2. ACIDS, BASES & SALTS

■ Acids

- According to Arrhenius theory, "An acid is a substance which when dissolved in water, ionizes and releases hydrogen ions [$H^+(aq)$] in solution".

Example,

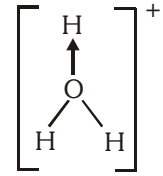
(i) $HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$

Hydrochloric acid Hydrogen ion Chloride ion

or $HCl(g) + H_2O(\ell) \longrightarrow H_3O^+(aq) + Cl^-(aq)$

(ii) $H_2SO_4(aq) \longrightarrow 2H^+(aq) + SO_4^{2-}(aq)$

Sulphuric acid Hydrogen ion Sulphate ion



Hydronium ion

- Hydrogen ion do not exist as H^+ ions in solution, they attach themselves to the polar water molecules to form hydronium ions (H_3O^+ or $H^+(aq)$) $H^+ + H_2O \rightarrow H_3O^+$.

● Properties of acid

- On the basis of sources can be classified as organic or inorganic.
- On the basis of number of displaceable H^+ ions (basicity) per molecule, can be classified as monobasic, dibasic or tribasic. Eg. HCl, H_2SO_4 and H_3PO_4 respectively.
- On the basis of degree of ionisation, can be classified as strong or weak acid. Eg. HCl and CH_3COOH respectively.
- On the basis of concentration, can be classified as concentrated and dilute acids.

■ Bases

- According to Arrhenius theory "Those substances which give hydroxide or hydroxyl ion (OH^-) in their aqueous solution are called bases".

Examples, (i) $NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)$

Sodium hydroxide Sodium ion Hydroxyl ion

(ii) $KOH(aq) \longrightarrow K^+(aq) + OH^-(aq)$

Potassium hydroxide Potassium ion Hydroxyl ion

● Properties of bases

- On the basis of number of hydroxyl ion (OH^-) produced (acidity), can be of classified as monoacidic, diacidic or triacidic bases. Eg. NaOH, $Ca(OH)_2$ & $Al(OH)_3$ respectively.
- On the basis of degree of ionization, can be classified as strong base and weak base. Eg. NaOH & NH_4OH respectively.
- On the basis of concentration, can be classified as concentrated or dilute bases.

■ Chemical properties of acids & bases

● Indicators

- China rose is a flower which has pink petals. The coloured solution extracted from it is light pink colour. When used as an indicator, its colour changes to green in basic solution and dark pink colour (magenta) in acidic solutions. In neutral solutions, there is no change in colour.

- Litmus solution is a purple dye, which is extracted from lichens. Its colour is purple in a neutral solution.
- Other natural materials like red cabbage leaves, turmeric, coloured petals of Hydrangea, Petunia and Geranium are also used as indicators.

Indicator	Change in acidic medium	Change in basic medium
Blue litmus paper	Blue to Red	Red to Blue
Methyl orange	Orange to red	Orange to yellow
Phenolphthalein	Remains colourless	Colourless to pink
Turmeric paper	No change in colour	Yellow to red brown

■ Reaction of Acids & Bases with Metals

Metal + Acid $\longrightarrow$ Metal Salt + $H_2(\uparrow)$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

Metal + Alkali $\xrightarrow{\text{warm}}$ Metal Salt + $H_2(\uparrow)$

$Zn + 2NaOH \xrightarrow{\text{warm}} Na_2ZnO_2 + H_2(\uparrow)$

- Al, Sn, Pb, Zn form $NaAlO_2$, Na_2SnO_2, Na_2PbO_2 and Na_2ZnO_2, respectively with NaOH (alkali).
- Evolved H_2 gas is tested with a burning splinter. It burns with a pop sound.

■ Reaction of Acid with Metal Carbonates/Hydrogen Carbonates

Metal Carbonate/Metal hydrogen carbonate + Acid $\longrightarrow$ Salt + Carbon dioxide + Water

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

$NaHCO_3 + HCl \longrightarrow NaCl + CO_2 + H_2O$

- Evolved CO_2 gas turns lime water milky.

  $Ca(OH)_2 + CO_2(g) \longrightarrow CaCO_3(s) + H_2O(\ell)$

  lime water calcium carbonate (insoluble white ppt.)
- On passing excess CO_2, the solution becomes clear due to conversion of insoluble $CaCO_3$ into soluble calcium hydrogen carbonate.

$CaCO_3(s) + H_2O(\ell) + CO_2(g) \longrightarrow Ca(HCO_3)_2(aq)$

Calcium hydrogen carbonate
(Soluble in water)

■ Reaction of Acids with Bases

Acid + Base $\longrightarrow$ Salt + H_2O

(i) $HCl + NaOH \longrightarrow NaCl + H_2O$

(ii) $\mathbf{CO_2} + Ca(OH)_2 \longrightarrow CaCO_3 + H_2O$

(iii) $H_2SO_4 + \mathbf{MgO} \longrightarrow MgSO_4 + H_2O$

- All reactions take place in aqueous solutions.
- Reaction (ii) and (iii) suggest that non-metallic oxides are generally acidic and metallic oxides are generally basic in nature.
- These reactions are generally exothermic.

All acids release H^+ ion in their aqueous solutions. H^+ ion released combines with H_2O and form hydronium ion (H_3O^+). The separation of H^+ ion from an acid molecule cannot occur in the absence of water. Hence, acids show acidic character only in presence of water.

- As acids and bases dissociate into ions they conduct electricity in their aqueous solution.
- As dilution of acids or bases occur, concentration of ions (H_3O^+/OH^-) per unit volume decreases.

pH scale

- A scale for measuring hydrogen ion concentration in a solution, called pH scale has been developed. The p in pH stands for '*potenz*' in German,meaning power. On the pH scale we can measure pH from 0 (very acidic) to 14 (very alkaline). pH should be thought of simply as a number which indicates the acidic or basic nature of a solution. Higher the hydronium ion concentration, lower is the pH value. The pH of a neutral solution is 7. Values less than 7 on the pH scale represent an acidic solution. As the pH value increases from 7 to 14, it represents an increase in OH^- ion concentration in the solution, that is, increase in the strength of alkali. Generally paper impregnated with the universal indicator is used for measuring pH.
- The strength of acids and bases depends on the number of H^+ ions and OH^- ions produced, respectively. If we take hydrochloric acid and acetic acid of the same concentration, say one molar, then these produce different amounts of hydrogen ions. Acids that give rise to more H^+ ions are said to be strong acids, and acids that give less H^+ ions are said to be weak acids.
- Solutions with pH = 0-3 are strongly acidic, with pH = 3–5 are moderately acidic while with pH = 5–7 are weakly acidic.
- Solution with pH = 7–9 are weakly basic, with pH = 9–12 are moderately basic while with pH = 12–14 are strongly basic.
- If pH = 7, then the solution is neutral. It is expressed as $pH = -\log_{10}[H^+]$.

Importance of pH in everyday life

- **Plants and animals are pH sensitive:** All living organisms are pH sensitive. e.g. human body works in a narrow pH range of 7.0 to 7.8. Aquatic life gets disturbed due to acid rain (pH below 5.6) when pH of water bodies falls.
- **Soil pH and plants :** Different plants prefer different pH range for their growth. Soil should be treated with suitable material (acidic/basic) accordingly to obtain required pH of the soil. Acidic soil can be treated with CaO, $Ca(OH)_2$ or $CaCO_3$ while basic soil can be treated with manure or compost.
- **Importance of pH in our digestive system:** The acid produced in our stomach kills the bacteria & germs. Excess of acid produced (due to overeating) causes acidity. Antacid such as $Mg(OH)_2$, $NaHCO_3$, etc., relieves us from such pains.
- **pH change as the cause of tooth decay:** pH of our mouth is > 7. Food, left in our mouth after eating; gets degraded by bacterial action. This results in lowering the pH to 5.5 (acidic). The acid so formed reacts with calcium phosphate and causes tooth enamel to corrode. Therefore, usage of toothpaste (base) neutralizes excess of acid and prevents tooth decay.
- **Self defence by animals and plants through chemical warfare:** Sting of honey bees containing formic acid can be neutralized by applying baking soda paste. Also, hair present on nettle leaves inject methanoic acid into the skin which can be neutralized by either applying baking soda or extract of dock plant leaves which grows beside nettle plant.

Salts

Salts are the ionic compounds consisting of two parts, one part carrying a positive charge called positive ion or **cation** and the other part carrying a negative charge called a negative ion or **anion**.

- The nature of acid and base produced when salt reacts with water, the salts can be classified into the following four types.

	Salt + Water ⟶	Acid + Base	Nature of salt
1.	$NaCl + H_2O \longrightarrow$	HCl (Strong acid) + NaOH (Strong base)	Both acids & base are strong. ∴, salt is neutral Hence, pH = 7
2.	$NH_4Cl + H_2O \longrightarrow$	HCl (Strong acid) + NH_4OH (Weak base)	Acid is strong. ∴, salt is acidic. Hence, pH < 7
3.	$Na_2CO_3 + H_2O \longrightarrow$	H_2CO_3 (Weak acid) + NaOH (Strong base)	Base is strong. ∴, salt is basic. Hence, pH > 7
4.	$CH_3COONH_4 + H_2O \longrightarrow$	CH_3COOH (Weak acid) + NH_4OH (Weak base)	Both acid & base are weak. ∴, salt is neutral. Hence, pH ≈ 7

■ Chemicals from common salt (NaCl)

● NaOH - Chloralkali process

NaCl + H_2O Brine —Electric current→

- Anode: Cl_2 + $Ca(OH)_2$ (dry slaked lime) ⟶ $CaOCl_2$ (Bleaching powder) + H_2O
- Cathode: H_2 + Cl_2 ⟶ 2HCl
- Near Cathode: NaOH + Cl_2 ⟶ NaOCl (Bleach)

▸ Uses of Bleaching powder

(i) for bleaching cotton and linen in the textile industry, for bleaching of wood pulp in paper factories and for bleaching washed clothes in laundry;

(ii) as an oxidising agent in many chemical industries; and

(iii) for disinfecting drinking water to make it free of germs.

● Baking soda - $NaHCO_3$ & Washing soda - Na_2CO_3 - Solvay's process or ammonia - soda process.

Step I: $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$ (g) (CO_2 used in this process is prepared from $CaCO_3$)

$$NaCl + H_2O + NH_3 + CO_2 \longrightarrow NH_4Cl(aq) + NaHCO_3(s)$$

▸ Uses of sodium hydrogencarbonate ($NaHCO_3$)

(i) For making baking powder, which is a mixture of baking soda (sodium hydrogencarbonate) and a mild edible acid such as tartaric acid. When baking powder is heated or mixed in water, the following reaction takes place

$NaHCO_3 + H^+ \longrightarrow CO_2 + H_2O$ + Sodium salt of acid
(From any acid)

Carbon dioxide produced during the reaction causes bread or cake to rise making them soft and spongy.

(ii) Sodium hydrogencarbonate is also an ingredient in antacids. Being alkaline, it neutralises excess acid in the stomach and provides relief.

(iii) It is also used in soda-acid fire extinguishers.

$NaHCO_3$ can be used to neutralize an acid because it is mild non-corrosive base due to the presence of HCO^-_3 ion.

$NaHCO_3$ produced in **Step I** is used in **Step II**.

Step II: $NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Anhydrous sodium carbonate (soda ash)

Step III: $Na_2CO_3(s) + H_2O(l) \longrightarrow Na_2CO_3\,(aq) \xrightarrow{\text{crystallization}} Na_2CO_3.10H_2O$

(Anhydrous sodium carbonate) (Washing soda) (Sodium carbonate deca hydrate)

- **Uses of washing soda**

(a) Washing soda (or sodium carbonate) is used for washing clothes (laundry purposes).

(b) Washing soda is used for softening hard water.

(c) Sodium carbonate (soda ash) is used for the manufacture of detergents.

(d) Sodium carbonate is used for the manufacture of many important compounds, such as borax ($Na_2B_4O_7$), hypo ($Na_2S_2O_3 \cdot 5H_2O$), etc.

(e) Sodium carbonate is also used in paper, glass, soap and paint industries.

■ Are the crystals of salts really dry ?

Crystals of some salts contain certain amount of associated water. The water associated with the crystal (or molecule) of any salt is called water of crystallisation. The salt containing water of crystallisation are called **hydrated salts**.

Water of crystallization is the fixed number of water molecules present in one formula unit of a crystalline salt.

e.g., $CuSO_4.\,5H_2O$ (blue), $FeSO_4.\,7H_2O$ (green).

- Crystalline salts on heating loose their water of crystallization. This can be seen by observing the colour change in the compound on heating.

e.g. $CuSO_4.\,5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$

(Blue) (White)

■ Plaster of Paris ($CaSO_4.1/2H_2O$)

$\begin{matrix} CaSO_4 \\ CaSO_4 \end{matrix}\!\!\diagdown\!\!\diagup H_2O$ Calcium sulphate hemihydrate

$2[CaSO_4.2H_2O] \xrightarrow[\Delta]{373K} (CaSO_4)_2.H_2O + 3H_2O$

Gypsum Plaster of Paris

- Gypsum requires controlled heating at 373 K to avoid complete loss of water resulting into $CaSO_4$ (anhydrous calcium sulphate) which does not set into a hard mass when water is mixed.

$CaSO_4.\frac{1}{2}H_2O + \frac{3}{2}H_2O \longrightarrow CaSO_4.2H_2O$

Plaster of Paris Water Gypsum(Hard mass)

$CaSO.2H_2O \xrightarrow[373K]{\text{More than}} CaSO_4 + 2H_2O$

Anhydrous calcium sulphate or Dead burnt plaster

- **Properties of Plaster of Paris**

(1) Plaster of Paris is a white, odourless powder.

(2) At room temperature, Plaster of Paris absorbs water and a large amount of heat is liberated.

(3) When mixed with a limited amount of water (50% by mass), it forms a plastic mass, evolves heat and quickly sets to a hard porous mass within minutes. This is called the **setting process**.

During setting, a slight expansion in volume occurs. It is due to this that it fills the mould completely and gives sharp impression. The reaction during process is

$$CaSO_4 . \frac{1}{2}H_2O(s) + \frac{3}{2} H_2O(\ell) \rightarrow CaSO_4 . 2H_2O(s)$$

Plaster of Paris Water Gypsum (Hard mass)

- **Uses of Plaster of Paris**

(1) Plaster of Paris is used in making casts and patterns for moulds and statues.

(2) Plaster of Paris is used as cement in ornamental casting and for making decorative materials.

(3) Plaster of Paris is used as a fire proofing material and for making chalks.

(4) Plaster of Paris is used in hospitals for immobilising the affected part in case of bone fracture or strain.

(5) Plaster of Paris (POP) is used to fill small gaps on walls & roofs.

1. Which of the following is a strong acid ?
(1) Lactic acid (2) Ascorbic acid
(3) Sulphuric acid (4) Formic acid

2. Which of the following is a strong acid ?
(1) H_2CO_3 (2) CH_3COOH
(3) HCl (4) HCOOH

3. Which of the following is a dibasic acid ?
(1) HCl (2) H_3PO_4
(3) HNO_3 (4) H_2SO_4

4. Acetic acid is a weak acid because
(1) its aqueous solution is acidic
(2) it is highly ionized
(3) it is weakly ionized
(4) it contains –COOH group

5. The incorrect statement about acids is
(1) they give H^+ ion in water
(2) they are sour in taste
(3) they turn blue litmus red
(4) they give pink colour with phenolphthalein

6. Choose an example of inorganic acid (mineral acid) from the following
(1) Oxalic acid (2) Acetic acid
(3) Nitric acid (4) Formic acid

7. Slaked lime is prepared by adding water to
(1) bleaching powder (2) lime water
(3) milk of lime (4) quicklime

8. Which of the following is not basic in nature ?
(1) KOH (2) ZnO
(3) $Al(OH)_3$ (4) NaCl

9. Which of the following is not basic in nature ?
(1) KOH (2) $Ca(OH)_2$
(3) K_2SO_4 (4) ZnO

10. Mark the correct statement.
(1) Both bases and alkalies are soluble in water.
(2) Alkalies are soluble in water but all bases are not.
(3) C_2H_5OH is a base because it has OH group.
(4) Bases are soluble in water but alkalies are not.

11. Acidity of ammonium hydroxide is
(1) 1 (2) 2 (3) 4 (4) 3

12. Which of the following is the weakest base ?
(1) NaOH (2) $Ca(OH)_2$
(3) NH_4OH (4) KOH

13. Which one of the following will turn red litmus blue?
(1) Vinegar (2) Baking soda solution
(3) Lemon juice (4) Soft drinks

14. Which of the following statements is true regarding acids and bases ?
(1) Acid and bases don't react with each other
(2) Acids mixed with bases neutralise each other
(3) Acids mixed with bases make stronger acids
(4) Acids mixed with bases make stronger bases

15. A blue litmus paper was first dipped in dil. HCl and then in dil. NaOH solution. It was observed that the colour of the litmus paper
(1) changed to red
(2) changed first to red and then to blue
(3) changed blue to colourless
(4) remained blue in both the solutions

16. Phenolphthalein is
(1) yellow in acidic medium, pink in basic medium
(2) pink in acidic medium, colourless in basic medium
(3) colourless in acidic medium, pink in basic medium
(4) pink in acidic medium, yellow in basic medium

17. When dilute hydrochloric acid is added to granulated zinc placed in a test tube, the observation made is that
(1) the surface of the metal turns shining
(2) the reaction mixture turns milky
(3) odour of chlorine is observed
(4) a colourless and odourless gas is evolved with bubbles

18. The reaction of metal with acid results in the formation of
(1) only hydrogen gas
(2) only salt
(3) both salt and hydrogen gas
(4) None of these

19. When zinc reacts with sodium hydroxide, the products formed are

(1) zinc hydroxide and sodium

(2) sodium zincate and water

(3) sodium zincate and hydrogen gas

(4) sodium zincate and oxygen

20. Which of the following metals can displace hydrogen from the aqueous solution of sodium hydroxide ?

(1) Mg (2) Cu (3) Al (4) Ag

21. Which gas is evolved when acids react with metal carbonates ?

(1) CO_2 (2) H_2 (3) NH_3 (4) O_2

22. Acetic acid was added to a solid X kept in a test tube. A colourless and odourless gas was evolved. The gas was passed through lime water which turned milky. It was concluded that

(1) solid X is sodium hydroxide and the gas evolved is CO_2

(2) solid X is sodium bicarbonate and the gas evolved is CO_2

(3) solid X is sodium acetate and the gas evolved is CO_2

(4) solid X is sodium chloride and the gas evolved is CO_2

23. When CO_2 is passed through lime water, it turns milky. The milkiness is due to formation of

(1) $CaCO_3$ (2) $Ca(OH)_2$

(3) H_2O (4) CO_2

24. A solution reacts with crushed egg-shells to give a gas that turns lime-water milky. The solution contains

(1) NaCl (2) HCl

(3) LiCl (4) KCl

25. $CuO + (X) \rightarrow CuSO_4 + H_2O$. Here (X) is

(1) $CuSO_4$ (2) HCl

(3) H_2SO_4 (4) HNO_3

26. When an oxide of a non-metal reacts with water which of the following is formed ?

(1) Acid (2) Base

(3) Salt (4) None of these

27. Which of the following is 'quicklime' ?

(1) CaO (2) $Ca(OH)_2$

(3) $CaCO_3$ (4) $CaCl_2.6H_2O$

28. Which acids are highly corrosive in nature?

(1) Acetic acid and oxalic acid

(2) Acetic acid and sulphuric acid

(3) Sulphuric acid and nitric acid

(4) Carbonic acid and acetic acid

29. Which of the following does not give H^+ ions in aqueous solution?

(1) H_2CO_3 (2) C_2H_5OH

(3) CH_3COOH (4) H_3PO_4

30. Which one of the following is a strong electrolyte?

(1) Carbon disulphide

(2) Ammonium hydroxide

(3) Sodium chloride

(4) Water

31. When sodium chloride reacts with sulphuric acid, a gas is evolved which gives dense white fumes with ammonia. Which gas is evolved?

(1) HCl (2) NH_4Cl

(3) NH_4OH (4) $(NH_4)_2SO_4$

32. For dilution of concentrated acid we should add

(1) water into concentrated acid

(2) concentrated acid into water

(3) first water into acid and then more acid

(4) Both (1) and (2) are correct

33. A solution turns blue litmus red. The pH of the solution is probably

(1) 8 (2) 10 (3) 12 (4) 6

34. When bitten by an ant, the sting causes irritation due to the presence of

(1) a base in the sting

(2) formic acid in the sting

(3) poisonous chemicals

(4) Both (1) and (2)

35. Which of the following is incorrectly matched ?

(1) Tomato – tartaric acid

(2) Ant sting – citric acid

(3) Citrus fruit – citric acid

(4) Curd – lactic acid

36. Two solution A and B were found to have pH value of 6 and 8 respectively. The inference which can be drawn is that

(1) the acid strength of the solution B is higher than that of A

(2) A is an acid while B is a base

(3) Both are acidic solutions

(4) Both are basic solutions

37. pH + pOH equals

(1) zero (2) fourteen

(3) a negative number (4) infinity

38. The acid used in making of vinegar is

(1) formic acid (2) acetic acid

(3) sulphuric acid (4) nitric acid

39. Antacids contain

(1) weak base (2) weak acid

(3) strong base (4) strong acid

40. The equation between an acid and a base is

$$XOH + HY \rightarrow XY + H_2O$$

Which of the following is the cation part of salt ?

(1) X (2) OH (3) H (4) Y

41. To prevent tooth decay we are advised to brush our teeth regularly. The nature of the tooth paste commonly used is

(1) acidic (2) neutral

(3) basic (4) corrosive

42. Which of the following compounds is neutral to litmus ?

(1) $NaNO_3$ (2) $CuSO_4.5H_2O$

(3) $NaHCO_3$ (4) $Ca(OH)_2$

43. On electrolysis of brine solution, the products formed are

(1) sodium and chlorine

(2) hydrogen, chlorine and oxygen

(3) hydrogen, chlorine and sodium hydroxide

(4) sodium hydroxide, chlorine and oxygen

44. Bleaching powder gives smell of chlorine because it -

(1) is unstable

(2) gives chlorine on exposure to atmosphere

(3) is a mixture of chlorine and slaked lime

(4) contains excess of chlorine

45. Chemical formula of baking soda is

(1) $MgSO_4$ (2) Na_2CO_3

(3) $NaHCO_3$ (4) $MgCO_3$

46. Soda-acid fire extinguisher extinguishes the fire by

(1) cutting the supply of air

(2) removing the combustible substance

(3) raising the ignition temperature

(4) None of these

47. Plaster of Paris is obtained

(1) by adding water to calcium sulphate

(2) by adding sulphuric acid to calcium hydroxide

(3) by heating gypsum to a very high temperature

(4) by cooling gypsum

48. The difference of water molecules in gypsum and Plaster of Paris is

(1) 5/2 (2) 2

(3) 1/2 (4) 3/2

49. Plaster of Paris $\left(CaSO_4 \cdot \frac{1}{2}H_2O\right)$ on mixing with water sets to form

(1) $CaSO_4.H_2O$ (2) $CaSO_4.1\frac{1}{2}H_2O$

(3) $CaSO_4.2H_2O$ (4) $CaSO_4.2\frac{1}{2}H_2O$

50. Plaster of Paris hardens by

(1) giving off CO_2

(2) changing into $CaCO_3$

(3) combining with water

(4) giving out water

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	3	4	3	4	3	4	4	3	2	1	3	2	2	2	3	4	3	3	3
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	1	2	3	1	1	3	2	3	1	2	4	2	2	2	2	2	1	1
Que.	41	42	43	44	45	46	47	48	49	50										
Ans.	3	1	3	2	3	1	3	4	3	3										