values are 13.04 and 0.96, respectively.

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 Why it is preferable to use pH meter over universal indicator?

Ans: **Preference to pH meter**

Althrough universal indicator is often more convenient preference is given to pH meter because it is much more reliable and accurate method of measuring pH. The pH meter consists of pH electrode connected to meter which shows pH either on scale or digitally when dipped into the solution and give precise value.

Q.2 Why HCl can make only one type of salt whereas H_2SO_4 can make two series of salts?

Ans: **HCl vs H_2SO_4**

HCl is a **monobasic acid** i.e it has only one replaceable H^+ ion, therefore it gives only one type of salt.

$$HCl \rightarrow H^+ + Cl^-$$

For example. $$HCl + KOH \rightarrow H_2O + KCl$$

Conversely, H_2SO_4 is **dibasic acid** i.e. it has two replaceable H^+ ions. It dissocates in two stages.

$$(i)\ H_2SO_{4(aq)} \rightarrow H^+ + HSO_4^-$$

$$(ii)\ HSO_{4(aq)}^- \rightarrow H^+ + SO_4^{-2}$$

Hence, it gives two series of salts.

Example: $$H_2SO_{4(aq)} + KOH_{(aq)} \rightarrow KHSO_4 + H_2O$$

(Acidic salt)

$$KHSO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O$$

(Normal salt)

Q.3 Why NaOH can make only one type of salt whereas $Al(OH)_3$ can make three series of salts?

Ans: **NaOH vs $Al(OH)_3$**

NaOH has only "1" replaceable hydroxide ion (OH^-) which results in formation of one type of salt.

$$NaOH \rightarrow Na^+ + OH^-$$

Eg. $$NaOH + HCl \rightarrow NaCl + H_2O$$

Conversely, $Al(OH)_3$ is a polyhydroxy base. It has 3 replaceable OH^- ions. It dissociates as follows:

$$Al(OH)_3 \rightarrow Al^{+3} + 3OH^-$$

Therefore, it gives three series of salts.

$$Al(OH)_3 + HCl \rightarrow Al(OH)_2Cl + H_2O$$

Basic Salt

$$Al(OH)_2Cl + HCl \rightarrow Al(OH)Cl_2 + H_2O$$

Basic Salt

$$Al(OH)Cl_2 + HCl \rightarrow AlCl_3 + H_2O$$

Normal Salt

Q.4 Why the precipate of same heavy metal give different colours?

Ans: Heavy metals are transition elements. There hydroxides give different colours of precipitates at **different oxidation states**.

E.g $FeSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + Fe(OH)_{2(s)}$

Dirty green ppt.

$FeCl_{3(aq)} + 3NaOH_{(aq)} \rightarrow 3NaCl_{(aq)} + Fe(OH)_{3(s)}$

Brown ppt.

Q.5 Differentiate between Acid and Basic radical.

Ans: **DIFFERENTIATE**

Acid Radical	Basic Radical
Definition: An anion is non-metallic ion derived from acid, therefore, it is called acid radical.	**Definition:** A cation is metallic ion and derived from a base, therefore, it is called basic radical.
Example: $NaOH + HCl \rightarrow NaCl + H_2O$ In this reaction Cl^- is an acid radical.	**Example:** $NaOH + HCl \rightarrow NaCl + H_2O$ In this reaction Na^+ is a basic radical.

Q.6 Why Bronsted acids are not lewis acids?

Ans: Bronsted acids can donate a proton to another substance whereas lewis acids are those that can accept a pair of electrons. All bronsted acids are not lewis acids because all proton donating species do not have tendency to accept electron pair.

Example:

- H_2SO_4
- HNO_3
- HCl

They can dissociate to give proton but cannot accept an electron pair.

Q.7 Find pH of 0.01M of H_2SO_4 and 0.001M of H_2SO_4. Which solution is more concentrated and why?

Ans: **pH of H_2SO_4**

Given Data:
(i) 0.01M H_2SO_4
(ii) 0.001M H_2SO_4
Required: pH = ?

Calculation:

(i) For 0.01M H_2SO_4

$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$

$2[H^+] = 2 \times 0.01 = 2 \times 10^{-2} M$

$pH = -\log[H^+]$

$= -\log[2 \times 10^{-2}]$

$= -\log 2 + 2\log 10$

$= 2\log 10 - \log 2$

$= 2 - \log 2$

$= 2 - 0.3010$

$= 1.7$

(ii) For 0.001M H_2SO_4

$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$

$2[H^+] = 2 \times 0.001 = 2 \times 10^{-3} M$

$pH = -\log[H^+]$

$= -\log[2 \times 10]^{-3}$

$= -\log 2 + 3\log 10$

$= 3\log 10 - \log 2$

$= 3 - 0.3010$

$= 2.7$

Conclusion

- 0.01 M H_2SO_4 is more concentrated due to larger value of molarity compared to 0.001M solution.
- Smaller value of pH of 0.01M H_2SO_4 make it more concentrated then 0.001M H_2SO_4.

Q.8 Differentiate between to the Acidic Salt and Basic Salt.

Ans: **DIFFERENTIATE**

Acidic Salt	Basic Salt
Definition: These salts are formed by partial replacement of replaceable H^+ ions of an acid by a positive metal ion. **Presence of Ion:** H^+ ion is present in it. **Example:** • $KHSO_4$ • $NaHPO_4$	**Definition:** These salts are formed by the incomplete neutralization of polyhydroxy base by an acid. **Presence of Ion:** OH^- ion is present in it. **Example:** • $Al(OH)_2Cl$ • $Zn(OH)NO_3$

Q.9 Differentiate between to the Double Salt and Complex Salt.

Ans: **DIFFERENTIATE**

Double Salt	Complex Salt
Definition: These salts are formed by two normal salts when they are crystallized from a mixture of equimolar saturated solution. **Example:** • $K_2SO_4.Al_2(SO_4)_3.24H_2O$ • $K_2SO_4.Fe_2(SO_4)_3.24H_2O$	**Definition:** The salts which on dissociation provides a simple cation and complex anion or vice versa. **Example:** • Potassium Ferrocyanide $K_4[Fe(CN)_6]$

Q.10 Why salts have high melting and boiling points?

Ans: Salts have high melting and boiling points because there exist strong electrostatic force of attraction between opposite charged ions.

Q.11 What is Soda lime? For what purpose it is used?

Ans: Mixture of CaO and NaOH is called Soda lime. For purification of sugar, it is used to remove carbon dioxide and water vapours from air.

Q.12 Differentiate between Conjugate Acid and Conjugate Base.

Ans: **DIFFERENTIATE**

Conjugate Acid	Conjugate Base
Definition: A conjugate acid is a specie formed by accepting a proton by a base. **Example:** • $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ Acid Base Conjugate Acid	**Definition:** A conjugate base is a specie formed by donating a proton by an acid. **Example:** • $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ Acid Base Conjugate Base

NOTE: *Every acid produces a Conjugate Base and every base produces a conjugate acid.*

Q.13 Why HS^{-1} is amphoteric but SO_4^{2-} is not?

Ans: Amphoteric substance can act as acid as well as base. HS^{-1} is amphoteric because it can act as acid by donating H^+ ion and become S^{2-} whereas, it can also accept H^+ ion and act as base to form H_2S, on the other hand SO_4^{2-} cannot donate a proton therefore it cannot act as an acid. It can only act as a base therefore it is not amphoteric substance.

Q.14 Give conjugate base of $[Al(H_2O)_6]^{3+}$ and conjugate acid of HPO_4^{2-}.

Ans: Conjugate Base of $[Al(H_2O)_6]^{3+}$: $[Al(H_2O)_5OH]^{2+}$

Conjugate Acid of HPO_4^{2-} : $H_2PO_4^{1-}$

Q.15 Justify bronsted bases are also lewis bases.

Ans: Bronsted bases are also lewis bases, For example $NH_3.NH_3$ is bronsted base as it can accept a proton, it is also lewis base as NH_3 contains lone pair of electrons and according to lewis concept, base is a substance which cn donate a pair of electrons, hence we can say that all bronsted bases are also lewi bases.

Q.16 Define water of crytallization.

Ans: The number of water molecules present in the crystals of a substance are called water of crystallization.

Example: $CaSO_4.2H_2O$

Q.17 How acidic salts are turned into normal salts?

Ans: Acidic salts are turned into normal salts by the reaction of acidic salts with its parent base.

$$KHSO_{4(aq)} + KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + H_2O_{(l)}$$

TERMS TO KNOW

Terms	Definitions
Arrhenius Acid	Acid is a substance which dissociates in aqueous solution to give hydrogen ions.
Arrhenius Base	Base is a substance which dissociates in aqueous solution to give hydroxide ions.
Bronsted-Lowry Acid	An acid is a substance (molecule or ion) that can donate a proton (H^+) to another substance.
Bronsted-Lowry Base	A base is a substance that can accept a proton (H^+) from another substance.
Amphoteric Specie	A substance that can act as an acid as well as a base is called amphoteric specie.
A Conjugate Acid	A conjugate acid is a specie formed by accepting a proton by a base.
A Conjugate Base	A conjugate base is a specie formed by donating a proton by an acid.
Lewis Acid	An acid is a substance (molecule or ion) which can accept a pair of electrons
Lewis Base	A base is a substance (molecule or ion) which can donate a pair of electrons.
Lewis Concept of Neutralization	A neutralization reaction according to Lewis concept is donation and acceptance of a electron pair to form a coordinate covalent bond in an adduct.
pH Scale	A logarithmic scale which is used to determine the pH of a solution is called pH scale. pH is the negative logarithm of molar concentration of the hydrogen ions.
pH	pH is the negative logarithm of molar concentration of the hydrogen ions.
Autoionization	Water is a weak electrolyte because it ionizes very slightly into ions in a process called autoionization or self ionization.
Universal Indicator	The mixture of indicators which gives different colours at different pH values is called universal indicator or pH indicator.
pH Meter	A pH meter is an instrument which is used to measure the pH of a solution.
Salts	Salts are ionic compounds generally formed by the neutralization of an acid with a base.
Basic Radical	A cation is metallic and derived from a base, therefore, it is called basic radical.
Acid Radical	An anion is derived from acid, therefore, it is called acid radical.
Acidic Salt	These salts are formed by partial replacement of a replaceable H^+ ions of an acid, by a positive metal ion.
Double Salts	Double salts are formed by two normal salts when they are crystallized from a mixture of equimolar saturated solutions.
Mixed Salts	Mixed salts contain more than one basic or acid radicals.
Complex Salts	Complex salts on dissociation provide a simple cation and a complex anion or vice versa.

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. (6×1=6)

1. Acetic acid is used for:

(A) Flavouring food (B) Making explosives

(C) Etching designs (D) Cleaning metals

2. What is the pOH of 0.02 M $Ca(OH)_2$?

(A) 1.698 (B) 1.397

(C) 12.31 (D) 12.61

3. Which one is a Lewis acid?

(A) BF_3 (B) $AlCl_3$

(C) $FeCl_3$ (D) All of above

4. pH value normally varies from:

(A) 0 – 14 (B) 1 – 14

(C) 7 – 14 (D) 10 – 14

5. Which salt is used as a table salt?

(A) NaCl (B) $NaCO_3$

(C) Na_2SiO_3 (D) $NaHCO_3$

6. Which is used as cleaning agent for domestic and commercial purposes?

(A) NaCl (B) $Na_2CO_3.10H_2O$

(C) $NaHCO_3$ (D) Na_2SiO_3

Q.2 Give short answers to the following questions. (5×2=10)

(i) Prove that water is an amphoteric specie.

(ii) How can you prepare hydrogen sulphide gas?

(iii) Describe the reaction of bases with ammonium salts.

(iv) Define the pH. What is pH of pure water?

(v) What H^+ act as Lewis acids?

Q.3 Answer the following questions in detail. (5+4=9)

(i) Explain the preparation of salts. **(5)**

(ii) Explain the Lewis concept of acids and bases. **(4)**

NOTE: Parents or guardians can conduct this test in their supervision in order to check the skill of students.