Acids, Bases And Salts

Chemistry – X CBSE

Chemical Reactions and Equations

The word acid is derived from the Latin word acidus meaning sour to taste. On the other hand, bases are substances which are bitter in taste and change the colour of red litmus to blue. We all are familiar with the sour taste of lemon, curd, vinegar, unripened grapes, green mangoes, tomatoes, etc. They have sour taste because of presence of acids in them. On the other hand, some substances such as washing soda, lime (chuna) and materials like soap which have soapy touch and a bitter taste. These substances are either bases or contain bases.

Indicator

"Indicator is a chemical compound which is added to the solution in very small amount to detect their acidic or basis nature."

As they show colour change in acidic and basic medium, they are also called acid-base indicators. In other words,

"An acid-base indicator is that substance which possesses one colour in acidic medium and a different colour in alkaline medium."

- **Litmus**

- Litmus is a mixture of water soluble dyes extracted from Lichens, especially Rocella tinctorina. It is the most commonly used indicator to detect acids and bases.
- Litmus solution is a purple coloured dye and most commonly used in the laboratory.
- In the neutral solution, it has purple colour. In the acidic solution, it turns red whereas in the basic solution, it turns blue.

In nutshell:

(i) An acid turns blue litmus into red

(ii) A base or an alkali turns red litmus into blue.

Acidic substances turning blue litmus solution into red	Basic substances turning red litmus solution into blue
Vinegar	Baking soda solution
Lemon juice, Orange juice	Washing soda solution
Juice or unripe mangoes	Bitter gourd (karela) extract
Tamarind (imli) juice	Cucumber (kheera) extract

Note: Litmus solution itself is neither acidic nor basic. It is neutral and has a purple colour. To use it as an indicator, it is made acidic or alkaline to give it red or blue colour.

- **Some Other Indicators**

- **Red cabbage juice:** It is purple in colour in neutral medium and turns red or pink in the acidic medium. In the basic or alkaline medium, its colour changes to green.
- Turmeric juice: It is yellow in colour and remains as such both in the neutral and acidic medium. In the basic medium, its colour becomes reddish or deep brown.
- Phenolphthalein: It is also an organic dye. In neutral or acidic solution, it is colourless while in the basic solution, the colour of indicator changes to pink.
- Methyl orange: Methyl orange is an orange coloured dye and keeps this colour in the neutral medium. In the acidic medium, the colour of indicator becomes red and in the basic medium it changes to yellow.

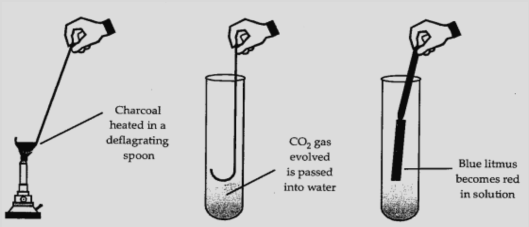
ACTIVITY CORNER

To show that an aqueous solution of CO_2 is acidic

- Take a piece of charcoal in a deflagrating spoon.
- When it starts burning, immediately lower in a tube containing water. After some time, transfer the solution to another tube.
- Now lower a blue litmus strip into it. What will you observe?
- **Observation:** The litmus paper will acquire a red colour.
- **Conclusion:** This shows that the solution is acidic. Actually, carbon present in coke upon burning has been oxidized to $CO_{2(g)}$. The gas upon passing

through water has formed carbonic acid (H_2CO_3). The acid has turned blue litmus red.

$$CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)}$$



ILLUSTRATION

1. What will you observe when:

(i) Red litmus paper is introduced into a solution of sodium sulphate.

(ii) Methyl orange is added to dilute hydrochloric acid.

(iii) A drop of phenolphthalein is added to the solution of lime water.

(iv) Blue litmus is introduced into a solution of ferric chloride.

Sol. (i) It will not undergo colour change because the solution of sodium sulphate (Na_2SO_4) in water is almost neutral. Both NaOH and H_2SO_4 expected to be formed in solution have nearly same strength.

(ii) In the acidic solution, the colour of methyl orange will change to red.

(iii) Lime water contains traces of calcium hydroxide, $Ca(OH)_2$. It is therefore, basic in nature. The colour of phenolphthalein will become pink.

(iv) Ferric chloride ($FeCl_3$) solution on reacting with water will form ferric hydroxide and hydrochloric acid. Since the acid is strong, the blue litmus will change to red.

$$FeCl_{3(aq)} + 3H_2O_{(l)} \rightarrow \underset{(Weak)}{Fe(OH)_{3(s)}} + \underset{(Strong)}{3HCl_{(aq)}}$$

2. What is the colour of phenolphthalein in basic medium and that of methyl orange in acidic medium?

Sol. Phenolphthalein gives pink colour in basic medium whereas methyl orange gives red colour in acidic medium.

- **Olfactory Indicators**

Indicators giving different odours in acidic and basic medium are called olfactory indicators.

Some natural olfactory indicators are:

- **Onion odoured cloth strips:** Onions have a characteristic ammoniacal smell which is retained in acidic medium but is destroyed in basic medium.
- **Vanilla essence:** Vanilla has characteristic sweet smell which is retained in acidic medium but is destroyed in basic medium.

ACTIVITY CORNER

To test acids and basses using olfactory indicators.

- Take two clean cloth strips. Smell the strips to check that they have no smell.
- Take a small onion and chop it finely. Place the chopped onion along with strips of cloth in a plastic bag. Tie up the bag tightly and them place in the fridge for 12 hours.
- Take out the strips and check their odour. You will observe that they smell like onion, i.e., a stingy smell.
- Place the strips on stainless steel plates separately. Pour few drops of dilute hydrochloric acid on one strip and few drops of sodium hydroxide solution on the other strip.
- Rinse both cloth strips with fresh water. Again check their odour.
- **Observation:** You will observe that the strip treated with hydrochloric acid no longer smell, but the strip rinsed with sodium hydroxide solution still smells like onion.
- **Conclusion:** It is because the onion essence is basic in nature, so it is neutralized by hydrochloric acid.

ILLUSTRATION

3. What is the name given to the indicators giving different odours in acidic and basic medium?

Sol. Olfactory indicators.

4. What is an acid-base indicator? Give two examples of synthetic acid-base indicators.

Sol. An acid-bases indicators is a substance which has one colour in the acidic medium and a different colour in the basic medium. Two examples of synthetic indicators are phenolphthalein and methyl orange.

5. What are olfactory indicators? Name two substance which can be used as olfactory indicators?

Sol. Olfactory indicators are those substances which have one odour in acidic medium and a different odour in basic medium. For example, onions, vanilla essence and clove oil can act as olfactory indicators.

Acids

- Liebig defined acids as "a compound which contains one or more hydrogen atoms replaceable partially or completely by a metal or a positive radical to produce a salt."
  Acids are substances which have sour taste and turn blue litmus solution to red. Some colour changes shown by various indicators with acids are:
- change the colour of blue litmus solution to red.
- give red colour with methyl orange.
- give colourless solution with phenolphthalein.
- no reaction with red litmus solution.

Basicity or Protocity of an Acid

The number of replaceable hydrogen atoms in one molecule of an acid or the number of H^+ ions produced in aqueous solution by one molecule of an acid is its basicity.

Acids are of three type: 1. Monoprotic acids, 2. Diprotic acids, 3. Polyprotic acids

The basicity of some acids are given in the following lines:

Acid	Basicity
HF, HCl, HBr, HI	1
HOCl, HOBr, HOI	1
$HClO_2$ (chlorous acid)	1
$HClO_3$ (chloric acid)	1
$HBrO_3$ (Bromic acid)	1
HIO_3 (Idic acid)	1
$HClO_4$ (Perchloric acid)	1
HIO_3 (Periodic acid)	1
HNO_3 (Nitric acid)	1
H_3PO_2 (Hypophosphorous acid)	1
H_3BO_3 (Boric acid)	1
H_2CO_3 (Carbonic acid)	2
H_2SO_3 (Sulphurous acid)	2
H_2PO_3 (Orthophosphorous acid)	2
H_2SO_4 (Sulphuric acid)	2
H_3PO_4 (Phosphuric acid)	3
$H_4P_2O_7$ (Pyrophosphoric acid)	4

The polybasic acids undergo complete ionization in several steps, i.e., one H^+ ion is separated from the molecule one at a time. Thus, the number of steps of complete ionization is equal to be the basicity of the acid.

- **Monoprotic Acids (Mono-basic Acids)**
  Acid which provides one proton in aqueous solution is known as monoprotic acid. Example: HCl (hydrochloric acid), HNO_3 (nitric acid), CH_3COOH (acetic acid), HPO_3 (metaphosphoric acid), H_3PO_2 (hypophosphorous acid).

$$HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO^-_{3(aq)}$$

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

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

- **Diprotic Acids (Dibasic Acids)**
  Acids which can donate two protons in aqueous solution are known as diprotic acids. Example: H_2SO_4 (sulphuric acid), $H_2C_2O_4$ (oxalic acid), H_3PO_3 (phosphorous acid), H_2CO_3 (carbonic acid), H_2S (hydrogen sulphide), H_2SO_3 (sulphurous acid), H_2CrO_4 (chromic acid).

$$\underset{\text{Sulphric acid}}{H_2SO_{4(aq)}} \rightarrow 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

$$\underset{\text{Oxalic acid}}{H_2C_2O_{4(aq)}} \rightleftharpoons 2H^+_{(aq)} + C_2O_4^{2-}{}_{(aq)}$$

$$\underset{\text{Carbonic acid}}{H_2CO_{3(aq)}} \rightleftharpoons 2H^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

$$\underset{\text{Hydrogen sulphide}}{H_2S_{(aq)}} \rightleftharpoons 2H^+_{(aq)} + S^{2-}{}_{(aq)}$$

- **Triprotic Acids (Tribasic Acids)**
  Acids which can donate three protons in aqueous solution are known as triprotic acids. Example: H_3PO_4 (orthophosphoric acid).
  These acids dissociate as: $H_3A \rightleftharpoons 3H^+ + A^{3-}$
  . i.e., H_3PO_4, etc. H_3PO_3 and H_3PO_2 must also be tribasic but actually they are dibasic and monobasic acids respectively.

$$\underset{\text{Phosphorous acid}}{H_3PO_3} \rightleftharpoons 2H^+ + HPO_3^{2-}$$

$$\underset{\text{Metaphosphorous acid}}{H_3PO_2} \rightleftharpoons H^+ + H_2PO_2^-$$

- **General Characteristics of Acids**
- Sour taste: As already discussed, almost all acidic substances have a sour taste.
- Action on litmus paper: Acids turn blue litmus solution red.
- Action on methyl orange: Methyl orange turns red when 1-2 drops of its solution are added to the solution of an acidic substance.
- Corrosive nature: Most of the acids are corrosive in nature. They produce a burning sensation on the skin and holes in the clothes on which they fall. They also attack metal structure and stone work. Hence, they are never stored in metal containers. They are always stored in containers made of glass or ceramics as they are not attacked by the acids.

ACTIVITY CORNER

To test the given samples with the help of red litmus solution, blue litmus solution, phenolphthalein and methyl orange indicators.

- **Requirements:** HCl, H_2SO_4 HNO_3, CH_3COOH, NaOH, $Ca(OH)_2$, KOH, $Mg(OH)_2$, NH_4OH, red litmus solution, blue litmus solution, phenolphthalein, methyl orange indicator and test tubes.
- **Procedure :**

1. Take each of the above solutions in separate test tubes.

2. Test the nature of these solutions by adding a drop of red litmus solution, blue litmus solution, phenolphthalein and methyl orange indicators.

3. Observe the change in colour and record your observations in observation table.

Sample solution	Red litmus solution	Blue litmus solution	Phenolphthalein indicator	Methyl orange indicator
HCl	No colour change	Red	Colourless	Pink
H_2SO_4	No colour change	Red	Colourless	Pink
HNO_3	No colour change	Red	Colourless	Pink
CH_3COOH	No colour change	Red	Colourless	Pink
NaOH	Blue	No colour change	Pink	Yellow
$Ca(OH)_2$	Blue	No colour change	Pink	Yellow
KOH	Blue	No colour change	Pink	Yellow
$Mg(OH)_2$	Blue	No colour change	Pink	Yellow
NH_4OH	Blue	No colour change	Pink (becomes colourless after sometimes)	Yellow (becomes colouress after sometimes)

- **Conclusion:** Adds turn blue litmus red but have no effect on red litmus. 'Bases rum red litmus blue but have no effect on blue litmus. Phenolphthalein is colourless in acidic medium and turns pink in basic medium. Methyl orange is yellow in basic medium and red in acidic medium.

Following table enlists some common organic acids and their natural sources.

S. No.	Name of the acid	Natural source of the acid
1.	Acetic acid	Vinegar
2.	Citric acid	Orange, lemon
3.	Tartaric acid	Tamarind, grapes
4.	Oxalic acid	Tomato
5.	Lactic acid	Sour milk (curd)
6.	Mechanoic acid	Ant sting, bees sting, hairs of nettle plants
7.	Oleic acid	Olive oil
8.	Hydrochloric acid	Gastric juice
9.	Malic acid	Apples (green)
10.	Stearic acid	Fats
11.	Butyric acid	Rancid butter
12.	Uric acid	Urine
13.	Ascorbic acid (Vitamin C)	Fresh fruits and vegetables
14.	Tannic acid	Bark, wood(of tree) and tea
15.	Folic acid	Green leafy vegetables

Chemical Properties of Adds

- Reactions With Metals

Reactive metals displace hydrogen from dilute acids which is evolved as hydrogen gas and metals salts are formed. Those metals which are more reactive than hydrogen i.e., come before hydrogen in reactivity series can displace hydrogen.

Metal + Dilute acid $\rightarrow$ Metal salt + Hydrogen

$Zn_{(s)} + H_2SO_{4\,(dil.)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$

$Mg_{(s)} + 2HCl_{(dil.)} \rightarrow MgCl_{4(aq)} + H_{2(g)}$

$Fe_{(s)} + H_2SO_{4\,(dil.)} \rightarrow FeSO_{4(aq)} + H_{2(g)}$

Do You Know

Metals which can displace hydrogen from dilute acids are known as active metals e.g., Na, K, Zn, Fe, Ca, Mg, etc. The active metals which lie above hydrogen in the activity series are electropositive in nature. Their atoms lose electrons to form positive ions and these are accepted by H^+ ions of the acid. As a result, $H_{2(g)}$ is evolved For example:

$$Zn_{(s)} \rightarrow Zn^{2+}{}_{(aq)} + 2e^-$$

$$2H^+{}_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \rightarrow H_{2(g)} + SO_4^{2-}{}_{(aq)}$$

$$Zn_{(s)} + \underset{(Acid)}{2H^+{}_{(aq)}} \rightarrow Zn^{2+}{}_{(aq)} + H_{2(g)}$$

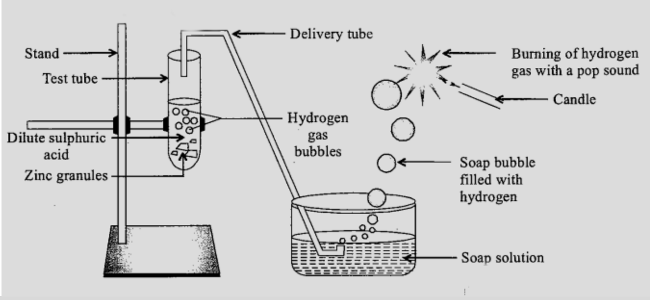
This reaction is a redox reaction in which $Zn_{(s)}$ has been oxidized to $Zn^{2+}{}_{(aq)}$ ions by losing electrons while

$H^+_{(aq)}$ ions have been reduced to $H_{2(g)}$ by accepting them.

ACTIVITY CORNER

To show that hydrogen gas is produced when metals react with dilute acids.

- Requirements: Zinc granules, dilute H_2SO_4, test tube, delivery tube, trough, stand and soap solution.



- Set up the apparatus as shown in the figure.
- Take about 5 ml of dilute H_2SO_4 in a test tube and add a few pieces of zinc granules to it.
- Some bubbles will form in the test tube, and the size of zinc granules will decreases. This is due to the reaction of zinc with dilute H_2SO_4 to liberate hydrogen gas.
- Pass this hydrogen gas through a delivery tube into a soap solution. We will observe that soap bubbles filled with hydrogen gas are produced.
- Now bring a lighted candle near a gas-filled bubble. A popping sound is produced due to the burning of hydrogen gas.
- **Observation :** Zinc reacts with dilute H_2SO_4 to give H_2 gas
  $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
- **Conclusion:** All acids (minerals or organic) on reaction with metals produce hydrogen gas. But, metals react with acids at different speeds. For example, metals like sodium, potassium and magnesium reacts rapidly while iron, zinc and aluminium react slowly to evolve hydrogen gas. Also, some metals like copper, silver and gold do not react with acids.

Do You Know

In the laboratory, for the preparation of hydrogen from granular zinc, the following acids (i) conc. H_2SO_4, (ii) Conc. HCl, (iii) Nitric acid cannot be used.

(a) Conc. H_2SO_4 is not used because it act as strong oxidizing agent. It react with nascent hydrogen to produce SO_2 i.e., a part of the acid gets reduced to sulphur dioxide.

$H_2SO_{4(Conc.)} + H_2 \rightarrow 2H_2O + SO_2$

(b) Hydrogen liberated by the action of cone. HCl on zinc will be impure as it will contain fumes of volatile HCl. Moreover, $ZnCl_2$ formed is insoluble in cone. HCl. It will form a coating on zinc and the reaction stops after sometime.

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

(c) HNO_3 plays a double role. It acts as an acid and as a strong oxidizing agent. The hydrogen (nascent) first formed reduces the nitric acid into various oxides.

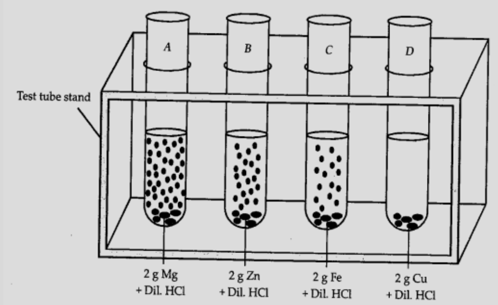
$2HNO_3 + 2H \rightarrow 2NO_2 + 2H_2O$.

- Mn and Mg react with dil. HNO_3 to evolve hydrogen.
- Most of the metals with the exception of noble metal like gold and platinum are attacked by nitric acid. Nitric acid plays a double role in the action of metals, i.e., it acts as an acid as well as an oxidizing agent.
  Metal + $HNO_3 \rightarrow$ Nitrate + H
  $2HNO_3 + 2H \rightarrow 2NO_2 + 2H_2O$
  $2HNO_3 + 6H \rightarrow 2NO + 4H_2O$
  $2HNO_3 + 10H \rightarrow N_2 + 6H_2O$

ACTIVITY CORNER

To test the reactivity of metals with acid by comparing the evolution of hydrogen

- Take four test tubes and label them as A, B, C and D. Place them in a test tube stand. Put small pieces of magnesium, zinc, iron and copper (same mass, say 2 g each) in the tubes A, B, C, D respectively. Now, pour equal amounts of dilute hydrochloric acid (say 5 mL) in each of the four test tubes. The following reactions will take place:



Reaction of different metals with the same acid

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Magnesium chloride}}{MgCl_2} + \underset{\text{Hydrogen}}{H_2}$$

$$\underset{\text{Zinc}}{Zn} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Zinc chloride}}{ZnCl_2} + \underset{\text{Hydrogen}}{H_2}$$

$$\underset{\text{Iron}}{Fe} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Iron (II) chloride}}{FeCl_2} + \underset{\text{Hydrogen}}{H_2}$$

$$\underset{\text{Copper}}{Cu} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \text{No recation}$$

- **Observation:** The rate of evolution of hydrogen gas from each of the test tubes. It is observed that at room temperature.
- Magnesium reacts most vigorously.
- Zinc reacts less vigorously than magnesium.
- Iron reacts slowly.
- Copper does not react at all.

Hence, the order of reactivity is
Mg > Zn > Fe > Cu.

- **Conclusion:** All metals do not react with the same acid with the same vigour.

- **Reaction with Metal Oxides**

Acids react with metal oxides to form salt and water. The reactions are generally endoergic and require heat. As metal oxide react with acids to produce neutral, salts they are called basic oxides.

Metal oxide + Acid $\rightarrow$ Salt + water

$CaO(g) + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(i)}$

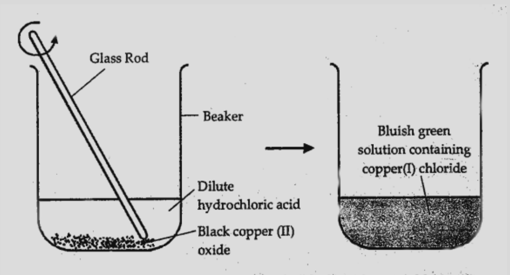
$MgO_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_2O_{(i)}$

ACTIVITY CORNER

Reaction of metal oxide with hydrochloric acid

- Take a pinch of cupric oxide in a test tube. Then add dilute HCl solution dropwise to the test tube. Gently shake the test tube if required.
- **Observation:** The black colour of cupric oxide slowly disappears and the bluish green solution is formed.
- **Conclusion:** Cupric oxide reacts with HCl to produce cupric chloride and water. This result in loss of black colour of cupric oxide during reaction and cupric chloride formed dissolve in water to produce a bluish green solution.

$$\underset{(Black)}{CuO_{(s)}} + 2HCl_{(dil.)} \longrightarrow \underset{(Bluish\ green)}{CuCl_{2(aq)}} + H_2O_{(l)}$$



Reaction between copper (II) oxide (black) with hydrochloric acid to form copper (II) chloride (bluish green)

- **Reaction with Metal Carbonates and Metal Hydrogen Carbonates (Metal Bicarbonates)**
- Acids react with metal carbonates and metal hydrogen carbonates producing metal salts and $CO_{2(g)}$ is evolved during reaction.

$$\underset{Calcium\ carbonate}{CaCO_{3(s)}} + 2HCl_{(dil.)} \rightarrow \underset{Calcium\ chloride}{CaCl_{2(aq)}} + H_2O_{(aq)} + CO_{2(g)}$$

$$\underset{Sodium\ biacarbonate}{2NaHCO_{3(s)}} + H_2SO_{4(aq.)} \rightarrow \underset{Sodium\ sulphate}{Na_2SO_{4(aq)}} + H_2O_{(aq)} + CO_{2(g)}$$

- All metal carbonates and hydrogen carbonates react with the acids to give the corresponding salt, carbon dioxide gas and water. Hence, we can write the reaction in general as.

Metal carbonates or hydrogen carbonate + Acid $\rightarrow$ Salt + CO_2 + H_2O

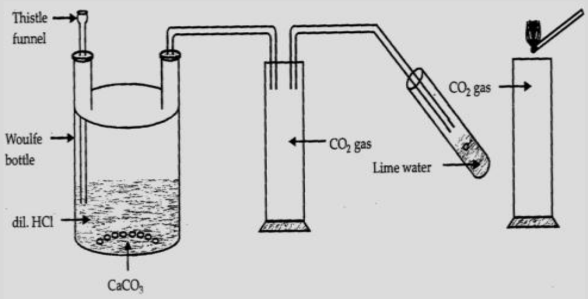
Do You Know

- The egg shells, chalk and marble also contains calcium carbonate as the main constituent. Hence, they react with acid as shown above.
- If a person is suffering from the problem of acidity then he is advise to take baking soda (sodium bicarbonate). Acids and $NaHCO_3$ reacts and person gets relief.

ACTIVITY CORNER

To show that acid reacts with metal carbonate to liberate carbon dioxide.

- **Requirements:** $CaCO_3$ (marble chips), Woulfe bottle, thistle funnel, dil. HCl, gas jar, match box, delivery tube bent at two right angles, limewater.
- **Procedure:**
- Take marble chips in a Woulfe-bottle.
- Set the apparatus as shown in diagram.
- Add dil. HCl with the help of thistle funnel.
- Collect the gas in gas jar by upward displacement of air.
- Bring a burning matchstick near the gas jar and record your observations.
- Pass the gas evolved through lime water and note down your observations.



Reaction of calcium carbonate with dilute hydrochloric acid liberate carbon dioxide gas which turns limewater milky and extinguishes burning matchstick

- **Observation:** The burning matchstick will get extinguished because carbon dioxide is neither combustible nor supporter of combustion. Lime water will turn milky due to formation of insoluble calcium carbonate. It can be used as test for CO_2.
- **Chemical Reactions :**

$$\underset{\text{Marble (Calcium carbonate)}}{CaCO_{3(s)}} + \underset{\text{Hydrochloric acid}}{2HCl_{(dil.)}} \rightarrow \underset{\text{(White ppt.) Calcium chloride}}{CaCl_{2(aq.)}} + \underset{\text{Water}}{H_2O_{(l)}} + \underset{\text{Carbon dioxdie}}{CO_{2(g)}}$$

$$\underset{\text{Lime water}}{Ca(OH)_{2(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}} \rightarrow \underset{\text{(White ppt.) Calcium chloride}}{CaCO_{3(s)}} + \underset{\text{Water}}{H_2O_{(l)}}$$

- **Conclusion:** Metal carbonate reacts with dilute acid to liberate carbon dioxide. All metal carbonates and hydrogen carbonates react with acids to form corresponding salts, water and carbon dioxide.

Let us take more reactions of metal carbonates with dilute acids.

$$\underset{\text{Magnesium carbonate}}{MgCO_{3(s)}} + \underset{\text{Hydrochloric acid}}{2HCl_{(dil.)}} \rightarrow \underset{\text{Magnesium chloride}}{MgCl_{2(aq.)}} + H_2O_{(l)} + CO_{2(g)}$$

$$\underset{\text{Zinc carbonate}}{ZnCO_{3(s)}} + 2HCl_{(dil.)} \longrightarrow \underset{\text{zinc chloride}}{ZnCl_{2(aq.)}} + H_2O_{(l)} + CO_{2(g)}$$

$$\underset{\text{Sodium carbonate}}{NaCO_{3(s)}} + 2HCl_{(dil.)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl_{2(s)}} + H_2O_{(l)} + CO_{2(g)}$$

- Metal hydrogen carbonates also react with dil. acids to liberate carbon dioxide gas.

$$\underset{\text{Sodium hydrogen carbonate}}{NaHCO_{3(s)}} + HCl_{(dil.)} \rightarrow NaCl_{(aq.)} + H_2O_{(l)} + CO_{2(g)}$$

$$\underset{\text{Sodium hydrogen carbonate}}{2NaHCO_{3(s)}} + H_2SO_{4(aq.)} \rightarrow \underset{\text{Sodium sulphate}}{NaSO_{4(aq.)}} + H_2O_{(aq)} + CO_{2(g)}$$

$$\underset{\text{Calcium hydrogen carbonate}}{Ca(HCO_3)_{2(s)}} + 2HCl_{(dil.)} \longrightarrow CaCl_{2(aq.)} + 2H_2O_{(l)} + 2CO_{2(g)}$$

Only alkali metals and alkaline earth metals are known to form bicarbonates. Other metals do not form bicarbonate salts.

- **Reaction of Acids with Bases**

Acids and bases react to produce a salt and water. In the reaction their acidity and basicity is destroyed and such reactions are called neutralization reactions. In general, a neutralization may be represented as:

Acid + Base $\rightarrow$ Salt + water

Sodium hydroxide react with hydrochloric acid to produce sodium choride (salt) and water.

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

Some other examples of neutralization reaction are:

$$\underset{\text{Nitric acid}}{HNO_{3(aq)}} + \underset{\text{Sodium hydroxide}}{NaOH_{(aq)}} \longrightarrow \underset{\text{Sodium nitrate}}{NaNO_{3(aq)}} + H_2O_{(l)}$$

$$\underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} + \underset{\text{Sodium hydroxide}}{2NaOH_{(aq)}} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_{4(aq)}} + 2H_2O_{(l)}$$

$$\underset{\text{Carbonic acid}}{H_2CO_{3(aq)}} + \underset{\text{Potassium hydroxide}}{2KOH_{(aq)}} \longrightarrow \underset{\text{Potassium carbonate}}{K_2CO_{3(aq)}} + 2H_2O_{(l)}$$

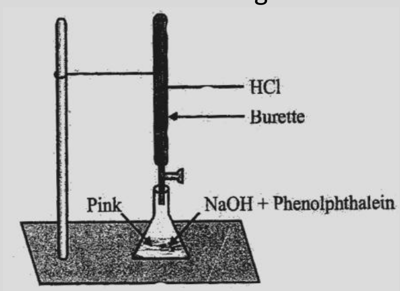
$$\underset{\text{Carbonic acid}}{H_2SO_{3(aq)}} + \underset{\text{Ammonium hydroxide}}{2NH_4OH_{(aq)}} \longrightarrow \underset{\text{Ammonium sulphate}}{(NH)_4SO_4} + 2H_2O_{(l)}$$

ACTIVITY CORNER

To demonstrate neutralization reaction between acid and base.

- **Requirements:** NaOH (1M), HCl (1M) phenolphthalein, burette, pipette, titration flask.
- **Procedure :**

- Take 10 mL of NaOH in titration flask with the help of pipette.
- Add a drop of phenolphthalein and observe the colour of the solution.
- Take HCl in a burette and note down the initial reading.
- Open the stop cock of burette and add HC1 into titration flask slowly drop wise till the pink colour due to NaOH becomes colourless.
- Note down the final reading.



Neutralization reaction between NaOH and HCL

- **Observation:** The pink colour of phenolphthalein changes to colourless.
- **Chemical Reaction:** NaOH + HCl $\longrightarrow$ NaCl+H_2O
- **Explanation:** Phenolphthalein gives pink colour with NaOH (base). When acid is added, NaOH reacts with acid to form NaCl and H_2O. When whole of NaOH reacts with acid, it becomes colourless because neutralization reaction is complete.
- **Conclusion:** NaOH (base) reacts with HCl (acid) to form (salt) and H_2O. It is an example of neutralization reaction.

- **Reaction of Acids with Sulphites and Bisulphites (Hydrogen Sulphites)**

Dilute acids react with sulphites and hydrogen sulphites (bisulphites) with evolution of sulphur dioxide gas to give salts.

Sulphite + Acid $\longrightarrow$ Salt + Water + Sulphur dioxide

Some examples are :

$$\underset{\text{Calcium sulphite}}{CaSO_{3(s)}} + \underset{\text{hydrochloric acid}}{2HCl_{(aq)}} \rightarrow \underset{\text{Calcium chloride}}{CaCl_{2(aq)}} + H_2O_{(l)} + \underset{\text{sulphur dioxide}}{SO_{2(g)}}$$

$$\underset{\text{Sodium sulphite}}{NaSO_{3(s)}} + \underset{\text{hydrochloric acid}}{H_2SO_{4(aq)}} \rightarrow \underset{\text{Sodium sulphate}}{Na_2SO_{4(aq)}} + H_2O_{(l)} + \underset{\text{sulphur dioxide}}{SO_{2(g)}}$$

$$\underset{\text{Sodium bisulphite}}{NaHSO_{3(s)}} + \underset{\text{hydrochloric acid}}{HCl_{(aq)}} \rightarrow \underset{\text{Sodium chloride}}{NaCl_{(aq)}} + H_2O_{(l)} + \underset{\text{sulphur dioxide}}{SO_{2(g)}}$$

$$\underset{\text{Potassium bisulphite}}{KHSO_{3(s)}} + \underset{\text{sulphuric acid}}{H_2SO_{4(aq)}} \rightarrow \underset{\text{Potassium hydrogen sulphate}}{KHSO_{4(aq)}} + H_2O_{(l)} + \underset{\text{sulphur dioxide}}{SO_{2(g)}}$$

- **Reaction of Acids with Metal Sulphides**
  When metal sulphides react with acid, metal salt is formed with evolution of hydrogen sulphide gas characterised by its rotten egg like smell.
  Metal sulphide + Acid $\longrightarrow$ Salt + Hydrogen sulphide

$$\underset{\text{Ferrous sulphite}}{FeS_{(s)}} + \underset{\text{sulphuric acid}}{H_2SO_{4(aq)}} \rightarrow \underset{\text{Ferrous sulphate}}{FeSO_{4(aq)}} + \underset{\text{Hydrogen sulphide}}{H_2S_{(g)}}$$

$$\underset{\text{zinc sulphite}}{ZnS_{(s)}} + \underset{\text{sulphuric acid}}{H_2SO_{4(aq)}} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_{4(aq)}} + \underset{\text{Hydrogen sulphide}}{H_2S_{(g)}}$$

Chemical Nature of Acids

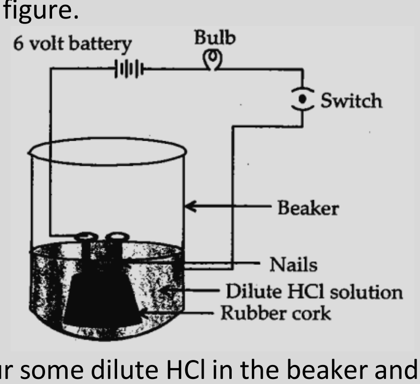
All acids produce hydrogen gas on reaction with metals. This means that hydrogen is common to all acids. It has been observed that the aqueous solutions of all acids conduct electricity. They allow the passage of electric current through them. For example, if electric current passed through aqueous solution of acids, then, current flows through their solutions.

ACTIVITY CORNER

To see what is common in all acids

Requirements: Solutions of hydrochloric acid, sulphuric acid, glucose, alcohol, etc.

Fix two iron nails on a cork and place the cork in a 100 mL beaker. Connect the nails to the two terminals of a 6 volt battery with wires through a bulb and a switch as shown in figure.



Now, pour some dilute HCl in the beaker and switch on the circuit. Note if the bulb glows or not.

Repeat the experiment with dilute H_2SO_4 glucose and alcohol. Does the bulb glow in all cases?

Observation: You will observe that the bulb glows in case of acids (dilute HCl and dilute H_2SO_4). This means that the aqueous solutions of acids conduct electricity. However, the bulb does not glow in case of glucose and alcohol.

Conclusion: This shows that alcohol and glucose do not conduct electricity. Since the electric current is carried by ions, this shows that aqueous solutions of all acids contain ions.

Conduction of electricity through a solution of a substance can take place only if ions are present in the solution. This shows that the acids when dissolved in water produce hydrogen ions (H^+). These H^+ ions do not exist as such in the solution. They combine with water molecules and exist as hydronium ions, H_3O^+ ($H_2O + H^+ \longrightarrow H_3O^+$). As each H^+ ion can combine with a number of water molecules, in the solution, we represent it as $H^+_{(aq)}$. The dissociation of a few acids in the aqueous solution to give $H^+_{(aq)}$ ions along with the corresponding negative ion is represented below:

$$\underset{\text{Hydrochlric acid}}{HCl_{(aq)}} \longrightarrow H^+_{(aq)} + \underset{\text{Chloride ions}}{Cl^-(aq)}$$

$$\underset{\text{Nitric acid}}{HNO_{3(aq)}} \longrightarrow H^+_{(aq)} + \underset{\text{Nitrate ions}}{NO_3^-(aq)}$$

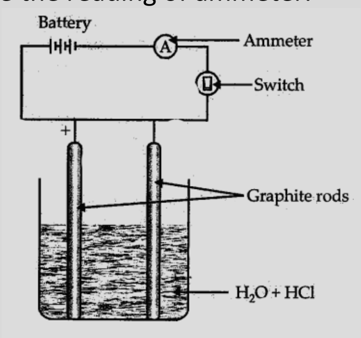
$$\underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} \rightarrow 2H^+_{(aq)} + \underset{\text{Sulphate ions}}{SO_4^{2-}}$$

$$\underset{\text{Acetic acid}}{CH_3COOH_{(aq)}} \longrightarrow \underset{\text{Acetate ions}}{CH_3COO^-_{(aq)}} + H^+_{(aq)}$$

ACTIVITY CORNER

To show that solution of acid can conduct electricity

- **Requirements:** Dil. HCl, battery, ammeter, connecting wires, switch, two graphic rods.
- Take dil. HCl in container as shown in the diagram.
- Put two graphite rods in dil. HCl and complete the circuit as shown in diagram.
- Switch on the current.
- Observe the reading of ammeter.



- **Observation:** The pointer of ammeter moves showing that current is passing through the solution.

- **Conclusion:** Acids conduct electricity in aqueous solution.

Arrhenius Concept of Acids

In 1984, Svante Arrhenius, a Swedish chemist proposed a theory to define acids and bases known as Arrhenius concept of acids. According to Arrhenius theory. Acids are substances which dissociate in aqueous solution to give hydrogen ions (or hydronium ions). For example, HCl, HNO_3, CH_3COOH and H_2SO_4 are all acids as they dissociate in aqueous medium to give hydrogen ions.

$$\underset{\text{Hydrochloric acid}}{HCl_{(aq)}} + H_2O_{(l)} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+_{(aq)}} + Cl^-_{(aq)}$$

$$\underset{\text{Nitric acid}}{HNO_{3(aq)}} + H_2O_{(l)} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+_{(aq)}} + NO^-_{3(aq)}$$

$$\underset{\text{Acetic acid}}{CH_3COOH_{(aq)}} + H_2O_{(l)} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+_{(aq)}} + CH_3COO^-_{(aq)}$$

- **Hydronium Ions**

  Acids dissociate in water to produce hydrogen ions in aqueous solutions. These hydrogen ions are highly unstable and combine with water molecules to form hydronium ions.

$$HCl \longrightarrow \underset{\text{Hydrogen ion}}{H^+} + Cl^-$$

$$H^+ + H_2O \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+}$$

  Thus, the properties of an acid are due to $H^+_{(aq)}$ ions or hydronium ions (H_3O^+) which it gives in the aqueous solution.

- **Strong and Weak Acids**

  Those acids which are completely ionized in water are called strong acids.

  Strong acids produce a large amount of hydrogen ions in aqueous medium. Perchloric acid ($HClO_4$), chromic acid (H_2CrO_4), sulphuric acid (H_2SO_4) and nitric acid (HNO_3) are all strong acids because they are completely ionized in water. When the concentrated solution of an add is diluted by mixing water, then the concentration of hydrogen ions H^+ [or hydronium ions H_3O^+] per unit volume decreases.

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

$$HNO_{3(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + NO_3^-{}_{(aq)}$$

$$H_2SO_{4(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

  Those acids which are partially ionized in water are called weak acids.

  Weak acids produce only a small amount of hydrogen ions in aqueous medium. Acetic acid (CH_3COOH), carbonic acid (H_2CO_3), formic acid (HCOOH) are example of weak acids as they are ionized to a limited extent in aqueous medium.

$$\underset{\text{Acetic acid}}{CH_3CHOOH_{(aq)}} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + \underset{\text{Acetate ion}}{CH_3COO^-_{(aq)}}$$

$$H_2CO_{3(aq)} + 2H_2O_{(l)} \rightleftharpoons 2H_3O^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

$$\underset{\text{Hydrogen cyanide}}{HCN_{(aq)}} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + \underset{\text{Cyanide ion}}{CN^-_{(aq)}}$$

  Double headed arrow ($\rightleftharpoons$) indicates incomplete ionization in case of weak acids.

Do You Know

- Except HF other halogen acids (HCl, HBr, HI) are strong acids.
- In acids of sulphur, H_2SO_4, H_2SO_5, $H_2S_2O_7$ are strong acids.
- Acid of chromium (H_2CrO_4, $H_2Cr_2O_7$) are strong acids.
- HNO_3 and $HC1O_4$ (perchloric acid) are strong acids.
- HCN, Phenol and all carboxylic acids are weak monoprotic acids.
- H_2CO_3, H_2S and H_3PO_3 are weak diprotic acids.
- $HClO_3$ HNO_3, Conc. H_2SO_4, H_2CrO_4 are strong oxidizing agents.
- HBr and HI are strong reducing agents.
- HCl is the weakest reducing agent.

ILLUSTRATION

6. A solution of acetic acid in water is highly concentrated. Will you call it a strong acid? Explain?

Sol. No, acetic acid will remain a weak acid even if it is highly concentrated because its degree of dissociation (α) is much less than one. This means that in water, only a small amount of the acid exists as ions whatever may be its concentration or amount dissolved in a given volume of water.

7. What are strong and weak acids? In the following list of acids, separate strong acids from weak acids.

Hydrochloric acid, citric acid, acetic acid, nitric acid, formic acid, suphurice acid

Sol. Strong acids are those which ionize almost completely in aqueous solution and hence

produce a large amount of H^+ ions and and therefore, conduct electricity to a large extent. Weak acids are those acids which ionize to a small extent in the aqueous solution and hence produce a small amount of H^+ ions, and therefore, conduct electricity to a small extent.
Strong acids: Hydrochloric acid, nitric acid, sulphuric acid.
Weak acids: Citric acid, acetic acid, formic acid.

Concentrate and Dilute Acids

- Mixing an acid with water results in decrease in the concentration of H_3O^+ ions per unit volume. This process is called dilution and the acids thus obtained are called dilute acids. Generally pure acids are used as concentrated acids. Example: H_2SO_4 and HCl. 68% HNO_3 solution in water is used as concentrated HNO_3. In case of weak adds, on dilution, total number of H^+ ions in the solution increases because dissociation of the weak add increases on dilution but even in this case, concentration of H^+ ions per unit volume decreases.
- The process of dissolving an acid into water is a highly exothermic process. During this a lot of heat is produced.

ILLUSTRATION

8. Why do HCl, HNO_3, etc., show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character?

Sol. It is because HCl and HNO_3 ionize in aqueous solution whereas ethanol and glucose do not ionize in aqueous solution.

Do You Know

It is always desirable to add acid to water slowly and not water to acid and keeping the solution continuously stirred. If water is added to a concentrated acid, the heat produced may cause the mixture to splash out and may spill on our clothes and body. This may cause serious burns. The glass container may also break due to excessive local heating.

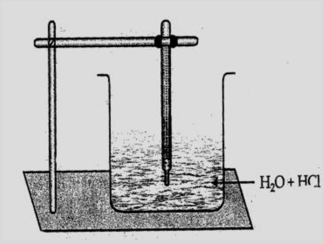
Industrial Uses of Acids

- Hydrochloric Acid (HCl): Used for cleaning metallic items and in dyestuffs, in tanning, and printing industry.
- Sulphuric acid (H_2SO_4): Used in the manufacture of fertilizers, chemicals, paints, dyes, plastics, synthetic fibres, detergents, explosives and car batteries. It is called King of Chemicals.
- Nitric acid (HNO_3): Used for manufacture of fertilizers, explosives (like TNT: trinitro toluene), dyes, plastics and drugs.
- Acetic acid (CH_3COOH): Used as vinegar in cooking and food preservatives.

ACTIVITY CORNER

To show mixing of acid in water is an exothermic process.

- **Requirements:** Water, HCl, HNO_3 H_2SO_4, thermometer, stirrer or glass rod.



- **Procedure:**
- Take water in a beaker.
- Dip thermometer it, hang it and note down the initial temperature.
- Pass HCl gas through water and stir it with glass rod.
- Note down rise in temperature.
- Repeat the experiment with H_2SO_4 (conc.) and HNO_3 (conc.)

- **Observation**: There is rise in temperature in each case.
- Chemical Reactions and Explanation: HCl ionizes in aqueous solution and the process is exothermic, i.e., heat is released.

$$HCl_{(g)} + H_2O_{(l)} \rightarrow H_3O^+{}_{(aq.)} + Cl^-{}_{(aq.)} + Heat\ energy$$

When conc. H_2SO_4 is added to water, the rise in temperature is maximum because it is highly exothermic process.

$$H_2SO_{4(l)} + 2H_2O_{(l)} \rightarrow 2H_3O^+{}_{(aq.)} + SO_4^{2-}{}_{(aq.)} + Heat\ energy$$

When HNO_3 is dissolved in water, there is rise in temperature.

$$HNO_{3(l)} + H_2O_{(l)} \rightarrow H_3O^+{}_{(aq.)} + NO_3^-{}_{(aq.)} + Heat\ energy$$

- **Conclusion:** Dissolution of acids in water is an exothermic process.

Bases

Bases are substances which have bitter taste, soapy touch and turn red litmus solution to blue. Some colour changes shown by various indicators with bases are:

- change red colour of red litmus solution to blue.
- give yellow colour with methyl orange.
- give pink colour with phenolphthalein.
- no reaction with blue litmus solution.

- **Strong Bases**
  The bases which completely ionize in aqueous solution to give hydroxide ions (OH^-) are called strong bases.
  Sodium hydroxide (NaOH), potassium hydroxide (KOH), etc. are called strong bases as they completely dissociate in aqueous solution to produce large number of OH^- ions on ionization. Bases (like NaOH, KOH) that are soluble in water are called alkalies.
  As they produce large number of ions on ionization, they are also strong electrolytes.

- **Weak Bases**
  The bases which ionize to small extent in aqueous solution to give hydroxide ions (OH^-) are called weak bases.
  Ammonium hydroxide (NH_4OH), calcium hydroxide [$Ca(OH)_2$] are called weak bases as they only partially (less than 100%) ionize in water. For example,

$$\underset{\text{Ammonium hydroxide}}{NH_4OH_{(aq)}} \xrightleftharpoons{\text{Water}} NH^+_{4(aq)} + OH^-_{(aq)}$$

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_{2(aq)}} \xrightleftharpoons{\text{Water}} Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$$

  Weak bases are also weak electrolytes as they ionize only to limited extent in water.

- **Acidity or Hydroxicity of Base**
  It is equal to the number of hydroxide ions (OH^-) furnished by a base molecule in its aqueous solution after complete dissociation.

- Mono-acidic bases : They dissociate as :

$$BOH \rightleftharpoons B^+ + OH^-$$

  i.e,. $NaOH, KOH, NH_4OH$, etc.
- Di-acidic bases : They dissociate as :

$$B(OH)_2 \rightleftharpoons B^{2+}\ 2OH^-$$

  i.e., $Ca(OH)_2$, $Mg(OH)_2$, etc.
- Tri-acidic bases : They dissociate as :

$$B(OH)_3 \rightleftharpoons B^{3+}\ 3OH^-$$

  i.e., $Al(OH)_3$, etc.

Chemical Properties of Bases

- **Reaction of Bases with Metals**
  Some metals react with bases to liberate hydrogen gas. For example, zinc reacts with sodium hydroxide and hydrogen gas is evolved. The reaction is:

$$\underset{\text{Sodium hydroxide}}{2NaOH} + \underset{\text{Zinc}}{Zn} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + \underset{\text{Hydrogen gas}}{H_2}$$

- **Reaction with Acids**
  Bases react with acids to undergo neutralization reaction forming salt and water. For example, sodium hydroxide reacts with hydrochloric acid to form sodium chloride (salt) and water.

$$\underset{\substack{\text{Sodium hydroxide}\\ \text{(Base)}}}{NaOH_{(aq)}} + \underset{\substack{\text{Hydrochloric acid}\\ \text{(Acid)}}}{HCl_{(aq)}} \longrightarrow \underset{\substack{\text{Sodium chloride}\\ \text{(Salt)}}}{NaCl_{(aq)}} + H_2O_{(l)}$$

$$\underset{\text{Sodium hydroxide}}{2NaOH_{(aq)}} + \underset{\text{Sulphuric acid}}{H_2SO_{4(aq)}} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_{4(aq)}} + 2H_2O_{(l)}$$

$$\underset{\text{Sodium hydroxide}}{CaOH_{2(aq)}} + \underset{\text{Hydrochloric acid}}{HCl_{(aq)}} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_{2(aq)}} + 2H_2O_{(l)}$$

- **Reaction of Bases with Non-metal Oxides**
  Bases when react with non-metallic oxides such as carbon dioxide then they produce metal salt and water. In the reaction, non-metal oxide reacts with base to form salt which indicates their acidic nature. For example, sodium hydroxide reacts with carbon dioxide to form sodium carbonate and water as:

$$\underset{\text{Sodium hydroxide}}{2NaOH_{(s)}} + \underset{\text{Carbon dioxide}}{CO_{2(g)}} \longrightarrow \underset{\text{Sodium carbonate}}{Na_2CO_{3(aq)}} + H_2O_{(l)}$$

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Carbon dioxide}}{CO_{2(g)}} \longrightarrow \underset{\text{Calciu carbonate}}{CaCO_{3(aq)}} + H_2O_{(l)}$$

- **Reaction of Bases with Heavy Metal Salts** Metal salts react with aqueous solution of bases to produce precipitates of insoluble metallic hydroxides. These reactions are just like double displacement reactions in which metal ions are exchanges between two salts in aqueous solution. In these reactions, metal ions are exchanged between salt and base in aqueous solution. For example,

$$\underset{\text{Zinc sulphate}}{ZnSO_{4(aq)}} + \underset{\text{Sodium hydorxide}}{2NaOH_{(aq)}} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_{4(aq)}} + \underset{\substack{\text{Zink hydroxide}\\ \text{(White ppt.)}}}{Zn(OH)_2}$$

$$\underset{\text{Cupper sulphate}}{CuSO_{4(aq)}} + \underset{\text{Ammonium hydorxide}}{2NH_4OH_{(aq)}} \rightarrow \underset{\text{Ammonium sulphate}}{(Na_4)_2SO_{4(aq)}} + \underset{\text{Copper hydroxide}}{Cu(OH)_2}$$

$$\underset{\text{Ferrous chloride}}{FeCl_{2(aq)}} + \underset{\text{Sodium hydorxide}}{2NaOH_{(aq)}} \rightarrow \underset{\text{Sodium chloride}}{2NaCl_{(aq)}} + \underset{\substack{\text{Ferrous hydroxide}\\ \text{(Brown ppt.)}}}{Fe(OH)_2}$$

Chemical Nature of Bases

Like acids, bases also possesses some general characteristic properties. This shows that chemically, they must have sometimes in common. It is observed that bases when dissolved in water produce hydroxide ions in the solution. Thus, this is the common characteristic of all bases. For example,

$$\underset{\text{Sodium hydorxide}}{NaOH_{(s)}} + Water \longrightarrow \underset{\text{Sodium ions}}{Na^+_{(aq)}} + \underset{\text{Hydroxide ions}}{OH^-_{(aq)}}$$

$$\underset{\text{Potassium hydorxide}}{KOH_{(s)}} + Water \longrightarrow \underset{\text{Potassium ions}}{K^+_{(aq)}} + \underset{\text{Hydroxide ions}}{OH^-_{(aq)}}$$

$$\underset{\text{Ammonium hydorxide}}{NH_4OH} + Water \longrightarrow \underset{\text{Ammonium ions}}{NH_4{}^+_{(aq)}} + \underset{\text{Hydroxide ions}}{OH^-_{(aq)}}$$

$$\underset{\text{Magnesium hydorxide}}{Mg(OH)_{2(s)}} + Water \longrightarrow \underset{\text{Magnesium ions}}{Mg^{2+}_{(aq)}} + \underset{\text{Hydroxide ions}}{2OH^-_{(aq)}}$$

Arrhenius Concept for Bases

According to Arrhenius concept, "bases are the substances which dissociate in aqueous solution to generate hydroxide (OH^-) ions". example, substances such as NaOH, KOH, $Mg(OH)_2$, Ca(OH)2, NH_4OH, etc. are bases. Bases like NaOH, KOH, etc. which produce single OH^- ion on ionization are called monoacidic bases. Bases like $Mg(OH)_2$, $Ca(OH)_2$ which produce two OH^- ions on ionization are called diacidic bases.

$$\underset{\text{Potassium hydorxide}}{KOH_{(s)}} \xrightarrow{H_2O} K^+_{(aq)} + OH^-_{(aq)}$$

$$\underset{\text{Magnesium hydorxide}}{Mg(OH)_{2(s)}} \xrightarrow{H_2O} Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$$

$$\underset{\text{Calcium hydorxide}}{Ca(OH)_{2(s)}} \xrightarrow{H_2O} Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$$

$$\underset{\text{Ammonium hydorxide}}{NH_4OH_{(s)}} \xrightarrow{H_2O} NH_4{}^+_{(aq)} + OH^-_{(aq)}$$

- **Applications of Arrhenius Concept**

- It explains the acidic nature of aqueous solution of non-metallic oxides, (i.e., CO_2, SO_2, SO_3 ,N_2O_3, N_2O_5, P_2O_3 etc.)

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$$

$$SO_3 + H_2O \rightleftharpoons H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$$

- It explains the basic nature of aqueous solutions of several substances like metal hydroxides, CaO, Na_2O, NH_3, N_2H_4 etc.

$$CaO + H_2O \rightleftharpoons Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2OH^-$$

$$NH_3 + H_2O \rightleftharpoons NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

- Water is amphoteric in nature as it furnishes both H^+ and OH^- in aqueous solution.

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

- Neutralization reaction: Basically it is a reaction between H^+ and OH^- to form H_2O.

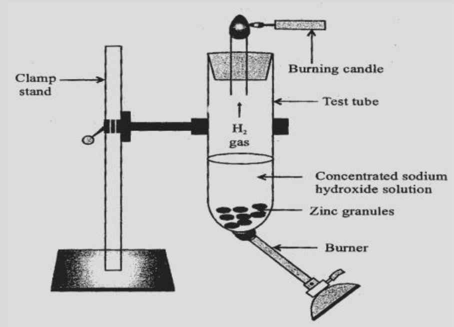
$$H^+_{(aq)} + OH^-_{(aq)} \rightleftharpoons H_2O_{(l)}$$

- Strength of acid/base: It depends upon the tendency of acid or base to furnish H^+ or OH^- in solution.

ACTIVITY CORNER

To study reaction of base with zinc metal.

- Take 2-3 pieces of granulated zinc in a test tube.
- Add about 2 mL of concentrated sodium hydroxide solution. Warm the contents of the test tube.



- **Observation:** It is observed that zinc metal dissolves and the hydrogen gas is evolved which is a combustible gas and can be tested by burning candle or the flame of a burner.
- **Conclusion:** Metals react with bases to give H_2 gas.

Industrial Uses of Bases

- **Sodium hydroxide (NaOH):** Used in manufacture of soap, paper, synthetic fibre (called rayon), petrol refining and as a laboratory reagent. It is also known as caustic soda.
- **Potassium hydroxide (KOH):** Used in alkaline batteries and soft soap known as caustic potash.
- **Calcium hydroxide, $Ca(OH)_2$:** Used in manufacture of bleaching powder, softening of hard water and neutralizing acid in the soil. Also known as slaked lime.
- **Magnesium hydroxide, $Mg(OH)_2$:** Used as an antacid to neutralize excess acid in the stomach and to cure indigestion. Also known as milk of lime.
- **Ammonium hydroxide (NK_4OH):** Used for removing grease stains from clothes.

ILLUSTRATION

9. The following reactions occur in aqueous solution. Predict the products and identify the acids and bases (and conjugate species) in the reaction of –

(a) NH_3 with CH_3COOH

(b) $N_2H_5^+$ with CO_3^{2-}

(c) H_3O^+ with OH^-

(d) HSO_4^- with $HCOO^-$.

Sol. (a) $\underset{Base}{NH_3} + \underset{Acid}{CH_3COOH} \rightarrow \underset{Acid}{NH_4^+} + \underset{Base}{CH_3COO^-}$

(b) $\underset{Acid}{N_2H_5^+} + \underset{Base}{CO_3^{2-}} \longrightarrow \underset{Base}{N_2H_4} + \underset{Acid}{HCO_3^-}$

(c) $\underset{Acid}{H_3O^+} + \underset{Base}{OH^-} \longrightarrow \underset{Acid\ and\ base}{2H_2O}$

(d) $\underset{Acid}{HSO_4^-} + \underset{Base}{HCOO^-} \rightarrow \underset{Base}{SO_4^{2-}} + \underset{Acid}{HCOOH}$

10. What is Arrhenius definition of bases?

Sol. A base is a substance which when dissolved in water gives hydroxide (OH^-) ions in the solution.

11. NH_3 does not hydroxyl group, then why is it a base?

Sol. NH_3 when dissolved in water forms ammonium hydroxide (NH_4OH) which ionizes to give OH^- ions in the solution. Hence, it is a base.

12. What is the difference between a strong base and a weak base. Give two examples. Of each of them.

Sol. **Strong base:** A base which dissociates completely in the aqueous solution to produce a large amount of OH^- ions is called a strong base. For example, sodium hydroxide (NaOH) and potassium hydroxide (KOH).

Weak base: A base which dissociates only partially in the aqueous solution and hence gives only a small amount of OH^- ions is called a weak base. For example, ammonium hydroxide (NH_4OH) and hydroxide, $Ca(OH)_2$.

Salts

A salt is a compound formed from an acid by the replacement of the hydrogen in the acid by a metal. Salts are formed when acids react with bases. Salts can be defined as chemical substances that are formed as a result of neutralization of acid by base. They can be divided into 4 classes:

- **Normal Salts**

  They do not generally contain any replaceable hydrogen atom. They are formed when all replaceable hydrogens of an acid are replaced by metal, e.g., NaCl, KCl etc. they are formed when a strong acid is completely neutralized by a strong base. These salts do not react with water on dissolving. In aqueous solution their pH is 7.0. e.g. When HCl is neutralized with NaOH, normal salt NaCl is produced.

  $HCl + NaOH \rightarrow NaCl + H_2O$

  All chlorides, bromides, iodides, sulphates, nitrates of alkali and alkaline earth metals are normal salts.

- **Neutral Salts**

  These salts are formed by the reaction of a weak acid with weak base. e.g. When CH_3COOH is neutralized with NH_4OH, neutral salt CH_3COONH_4 is produced.

  $CH_3COOH + NH_4OH \rightarrow CH3COONH_4 + H_2O$

- **Acidic Salts**

  These salts contain replaceable hydrogen which is released in aqueous solvent. They are formed when a polybasic acid is partially neutralized by a weak base. e.g. $NaHCO_3$, $NaHSO_3$. They are acidic because they retain one or more hydrogen of parent acid.

  e.g. When weak base NH_4OH reacts with strong acid HCl, acidic salt NH_4Cl is formed.

  $NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

  In aqueous solution their pH is less then 7.0. These salts further react with bases to form neutral salts, e.g. NH_4Cl, $(NH_4)_2CO_3$.

Note:

- Ammonium halides (NH_4Cl, NH_4Br, NH_4I), NH_4NO_3, $(NH_4)_2SO_4$ are acidic salts.
- Metal sulphates except of alkali & alkaline earth metals, all metal sulphates are acidic salts.
- Except nitrates of alkali & alkaline earth metals, almost all metal nitrates are acidic salts.

- **Basic Salts**

  These salts are formed by partial neutralization of a polyacidic base with weak acid. They contain replaceable OH^- group that ionizes in aqueous medium. They are basic because they retain one or more hydroxyl group of parent base. In aqueous solution their pH is more then 7.0. These salts further react with acids to form neutral salts.

- Except hydroxides of alkali metals and alkaline earth metals other hydroxides are weak hydroxides.
- Most metal acetates, carbonates, oxalates, cyanides and fluorides are basic salts.

Family of Salts

Various salts having common metal ion can be grouped in a single family. Few families of salts are:

- The salts of 'hydrochloric acid' are called 'chlorides'
- The salts of 'sulphuric acid' are called 'sulphates'.
- The salts of 'nitric acid' are called 'nitrates'.
- The salts of 'carbonic acid' are called 'carbonates'.
- The salts of 'acetic acid' are called 'acetates'.

Family	Sodium salts	Potassium salts
Common ion	Na^+	K^+
Chlorides	NaCl	KCl
Bromides	NaBr	KBr

Nitrates	$NaNO_3$	KNO_3
Sulphates	Na_2SO_4	K_2SO_4
Carbonates	Na_2CO_3	K_2CO_3

ACTIVITY CORNER

To write the formulae of the salts and to identify their acids and bases and the families.

- Write down the formulae of the salts given below: (1) Potassium sulphate, (2) Sodium sulphate (3) Calcium sulphate (4) Magnesium sulphate (5) Copper sulphate (6) Sodium chloride (7) Sodium nitrate (8) Sodium carbonate (9) Ammonium chloride.
- Identify the acids and bases from which the above salts may be obtained.
- Salts having the same positive or negative radicals are said to belong to a family. For example NaCl and Na_2SO_4 belong to the family of sodium salts. Similarly, NaCl and KCl belong to the family of chloride salts.
- How many families can you identify among the salts given in this activity?

- **Discussion and Conclusion:**

	Salt	Formula	Acid	Base
1.	Potassium sulphate	K_2SO_4	H_2SO_4	KOH
2.	Sodium sulphate	Na_2SO_4	H_2SO_4	NaOH
3.	Calcium sulphate	$CaSO_4$	H_2SO_4	$Ca(OH)_2$
4.	Magnesium sulphate	$MgSO_4$	H_2SO_4	$Mg(OH)_2$
5.	Copper sulphate	$CuSO_4$	H_2SO_4	$Cu(OH)_2$
6.	Sodium chloride	NaCl	HCl	NaOH
7.	Sodium nitrate	$NaNO_3$	HNO_3	NaOH
8.	Sodium carbonate	Na_2CO_3	H_2CO_3	NaOH
9.	Ammonium chloride	NH_4Cl	HCl	NH_4OH.

- **Families:**
  - On the basis of common acids
  Sulphates: K_2SO_4 Na_2SO_4, $CaSO_4$, $MgSO_4$, $CuSO_4$
  Chlorides: NaCl, NH_4Cl; Carbonates: Na_2CO_3; Nitrates: $NaNO_3$
  - On the basis of common bases.
  Sodium salts: Na_2SO_4, NaCl, $NaNO_3$, Na_2CO_3
  Potassium salts: K_2SO_4; Calcium salts: $CaSO_4$
  Magnesium salts: $MgSO_4$; Copper salts: $CuSO_4$
  Ammonium salts: NH_4Cl

- **Mixed Salts**
  Salts containing more than one cation or anion other than H^+ or H^- ions are called mixed salts, e.g. $CaOCl_2$, $NaKCO_3$, $Na(NH_4)HPO_4$. They are generally produced by simultaneous neutralization of single acid by more than one base or single base by more than one acid.

- **Double Salts**
  When saturated solutions of two salts containing different cations are crystallized in a single solution, crystals obtained are of a double salt. e.g. when K_2SO_4 & $Al_2(SO_4)_3$ are crystallized by mixing their equimolar solutions a double salt $K_2SO_4.Al_2(SO_4)_3.24H_2O$ is formed. These salts give positive tests for all constituent ions,

- **What Do Acids and Bases have in Common?**

Water itself shows acidic and basic nature to some extent as:

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

But water is overall neutral because H^+ and OH^- ions present are equal in number. When acidic substances are dissolved in water, they increase the concentration of H^+ ions in the solution which makes it overall acidic. However OH^- ions are present in the solution but in less concentration as compared to H^+ ions.
When basic substances are dissolved in water, they increase the concentration of OH^- ions in the solution which makes it overall basic. However H^+ ions are present in the solution but in less concentration as compared to OH^- ions.

pH Scale

- The hydrogen ion concentration [H^+] in aqueous solution is represented in moles per litre. Since, [H^+] is very small, it is inconvenient to express the acidity or alkalinity of an aqueous solution on the basis of [H^+] ion concentration.
- pH scale is an scale used to major the strength of Arrhenius acids and bases. It was designed by Sorensen in 1909. In pH/ p stands for potenz meaning power in German and H stands for hydrogen ions. As acidic or basic nature is due to

active H^+ ions in aqueous medium, pH can also be defined as a scale to represent the activity of H^+ ions in aqueous solution.

- In chemical terms pH can be defined as logarithm of reciprocal of H_3O^+ ions in aqueous solution.

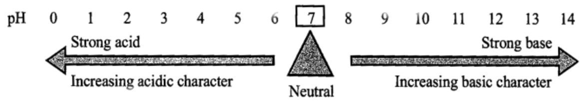
or $pH = \log\frac{1}{[H_3O^+]}$ OR $[H^+]=10^{-pH}$

In pH scale less is the value of pH more is the acidic nature of the substance. In pH scale:

- all substances having pH value between 0 and 7 are called acids.

- all substances having pH value equal to 7 are neutral.

- all substances having pH value between 7 and 14 are called bases.



- **Logarithmic Values for Some Common Digits**

$\text{Log}_{10} 2 = 0.3010$ $\log_{10} 3 = 0.48$ $\log_{10} 4 = 0.60$

$\log_{10} 5 = 0.69$ $\log_{10}10^x = x$ i.e., $\log_{10}10^5 = 5$

If concentration of H^+ ion is more than 1, pH value comes less than 0 and pH scale only include numeric values between 0 to 14 and pH value of a solution cannot be negative. If negative value is calculated for pH than it must be stated that pH value of solution is less than 0, but use of negative sign is omitted.

ILLUSTRATION

13. Calculate Ph value of

(a) 2×10^{-3} M HCl, 2×10^{-4}M H_2SO_4

Sol. $(a)\ pH = \log\frac{1}{[H^+]}$ $[H^+]=2\times10^{-3}$

$$pH = \log\frac{1}{2\times10^{-3}} = \log_{10}\frac{10^3}{2} = \log_{10}10^3 - \log_{10}2$$

(b) 2×10^{-4}M H_2SO_4 $Given, M =\ 2\times10^{-4}$M

$[H^+] =\ 2\times2\times10^{-4} = 4\times10^{-4}$

$$\text{pH} = \log_{10}\frac{1}{2\times10^{-4}} = \log_{10}\frac{10^4}{4}$$

$= \log_{10}10^4 - \log_{10}4 = 4 - 0.60 = 3.4$

14. Determine the Ph of the solution when hydrogen ion concentration is

$(i)1.0\times10^{-3}\ M\ HCl, (ii)1.0\times10^{-5}\ M\ HNO_3$

Sol.

(i) $\text{pH} = -\log[\text{H}^+]$. $[\text{H}^+] = 1.0\times10^{-3}$ M

$\therefore\ \text{pH} = -\log(1.0\times10^{-3})$

= - (-3) log 10 = 3 $(\because \log10 = 1)$

(ii) $[\text{H}^+] = 1.0\times10^{-5}$ M.

$\text{pH} = -\log[\text{H}^+] = -\log(1.0\times10^{-5})$

= - (- 5) log 10 = 5

15. Ph of a solution changes from 6 to 5. What changes do not you expect in hydrogen ion concentration?

Sol. We know that Ph = -log[H^+]

If pH is 6, then [H^+]will be $1.0\times10^{-6}\ mol\,L^{-1}$

If pH is 5, then [H^+]will be $1.0\times10^{-5}\ mol\,L^{-1}$

Increase in concentration of H^+ ions

$$= \frac{1.0\times10^{-5}\ \text{mol}\,\text{L}^{-1}}{1.0\times10^{-6}\ \text{mol}\,\text{L}^{-1}} = 10\,\text{times}$$

Therefore, H^+ concentration is increased 10 times when pH changes from 6 to 5.

16. What is the pH of a 0.01 M NaOH solution?

Sol. Since NaOH is completely dissociated, thus gives 0.01 M OH^- ions. Since OH^- ion concentration is known, we can calculate the H^+ ions concentration from ionic product value.

Ionic product of water,

$$[H^+][OH^-] = 1\times10^{-14}\ or\ [H^+] = \frac{1\times10^{-14}}{[OH^-]}$$

$Now, [OH^-] = 0.01M = 1\times10^{-2}\ M$

$$\therefore\ [H^+] = \frac{1\times10^{-14}}{1\ \times10^{-2}} = 10^{-12}\ M$$

$pH = -\log[H^+] = -\log[10^{-12}] = -(-12)\log10 = 12.$

17. Calculate the concentration of H^+ and OH^- of a solution whose (a) pH =0, (b) pH = 14.

Sol. (a) pH = 0, $[H^+] = 10^{-pH} = 10^{-0} = 1$

$$[OH^-] = \frac{K_w}{[H^+]} = \frac{1\times10^{-14}}{1} = 1\times10^{-14}$$

(b) $pH = 14, [H^+] = 10^{-pH} = 10^{-14}$

$$[OH^-] = \frac{K_w}{[H^+]} = \frac{1\times10^{-14}}{10^{-14}} = 1$$

18. Determine the pH of solution when hydrogen ion concentration is

$(a)1.0\times10^{-9}\ M\ \ (b)1.0\times10^{-5}\ M.$

Sol. (i) $pH = -\log[H^+].[H^+] = 1.0\times10^{-9}\ M$

$\therefore pH = -\log(1.0\times10^{-9}) = -(-9)\log10 = 9$

$(\because \log10 = 1)$

(ii) $[H^+] = 1.0\times10^{-5}\ M.$ $pH = -\log[H^+]$

$= -\log(1.0\times10^{-9}) = (-5)\log = 5.$

19. Calculate the pH of 10^{-5} M NaOH solution.

Sol. NaOH is a strong base. It ionizes completely in aqueous solution as

$$NaOH \xrightarrow{+Water} Na^+_{(aq)} + OH^-_{(aq)}$$

$\therefore p[OH^-] = [NaOH] = 10^{-5}\ M$

To calculate the pH of the solution, we should know [H^+]. This can be calculated by using the formula

$$[H^+][OH^-] = K_w = 10^{-14}\,M^2$$

Or $[H^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{10^{-5}} = 10^{-9}M.\ \ \therefore\ pH = 9$

20. How many grams of NaOH should be dissolved in one litre of the solution to prepare a solution with pH =12?

Sol. pH = 12 means $[H^+] = 10^{-12}\,M$

$$\therefore [H^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}M^2}{10^{-12}M} = 10^{-2}M$$

As NaOH ionizes completely as

$$NaOH \xrightarrow{+Water} Na^+ + OH^-$$

$$\therefore [NaOH] = [OH^-] = 10^{-2}\,M = 10^{-2}\,mol\,L^{-1}$$

$$= (10^{-2}\,mol\,L^{-1})(40\,g\,mol^{-1}) = 0.4\,g\,L^{-1}$$

$$(\because Molar\ mass\ of\ NaOH$$

$$= 23+16+1 = 40\,g\,mol^{-1})$$

21. Calculate the pH of a solution obtained by dissolving
(i) 0.02 mole of hydrochloric acid in 2 litres of the solution.
(ii) 0.01 mole of sulphuric acid in 2 litres of the solution.

Sol. (i) Molar concentration of HCl acid solution

$$= \frac{0.02\,mol}{2\,L} = 0.01\,mol\,L^{-1} = 10^{-2}\,mol\,L^{-1}$$

As HCl is a strong acid, it completely ionizes as

$$HCl \xrightarrow{+Water} H^+ + Cl^-$$

$\therefore [H^+] = [HCl] = 10^{-12}\,M$. Hence, pH = 2

(ii) Molar concentration of H_2SO_4 solution

$$= \frac{0.01\,mol}{2\,L} = 0.005\,mol\,L^{-1}$$

As H_2SO_4 is a strong acid, it completely ionizes as: $H_2SO_4 \xrightarrow{+Water} 2H^+ + SO^{2-}{}_4$

Thus, 1 molecule of H_2SO_4 gives $2H^+$ ions

$$\therefore [H^+] = 2\times[H_2SO_4] = 2\times 0.005 = 0.01\,mol/L$$

$$= 10^{-2}\,mol\,L^{-1}.Hence, pH = 2$$

- **Dilution Concept**
  If molarity of an acid is M_1 and volume is V_1 , when some water is added in this acid, then volume According to dilution concept,
  $M_1V_1 = M_2V_2$

ILLUSTRATION

22. When 900 mL H_2O is added in 2M, 100 ml HCl, calculate pH value of this acidic solution.

Sol. According to,
$M_1V_1 = M_2V_2$
V1= 100 mL, V_2=100 + 900 = 1000 mL,
M_1 = 2, M_2 =?

$$\Rightarrow 2\times 100 = M_2\times 1000$$

$$\Rightarrow M_2 = 2\times 10^{-1} = 0.2\,M$$

$$[H^+] = 0.2$$

$$pH = \log\frac{1}{0.2} = \log\frac{10}{2} = \log 5 = 0.69$$

Importance of pH in Daily Life

pH is quite useful to us in a number of ways in daily life. These applications are based on the neutralization reactions which we have studied.

- **Comparison of Relative Acidic and Basic Strengths of Acids and Bases**
  The main utility of pH is to know about the acidic and basic strengths of solutions and also to compare these.
  In general, lesser the pH of a solution, more will be its acidic strength, similarly, higher the pH of a solution, more will be its basic strength. For example, pH of vinegar is about 3.0 while that of coffee is nearly 4.5. This means that vinegar is a stronger acid than coffee. Similarly, pH of washing soda solution (Na_2CO_3 solution) is nearly 9.0 and that of lime water containing $Ca(OH)_2$ is 10.5. This indicates that lime water is a stronger base than washing soda solution.
- **pH of Our Digestive System**
  Our stomach produces hydrochloric acid. It helps in the digestion of food without harming our stomach. The stomach produces too much acid and this causes pain and irritation and feeling of burning. This stage is called acidity. To get relief from this pain, we take tablets known as antacids. These contain bases to neutralize the excess acids. Magnesium hydroxide (called milk of magnesia), a mild base is also used for this purpose.
- **pH of Change Leads to Tooth Decay**
  The white enamel coating on our teeth is made up of insoluble calcium phosphate which is quite hard. When the pH in the mouth falls below 5.5, the enamel gets corroded. The bacteria's present in the mouth break down the sugar to lactic acid. The formation of these acids causes decrease in pH. It is therefore, advisable to avoid eating sugary foods and also to keep the mouth clean so that sugar and food particles may not be present. The toothpastes contain in them some basic ingredients and they help in neutralizing the effect of the acids and also in increasing the pH in the mouth.

- **Self-Defence by Animals and Plants Through Chemical Warfare**
  Stings of bees and ants contain methanoic acid (or formic acid). When stung, they cause lot of pain and irritation. The cure is the rubbing of the affected area with soap. Sodium hydroxide (NaOH) present in the soap neutralizes acid injected in the body and thus brings the pH back to its original level. The effect of stings by wasps containing alkali is neutralized by the application of vinegar which is ethanoic acid (or acetic acid).
  Nettle plants are herbaceous in nature and grow in the wild. These have sharp hairs which contain in them methanoic acid. If they happen to touch the body by accident, their stings are very painful because methanoic acid present gets injected in the body. These are commonly known as stinging nettles. The stung area is rubbed by the leaves of "dock plants' which often grow beside nettle plants.
- **Soil pH and Plant Growth**
  The growth of plants in a particular soil is also related to its pH. Soils with high peat content or iron minerals or with rotting vegetation tend to become acidic. The soil pH can reach as low as 4. The acidic effect can be neutralized by 'liming the soil' which is carried by adding calcium hydroxide, calcium oxide or powdered chalk. Similarly, the soil with excess of lime stone or chalk is usually alkaline. Sometimes, its pH reaches as high as 8.3 and is quite harmful for the plant growth. In order to reduce the alkaline effect, it is better to add some decaying organic matter which is acidic in nature (compost or manure).

Plants	Preferred pH range
Potatoes	4.5 – 6.0
Carrot, sweet potato	5.5 – 6.5
Cauliflower, garlic, tomato	5.5 – 7.5
Onion, cabbage	6.6 – 7.5

ILLUSTRATION

23. What type of pH should the soil have for healthy growth of plants?

Sol. Soil should neither be alkaline nor highly acidic.

24. Why do we feel a burning sensation in the stomach when we overeat? What is the medicine used called? Give one example.

Sol. When we overeat, the burning sensation in the stomach is due to excess hydrochloric acid produced in the stomach. The medicine used to neutralize it is called “antacid”. The most commonly used antacid is magnesium hydroxide (milk of magnesia)

25. Why does tooth decay start when the pH of the mouth is lower than 5.5?

Sol. The tooth enamel is made up of calcium phosphate which is insoluble in water. When pH in the mouth is lower than 5.5, it becomes moderately acidic, the dissolution of calcium phosphate starts, i.e., tooth decay begins.

Some Important Acids, Bases and Salts

Sodium Hydroxide, NaOH

Chemical Formula	NaOH
Common name	Caustic soda
Action on litmus	Turn red litmus blue
Solubility	Soluble in water
(Highly alkaline)	

- **Pure Sodium Hydroxide**
  Commercial sodium hydroxide, besides impurities such as Na_2SO_4, NaCl etc. invariably contains some amount of sodium carbonate due to the absorption of atmospheric CO_2. However, it may be purified by dissolving it in alcohol in which impurities including Na_2CO_3 NaCl, Na_2SO_4 are insoluble. The filtrate on evaporation given off alcohol leaving behind pure solid NaOH.

- **Physical Properties**
  (i) It is a deliquescent, white crystalline solid.
  (ii) It is highly soluble in water and the solution is bitter in taste, corrosive and soapy to touch.
  (iii)It is sparingly soluble in alcohol. However, KOH is fairly soluble in alcohol.
- **Chemical Properties**
  (i) Action of atmosphere: NaOH on exposure to atmosphere absorbs moisture and CO_2 to form Na_2CO_3.
  $$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$
  (ii) Strong alkali nature: Sodium hydroxide is a strong alkali as it ionizes completely in water furnishing OH^- ions.
  $$NaOH \longrightarrow Na^+ + OH^-$$
  (a) It reacts with acids forming salts.
  Type 1: NaOH reacts with strong acids give normal salts which are neutral salts.
  $$NaOH + HCl \longrightarrow NaCl + H_2O$$
  $$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$$
  $$NaOH + HNO_3 \longrightarrow NaNO_3 + H_2O$$
  Type 2: NaOH reacts with weak acids give basic salt.
  $$NaOH + CH_3COOH \longrightarrow CH_3COONa + H_2O$$
  (b) It combines with acidic oxides to form salts which may be acidic, basic or neutral.

NaOH + Acidic oxide $\longrightarrow$ Salt + Water

$$2NaOH + CO_2 \longrightarrow \underset{Sodium\,carbonate}{Na_2CO_3} + H_2O$$

$$2NaOH + SO_2 \longrightarrow \underset{Sodium\,sulphite}{Na_2SO_3} + H_2O$$

$$2NaOH + 2NO_2 \longrightarrow \underset{Sodium\,nitrate}{NaNO_3} + NaNO_2 + H_2O$$

(c) Oxides of Amphoteric metals (aluminium, zinc, tin and lead) dissolve in sodium hydroxide forming corresponding salts. These metals are called amphoteric metals as they form amphoteric oxides.

$$Al_2O_3 + 2NaOH \longrightarrow \underset{Sodium\,meta-aluminate}{2NaAlO_2} + H_2O$$

$$ZnO + 2NaOH \longrightarrow \underset{Sodium\,zincate}{Na_2ZnO_2} + H_2O$$

$$SnO + 2NaOH \longrightarrow \underset{Sodium\,stannite}{Na_2SnO_2} + H_2O$$

$$SnO_2 + 2NaOH \longrightarrow \underset{Sodium\,stannate}{Na_2SnO_3} + H_2O$$

$$PbO + 2NaOH \longrightarrow \underset{Sodium\,plumbite}{Na_2PbO_2} + H_2O$$

$$PbO_2 + 2NaOH \longrightarrow \underset{Sodium\,plumbate}{Na_2PbO_3} + H_2O$$

(iii) **Action on amphoteric metals:** Amphoteric metals (Be, Al, Ga, Zn, Sn and Pb) react with NaOH to liberate hydrogen gas.

$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_3 + 3H_2$

$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$

$Sn + 2NaOH + H_2O \longrightarrow Na_2SnO_3 + 2H_2$

$Pb + 2NaOH + H_2O \longrightarrow Na_2PbO_3 + 2H_2$

(iv) Action on ammonium salts: Ammonium salts on heating with sodium hydroxide solution release ammonia gas.

$$NH_4Cl + NaOH \longrightarrow NH_3\uparrow + NaCl + H_2O$$

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2NH_3\uparrow + 2H_2O$$

(v) Action of carbon monoxide: NaOH reacts with carbon monoxide under pressure at 150-200°C to form sodium formate.

$$NaOH + CO \xrightarrow[5-10\,atm.]{150-200^o C} \underset{Sodium\ formate}{HCOONa}$$

Note: carbon monoxide is neutral gas but it show acidic nature with NaOH. For this reaction its structure is responsible.

(vi) Hydroxides of Amphoteric metals (Be, Al, Ga, Zn, Sn and Pb) are soluble in NaOH, due to complex formation, but other hydroxides do not dissolve in NaOH.

Note:

1. Any mixture of hydroxides of amphoteric metals and other metals can be separated by NaOH.

Example: Mixture of $Fe(OH)_3$ and $Al(OH)_3$ is separated by NaOH.

2. Some Hydroxide [$Zn(OH)_2$, $Cu(OH)_2$, $Cd(OH)_3$] are soluble in NH_4OH. Example: Mixture of $Al(OH)_3$ and $Zn(OH)_2$ cannot be separated by NaOH, because both are soluble in NaOH. This mixture is separated by NH_4OH.

(vii) Caustic Property: Sodium hydroxide breaks down the proteins to a pasty mass. On account of this property, it is commonly called as Caustic soda. $NaOH_{(aq.)}$, is also called as soda lye.

- **Uses**

Sodium hydroxide is used as a reagent in the laboratory. Sodium hydroxide is a strong alkali and is used widely in the chemical industry, e.g., soap manufacture, purification of bauxite, manufacture of rayon etc. However, when a base is required to neutralize acids, it is more economical to use sodium carbonate, ammonia or lime. Chlorine gas which is a valuable by-product in NaOH manufacture can be used for the production of chemicals such as polyvinyl chloride (PVC), an important plastic.

Sodium Carbonate ($NaCO_3.10H_2O$)

Chemical Formula	Na_2CO_3-$10H_2O$
Common name	Washing soda
Action on litmus	Neutral
Solubility	Sparingly soluble in water (weakly basic)

It is the most important chemical of commercial use. It exists in various forms such as:

(a) Anhydrous sodium carbonate or Na_2CO_3 or soda ash.

(b) Monohydrate sodium carbonate or $Na_2CO_3.H_2O$ or crystal carbonate.

(c) Heptahydrate sodium carbonate or $Na_2CO_3.7H_2O$.

(d) Decahydrate sodium carbonate or $Na_2CO_3.10H_2O$.

The first process for the manufacture of Na_2CO_3 was invented by Le-Blanc. However, this process has become obsolete and replaced by modern methods. The most important method for the preparation of sodium carbonate is Solvay process or ammonia soda process.

- **Solvay Process or Ammonia Soda Process**

The raw materials used in this process are the common salt (NaCl) or brine solution, ammonia and lime stone. The process in brief, involves the formation of a sparingly soluble sodium bicarbonate by the reaction of sodium chloride and ammonium bicarbonate in aqueous solution. Sodium bicarbonate on heating decomposes into sodium carbonate. The reactions taking place in the process are:

$$NH_3 + H_2O + CO_2 \longrightarrow \underset{\text{Ammonium blcarbonate}}{NH_4HCO_3}$$

$$NaCl + NH_4HCO_2 \longrightarrow \underset{\text{Soudium blcarbonate}}{NaHCO_3} \downarrow + NH_4Cl$$

$$\underset{\text{Filtered and heated}}{2NaHCO_3} \xrightarrow{\Delta} Na_2CO_3 + \underbrace{H_2O + CO_2}_{\text{Can be used again}}$$

- **Electrolytic Process**
  In the Nelson cell used in the manufacture of sodium hydroxide, carbon dioxide under pressure is blown along with steam. The sodium hydroxide produced then reacts with carbon dioxide to form sodium carbonate. The solution is concentrated and crystallized.
  $$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

- **Physical Properties**
  (i) Sodium carbonate is a white crystalline solid. The decahydrate form on standing in air effloresces and crumbles to powder.
  (ii) On heating, the monohydrate changes into the anhydrous form which does not decompose on further heating even to redness.
  (iii)It is soluble in water with the evolution of considerable amount of heat to show alkaline nature due to hydrolysis.
  $$Na_2CO_3 + 2H_2O \longrightarrow 2NaOH + H_2CO_3$$

- **Chemical Properties**
  (i) Action of acids: It is readily decomposed by acids with evolution of carbon dioxide. The reaction involves two steps.
  $Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$
  $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$
  (ii) Action of CO_2: On passing CO_2 through the concentrated solution of sodium carbonate, sodium bicarbonate gets precipitated.
  $$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$
  (iii) Action of Silica: The mixture of sodium carbonate and silica on fusion gives sodium silicate.
  $Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2\uparrow$
  Sodium silicate is called soluble glass or water glass as it is soluble in water.
  (iv) Action of slaked lime: Sodium hydroxide is formed when the solution of sodium carbonate containing sulphur on treatment with sulphur dioxide gives sodium thiosulphate ($Na_2S_2O_3$).
  $$Na_2CO_3 + SO_2 \xrightarrow{H_2O} Na_2SO_3 + CO_2\uparrow$$
  $$Na_2SO_3 + S \longrightarrow Na_2S_2O_3$$

- **Uses**
  Sodium carbonate is used:
  - in the manufacture of glass, sodium silicate, paper, borax, soap powders, caustic soda etc.
  - in laundry and in softening of water as washing soda.
  - in textile and petroleum refining.
  - as a laboratory reagent. The mixture of Na_2CO_3 and K_2CO_3 is used as a fusion mixture. It is used in quantitative analysis to standardize acid solutions. In qualitative analysis, it is used in the detection of acidic radicals especially of insoluble salts.
  - for the preparation of various carbonates of metals.
  - $Na_2CO_3.NaHCO_3.2H_2O$ is sodium sesqui carbonate. It is neither deliquescent nor efflorescent and is used for wood washing.
  - A mixture of Na_2CO_3 + CaS is called black ash.

Sodium Hydrogen Carbonate ($NaHCO_3$)

Chemical Formula	$NaHCO_3$
Common name	Baking soda
Action on litmus	Turn red litmus to blue
Solubility	Sparingly soluble in water (weakly basic)

- **Preparation**
  It is obtained as the intermediate product in the Solvay or ammonia soda process. Normal carbonate can be changed to bicarbonate by passing carbon dioxide through its saturated solution.
  $$Na_2CO_3 + CO_2 + H_2O \longrightarrow \underset{\text{Sparingly soluble}}{2NaHCO_3}$$

- **Properties**
  - $NaHCO_3$ is a white crystalline solid, sparingly soluble in water.
  - The solution is alkaline in nature due to hydrolysis.
  $$NaHCO_3 + H_2O \rightleftharpoons NaOH + H_2CO_3$$
  Its aqueous solution gives yellow colour with methyl orange but no colour with phenolphthalein and thus is weak base.
  - On heating, it releases carbon dioxide and water forming sodium carbonate.
  $$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$$

- **Uses**
  $NaHCO_3$ is used :
  - as a medicine (antacid) to neutralize the acidity in the stomach.
  - in making effervescent drinks.
  - for making baking powder (a mixture of potassium hydrogen tartar ate and sodium bicarbonate).
  - for production of CO_2.
  - in fire extinguishers.

- **Sodium Chloride**

Chemical Formula	NaCl
Common name	Rock salt
Action on litmus	Neutral
Solubility	Soluble in water

- **Occurrence**

  It occurs abundantly in nature. The three major sources are:
  - Sea water which contains about 3% of sodium chloride.
  - Water of inland lakes such as Sambhar lake in Rajasthan.
  - Salt mines.

- **Preparation of NaCl**

  Salty water is subjected to evaporation in open air in fields which leaves behind residue of impure sodium chloride as deposits.

- **Purification of Common Salt**

  Sodium chloride obtained from sea water or from lakes contains many impurities such as sulphates of sodium and magnesium along with chlorides of calcium and magnesium. The chlorides of calcium and magnesium are particularly undesirable on account of their deliquescent nature.

  For its purification common salt is dissolved in minimum quantity of water to get a saturated solution. Insoluble impurities are filtered off. Hydrogen chloride gas is passed through the saturated solution. Due to common ion effect, the ionic product of NaCl increases above the solubility product and therefore NaCl is then thrown out as pure crystals. The impurities being more soluble remain in the mother liquor. The crystals are filtered, washed and dried.

  $$NaCl_{(g)} \underset{}{\overset{Water}{\rightleftharpoons}} Na^+_{(aq.)} + Cl^-_{(aq.)}$$

  $$HCl_{(g)} \underset{}{\overset{Water}{\rightleftharpoons}} H^+_{(aq.)} + Cl^-_{(aq.)}$$

  Thus, $[Na^+][Cl^-] > K_{sp_{NaCl}}$

- **Properties**

  - It is white crystalline solid (m.pt. 1073 K), soluble in water (solubility 36/100 g at 239 K). It dissolves in water with absorption of heat.
  - It is insoluble in alcohol.
  - The common salt is the starting material for the preparation of all other sodium compounds e.g., NaOH, Na_2CO_3, $NaHCO_3$, etc. and extraction of sodium.

- **Uses**

  NaCl is used as:
  - an essential constituent of food.
  - a preservative of food articles like fish, meat, etc.
  - for making useful sodium compounds.
  - in 'salting out' of soap, and in making freezing mixture.

  Note: Pure NaCl is not hygroscopic. It shows hygroscopic nature due to impurities.

Calcium Carbonate, $CaCO_3$

Chemical Formula	$CaCO_3$
Action on litmus	Neutral
Solubility	Slightly soluble in water

It exists in nature in huge quantities in various forms such as lime stone, marble, chalk, etc.

- **Preparation**

  It is obtained by passing carbon dioxide through lime water or by adding sodium carbonate solution to $CaCl_2$.

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

  $$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$$

- **Properties**

  - It is a white powder, insoluble in water.
  - It dissolves in water in presence of CO_2 due to formation of calcium bicarbonate.

  $$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

- **Uses**

  - Precipitated chalk is used in toothpastes and face powders, in medicine for indigestion, in adhesives and in cosmetics.
  - Chalk is used in paints and distempers.
  - Marble is used for building purposes, in the production of CO_2 in laboratory.
  - Limestone is used in the manufacture of quick lime, slaked lime, cement, washing soda and glass.
  - As flux in the smelting of iron and lead ores.

Calcium Sulphate

Chemical Formula	$CaSO_4.2H_2O$
Common name	Gypsum
Action on litmus	Neutral
Solubility	Slightly soluble in water

It occurs in nature as Anhydrite ($CaSO_4$) and Gypsum ($CaSO_4.2H_2O$). $CaSO_4.2H_2O$ is also known as alabaster.

- **Preparation**

It is prepared by reacting any calcium salt either sulphuric acid or a soluble sulphate (i.e., Na_2SO_4).

$$CaCl_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HCl$$

$$CaCl_2 + Na_2SO_4 \longrightarrow CaSO_4 + 2NaCI$$

- **Properties**

  - It is a white crystalline solid, sparingly soluble in water and solubility decreases as the temperature increases.

  - It dissolves in dilute acids. It also dissolves in ammonium sulphate due to the formation of double sulphate, $(NH_4)_2SO_4.CaSO_4.H_2O$.

  - Gypsum on heating first changes from monochnic form to orthorhombic form without loss of water. At 120°C, it loses three-fourth of its water of crystallization and forms hemihydrates $(2CaSO_4).H_2O$ or $CaSO_4.(1/2)H_2O$ which is commonly known as Plaster of Paris. It becomes anhydrous at 200°C. The anhydrous form is known as burnt plaster or dead plaster. On strongly heating, it decomposes to give calcium oxide.

$$2[CaSO_4.2H_2O] \xrightarrow{120^\circ C} \underset{Plaster\ of\ Paris}{[2CaSO_4.H_2O]} + 3H_2O$$

$$[2CaSO_4.H_2O] \xrightarrow{200^\circ C} \underset{Dead\ plaster}{2CaSO_4} + H_2O$$

$$2CaSO_4 \xrightarrow[Strongly]{Heated} 2CaO + 2SO_2 + O_2$$

  - A suspension of gypsum when saturated with ammonia and carbon dioxide forms ammonium sulphate, a nitrogenous fertilizer.

$$2NH_3 + CaSO_4 + CO_2 + H_2O \longrightarrow (NH_4)_2SO_4 + CaCO_3$$

  It forms calcium sulphide on heating strongly with carbon.

$$CaSO_4 + 4C \longrightarrow CaS + 4CO$$

- **Uses**

  It is used:
  - For the manufacture of plaster of Paris, cement, ammonium sulphate, sulphuric acid, etc.
  - For preparing blackboard chalks.
  - In anhydrous form as drying agent.

Calcium Sulphate Hemihydrate

Chemical Formula	$2CaSO_4.H_2O$ or $CaSO_4.\frac{1}{2}H_2O$
Common name	Plaster of Paris
Action on litmus	Neutral
Solubility	Insoluble

- **Preparation**

  It is obtained when gypsum is heated at 120°C.

$$2[CaSO_4.2H_2O] \xrightarrow{120^\circ C} \underset{\substack{Plaster\ of\ Paris \\ (Calcuim\ sulphate\ hemihydrate)}}{2CaSO_4.H_2O} + 3H_2O$$

- **Properties**

  - Plaster of Paris is a white powder.
  - Plaster of Paris has the property of setting to hard mass when a paste with water is allowed to stand aside for some time. Slight expansion occurs during the setting as water is absorbed to reform $CaSO_4.2H_2O$ (gypsum). The setting process is exothermic.

$$\underset{Plaster\ of\ Paris}{2CaSO_4.2H_2O} \xrightarrow[H_2O]{Setting} \underset{\substack{Gypsum \\ (Orthorhombic)}}{CaSO_4.2H_2O} \xrightarrow{Hardening} \underset{\substack{Gypsum \\ (Monoclinic)}}{CaSO_4.2H_2O}$$

  The setting of Plaster of Paris is catalyzed by sodium chloride and is retarded by borax or alum. Addition of alum to Plaster of Paris gives hard setting. The mixture is known as Keene's cement.
  - When Plaster of Paris is heated at 200°C, it forms anhydrous calcium sulphate which is known as dead plaster. It has no setting property as it takes up water only very slowly.

- **Uses**

  It is used:
  - In making blue paint.
  - In laundry for blueing purposes.
  - In making wallpaper and blue tinted paper.
  - In calico printing.
  - In making ornamental casts and idols.
  - For making casts for supporting fractured bones (Plaster).

Calcium Oxychloride

Chemical Formula	$Ca(OCl)_2.2H_2O$
Common name	Bleaching powder
Solubility	Soluble

Bleaching powder is a mixed salt of calcium hypo-chloride [$Ca(OCl)_2.2H_2O$] and basic calcium chloride [$CaCl_2.Ca(OH)_2.H_2O$]. Actually it is not a true compound but simply it is represented by formula $CaOCl_2$.

- **Methods of Preparation**

  It is prepared by action of Cl_2 on dry slaked lime.

$$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$$

  According of Cliffored, the formation of bleaching powder is explained as:

$$2Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$$

$$CaCl_2 + Ca(OH)_2 + H_2O \rightarrow CaCl_2.Ca(OH)_2.H_2O$$

$$3Ca(OH)_2 + 2Cl_2 \longrightarrow Ca(OCl)_2 + \underbrace{CaCl_2.Ca(OH)_2.H_2O}_{Bleaching\ powder} + H_2O$$

- **Physical Properties**

  It is pale yellow powder having smell of NH_3. It is sparingly soluble in water and gives a milky suspension when dissolved in water. Its aqueous solution gives positive test for Ca^{2+}, Cl^{-} and OCl.

- **Chemical Properties**
 - **Decomposition:** On standing, it decomposes (auto oxidation) to calcium chloride and calcium chlorate.

$$6CaOCl_2 \longrightarrow 5CaCl_2 + Ca(ClO_3)_2$$

On standing chlorine percentage decreases regularly. Due to this germicidal nature is lost. Decomposition of bleaching powder is catalyzed by cobalt chloride.

$$2CaOCl_2 \xrightarrow{CoCl_2} 2CaCl_2 + O_2$$

- Reaction with Dilute Acid:

(a) With limited quantity of acid: With limited quantity of dilute acids (HCl, H_2SO_4 etc.) bleaching powder liberates oxygen.

$$2CaOCl_2 + H_2SO_4 \longrightarrow CaSO_4 + CaCl_2 + 2HOCl$$

$$HOCl \longrightarrow HCl + [O]$$

Evolution of oxygen is responsible for its bleaching action.

(b) With excess of acid: With excess of acid, bleaching powder liberates chlorine which is called available chlorine. Due to available chloride, bleaching powder acts as disinfectant.

$$CaOCl_2 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + Cl_2$$

$$CaOCl_2 + 2HCl \longrightarrow CaCl_2 + H_2O + Cl_2$$

Cl_2 is liberated with CO_2 also.

$$CaOCl_2 + CO_2 \longrightarrow CaCO_3 + Cl_2$$

- Oxidizing Nature: Bleaching powder is good oxidizing agent because it gives nascent oxygen. i.e.,

$$CaOCl_2 + Na_3AsO_3 \longrightarrow Na_3AsO_4 + CaCl_2$$

$$CaOCl_2 + 2FeSO_4 + H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + CaCl_2 + H_2O$$

$$CaOCl_2 + KNO_2 \longrightarrow CaCl_2 + KNO_3$$

$$3CaOCl_2 + 2NH_3 \longrightarrow 3CaCl_2 + 3H_2O + N_2$$ -

Ethyl alcohol, acetone etc. give chloroform when treated with bleaching powder.

- Bleaching Action: As bleaching powder gives nascent oxygen, it shows bleaching property.

$$\text{Coloured matter} + [O] \longrightarrow \text{Colourless matter}$$

Bleaching Process

1. The material to be bleached is first passed through solution of NaOH to remove greasy matter.
2. Now material is passed through aqueous solution of bleaching powder and then through very dilutes HCl solution. HCl reacts with bleaching powder to liberate nascent oxygen which bleaches the material.
3. To remove excess of Cl_2, material is dipped in antichlor substances like hypo or sodium bisulphite.

$$2Na_2S_2O_3 + Cl_2 \longrightarrow 2NaCl + Na_2S_4O_6$$

$$NaHSO_3 + Cl_2 + H_2O \longrightarrow NaHSO_4 + 2HCl$$

- **Uses**
 Bleaching powder is used:
 - As bleaching agent in textile, paper and jute industry.
 - As disinfectant.
 - As oxidant.
 - In the preparation of several compounds.
 - For making wool unshrinkable.

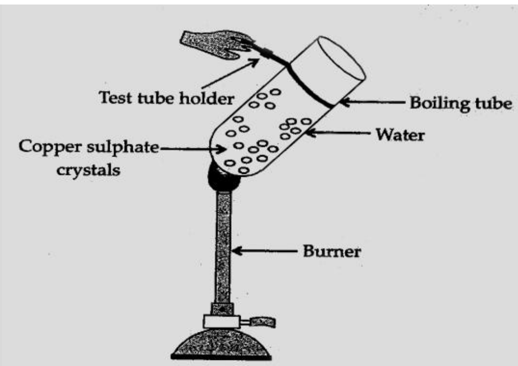
Water of Crystallization

Water of crystallization is the fixed number of water molecules present in one formula unit of a salt. For example, five water molecules are present in one formula unit of copper sulphate. So, the chemical formula of hydrated copper sulphate is $CuSO_4.5H_2O$ Similarly, ten water molecules are present in one formula unit of washing soda. The chemical formula of hydrated sodium carbonate is $Na_2CO_3.10H_2O$. Another important hydrated salt is gypsum which has two molecules of water of crystallization. It has the formula $CaSO_4.2H_2O$.

ACTIVITY CORNER

To test the presence of water of crystallization in copper sulphate crystal

- Take a few crystals of copper sulphate in a dry boiling tube. These have bluish green colour. Heat the tube by holding it with a test tube holder on the flame of the burner.
- You will observe that the colour of copper sulphate after heating becomes white. You may notice water droplets in the holding tube which are obtained from water of crystallization.



- Now, add 2-3 drops of water on the sample of copper sulphate obtained after heating. You will observe that the blue colour of copper sulphate is restored.
- **Observation:** We observe that copper sulphate crystals which seems to be dry contain water of crystallization. When we heat the crystals this water is removed and the salt becomes white. When we again moisten the crystals, the blue colour of crystals again reappears.
- **Conclusion :** The water of crystallization is given out on heating according to the reaction given below:

$$\underset{(Blue)}{CuSO_4.5H_2O} \xrightarrow{Heat} \underset{(White)}{CuSO_4} + 5H_2O$$

$$\underset{(White)}{CuSO_4} + 5H_2O \longrightarrow \underset{(Blue)}{CuSO_4.5H_2O}$$

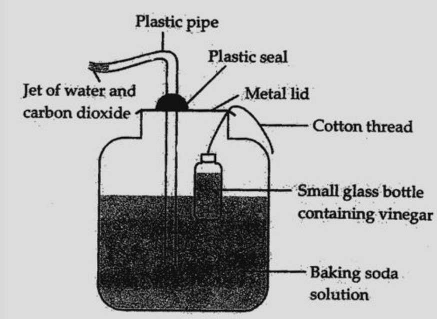
Do You Know

Crystalline salts like $Na_2CO_3.10H_2O$, $CaSO_4.2H_2O, CaSO_4.\frac{1}{4}H_2O, CuSO_4.5H_2O$, etc. which seem to dry contain water of crystallization. Water of crystallization is a fixed number of water molecules present in one formula unit of the salt.

Activity Corner

To prepare soda acid fire extinguisher

- **Requirements:** (i) An empty and clean 1/2 litre jam jar with a metal lid, (ii) a small bottle, (iii) a plastic tube about 1 m long and 5 mm diameter, (iv) plasticine, baking soda, vinegar, a cotton thread and water, proceed as follows:
- Remove the metal lid from the empty jam jar and in the middle of it make a hole with the help of a nail and hammer, such that the size of the hole is just equal to the diameter of plastic pipe.
- Pass the plastic pipe through the hole in the lid, such that, when lid is placed on the jar, it is close to the base. Apply plasticine on the upper side of lid to make it air tight.



- Make a solution of baking soda by dissolving about 30 g of it in 300 cc of water. Pour the solution in the jar.
- Take a small glass bottle (such as inkpot) and tie a loop around its neck with a long cotton thread. Fill 3/4 of the bottle with vinegar.
- Suspend the glass bottle in the jar by holding the cotton thread such that a part of it is above the baking soda solution.
- Fix the lid on the jar. The lid will hold the cotton thread. Now, your working model of fire extinguishers is ready.
- In order to use it, life the vinegar mixes with baking soda solution, it produces carbon dioxide gas, which forces out the contents in the bottle.
- **Observation:** When sulphuric acid reacts with NaHCO3 to give CO_2.

$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + CO_2.$$

CONCEPT MAP

Acids

An acid is a substance that dissociates to form hydrogen ions.

Classification

- **Strong acids** : The acids which are completely ionised in water. *e.g.* HCl, HNO_3, H_2SO_4, etc.
- **Weak acids** : The acids which are ionised to only very small extent in water. *e.g.* CH_3COOH, HCN, H_2CO_3 and H_3PO_4, etc.

Properties

Acids taste sour.
Acids are good electrolytes.
Acids change the colour of litmus from blue to red.

Reactions

- Acids react with certain metals to form salt and H_2 gas. → The reactive metal will dissolve and will give out heat.
- Acids react with metal oxides/hydroxides to give salt and water. → The bubbles of gas produced contain H_2 gas. H_2 gas can be tested by inserting a lighted splint into a test tube. If the gas is hydrogen, the splint will continue burning with a 'pop' sound.
  - Types of oxides
    - Acidic oxides
    - Basic oxides
    - Amphoteric oxides
    - Neutral oxides
- Acids react with all carbonates to produce salt, water and CO_2 → The bubbles of gas produced contain CO_2 gas. CO_2 can be tested by bubbling the gas into calcium hydroxide solution also known as lime water. If the gas is CO_2, a white ppt. will be observed in the calcium hydroxide solution.

Uses

HNO_3 : Toilet cleaner, pickling of metal, digestion of food, etc.
H_3BO_3 : Eye-wash, talcum powder.
H_2CO_3 : Making aerated drinks.
CH_3COOH : Food preservation, manufacturing of rubber.

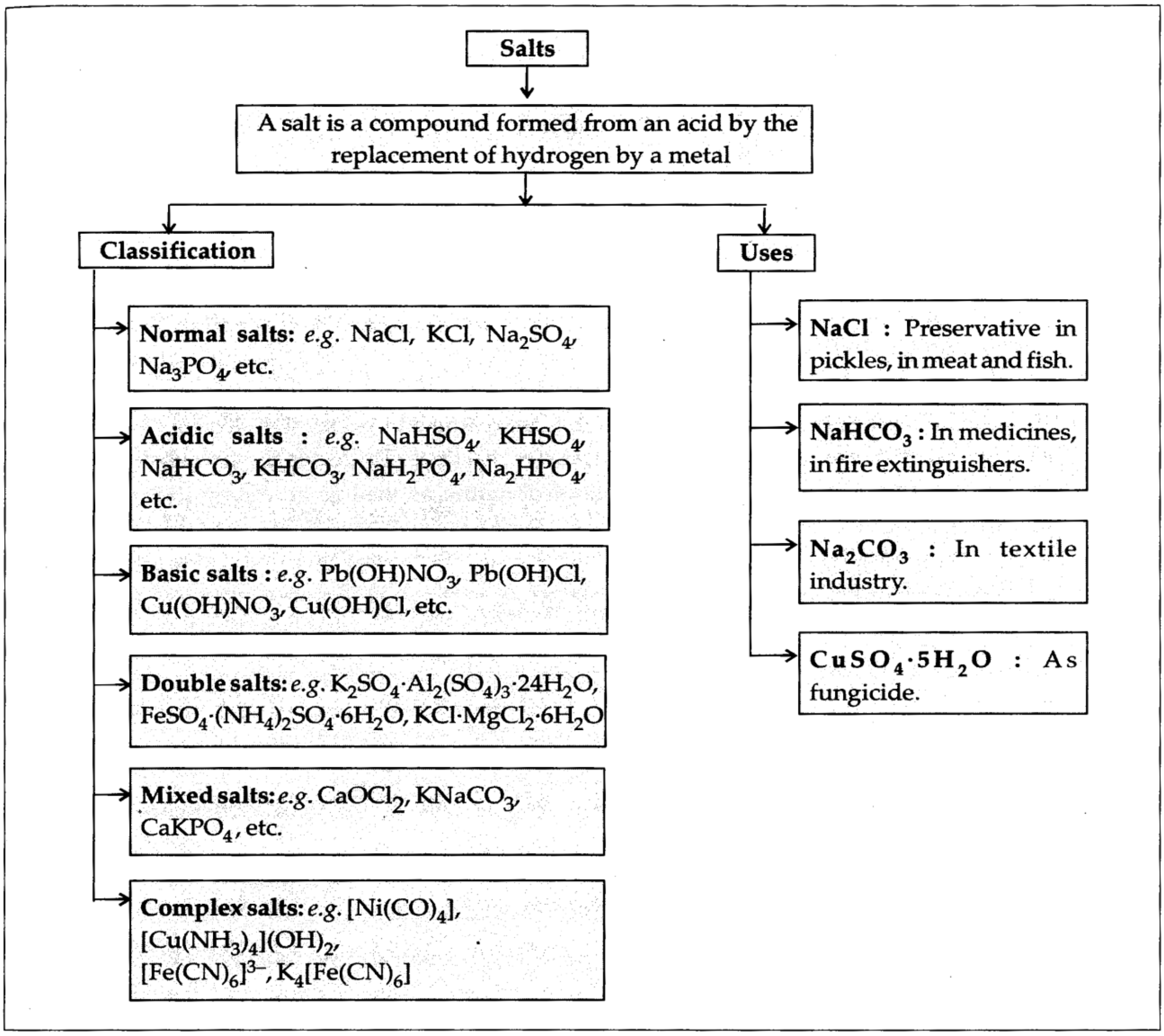
CONCEPT MAP

Bases

A base is a substance that contains hydroxide ions (OH^-) when dissolved in water.

- **Classification**
  - **Strong bases** : The bases which completely ionise to give hydroxide ions (OH^-). *e.g.* NaOH, KOH, etc.
  - **Weak bases** : The bases which ionise to only small extent in water to give hydroxide ions (OH^-). *e.g.* NH_4OH, $Ca(OH)_2$, etc.
- **Properties**
  - Bases have a bitter taste.
    Alkalies are soapy to feel.
    They turns red litmus blue.
- **Reactions**
  - Ammonium salt + base $\rightarrow$ salt water + ammonia
  - Metallic hydroxide $\xrightarrow{\text{heat}}$ metallic oxide + water
  - Acid + base $\rightarrow$ salt + water
- **Uses**
  - **NaOH** : Manufacture of soap, rayon, petrol refining, etc.
  - **KOH** : Manufacture of toilet soap, drain cleaner, etc.
  - **NH_4OH** : Used for removing grease stains from clothes.

CONCEPT MAP



ESSENTIAL POINTS For COMPETITIVE EXAMS

Bronsted-Lowry Concept

The Arrhenius concept of acids and bases was extended further by Johannes Bronsted and Thomas M. Lowry (1923).

According to Bronsted-Lowry concept, an acid is a substance which can donate proton (H^+) while a base is a substance which can accept a proton (H^+).

In other words, according to Bronsted-Lowry concept, acid is a proton donor and base is a proton acceptor. For example, in the following reaction, HCl loses a proton and is an acid whereas NH_3 accepts a proton and is a base.

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

The main advantage of this concept is that it is not restricted to neutral molecules. In this concept acid-base reaction are regarded as proton transfer reactions. There are certain substances such as H_2O, HCO_3^-, HSO_4^-, etc. which are capable of donating as well as accepting the proton. These substances are called amphoteric substances. For example, water behaves as an acid as well as base as illustrated below:

As a base: $\underset{acid}{HCl_{(aq)}} + \underset{base}{H_2O_{(l)}} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$

As an acid: $\underset{acid}{H_2O_{(l)}} + \underset{base}{NH_{3(aq)}} \rightleftharpoons NH^+_{4(aq)} + OH^-_{(aq)}$

Similarly, bicarbonate ion (HCO_3^-) behaves as an acid and a base as:

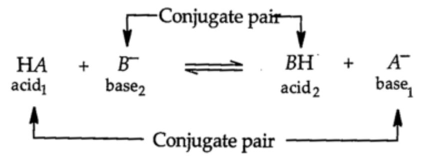
$$\underset{acid}{HCO^-_{3(aq)}} + \underset{(base)}{H_2O_{(l)}} \rightleftharpoons NH^+_{4(aq)} + CO^{2-}_{3(aq)}$$

$$\underset{acid}{HCl_{(aq)}} + \underset{base}{HCO^-_{3(aq)}} \rightleftharpoons H_2CO_{3(aq)} + Cl^-_{(aq)}$$

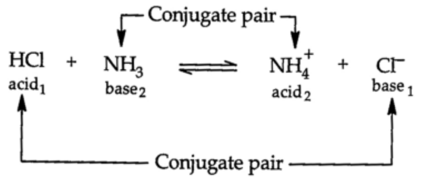
All Arrhenius acids are also Bronsted acids but Arrhenius bases are not Bronsted bases.

Conjugate Acid-Base Pair

In case of acid-base reaction, the reverse reaction is also an acid-base reaction. Every acid forms a conjugate base by the loss of a proton while every base forms a conjugate acid by the gain of a proton (H^+).



For example,



- Add base reactions always proceed in the direction from the stronger to weaker acid-base combination.

For example,

$$\underset{\text{stronger acid}}{H_2SO_4} + \underset{\text{stronger base}}{NH_3} \xrightarrow{\text{Water}} \underset{\text{weaker acid}}{NH_4^+} + \underset{\text{weaker base}}{HSO_4^-}$$

Lewis Concept of Acids and Bases

According to Lewis concept, an add is a substance which can accept a pair of electrons, whereas a base is a substance which can donate a pair of electrons i.e., acids are electron acceptors and bases are electron donors.

- Chemical Species which can act as Lewis Acid
  - Electron deficient neutral compounds i.e. molecules in which central atom has incomplete octet, e.g., BF_3, $FeCl_3, AlCl_3$, etc.
  - All simple cations, e.g., $H^+, Mg^{2+}, Ag^+, Fe^{3+}$, etc.
  - Molecules having a multiple bond between atoms of different electro negativities, e.g., SO_3, CO_2, etc.
  - In coordinate complexes, metal atoms act as Lewis acid e.g., in $Ni(CO)$ Ni acts as Lewis acid.
  - Molecules having a central atom with empty d-orbital's, e.g., SiF_4, $SnCl_4$.
- **Chemical Species which can act as Lewis Base**
  - Electron rich neutral compounds i.e. molecules with at least one lone pair of electrons, e.g., $\ddot{N}H_3$, R-$\ddot{O}$-H, R-$\ddot{N}H_2$
  - All negatively charged ions, e.g., CN^-, OH^-, Cl^-, etc.

Buffer Solutions

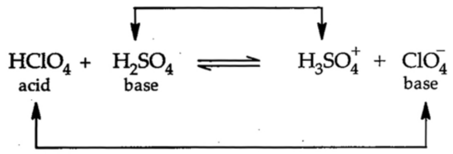
Buffer solution is denned as a solution which resists the change in its pH value when small amount of add or base is added to it or when the solution is diluted. A conjugate pair of acid and base differ by a proton only.

$$Acid \rightleftharpoons Base + H^+$$

- A strong acid gives a weak conjugate base and vice versa.

- If two acids (with respect to water) are mixed together then the weaker acid will act as a base with respect to the stronger acid.

For example,



Buffer solution has a definite pH value at specific temperature and it does not change on keeping for a long time. Buffers are classified into two categories:

- **Simple Buffers**
  These are the solutions of salt of weak acid and weak base. For example CH_3COONH_4 (ammonium acetate), NH_4CN, etc.
- **Mixed Buffers**
  These are the mixture of two solutions. These are further of two types:
  (i) Acidic buffers
  These are the solutions of a mixture of weak acid and salt of this weak acid with strong base.
  For example $CH_3CHOOH + CH_3COONa$. They have pH value lesser than 7 i.e., pH < 7.
  (ii) Basic buffers
  These are the solutions of mixture of a weak base and salt of this weak base with strong acid.
  For example $NH_4OH + NH_4Cl$. They have the pH value more than 7 i.e., pH > 7.
  Solution of ampholytes e.g. proteins and amino acids also serve as simple buffers.
  A mixture of an acid salt and a normal salt of polybasic acid e.g., $Na_2HPO_4 + Na_3PO_4$ are also included in simple buffers.

- **pH of a Buffer Solution**
  pH value of a buffer solution is given by Henderson-Hasselbalch equation

  (i) Acidic buffer: $\boxed{pH = pK_a + \log\frac{[Salt]}{[Acid]}}$

  where K_a is dissociation constant of acid and $pK_a = -\log K_a$, [Salt] and [Acid] are molar concentrations of salt and acid respectively.

(ii) Basic buffer: $\boxed{pOH = pK_b + \log\frac{[Salt]}{[Base]}}$

where K_b, is dissociation constant of base and $pK_b = -\log K_b$, [Salt] and [Base] are molar concentrations of salt and base respectively. By calculating the value of pOH, pH can be determined as

$\boxed{pH = 14 - pOH}$

pH of buffer varies with temperature because value of K_w, changes with temperature.

- **Buffer Capacity (Buffer Index)**
  Buffer capacity is the number of moles of an acid or base added to change pH of one litre of buffer solution by one unit.
  Hence, Buffer capacity =
  $$\frac{\textit{Number of moles of acid or base added per litre of buffer}}{\textit{Change in pH}} = \frac{dn}{d(pH)}$$
  Buffer capacity is maximum for those buffers which have equimolar concentration of weak acid and its salt or weak base and its salt
  i.e., [Salt] = [Acid] or [Salt] = [Base]
  Hence, pH = pK_a or pOH = pK_a,

- **Blood as a Buffer Solution**
  Blood acts as a buffer solution and maintains a pH level of about 7.4. Any change in pH of blood can produce illness or even causes death.

Oxyacids

Compound in which -OH group is attached to non-metal is known as oxyacids. In these acids ions are derived from - OH group.

Oxyacids of Nitrogen

- Nitrous Acid, HNO_2
  The free acid is unknown. It is known only in solution.
  Properties:
  - Aqueous solution of nitrous acid is pale blue. This is due to the presence of nitrogen trioxide, N_2O_3
  The colour fades on standing for some time.
  - It is a weak add and reacts with alkalies to form salts known as nitrites.
  $$HNO_2 + NaOH \longrightarrow NaNO_2 + H_2O$$
  - The arid is unstable and even in cold solution, it undergoes auto-oxidation.
  $$3HNO_2 \longrightarrow 2NO + HNO_3 + H_2O$$ -
  Oxidizing nature: It acts as an oxidizing agent due to ease with which it decomposes to give nascent oxygen.
  $$2HNO2 \longrightarrow H_2O + 2NO + O$$
  Reducing nature: Nitrous arid also acts as a reducing agent as it can be oxidized into nitric acid.
  Uses: In analytical chemistry, it is used both as an oxidizing and reducing agent.

- **Nitric Acid, HNO_3**
  Chemical properties:
  - It is a very strong arid. It exhibits usual properties of acids. It reacts with basic oxides, carbonates, bicarbonates and hydroxides forming corresponding salts.
  $$CaO + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O$$
  $$Na_2CO_3 + 2HNO_3 \longrightarrow 2NaNO_3 + H_2O + CO_2$$
  $$NaOH + HNO_3 \longrightarrow NaNO_3 + H_2O$$
  - **Oxidizing nature:** Nitric acid acts as a strong oxidizing agent as it decomposes to give nascent oxygen easily.
  - **Oxidation of non-metal (Reaction with non-metal):**
  (i) Sulphur reacts with hot and cone. Nitric acid to give H_2SO_4 and nitrogen dioxide gas i.e., sulphur is oxidized to sulphuric acid.
  $$S + \underset{\text{conc.and hot}}{6HNO_3} \longrightarrow H_2SO_4 + 6NO_2 + 2H_2O$$
  (ii) Carbon is oxidized to carbonic arid.
  $$C + 4HNO_3 \longrightarrow H_2CO_3 + 4NO_2 + H_2O$$
  (iii) Phosphorus reacts with hot and conc. nitric acid to give H3P04 and N03 i.e., it is oxidized to orthophosphoric arid.
  $$2P + \underset{\textit{conc.and hot}}{10HNO_3} \longrightarrow 2H_3PO_4 + 10NO_2 + 2H_2O$$
  (iv) Iodine reacts with hot and cone. HNO_3 to give iodic acid i.e., it is oxidized to iodic acid.
  $$I_2 + \underset{\textit{hot and conc.}}{10HNO_3} \longrightarrow 2HIO_3 + 10NO_2 + 4H_2O$$
  - Action on metals:
  Mostly active metals react with arid to give hydrogen. Nitric acid cannot be used in preparation of hydrogen because it is strong oxidizing agent. It react with hydrogen (at the moment of formation) to produce any oxide of nitrogen (NO, N_2O or NO_2).

- **Metals which are above hydrogen in electro-chemical series :**
  1. Magnesium and manganese are the metals that liberate hydrogen with 6 % dilute nitric acid.
  $$Mg + \underset{\text{dilute}}{2HNO_3} \longrightarrow Mg(NO_3)_2 + H_2$$

$$\underset{dilute}{Mn + 2HNO_3} \longrightarrow Mn(NO_3)_2 + H_2$$

2. When metal nitrates are formed and nitric acid is reduced:

(a) Reaction of nitric acid with zinc:

Case 1: Zinc react with 6% diluted HNO_3 to produce zinc nitrate and ammonium nitrate

$$\text{Zinc} + \text{nitric acid } (6\%) =$$
$$\text{zinc nitrate} + \text{ammonium nitrate} + \text{water}$$

$$4Zn + \underset{very\ dilute}{10HNO_3} \rightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

Case 2: Zinc reacts with dil. HNO_3 (20%) to form zinc nitrate and nitrous oxide (N_2O).

Zinc + nitric acid (20%) = zinc nitrate + nitrous oxide + water

$$4Zn + \underset{dilute}{10HNO_3} \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$$

Case 3: It reacts with conc. HNO_3 (70%) to form nitrogen dioxide.

Zinc + nitric acid (70%) = zinc nitrate + nitrogen dioxide + water

$$Zn + \underset{conc.}{4HNO_3} \rightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$$

(b) Reaction of nitric acid with iron:

Case 1: Iron with very dilute nitric acid forms ammonium nitrate.

Iron + nitric acid (6%) = ferrous nitrate + ammonium nitrate + water

$$4Fe + 10HNO_3 \rightarrow \underset{\text{Ferrous nitrate}}{4Fe(NO_3)_2} + NH_4NO_3 + 3H_2O$$

Case 2: Iron with dilute nitric acid forms nitrous oxide.

Iron + nitric acid (20%) = ferrous nitrate + nitrous oxides + water

$$4Fe + \underset{\text{dilute}}{10HNO_3} \longrightarrow 4Fe(NO_3)_2 + N_2O + 5H_2O$$

Case 3: Iron with cone. HN03 forms nitrogen dioxide (NO_2).

Iron + nitric acid (70%) = ferric nitrate + nitrogen dioxide + water

$$Fe + \underset{conc.}{6HNO_3} \longrightarrow \underset{Ferric\ nitrate}{Fe(NO_3)_3} + 3NO_2 + 3H_2O$$

Iron is rendered passive by highly concentrated nitric acid 80%.

(c) Reaction of nitric acid with tin:

Case 1: Tin forms ammonium nitrate with dilute nitric acid.

Tin + nitric acid (20%) = Stannous nitrate + ammonium nitrate + water

$$4Sn + \underset{dilute}{10HNO_3} \rightarrow \underset{Stannous\ nitrate}{4Sn(NO_3)_2} + NH_4NO_3 + 3H_2O$$

Case 2: Tin forms metastannic acid with cone. HNO_3 and evolves nitrogen dioxide.

Tin + nitric acid (hot and cone.) = Meta stannic acid + nitrogen dioxide + water

$$Sn + \underset{hot\ conc.}{4HNO_3} \longrightarrow \underset{metastannic\ acid}{H_2SnO_3} + 4NO_2 + H_2O$$

(d) Reaction of nitric acid with lead:

Case 1: It forms nitric oxide with dilute HNO_3.

Lead + nitric acid (20%) = lead nitrate + nitric oxide + water

$$3Pb + \underset{Dilute}{8HNO_3} \rightarrow 3Pb(NO_3)_2 + 2NO + 4H_2O$$

Case 2: It forms nitrogen dioxide with conc. HNO_3.

Lead + nitric acid (conc.) = lead nitrate + nitrogen dioxide + water

$$Pb + \underset{Conc.}{4HNO_3} \longrightarrow Pb(NO_3)_2 + 2NO_2 + 2H_2O$$

- **Metals which are below hydrogen in the electrochemical series**

(a) Reaction of nitric acid with copper:

Case 1: Copper with cold dil. HNO_3 forms nitric oxide (NO).

Copper + nitric acid (20%) = copper nitrate + nitric oxide + water

$$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

Case 2: Copper with hot cone. HNO_3 forms nitrogen dioxide (NO_3)

Copper + nitric acid (hot and conc.) = copper nitrate + nitrogen dioxide + water

$$Cu + \underset{Hot\ conc.}{4HNO_3} \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

(b) Reaction of nitric acid with silver:

Case 1: Silver behaves similarly as copper.

Silver + nitric acid (20%) = silver nitrate + nitric oxide + water

$$3Ag + \underset{dilute}{4HNO_3} \rightarrow 3AgNO_3 + NO + 2H_2O$$

Silver + nitric acid (conc.) = silver nitrate + nitrogen dioxide + water

$$Ag + \underset{Conc.}{2HNO_3} \longrightarrow AgNO_3 + NO_2 + H_2O$$

(c) Reaction of nitric acid with mercury:

Case 1: Mercury with dilute nitric acid forms mercurous nitrate and nitric oxide.

Mercury + nitric acid (20%) = mercurous nitrate + nitric oxide + water

$$6Hg + \underset{dilute}{8HNO_3} \rightarrow \underset{Mercurous\ nitrate}{3Hg_2(NO_3)_2} + 2NO + 4H_2O$$

Case 2: Mercury with conc. HNO_3 forms mercuric nitrate and nitrogen dioxide.

Mercury + nitric acid (conc.) = mercuric nitrate + nitrogen dioxide + water

$$Hg + \underset{conc.}{4HNO_3} \rightarrow \underset{mercuric\ nitrate}{3Hg_2(NO_3)_2} + 2NO_2 + 2H_2O$$

- **Metals which become passive**

The concentrated nitric acid renders metals like iron, cobalt, nickel, chromium etc. The inertness exhibited by metals under conditions in which chemical activity is expected is known as passivity. For example, iron displaces copper from copper sulphate solution. This property of iron is lost if it is dipped in cone. HNO_3.

- **Metals which do not react**
  Noble metals like gold, platinum, iridium, rhodium, etc., are not acted upon nitric acid. However, these metals dissolve in aqua-regia (3 parts conc. HCl and one part conc. HNO_3). Aqua-regia forms nascent chlorine which attacks metals.

- **Gold:**

$$\left[HNO_3 + 3HCl \rightarrow \underset{\text{Nitrosyl chloride}}{NOCl} + 2H_2O + 2Cl\right] \times 3$$

$$[Au + 3Cl \longrightarrow AuCl_3] \times 2$$

$$[AuCl_3 + HCl] \longrightarrow HAuCl_4 \times 2$$

$$2Au + 3HNO_3 + 11\,HCl \longrightarrow \underset{\text{Chloroauric acid}}{2HAuCl_4} + 3NOCl + 6H_2O$$

- **Platinum:**

$$\left[HNo_3 + 3HC1 \longrightarrow NOCl + 2H_2O + 2Cl\right] \times 2$$

$$Pt + 4Cl \longrightarrow PtCl_4$$

$$PtCl_4 + 2HNO_3 \longrightarrow H_2PtCl_6$$

$$Pt + 2HNO_3 + 8HCl \longrightarrow \underset{\text{Chloroplantic acid}}{H_2PtCl_6} + 2NOCl + 4H_2O$$

Oxyacids of Sulphur

A large number of oxyacids are known in the case of sulphur either in Free State or in the form of salts or both. Oxyacids with S — S links are called thioacids. Acids having sulphur in lower oxidation state belong to -ous series while those having sulphur in higher oxidation state belong to *-ic* series.

For example:

Sulphurous acid ((H_2SO_3)) O.N. of sulphur, + 4.

Sulphuric acid (H_2SO_4) O.N. of sulphur, + 6.

The following are main oxyacids of sulphur:

1. Sulphurous acid series:	**Oxidation number**
(i) Sulphurous acid, H_2SO_3	+4
(ii) Thiosulphurous acid, $H_2S_2O_2$	+1
(iii) Hyposulphurous acid, $H_2S_2O_2$	+3
(iv) Pyrosulphurous acid, $H_2S_2O_7$	+4
2. Sulphuric acid series:	**Oxidation Number**
(i) Sulphuric acid, H_2SO_4	+6
(ii) Thiosulphuric acid, $H_2S_2O_3$	+5, -1
(iii) Pyrosulphuric acid, $H_2S_2O_7$	+5
3. Thionic acid series:	
(i) Dithionic acid, $H_2S_2O_6$	
(ii) Polythionic acid, $H_2S_nO_6$ (n = 3, 4, 5, 6)	
4. Peroxy acid series:	**Oxidation number**
(i) Peroxy monosulphuric acid, H_2SO_5 (Caro's acid)	+6
(ii) Peroxy disulphuric acid, $H_2S_2O_8$ (Marshall's acid)	+6

- **Sulphuric Add (Oil of Vitriol) H_2SO_4**
  Sulphuric acid is considered as the King of chemicals. In ancient days. It was called oil of vitriol as it was prepared by distilling ferrous sulphate (Green vitriol).
  Heat is evolved when dissolved in water, usually bumping occurs. Due to this reason water should not be added to concentrated sulphuric acid for dilution but concentrated sulphuric add should be added slowly to cold water with constant stirring. Due to its great affinity for water, it is used as a dehydrating substance.

- It decomposes carbonates and bicarbonates into carbon dioxide.
- It reacts with electropositive metals evolving hydrogen.
- It displaces more volatile acids forming their metal salts.

$$Ca_3(PO_4)_2 + 3H_2SO_4 \longrightarrow 3CaSO_4 + 2H_3PO_4$$

$$\underset{\text{Calcium oxalate}}{CaC_2O_4} + H_2SO_4 \longrightarrow CaSO_4 + \underset{\text{Oxalic acid}}{H_2C_2O_4}$$

- **Oxidizing nature:** It acts as a strong oxidizing agent.

(a) Non-metals such as carbon and sulphur are oxidized to their oxides.

$$C + 2H_2SO_4 \longrightarrow CO_2 + 2SO_2 + 2H_2O$$

$$S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$$

Phosphorus is oxidized to orthophosphoric acid.

$$2P + 5H_2SO_4 \rightarrow 2H_3PO_4 + 5SO_2 + 2H_2O$$

(b) Metals like copper, silver, mercury, etc. react with cone. H_2SO_4 to produce metal salt and SO_2 gas.

$$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$$

$$Ag + 2H_2SO_4 \longrightarrow Ag_2SO_4 + SO_2 + 2H_2O$$

$$Hg + 2H_2SO_4 \longrightarrow HgSO_4 + SO_2 + 2H_2O$$

- **Dehydrating nature:** H_2SO_4 act as strong dehydrating agent.

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} \xrightarrow[\text{(-11H}_2\text{O)}]{H_2SO_4} 12C$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{(-6H}_2\text{O)}]{H_2SO_4} 6C$$

H_2SO_4 absorbs sulphur trioxide forming oleum or fuming sulphuric acid.

$$H_2SO_4 + SO_3 \longrightarrow \underset{Oleum}{H_2S_2O_7}$$

- **It is used:**
  1. In the refining of petroleum.
  2. In storage batteries.
  3. As an important laboratory reagent. In organic chemistry it is used for synthesis of various organic compounds and sulphonation reactions. It is also used as an oxidizing and a dehydrating agent.

Important Points

- AH organic acids (except those having — SO_3H, i.e., sulphonic acids) are weak acids. However halogen substituted acids are stronger one. CCl_3COOH is as stronger as HCl.
- **Mineral acids:** (H_2SO_4, HCl, HNO_3) are strong acids.
- In oxo-acids only those H-atoms are replaceable which are attached on O-atom, i.e.,

$$HO-\overset{\overset{O}{\|}}{\underset{\underset{OH}{|}}{P}}-OH$$, i.e., H_3PO_4 is tri basic acid.

$$HO-\overset{\overset{O}{\|}}{\underset{\underset{H}{|}}{P}}-OH$$, i.e., H_3SO_3 is dibasic acid.

- An add salt has at least one replaceable H-atom, $NaHSO_4, NaHS, NaHCO_3, NaHC_2O_4$, $NaHC_2O_4$, $NaH_2PO_4, Na_2HPO_4, NaH_2PO_3$.

NaH_2PO_3 is not an acid salt since it does not have replaceable H-atom.

- Basic character of oxides decreases along the period and increases down the group i.e., Basic character decreases along the period:

$$Na_2O > MgO > A1_2O_3 > SiO_2 > P_2O_5 > SO_2 > Cl_2O_3$$

Basic character increases down the group:

(a) $Li_2O < Na_2O < K_2O < Rb_2O < Cs_2O$

(b) $OF_2 < Cl_2O < Br_2O < I_2O$

- Oxides of metals are normally basic, oxides of non-metals are normally acidic. CO, N_2O and NO are neutral.

Basic oxides	Acidic oxides	Amphoteric
K_2O, CaO, MgO	$\underset{(Neutral)}{CO}$ and CO_2	ZnO, Al_2O_3, BeO, SnO_2 (All are metal oxides)
CuO, Fe_2O_3 etc.	$\underbrace{NaO, NO}_{(Neutral)}, N_2O_3,$ N_2O_4, N_2O_5	As_2O_3 (metalloid oxide)
All are metal oxides	$F2O, SiO_2, P_2O_3,$ P_2O_5, SO_2 etc.	As_2O_3 (metalloid oxide)

Notes: CO acts as an acid if allowed to react with NaOH at high P and T.

$$CO + NaOH \xrightarrow{P,T} HCOONa$$

CO acts as Lewis base (ligand) in complex formation.

(a) Oxides of non-metals having same oxidation no. of non-metal in their respective oxo-acids are known as acid anhydrides.

(b) The greater the number of oxygen atoms and the more electronegative the atom present in a molecule of Oxo-acid, the stronger the acid. i.e., $HClO_4 > HClO_3$.

Notes: However this rule is not obeyed in oxo-acids of phosphorus.

$$\underset{6.3\times10^{-2}}{H_3PO_2} > \underset{1.5\times10^{-2}}{H_3PO_3} > \underset{7.5\times10^{-2}}{H_3PO_4}$$

- **Some Acidic Strength Order**

  1. Acidic strength mineral acid:

  $HClO_4 > HI > HBr > H_2SO_4 > HCl > HNO_3 > H_3PO_4 > H_3AsO_4$

  2. Acidic strength halogen acids:

  $HI > HBr > HCl > HF$

  3. Acidic strength of hydride of oxygen family:

  $H_2Te > H_2Se > H_2S > H_2O$

  4. Acidic strength of oxacids of halogen family:

  $HOCl > HOBr > HOI$

  $HC1O_3 > HBrO_3 > HIO_3$

  $HC1O_4 > HClO_3 > HCIO_2 > HClO$

5. Acidic strength of organic acids: Acidic strength of aliphatic acid decreases with increasing number of carbon atom.
HCOOH > CH_3COOH > C_2CH_5OOH

- **Some Basic Strength Order**
1. KOH > NaOH > $Ca(OH)_2$ > NH_4OH
2. NaOH > NH_3 > H_2O
3. LiOH < NaOH < KOH < Rb(OH) < CsOH
- **Salient Features of pH Concept**
- pH of a solution decreases as [H^+] is solution increases.
- For most practical purposes, the pH scale extends form 0 to 14 (at 25°C). A solution of pH = 0 is acidic and pH = 14 is alkaline.
- The midpoint of the scale at pH = 7 represents neutrality. pH below 7 being increasingly acidic and those above 7 increasingly basic.
- For any aqueous solution at 25° it must be true that [H^+] [OH^-] = 10^{-14}
No matter how acidic or basic a solution might be, it must contain H^+ and OH^- ions and the product of effective molar concentration equal to 10^{-14} or K_w.
Also, log [H^+] + log [OH^-] = - 14 or,
- log [H^+] + (- log [OH^-]) = 14
or pH + pOH = 14.
- At the temperature of human body, about 37°C neutrality occurs at pH 6.8 and pH scale lies between 0 to 13.6.

pH of some solutions

Substances	pH range
Gastric juice	1.0 – 3.0
Soft drinks	2.0 – 4.0
Lemons	2.2 – 2.4
Vinegar	2.4 – 3.4
Apples	2.9 - 3.3
Urine (human)	4.8 – 8.4
Rain water	6.0
Soda water	Less than 7.0
Milk	6.3 – 6.6
Saliva (human)	6.5 – 7.5
Blood (human)	7.3 – 7.5
Milk of Magnesia	10.5
Sea water	8.5
Black Coffee	5.0
Tomato	4.0
Tears	7.4

- **pH Value of Acidic Mixture**

When V_1 ml acid (whose normality is N_1) and V_2 ml of other strong acid are mixed together then,
Resultant normality, $N_R = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$

pH value of resultant acidic solution $pH = \log \frac{1}{N_R}$

50 mL $\frac{N}{10} HCl$ and 50 mL $\frac{N}{10} H_2SO_4$ are mixed together $N_R = \frac{50 \times \frac{1}{10} + 50 \times \frac{1}{10}}{100} = \frac{10}{100} = 0.1$

$pH = \log \frac{1}{N_R} = \log \frac{1}{0.1} = 1$

SOLVED EXAMPLES

1. Give general equations for the reactions of acids with
(i) metal carbonates (ii) metal sulphites
(iii) metal oxides

Sol. (i) Metal carbonate + Add $\rightarrow$ Salt + Carbon dioxide + water
(ii) Metal sulphite + Acid $\rightarrow$ Salt + Sulphur dioxide + water
(iii) Metal oxide + Add $\rightarrow$ Salt + water

2. How will you treat the bee sting?

Sol. Bee stings are acidic. You can ease the pain by neutralizing the acid with sodium hydrogen carbonate which is basic in nature.

3. How does the flow of acid rain water into a river make the survival of aquatic life in the river difficult?

Sol. Acid rain water when flows into the river the pH of river water changes which makes the aquatic life difficult to survive. The pH range suitable for aquatic survival is 7.0 to 7.8 and due to acid rain water pH decreases.

4. A white powder having an odour of chlorine is used to remove yellowness of white clothes in laundries. Name this powder. How is it prepared? Write the chemical reaction involved in its preparation.

Sol. The white powder is bleaching powder, $CaCl_2$. It is prepared by passing Cl_2 gas over dry slaked lime.

$\underset{\text{Slaked lime}}{Ca(OH)_2} + Cl_2 \rightarrow \underset{\text{Bleaching powder}}{CaOCl_2} + H_2O$

5. Write the chemical formula of washing soda. What happens when crystals of washing soda are exposed to air?

Sol. The chemical formula of washing soda is $Na_2CO_3.10H_2O$.

When crystals of washing soda are exposed to air/ they lose nine molecules of water of crystallization and form a monohydrate. This process is known as efflorescence.

$$\underset{\underset{(decahydrate)}{Sod.carbonate}}{Na_2CO_3.10H_2O} \xrightarrow{Air} \underset{\underset{(monohydrate)}{Sod.carbonate}}{Na_2CO_3.H_2O} + 9H_2O$$

6. A housewife found that the cake prepared by her is hard and small in size. Which ingredient has she forgotten to add that would have made the cake fluffy? Give reason.

Sol. She has forgotten to add baking powder. When baking powder (sodium bicarbonate and tartaric acid mixture) is added during the preparation of cake and heated then sodium bicarbonate reacts with tartaric acid to form carbon dioxide gas. This CO_2 evolved makes the cake light and fluffy. Since the cake prepared by the housewife is small and hard, it means that she has forgotten to add baking powder.

7. Why does blue litmus paper not show colour change with the solution of dry HCl gas in dry toluene?

Sol. When dry blue litmus paper is dipped into a solution of dry HCl gas in dry toluene, the colour of blue litmus paper does not change. This is because both $HCl_{(g)}$ and toluene are covalent compounds and $HCl_{(g)}$ does not undergo ionization in toluene solution. Toluene is unable to pull out H^+ ions from $HCl_{(g)}$ and H^+ ions are not formed in toluene.

8. Name the substance obtained by action of chlorine on dry slaked lime. Write chemical equation of the reaction.

Sol. Bleaching powder is obtained.

$$\underset{Slaked\ lime}{Ca(OH)_2} + Cl_2 \rightarrow \underset{Bleaching\ powder}{CaOCl_2} + H_2O$$

9. A white powdered solid when added to water produces hissing sound. Identify the compound. How does this compound react with moist hydrogen chloride gas? Write the chemical equation.

Sol. The white powdered solid is lime. It reacts with moist hydrogen chloride gas to form calcium chloride.

$$CaO + 2HCl \rightarrow \underset{Calcium\,Chloride}{CaCl_2} + H_2O$$

10. Tooth enamel is one of the hardest substances in our body. How does it gets damaged due to eating chocolates and sweets? What should we do to prevent it?

Sol. Tooth enamel is made up of caldum phosphate, $Ca_3(PO_4)_2$, which gets corroded when the pH in the mouth becomes lower than 5.5. When we eat chocolates and sweets, some particles remain in the mouth. The bacteria present in the mouth produce acids by degradation of sugar and food particles remaining in the mouth after eating. This lowers the pH in the mouth and results in tooth decay.

This can be prevented by cleaning the mouth after eating sugary foods. We can also use toothpastes which are alkaline and neutralize the excess add and hence prevent tooth decay.

11. Tap water conducts electricity whereas distilled water does not. Why?

Sol. Tap water contains dissolved salts and minerals which ionize in water and hence conducts electricity.

On the other hand, distilled water does not contain dissolved salts and minerals. It is a covalent compound and hence does not conduct electricity.

12. Dry hydrogen chloride gas does not turn blue litmus red whereas hydrochloric acid does. Given one reason.

Sol. Acids give $H^+_{(aq)}$ in aqueous solution, which are responsible for turning blue litmus red. Dry HCl does not give $H^+_{(aq)}$ ions in the absence of water and hence does riot turn blue litmus red.

13. Describe an activity to show that acids produce ions only in aqueous solutions.

Sol. Heat a pinch of solid NaCl with cone sulphuric add in a clean and dry test tube. Test the gas (HCl) evolved with dry litmus paper. No change in colour takes place. Now, pass the gas through blue litmus solution. It will turn red. This is because in aqueous solution H^+ ions are produced which turn blue litmus solution to red.

14. Write the chemical formula for bleaching powder. How is bleaching powder prepared? For what purpose is it used in paper factories?

Sol. Bleaching powder is $CaOCl_2$.

It is prepared by passing Cl_2 gas through dry slaked lime:

$$\underset{Slkaed\ lime}{Ca(OH)_2} + Cl_2 \rightarrow \underset{Bleaching\ powder}{CaOCl_2} + H_2O$$

It is used for bleaching wood pulp in paper factories.

15. Fresh milk has pH of 6. When it changes into curd (yoghurt) will its pH value increase or decrease?

Sol. When the milk changes into curd (yoghurt), its pH decreases due to the formation of lactic acid (which is acidic in nature).

16. A compound which is prepared from gypsum has the property of hardening when mixed with proper quantity of water. Identify the compound. Write the chemical equation for its preparation. For what purpose is it used in hospitals?

Sol. The compound is plaster of Paris, chemically known as calcium sulphate hemi-hydrate ($CaSO_4.\frac{1}{2}H_2O$).

$$\underset{Gypsum}{CaSO_4.2H_2O} \xrightarrow{373K} \underset{Plaster\ of\ Paris}{CaSO_4.\frac{1}{2}H_2O} + \frac{3}{2}H_2O$$

It is used for plasting fractured bones in hospitals.

17. Which one of these has a higher concentration of H^+ ions? 1 M HCl or 1 M CH_3COOH.

Sol. 1M HCl has higher concentration of H^+ ions because it is a strong acid and therefore, ionizes completely to give H^+ ions.

18. How would you distinguish between baking powder and washing soda by heating?

Sol. Washing soda is a hydrated salt. Its molecular formula is $Na_2CO_3.10H_2O$. Baking powder ($NaHCO_3$) does not contain water of crystallization. On heating washing soda loses its water of crystallization. This water can be seen as droplets in the upper part of the test tube.

$$Na_2CO_3.10H_2O \xrightarrow{heat} Na_2CO_3 + 10H_2O$$

On heating, baking soda ($NaHCO_3$) decomposes to give CO_2 gas. CO_2 gas when passed through limewater, turns it milky.

$$2NaHCO_{3(s)} \xrightarrow{heat} Na_2CO_{3(s)} + H_2O + CO_2$$

$$CO_2 \xrightarrow{\text{passed through limewater}} \text{Limewater turns milky}$$

19. Which bases are called alkalis? Give an example of alkali.

Sol. The bases which are soluble in water and give hydroxide ions in solution are called alkalies. For example: Sodium hydroxide, NaOH.

20. Solutions *X, Y* and Z have pH values 8, 9 and 10 respectively. Arrange them in increasing order of basic character giving reasons.

Sol. The increasing basic character will be X < Y < Z,

Reason: H^+ ion concentration of solutions X, *Y* and Z will be $10^{-8}, 10^{-9}$ *and* 10^{-10} M respectively. As $[H^+]\ [OH^-]$ = Ionic product of water = 10^{-14} therefore, $[OH^-]$ of X, Y and Z will be 10^{-6}, 10^{-5} and 10^{-4} M respectively Obviously, $10^{-6} < 10^{-5} < 10^{-4}$. Higher the $[OH^-]$, more basic is the solution. Hence, they have the above order.

21. Answer the following:

(a) Why is Plaster of Paris written as $CaSO_4.1/2H_2O$? How is it possible to have half a water molecule attached to $CaSO_4$?

(b) Why is sodium hydrogen carbonate an essential ingredient in antacids?

(c) When electricity is passed through an aqueous solution of sodium chloride, three products are obtained. Why is the process called chlor-alkali?

Sol. (a) The formula of Plaster of Paris is written as $CaSO_4.1/2H_2O$ because one molecule of water is shared by two formula units of $CaSO_4$ *i.e.,* the formula is $(CaSO_4)_2.H_2O$. Thus, it represents half molecule of H_2O per formula unit of $CaSO_4$.

(b) Sodium hydrogen carbonate being basic, neutralizes the excess acid produced in the stomach. Hence, it is used as antacid.

(c) Electrolysis of an aqueous solution of sodium chloride gives NaOH, Cl_2 and H_2. Due to the products Cl_2 and NaOH formed, the process is called chlor-alkali process (Chlor for chlorine and alkali for sodium hydroxide).

22. Write the balanced equation in molecular form illustrating the complete neutralization of $2Al(OH)_3$ With H_2SO_4.

Sol. Complete neutralization requires one for each OH^-. Since Al(OH)g has three available OH^- ions and H_2SO_4 can only provide two H^+ ions, the reaction requires two moles of $Al(OH)_3$ for three moles of H_2SO_4.

$$2A1(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$$

23. The pH of two solutions A and B are 2 and 4 respectively. Which one of them is more acidic? What is the ratio of H^+ ion concentration of the two solutions?

Sol. pH = 2 means $[H^+]$ = 10^{-2} M

pH = 4 means $[H^+]$ = *10^{-4} M*

As $10^{-2} > 10^{-4}$, solution A is more acidic than solution *B.*

$$\frac{[H^+] in\, solution\, A}{[H^+] in\, solution\, B} = \frac{10^{-2}\, M}{10^{-4}\, M} = 10^2$$

i.e., $[H^+]$ in solution A is 100 times more than that in solution *B.*

24. Predict whether the aqueous solution of the following salts are acidic, basic or neutral.
(i) Silver chloride
(ii) Ammonium sulphate
(iii) Sodium nitrate
(iv) Sodium phosphate
(v) Sodium acetate.

Sol. (i) acidic (ii) acidic (iii) neutral (iv) basic (v) basic.

25. Write the formula for the following salts :
(i) Calcium chloride
(ii) Potassium nitrate
(iii) Calcium phosphate
(iv) Iron (III) chloride
(v) Magnesium nitrate
(vi) Sodium sulphate
(vii) Iron (II) phosphate
(viii) Copper (I) phosphate.

Sol. (i) $\mathrm{CaCl_2}$ (ii) $\mathrm{KNO_3}$ (iii) $\mathrm{Ca_3}(PO_4)_2$ (iv) $\mathrm{FeCl_3}$
(v) $Mg(NO_3)_2$ (vi) Na_2SO_4 (vii) $Fe_3(PO_4)_2$
(viii) $Cu_3(PO_4)$.

26. pH of a solution changes from 6 to 3. What changes do you expect in hydrogen ion concentration?

Sol. We know that pH =-log $[H^+]$

If pH is 6, then $[H^+]$ will be 1.0 x 10^{-6} mol L^{-1}

If pH is 3, then $[H^+]$ will be 1.0 x 10^{-3} mol L^{-1}

Increase in concentration of H^+ ions =

$$\frac{1.0\times10^{-3}\,mol\,L^{-1}}{1.0\times10^{-6}\,mol\,L^{-1}}=1000\,times$$

Therefore, H^+ concentration is increased 100 times when pH changes from 6 to 3.

27. Give some applications of neutralization.

Sol. Neutralization reactions have many practical applications. Some of these are:

(i) Persons suffering from acidity are given antacid tablets which contain basic magnesium hydroxide to neutralize excess acid produced in the stomach.

(ii) The stings of bees and ants contain formic acid. This is neutralized by rubbing soap which contains the alkali sodium hydroxide. This can also be neutralized with sodium hydrogen carbonate.

(iii) If the soil is too acidic, the crops will not grow well. Therefore, the farmers spread slaked lime.

(iv) Baking powder helps cake mixture to rise. This is because it contains sodium hydrogen carbonate and a weak acid. When water is added, the two react. This reaction is a neutralization reaction of hydrogen carbonate and an acid. The carbon dioxide produced gets trapped in the cake mixture and makes it to rise.

28. What happens when Bleaching powder reacts with dilute sulphuric acid. Slaked lime reacts with chlorine. Sodium hydrogen carbonate is heated. Gypsum is heated.

Sol. (i) Calcium sulphate is formed.

$CaOCl_2 + H_2SO_4 \rightarrow CaSO_4 + H_2O + Cl_2$

(ii) Bleaching powder is formed.

$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

(iii) Sodium carbonate is formed.

$2NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + H_2O + CO_2$

(iv) Plaster of Paris is formed.

$$\underset{Gypsum}{CaSO_4.2H_2O} \xrightarrow{Heat} CaSO_4.\frac{1}{2}H_2O + \frac{3}{2}H_2O$$

29. Complete the following reactions :
(i) Sodium hydroxide + _____ acid $\rightarrow$ Sodium chloride + Water
(ii) Copper oxide + Sulphuric acid $\rightarrow$ ___ + ___
(iii) Sodium carbonate + ___ acid $\rightarrow$ Sodium nitrate + ___ + ___
(iv) $Ca(OH)_{2(aq)}$+ $\rightarrow$ $CaCO_{3(s)}$+———
(v) Sodium hydrogen carbonate + ___ $\rightarrow$ Sodium chloride + ___ + ___

Sol. (i) Hydrochloric
(ii) Copper sulphate + water
(iii) Nitric, water + carbon dioxide
(iv) $CO_{2(g)}, H_2O_{(l)}$
(v) Hydrochloric acid, carbon dioxide + water.

NCERT SECTION

1. You have been provided with three test tubes. One of them contains, distilled water and the other two contain an acidic solution and a basic solution, respectively. If you are given only red litmus paper, how will you identify the contents of each test tubes?

Ans.: Take three small pieces of red litmus paper. Put one drop each of the given solutions on these litmus papers.

The liquid which turns red litmus into blue is a basic solution.

Divide the blue litmus paper so formed into two parts. Put one drop each of the other two liquids separately on these two pieces of litmus paper;

The solution which turns blue litmus paper red is acidic solution.

The solution which does not affect the colour of litmus paper is water.

2. Why should curd and sour substances not be kept in brass and copper vessels?

Ans.: The curd and sour substances are acidic. They will react with brass (alloy of copper and zinc metals) and copper vessels and will spoil the vessels.

3. Which gas is usually liberated when an acid reacts with a metal? Illustrate with an example.
How will you test for the presence of this gas?

Ans.: Hydrogen gas is liberated when an acid reacts with a metal. For example, when zinc metal reacts with dil. $HCl,$ hydrogen is evolved and salt zinc chloride is formed as:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

It can be tested by bringing a burning candle near the gas. The candle continues burning with a pop sound.

4. A metal compound A reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride.

Ans.: The compound A must be calcium carbonate because carbonates react with the acids to produce carbon dioxide gas which extinguishes fire, and also the compound formed will be calcium chloride as follows:

$$\underset{Calcium\,carbonate}{CaCO_{3(s)}} + \underset{hydrochloric\,acid}{2HCl_{(aq)}} \rightarrow \underset{calcium\,chloride}{CaCl_{2(aq)}} + \underset{water}{H_2O_{(l)}} + \underset{Carbon\,dioxide}{CO_{2(g)}}$$

5. Why do $HCl, HNO_3,$ etc. show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character?

Ans.: HCl and $HNO_3,$ produce $H^+_{(aq)}$ ions in aqueous solution, which is responsible for their acidic character.

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

$$HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO^-_{3\,(aq)}$$

Alcohol (C_2H_5OH) and glucose $(C_6H_{12}O_6)$ are covalent compounds and they do not undergo dissociation in aqueous solution. This is evident from the fact that their aqueous solutions do not conduct electricity. Hence, the aqueous solutions of alcohol and glucose do not show acidic character even though they contain hydrogen atoms.

6. Why does an aqueous solution of acid conduct electricity?

Ans.: An aqueous solution of an acid produces ions and therefore, it conducts electricity. The electric current is carried through the solution by ions.

7. Why does dry HCl gas not change the colour of the dry litmus paper?

Ans.: Dry HCl gas does not show acidic character due to absence of H^+ ions and therefore, does not change the colour of the dry litmus paper.

8. While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?

Ans.: Dilution of a concentrated acid, particularly concentrated sulphuric acid, is a highly exothermic reaction. When water is added to a concentrated acid, the heat liberated is so large that the solution starts almost boiling. This may cause spurting of the hot acid solution and harm the person. Excessive local heating may even break the glass container. That is way concentrated acids are diluted by slowly adding concentrated acid into water with constant stirring and not by adding water to the add.

9. How is the concentration of hydronium ions (H_3O^+) affected when a solution of an acid a diluted?

Ans.: When the solution of acid is diluted the H^+ ions are released from the add to combine with H_2O and H_3O^+ ions is increased,

10. How is the concentration of hydroxide ions (OH^+) affected when excess base is dissolved in a solution of sodium hydroxide?

Ans.: The OH^- concentration increases with the concentration of $NaOH$ and reaches a limiting value.

11. You have two solutions, A and *B.* The pH of solution A is 6 and pH of solution B is 8. Which solution has more hydrogen ion concentration? Which of this is acidic and which one is basic?

Ans.: pH of solution A = 6.

$\therefore H^+$ ion concentration $= 10^{-6} M.$

pH of solution B = 8.

$\therefore H^+$ ion concentration $= 10^{-8} M.$

As $10^{-6} > 10^{-8},$ hence solution A has more H1" ion concentration.

A solution with pH < 7 is acidic. Hence, solution A is acidic.

A solution with pH > 7 is basic. Hence, solution *B* is basic.

12. What effect does the concentration of $H^+{}_{(aq)}$ ions have on the nature of the solution?

Ans.: If a solution has higher concentration of H^+ ions it is more acidic in nature,

13. Do basic solutions also have $H^+{}_{(aq)}$ ions? If yes, then why are these basic?

Ans.: Yes, basic solutions also have $H^+{}_{(aq)}$ ions. This is because in all aqueous solutions, $H^+{}_{(aq)}$ and $OH^-{}_{(aq)}$ exist in equilibrium with each other. The equilibrium constant for this equilibrium is given by

$K_w = [H^+][OH^-]$ In a basic solution, $H^+{}_{(aq)}$ concentration is much lower than the $OH^-{}_{(aq)}$ concentration.

14. Under what soil condition do you think a farmer would treat the soil of his fields with quick lime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate)?

Ans.: If the soil condition is more acidic than optimum conditions.

15. What is the common name of the compound $CaOCl_2$?

Ans.: Bleaching powder,

16. Name the substance which on treatment with chlorine yields bleaching powder.

Ans.: Dry slaked lime, $Ca(OH)_2$.

17. Name the sodium compound which is used for softening hard water.

Ans.: Sodium carbonate (washing powder).

18. What will happen if a solution of sodium hydrogen carbonate is heated? Give the equation of the reaction involved.

Ans.: When a solution of sodium hydrogen carbonate is heated it gives sodium carbonate, Bite **carbon dioxide and** water.

$$\underset{\text{Sodium hydrogen carbonate}}{2NaHCO_3} \xrightarrow{Heat} \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O + CO_2$$

19. Write an equation to show the reaction between plaster of Paris and water.

Ans.: It forms gypsum giving a hard solid mass.

$$\underset{\substack{\text{Plaster of Paris}\\ \text{(White powder)}}}{CaSO_4 \cdot \frac{1}{2}H_2O} + \frac{3}{2}H_2O \rightarrow \underset{\substack{\text{Gypsum}\\ \text{(solid mass)}}}{CaSO_4 + 2H_2O}$$

20. A solution turns red litmus blue, its pH is likely to be

(a) 10 (b) 4

(c) 5 (d) 10

Ans.: **(d):** Because pH should be greater than 7.

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

(a) $NaCl$ (b) HCl

(c) $LiCl$ (d) KCl

Ans.: **(b):** Egg-shells contain calcium carbonate. Calcium carbonate reacts with HCl to give out CO_2 gas, which turns lime water milky.

22. 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solution of HCl. If we take 20 mL of the same solution of NaOH/ the amount of HCl solution (the same solution as before) required to neutralize it will be

(a) 4 mL (b) 8mL

(c) 12 mL (d) 16 mL

Ans.: **(d):** $20\,mL$ of $NaOH = 2 \times 8\,mL$ of $HCl = 16\,mL$ of HCl.

23. Which one of the following types of medicines is used for treating indigestion?

(a) Antibiotic (b) Analgesic

(c) Antacid (d) Antiseptic

Ans.: **(c):** The indigestion is due to excess of acid produced in the stomach. The medicine used to neutralize it is called antacid,

24. Write word equations and then balanced equations for the reaction taking place when:

(a) Dilute sulphuric add reacts with zinc granules

(b) Dilute hydrochloric add reacts with magnesium ribbon

(c) Dilute sulphuric acid reacts with aluminium powder

(d) Dilute hydrochloric acid reacts with iron fillings.

Ans.: **(a)** Zinc + Sulphuric acids (dil). $\rightarrow$ Zinc sulphate + Hydrogen

$$Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$$

(b) Magnesium ribbon + Hydrochloric add (dil.) $\rightarrow$ Magnesium chloride + Hydrogen

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

(c) Aluminium powder + Sulphuric acid (dil.) $\rightarrow$ Aluminium sulphate + Hydrogen

$$2Al + 3H_2SO_4(dil) \rightarrow Al_2(SO_4)_{3(aq)} + 3H_{2(g)}$$

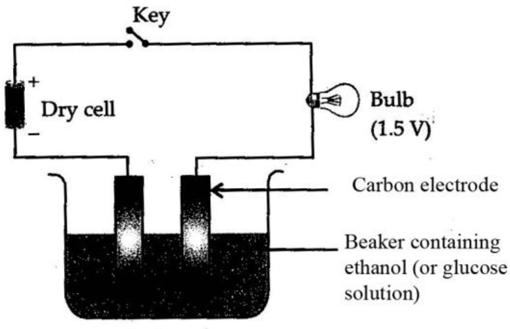
(d) Iron filings + Hydrochloric acid (dil.) $\rightarrow$ Iron (II) chloride + Hydrogen

$$Fe_{(s)} + 2HCl \rightarrow FeCl_{2(aq)} + H_{2(g)}$$

25. Compounds such as alcohol and glucose also contain hydrogen but are not categorized as acids. Describe an activity to prove it.

Ans. **Activity:** To show that alcohols and glucose are not acids.

Materials required: Dilute solution of ethanol and glucose solution **Apparatus required:** Beaker (1), carbon electrodes (2), dry cells (2), bulb 1.5 V (1),



Ethanol and glucose solutions do not conduct electricity

Procedure: Take a beaker and place two carbon electrodes into it. Connect the electrodes to a battery bulb through a key and a dry cell. Pour ethanol into the beaker and press the key. See, if the bulb glows. Bulb does not glow. Repeat similar experiment with glucose solution. Record your observations.

Observation: It is observed that the bulb does not glow with both the solutions.

Conclusion: The solutions of glucose and ethanol are non-conductors of electricity.

Explanation: Ethanol and the solution of glucose containing hydrogen in their molecules do not conduct electricity. Therefore/ these compounds do not produce H^+ ions in solutions.

Hence these are not categorized as acids.

26. Why does distilled water not conduct electricity, whereas rain water does?

Ans.: Distilled water is pure and it does not form ions. Where as rain water contains impurities in it like acid which contains ions and release them when dissolved in water. Hence no ioig distilled water, so electricity is not conducted but ions are there in rain water so electric conducted.

27. Why do acids not show acidic behaviour in the absence of water?

Ans.: Acids ionize only in the presence of water to give ions. $HCl + H_2O \rightarrow H_3O^+ + Cl^-$

However, in the absence of water, acids do not ionize to give $H30^+$ ions and therefore, do not behave as acids.

28. Five solutions A, B, C, *D* and £ when tested with universal indicator showed pH as 4, 1, 11, 7 and 9 respectively. Which solution is :

(a) neutral ? (b) strongly alkaline?
(c) strongly acidic? (d) weakly acidic?
(e) weakly alkaline?
(f) Arrange the pH in increasing order of hydrogen-ion concentration.

Ans.: (a) Solution *D is* neutral (pH =7)
(b) Solution C is strongly alkaline (pH =11)
(c) Solution B is weakly acidic (pH =1)
(d) Solution A is strongly acidic (pH = 4)
(e) Solution E is weakly alkaline (pH = 9)
(f) pH in the increasing order of hydrogen ion concentration:
$pH = 11 < pH = 9 < pH = 7 < pH = 4 < pH = 1$

29. Equal lengths of magnesium ribbons are taken in test tubes A and *B.* Hydrochloric acid (HCl) is added to test tube A, while acetic acid (CH_3COOH) is added to test tube B. In which test tube will the fizzing occur more vigorously and why?

Ans.: In test tube A hydrochloric acid is present which is a strong acid as compared to acetic acid present in test tube B.

The fizzing occurs more vigorously in test tube A as HCl is strong and dissociates completely into Cl^- and CF ions for the reaction.

30. Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd? Explain your answer.

Ans.: Curd is sour in taste and becomes acidic. Therefore, its pH will decrease from pH of 6 to a lower value.

31. A milkman adds a very small amount of baking soda to fresh milk.

(a) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?

(b) Why does this milk take a long time to set as curd?

Ans.: **(a)** The milkman adds baking soda to milk so that the milk becomes slightly alkaline.

Thus, milk will not be converted to acidic curd readily

(b) This will take a longer time to set to curd because it is alkaline and takes longer time for it bacteria to make it acidic.

32. Plaster of Paris should be stored in a moisture proof container. Explain Why?

Ans.: Plaster of Paris in contact with moisture (water) changes to solid hard mass, gypsum.

Therefore, it gets wasted. Hence it should be stored in a moisture proof containers.

$$\underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + H_2O \longrightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O}$$

33. What is neutralization reaction? Give two examples.

Ans.: The reaction of an acid and a base to form salt and water is a neutralization reaction. For example,

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

(ii) $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

34. Give two important uses of washing soda and baking soda.

Ans.: **Washing Soda**

(1) It is used for softening of hard water.

(2) It is used for the manufacture of soap, glass, paper, borax, caustic soda, etc.

Baking soda

(1) Baking soda is mainly used in the preparation of baking powder. Baking powder contains sodium hydrogen carbonate and an acid like tartaric acid or citric acid.

(2) Baking soda is used in medicines as an antacid. It is used in medicines to remove acidity of the stomach. Therefore, it is an important constituent of an antacid.

NCERT EXEMPLAR PROBLEMS-SOLUTIONS

Multiple Choice Questions (MCQs)

1. What happens when a solution of an acid is mixed with a solution of a base in a test tube?

(i) The temperature of the solution increases.

(ii) The temperature of the solution decreases.

(iii) The temperature of the solution remains the same.

(iv) Salt formation takes place.

(a) Only (i) (b) (i) and (iii)

(c) (ii) and (iii) (d) (i) and (iv)

Thinking Process

(i) Neutralisation is defined as the process in which an acid reacts with a base to form salt and water.

(ii) In exothermic process, heat is evolved.

Ans. **(d)** When an acid reacts with a base, neutralization reaction takes place to form salt and water and it is an exothermic reaction. So, the temperature of the solution increases.

2. An aqueous solution turns red litmus solution blue. Excess addition of which of the following solution would reverse the change?

(a) Baking powder

(b) Lime

(c) Ammonium hydroxide solution

(d) Hydrochloric acid

Ans. **(d)** Since, the aqueous solution turns red litmus solution blue. So, it is a basic compound.

An acid solution (HCl) would reverse the change. That is HCl would turn blue litmus solution to red.

Other options baking powder, lime and ammonium hydroxide solution are basic compounds. So, the blue litmus solution would not change the colour by adding these compounds.

3. During the preparation of hydrogen chloride gas on a humid day, the gas is usually passed through the guard tube containing calcium chloride. The role of calcium chloride taken in the guard tube is to

(a) absorb the evolved gas

(b) moisten the gas

(c) absorb moisture from the gas

(d) absorb Cl^- ions from the evolved gas

Ans. **(c)** The role of calcium chloride $CaCl_2$ is to absorb moisture from the gas, because calcium chloride is a good dehydrating agent.

4. Which of the following salts does not contain water of crystallization?

(a) Blue vitriol (b) Baking soda

(c) Washing soda (d) Gypsum

Thinking Process

The water molecules which form part of the structure of a crystal (of a salt) are called water of crystallization. The salts which contain water of crystallisation are called hydrated salts.

Ans. **(b)** Chemical formula of baking soda is NaHC03 (sodium hydrogen carbonate). Chemical formulae of blue vitriol is $CuSO_4\,5H_2O$, washing soda is $Na_2CO_3 \cdot 10H_2O$ and gypsum is $CaSO_4 \cdot 2H_2O$

So, baking powder does not contain water of crystallization.

5. Sodium carbonate is a basic salt because it is a salt of

(a) strong acid and strong base

(b) weak acid and weak base

(c) strong acid and weak base

(d) weak acid and strong base

Thinking Process

The salts of weak acids and strong bases give basic solutions (or alkaline solutions) having pH more than 7.

Ans. **(d)** Sodium carbonate (Na_2CO_3) is the salt of weak acid carbonic acid (H_2CO_3) and a strong base sodium hydroxide (NaOH).

$$\underset{\text{Sodium hydroxide}}{2\text{NaOH}} + \underset{\text{Carbonic acid}}{\text{H}_2\text{CO}_3} \longrightarrow \underset{\text{Sodium carbonate (salt)}}{Na_2CO_3} + \underset{\text{Water}}{2H_2O}$$

6. Calcium phosphate is present in tooth enamel. Its nature is

(a) basic (b) acidic

(c) neutral (d) amphoteric

Thinking Process

$$\underset{\text{Sodium hydroxide}}{3\text{Ca(OH)}_2} + \underset{\text{Phosphoric acid}}{2\text{H}_3\text{PO}_4} \longrightarrow \underset{\text{Calcium phosphate}}{Ca_3(\text{PO}_4)} + 6H_2O$$

Ans. (a) Calcium phosphate $Ca_3(PO_4)$ is basic salt, as it is a salt of weak acid (phosphoric acid) and slightly stronger base (calcium hydroxide) (though both are weak). Also when pH of our mouth falls below 5.5 due to eating of sweets etc., i.e., mouth is acidic, the dissolution of enamel (calcium phosphate) starts which shows that calcium phosphate is basic in nature.

7. A sample of soil is mixed with water and allowed to settle. The clear supernatant solution turns the pH paper yellowish-orange. Which of the following would change the colour of this pH paper to greenish-blue?

(a) Lemon juice (b) Vinegar

(c) Common salt (d) An antacid

Ans. (d) As pH paper turns greenish blue for weakly basic compound and antacids contain weak base like $Mg(OH)_2$. So, an antacid would change the colour of this pH paper to greenish-blue. Other options (a) and (b) contain acids and option (c) is a neutral salt.

8. Which of the following gives the correct increasing order of acid strength?

(a) Water < acetic acid < hydrochloric acid

(b) Water < hydrochloric acid < acetic acid

(c) Acetic acid < water < hydrochloric acid

(d) Hydrochloric acid < water < acetic acid

Ans. **(a)** Hydrochloric acid is a mineral acid and ionises completely in water, that's why it is a strong acid. Acetic acid is an organic acid and ionises only partially in water, hence, it is a weak acid. Water has some what neutral nature. Thus, the order of acidity is water < acetic acid < hydrochloric acid.

9. If a few drops of a concentrated acid accidentally spills over the hand of a student, what should be done?

(a) Wash the hand with saline solution

(b) Wash the hand immediately with plenty of water and apply a paste of sodium hydrogen carbonate

(c) After washing with plenty of water apply solution of sodium hydroxide on the hand

(d) Neutralise the acid with a strong alkali

Ans. **(b)** Wash the hand immediately with plenty of water to wash away most of the acid and then apply a paste of baking soda $(NaHCO_3)$ to neutralize the little acid left. Here a strong base cannot be used to neutralise the acid due to its corrosive nature.

10. Sodium hydrogen carbonate when added to acetic acid evolves a gas. Which of the following statements are true about the gas evolved?

(i) It turns lime water milky.

(ii) It extinguishes a burning splinter.

(iii)It dissolves in a solution of sodium hydroxide.

(iv) It has a pungent odour.

(a) (i) and (ii) (b) (i), (ii) and (iii)

(c) (ii), (iii) and (iv) (d) (i) and (iv)

Ans. **(b)** When sodium hydrogen carbonate is added to acetic acid then carbon dioxide (CO_2) gas is evolved.

$$\underset{\text{Sodium hydrogen carbonate}}{NaHCO_3} + \underset{\text{Acetic acid}}{CH_3COOH} \longrightarrow \underset{\text{Sodium acetate}}{CH_3COONa} + CO_2 + H_2O$$

CO_2 turns lime water milky, it is a non-supporter of combustion and is absorbed by strong alkalies like NaOH.

11. Common salt besides being used in kitchen can also be used as the raw material for making

(i) washing soda (ii) bleaching powder

(iii) baking soda (iv) slaked lime

(a) (i) and (ii) (b) (i), (ii) and (iv)

(c) (i), (ii) and (iii) (d) (i), (iii) and (iv)

Ans. **(c)** Common salt (sodium chloride) is used as a raw material for making a large number of chemicals in industry such as sodium hydroxide, washing soda, baking soda, hydrochloric acid, hydrogen, chlorine and sodium metal. Chlorine gas obtained is used for making bleaching powder.

12. One of the constituents of baking powder is sodium hydrogen carbonate, the other constituent is

(a) hydrochloric acid (b) tartaric acid

(c) acetic acid (d) sulphuric acid

Ans. **(b)** Baking powder is a mixture of baking soda $NaHCO_3$, (sodium hydrogen carbonate) and a mild edible acid such as tartaric acid. When baking powder mixes with water (for making cake or bread), sodium hydrogen carbonate reacts with tartaric acid to evolve carbon dioxide gas.

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

(a) acidic (b) neutral
(c) basic (d) corrosive

Thinking Process

When pH of our mouth fails below 5.5 due to eating of sweets etc., (i.e., our mouth is moderately acidic) then the-acid becomes strong enough to attack the enamel which is made up of calcium phosphate of our teeth and corrodes it. This sets in tooth decay.

Ans. **(c)** The tooth paste commonly used is basic so that the extra acid formed during tooth decay is neutralised and prevent tooth decay.

14. Which of the following statements is correct about an aqueous solution of an acid and a base?

(i) Higher the pH, stronger the acid
(ii) Higher the pH, weaker the acid
(iii) Lower the pH, stronger the base
(iv) Lower the pH, weaker the base
(a) (i) and (iii) (b) (ii) and (iii)
(c) (i) and (iv) (d) (ii) and (iv)

Thinking Process

The common pH scale having pH value from 0 to 14. At pH 7, a solution is neutral. As the pH of solution decreases from 7 to 0, the hydrogen ion concentration in the solution goes on increasing and hence the strength of acid goes on increasing. As the pH of solution increases from 7 to 14, the hydroxide ion concentration in the solution goes on increasing due to which the strength of base also goes on increasing.

Ans. **(d)** It depends on the solution i.e., higher the pH, weaker the acid and lower the pH weaker the base.

15. The pH of the gastric juices released during digestion is

(a) less than 7 (b) more than 7
(c) equal to 7 (d) equal to 0

Ans. **(c)** Our stomach produces hydrochloric acid (of pH about 1.4). This dilute hydrochloric acid helps in digesting our food.

16. Which of the following phenomena occur, when a small amount of acid is added to water?

(i) Ionisation (ii) Neutralisation
(iii) Dilution (iv) Formation
(a) (i)and(ii) (b) (i) and (iii)
(c) (ii) and (iii) (d) (ii) and (iv)

And. B (i) When water is added to an acid, their molecules dissociate to form ions.

$$HCl + H_2O \longrightarrow H^+ + Cl^- + H_2O$$

$$H_2O + H^+ \longrightarrow H_3O^+ \text{ (Hydronium ion)}$$

(iii) Mixing of an acid with water is called dilution, it results in the decrease in the concentration of ions, (H_3O^+) per unit volume.

17. Which one of the following can be used as an acid-base indicator by a visually impared student?

(a) Litmus (b) Turmeric
(c) Vanilla essence (d) Petunia leaves

Ans. **(c)** Vanilla essence is an olfactory indicator. So, its smell is different in acid and basic media which can be detected easily by a visually impared student. Vanilla extract has a characteristic pleasant smell.
If a basic solution like sodium hydroxide solution is added to vanilla extract then we cannot detect the characteristic smell of vanilla extract. An acidic solution like hydrochloric acid, however, does not destroy the smell of vanilla extract.

18. Which of the following substances will not give carbon dioxide on treatment with dilute acid?

(a) Marble (b) Limestone
(c) Baking soda (d) Lime

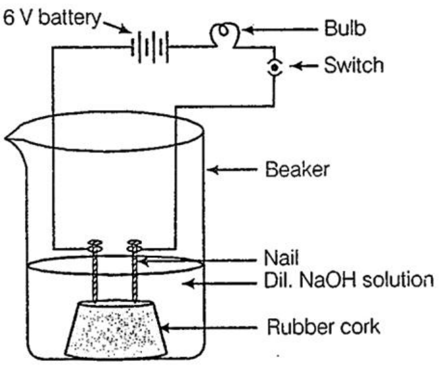
Ans. **(d)** Lime, CaO (calcium oxide) does not evolve CO_2 when reacted with dilute acid. Other given compounds are carbonates and hydrogen carbonates, so evolve CO_2 with dilute acid.

19. Which of the following is acidic in nature?

(a) Lime juice (b) Human blood
(c) Lime water (d) Antacid

Ans. **(a)** Lime juice is acidic in nature because it contains citric acid. Human blood is slightly basic (i.e., having pH 7.8). Lime water and antacid are basic in nature as they contain hydroxide (OH^-) ion.

20. In an attempt to demonstrate electrical conductivity through an electrolyte, the following apparatus (figure) was set up.



Which among the following statement(s) is/are correct?

(i) Bulb will not glow because electrolyte is not acidic.

(ii) Bulb will glow because NaOH is a strong base and furnishes ions for conduction.

(iii) Bulb will not glow because circuit is incomplete.

(iv) Bulb will not glow because it depends upon the type of electrolytic solution.

(a) (i) and (iii) (b) (ii) and (iv)

(c) Only (ii) (d) Only (iv)

Ans. **(c)** Bulb will glow because NaOH being a strong base furnishes OH^- and Na^+ ions (which are responsible for electrical conductivity).

21. Which of the following is used for dissolution of gold?

(a) Hydrochloric acid (b) Sulphuric acid

(c) Nitric acid (d) Aqua-regia

Ans. **(d)** Aqua-regia is used for the dissolution of gold. Gold dissolves only in aqua-regia.

Aqua-regia is a mixture of cone, HN03 and cone. HCI in the ratio 1 : 3.

Aqua-regia = $[\underset{1:3}{Conc.HNO_3 + \quad conc\ HCl}]$

22. Which of the following is not a mineral acid?

(a) Hydrochloric acid (b) Citric acid

(c) Sulphuric acid (d) Nitric acid

Thinking Process

Mineral acids or inorganic acids are generally repared from the minerals present in the earth's crust, e.g., HCI (hydrochloric acid), H_2SO_4 (sulphuric acid) and HNO_2 (nitric acid) are mineral acids.

Edible acids or organic acids are produced by plants or animals. e.g., acetic acid, citric acid, lactic acid etc., are edible acids.

Ans. **(b)** Citric acid is an example of organic acid or edible acid.

23. Which among the following is not a base?

(a) NaOH (b) KOH

(c) NH_4OH (d) C_2H_5OH

Ans. **(c)** C_2H_5OH is not a base. It is an example of an organic compound known as alcohol (ethyl alcohol) which has somewhat acidic nature. And also C_2H_5OH does not give OH^- ions in the solution, so it is not a base.

24. Which of the following statements is not correct?

(a) All metal carbonates react with acid to give a salt, water and carbo.n dioxide

(b) All metal oxides react with water to give salt and acid

(c) Some metals react with acids to give salt and hydrogen

(d) Some non-metal oxides react with water to form an acid

Ans. **(b)** Most metal oxides are insoluble in water but some of these (e.g., Na_2O, CaO) dissolve in water to form alkalies not salt and acid e.g.,

$$Na_2O(s) + H_2O(l) \longrightarrow 2\ NaOH(aq)$$

25. Match the chemical substances given in Column I with their appropriate application given in Column II.

Column I	Column II
A. Bleaching powder	1. Preparation of glass
B. Baking soda	2. Production of H_2 and Cl_2
C. Washing soda	3. Decolourisation
D. Sodium chloride	4. Antacid

Codes

	A	B	C	D
(a)	2	1	4	3
(b)	3	2	4	1
(c)	3	4	1	2
(d)	2	4	1	3

Ans. **(c)** Bleaching powder bleaches the clothes and other coloured substances, baking soda is a constituent of antacid, washing soda is used in the preparation of glass and sodium chloride when subjected to electrolyses gives N_2 and Cl_2 gases.

26. Equal volumes of hydrochloric acid and sodium hydroxide solutions of same concentration are mixed and the pH of the resulting solution is checked with a pH paper. What would be the colour obtained? (You may use colour guide given in figure of NCERT Book (Science Class X) on page 26).

(a) Red (b) Yellow

(c) Yellowish green (d) Blue

Ans. **(c)** Because the resulting solution is obtained as a result of neutralization reaction.

$$\underset{\text{Strong acid}}{HCl} + \underset{\text{Strong base}}{NaOH} \longrightarrow \underset{\text{Sodium chloride neutral}}{NaCl} + H_2O$$

The colour of the neutral solution (with pH=7) obtained is yellowish green.

27. Which of the following is/are true when HCl (g) is passed through water

(i) It does not ionise in the solution as it is a covalent compound.

(ii) It ionises in the solution.

(iii) It gives both hydrogen and hydroxyl ion in the solution.

(iv) It forms hydronium ion in the solution due to the combination of hydrogen ion with water molecule.

(a) Only (i) (b) Only (iii)

(c) (ii) and (iv) (d) (iii) and (iv)

Ans. **(c)** When HCl is passed through water then HCl being a polar covalent compound, ionises in water as

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

$$H^+ + H_2O \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+}$$

28. Which of the following statement is true for acids?

(a) Bitter and change red litmus to blue

(b) Sour and change red litmus to blue

(c) Sour and change blue litmus to red

(d) Bitter and change blue litmus to red

Ans. **(c)** Acids are those chemical substances which have a sour taste and turn blue titmus solution to red. On the other hand, bases are bitter in taste and soapy to touch and turn red litmus solution to blue.

29. Which of the following are present in a dilute aqueous solution of hydrochloric acid?

(a) $H_3O^+ + Cl^-$ (b) $H_3O^+ + OH^-$

(c) $Cl^- + OH^-$ (d) Unionized HCl

Ans. **(a)** When acid is mixed with water, their molecules dissociate to form ions.

The H^+ ions combine with H_2O to form H_3O^+ ions.

$$HCl + H_2O \longrightarrow H^+ + Cl^- + H_2O$$

$$H_2O + H^+ \longrightarrow H_3O^+ \text{ (Hydronium ion)}$$

30. Identify the correct representation of reaction occurring during chloralkali process.

(a) $2NaCl(l) + 2H_2O(l) \longrightarrow 2NaOH(l) + Cl_2(g) + H_2(g)$

(b) $2NaCl(aq) + 2H_2O(aq) \longrightarrow 2NaOH(aq) + Cl_2(l) + H_2(aq)$

(c) $2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(aq) + H_2(aq)$

(d) $2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

Ans. **(d)** $2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

(because state of Cl_2 and H, is gaseous, H_2O is liquid and that of NaCl and NaOH is aqueous).

31. Match the adds given in Column I with their correct source given in Column II

Column I	Column II
A. Lactic acid	1. Tomato
B. Acetic acid	2. Lemon
c. Citric acid	3. Vinegar
D. Oxalic acid	4. Curd

Ans.

Column I	Column II
a. Lactic acid	Curd
B. Acetic actd	Vinegar
C. Citric acid	Lemon
D. Oxalic acid	Tomato

32. Match the important chemicals given in Column I with the chemical formulae given in Column II.

Column I	Column II
A. Plaster of Paris	1. $Ca(OH)_2$
B. Gypsum	2. $CaSO_4 \cdot \frac{1}{2} H_2O$
C. Bleaching powder	3. $CaSO_4 \cdot 2H_2O$
D. Slaked lime	4. $CaOCl_2$

Ans.

Column I	Column II
A. Plaster of Paris	$CaSO_4 \cdot \frac{1}{2} H_2O$
B. Gypsum	$CaSO_4 \cdot 2H_2O$
C. Bleaching powder	$CaOCl_2$
D. Slaked lime	$Ca(OH)_2$

33. What will be the action of the following substances on litmus paper? Dry HCl gas, moistened NH_3 gas, lemon juice, carbonated soft drink, curd, soap solution.

Ans. (i) Dry HCl gas No change on litmus paper

(ii) Moistened NH_3 gas (basic) Red litmus will turn blue.

(iii) Lemon Juice (contains citric acid) Blue litmus will turn red.

(iv) Carbonated soft drinks (contains carbonic acid) Blue litmus will turn red.

(v) Curd (contains lactic acid) Blue litmus will turn red.
(vi) Soap solution (basic) Red litmus will turn blue.

34. Name the add present in ant sting and give its chemical formula. Also give the common method to get relief from the discomfort caused by the ant sting.

Ans. Formic acid (or methanoic acid) is present in the ant sting. The chemical formula is HCOOH. By applying some wet baking soda on the affected area, it gives relief.

35. What happens when nitric acid is added to egg shell?

Ans. Egg shells contain calcium carbonate $(CaCO_3)$. When nitric acid is added to it, brisk effervescence due to the formation of CO_2 gas is observed. The reaction is

$$\underset{\substack{\text{calcium}\\\text{carbonate}}}{CaCO_3(s)} + \underset{\substack{\text{Nitric}\\\text{acid}}}{2HNO_3(aq)} \longrightarrow \underset{\substack{\text{Calcium}\\\text{nitrate}}}{Ca(NO_3)_2(aq)} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2(g)} + \underset{\text{Water}}{H_2O(l)}$$

36. A student prepared solutions of (i) an acid and (ii) a base in two separate beakers. She forgot to label the solutions and litmus paper is not available in the laboratory. Since, both the solutions are colourless, how will she distinguish between the two?

Ans. In the absence of litmus, any other indicator like methyl orange, phenolphthalein, etc., can be used. Otherwise a natural indicator like turmeric can also be used.
Some common indicators with characteristic colours are tabulated below

S. No.	Indicator	Colour in acidic solution	Colour in neutral solution	Colour in basic solution
1. 2. 3. 4.	Litmus Phenolp hthalein Methyl orange Turmeric juice	Red Colourless Red/pink Yellow	Purple Colourless Orange Yellow	Blue Pink Yellow Reddish Brown

37. How would you distinguish between baking powder and washing soda by heating?

Ans. On heating $NaHCO_3$ (baking soda), CO_2 (carbon dioxide) gas is given out that turns lime water milky

$$\underset{\text{Baking soda}}{2NaHCO_3} \xrightarrow{\text{Heat}} \underset{\text{Sodium carbonate}}{Na2Co_3} + H_2O + Co_2 \uparrow$$

While on heating $NaHCO_3 \cdot 10H_2O$ (washing soda) water of crystallization is given out and the salt becomes anhydrous. The presence of water of crystallization given as product can be tested by treating it with anhydrous $CuSO_4$ (white) which becomes blue in colour in its contact.

$$Na_2CO_3{\cdot}10H_2O \xrightarrow{\text{Heat}} Na_2CO_3 + 10H_2O$$

38. Salt A commonly used in bakery products on heating gets converted into another salt B which itself is used for removal of hardness of water and a gas C is evolved. The gas C when passed through lime water, turns it milky. Identify A, B and C.

Ans. Salt A is sodium bicarbonate $NaHCO_2$ (as it is used in bakery products and gives Na_2CO_3 on heating). Salt B is sodium carbonate Na_2CO_3 (it is used for removal of hardness of water) Gas C is carbon dioxide COg (as it turns lime water milky).

This can be shown as floows

$$\underset{\substack{\text{Sodium}\\\text{bicarbonate}}}{2NaHCO_3} \xrightarrow{\text{Heat}} \underset{\substack{\text{Sodium}\\\text{carbonate}}}{Na_2CO_3} + H_2O + CO_2 \uparrow$$

39. In one of the industrial processes for manufacture of sodium hydroxide, a gas X is formed as by-product. The gas X reacts with lime water to give a compound Y which is used as a bleaching agent in chemical industry. Identify X and Y giving the chemical equation of the reactions involved.

Ans. In the manufacture of sodium hydroxide, hydrogen gas and chlorine gas (X) are formed as by-product. Chlorine gas reacts with lime water to give bleaching powder, a bleaching agent. Thus, X is chlorine gas (Cl_2 gas).
Y is calcium oxychloride or bleaching powder ($CaOCl_2$).
The equation for the preparation of sodium hydroxide is

$$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + \underset{(X)}{Cl_2(g)} + H_2(g)$$

$$Cl_2 + Ca(OH)_2 \longrightarrow CaOCl_2 + H_2O$$

40. Fill in the missing data in the given table.

Name of the salt	Formula	Salt obtained from	
		Base	Acid
(i) Ammonium chloride	NH_4Cl	NH_4OH	–
(ii) Copper Sulphate Sodium	–	–	H_2SO_4
(iii) Sodium chloride	$NaCl$	$NaOH$	–
(iv) Magnesium nitrate	$Mg(NO_3)_2$	–	HNO_3
(v) Potassium sulphate	K_2SO_4	–	–
(v) Calcium sulphate	$Ca(NO_3)_2$	$Ca(OH)_2$	–

Ans. (i) Acid: HCl $[\because NH_4OH + HCl \longrightarrow NH4Cl + H_2O]$

(ii) Formula: $CuSO_4$

Base: $Cu(OH)_2$ $[\because Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4 + 2H_2O]$

(iii) Acid: HCl $[\because NaOH + HCl \longrightarrow NaCl + H_2O]$

(iv) Base: $Mg(OH)_2$

$[\because Mg(OH)_2 + 2HNO_3 \longrightarrow Mg(NO_3)_2 + 2H_2O]$

(v) base: KOH

Acid: H_2SO_4 $[\because 2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O]$

(vi) Acid: HNO_3 $[\because Ca(OH)_2 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + 2H_2O]$

41. What are strong and weak acids? In the following list of acids, separate strong acids from weak acids. Hydrochloric acid, citric acid, acetic acid, nitric acid, formic acid, sulphuric acid.

Ans. Strong acid The acid that ionises completely in aqueous solution, thus producing a high concentration of H_3O^+ ions, is called a strong acid, e.g., HCl, H_2SO_4 HNO_3 etc.

Weak acid Weak acid ionises only partially in aqueous solution and thus it produces ions as well as molecules, e.g., acetic acid, carbonic acid.

Strong Acid	Weak Acid
Hydrochloric acid	Citric acid
Nitric acid	Acetic acid
Sulphuri acid	Formic acid

42. When zinc metal is treated .with a dilute solution of a strong acid, a gas is evolved, which is utilized in the hydrogenation of oil. Name the gas evolved. Write the chemical equation of the reaction involved and also write a test to detect the gas formed.

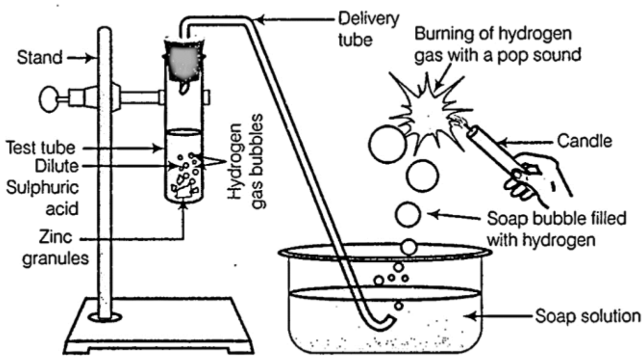
Ans. When zinc reacts with dilute solution of strong acid (like hydrochloric acid HCl), it forms salt and hydrogen gas is evolved which is used in hydrogenation of oil.

$$Zn + \underset{\text{Dil hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Zinc chloride}}{ZnCl_2} + H_2 \uparrow$$

To test the presence of Hg gas when a burning splinter is brought near the mouth of the test tube, the gas burns with a pop sound.

Long Answer Type Questions

43. In the following schematic diagram for the preparation of hydrogen gas as shown in the figure, what would happen if the following changes are made?



(a) In place of zinc granules, same amount of zinc dust is taken in the test tube.
(b) Instead of dilute sulphuric acid, dilute hydrochloric acid is taken.
(c) In place of zinc, copper turnings are taken.
(d) Sodium hydroxide is taken in place of dilute sulphuric acid and the tube is heated.

Ans. **(a)** It same amount of zinc dust is taken in the test tube then the reaction will be comparatively faster and hydrogen gas will evolve with greater speed. It is because dust has larger surface area than zinc granules.
(b) With dilute hydrochloric acid, almost same amount of gas is evolved.
(c) With copper turnings, hydrogen gas will not evolve because copper is less reactive, it does no react with dil. H_2SO_4 or dil. HCI. Hence, no reaction will take place.
(d) Zinc also react with NaOH, So, if sodium hydroxide is taken, then hydrogen gas will evolved.

$$\underset{Zinc}{Zn} + \underset{\substack{Sodium\\hydroxide}}{2NaOH} \longrightarrow \underset{\substack{Sodium\\zincate}}{Na_2ZnO_2} + \underset{\substack{Hydrogen\\gas}}{H_2} \uparrow$$

44. For making cake, baking powder is taken. If at home your mother uses baking soda instead of baking powder in cake.

(a) How will it affect the taste of the cake and why?

(b) How can baking soda be converted into baking powder?

(c) What is the role of tartaric acid added to baking soda?

Ans. (a) The advantage of using baking powder is that tartaric acid present in baking powder reacts with sodium carbonate (Na_2CO_3) produced during decomposition of $NaHCO_3$ and neutralizes it. If only sodium hydrogen carbonate (baking soda) is used in making cake, then sodium carbonate formed from it by the action of heat (during baking) give a bitter taste to cake.

(b) By adding tartaric acid to baking soda we can form baking powder.

(c) Tartaric acid neutralises the sodium carbonate formed during decomposition $NaHCO_3$ hence, making the cake tasty and not bitter in taste.

45. A metal carbonate X on reacting with an acid gives a gas which when passed through a solution Y gives the carbonate back. On the other hand, a gas G that is obtained at anode during electrolysis of brine passed on dry Y, it gives a compound Z, used for disinfecting drinking water. Identify X, Y, G and Z.

Ans. X is calcium carbonate and the gas evolved is carbon dioxide, when calcium carbon reacts with acid.

$$\mathrm{CaCO_3 + Dil.2HCl \longrightarrow CaCl_2 + H_2O + CO_2 \uparrow}$$

Solution Y is lime water $\mathrm{Ca(OH)_2}$ because, when $\mathrm{CO_2}$ is passed through it, it gives the carbonate back as shown by the given equation.

$$\underset{Y}{\mathrm{Ca(OH)_2}} + \mathrm{CO_2} \longrightarrow \underset{X}{\mathrm{CaCO_3}} \downarrow + \mathrm{H_2O}$$

The gas evolved at anode during electrolysis of brine is chlorine (G).

$$\underset{\substack{\text{Sodium}\\\text{chloride}\\\text{(brine)}}}{\mathrm{2NaCl}} + \mathrm{2H_2O} \xrightarrow{\text{Electrolysis}} \mathrm{2NaOH} + \underset{\substack{\text{Chlorine}\\\text{gas}\\\text{(G)}}}{\mathrm{Cl_2(g)}} + \mathrm{H_2(g)}$$

When chlorine gas is passed through dry $\mathrm{Ca(OH)_2}$ (Y), it produces bleaching powder (Z), used for disinfecting drinking water.

$$\mathrm{Ca(OH)_2 + Cl_2} \longrightarrow \underset{\substack{\text{Bleaching}\\\text{powder}\\\text{(Z)}}}{\mathrm{CaOCl_2}} + \mathrm{H_2O}$$

Hence, Z is calcium oxy-chloride ($CaOCl_2$) or bleaching powder.

46. A dry pellet of a common base B, when kept in open absorbs moisture and turns sticky. The compound is also a by-product of chlor-alkali process. Identify B, what type of reaction occurs when B is treated with an acidic oxide? Write a balanced chemical equation for one such solution.

Ans. Sodium hydroxide (NaOH) is commonly used base and is hygroscopic, that is, it absorbs moisture from the atmosphere and becomes sticky.

Thus, base B is NaOH (sodium hydroxide).It is also a by-product of chlor-alkali process. The acidic oxide reacts with base to give salt and water.

If $\mathrm{CO_2}$ is the acidic oxide taken, then the following reaction takes place with 'B'.

$$\underset{\substack{Sodium\\hydroxide\\(B)}}{2NaOH} + CO_2 \longrightarrow \underset{\substack{Sodium\\carbonate}}{Na_2CO_3} + H_2O$$

Such reaction is called neutralization reaction.

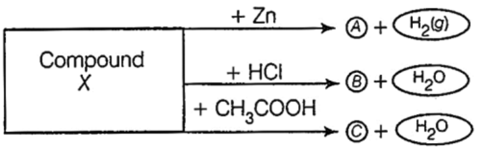
47. A sulphate salt of group 2 element of the periodic table is a white, soft substance, which can be moulded into different shapes by making its dough. When this compound is left in open for some time, it becomes a solid mass and cannot be used for moulding purposes. Identify the sulphate salt and why does it show such a behaviour? Give the reaction involved.

Ans. The sulphate salt which is used for making different shapes is plaster of Paris. Its chemical name is calcium sulphate hemihydrate $\mathrm{CaSO_4 \cdot \frac{1}{2} H_2O}$. The two formula units of $CaSO_4$ share one molecule of water. As a result, it is soft. When it is left open for some time, it absorbs moisture from the atmosphere and forms gypsum which is a hard solid mass.

So, gypsum sets as a hard solid mass and cannot be used for moulding purposes.

$$\underset{\substack{\text{(Plaster}\\\text{of paris)}\\\text{Sulphate}\\\text{salt(soft)}}}{\mathrm{CaSO_4 \cdot \frac{1}{2} H_2O}} + \underset{\text{Water}}{\mathrm{1\frac{1}{2} H_2O}} \longrightarrow \underset{\substack{\text{Gypsum}\\\text{(hard mass}\\\text{sets as)}}}{\mathrm{CaSO_4 \cdot 2H_2O}}.$$

48. Identify the compound X on the basis of the reactions given below. Also, write the name and chemical formulae of A, B and C.



Ans. Compound X is NaOH (sodium hydroxide).

$$2NaOH + Zn \longrightarrow \underset{\substack{\text{Sodium}\\\text{zincate}\\\text{(A)}}}{Na_2ZnO_2} + H_2(g)$$

$$NaOH + HCl \longrightarrow \underset{\substack{\text{Sodium}\\\textit{chloride}\\(B)}}{NaCl} + H_2O$$

$$NaOH + CH_3COOH \longrightarrow \underset{\substack{\text{Sodium}\\\text{acetate}\\\text{(C)}}}{CH_3COONa} + H_2O$$

EXERCISE

Multiple Choice Questions

1. Which one of the following will turn red litmus blue?
(a) Vinegar
(b) Baking soda solution
(c) Lemon juice
(d) Soft drinks

2. Which one of the following will turn blue litmus red?
(a) Vinegar
(b) Lime water
(c) Baking soda solution
(d) Washing soda solution

3. When zinc reacts with sodium hydroxide, the products formed are
(a) zinc hydroxide and sodium
(b) sodium zincate and water
(c) sodium zincate and hydrogen
(d) sodium zincate and oxygen

4. pH of sodium carbonate (Na_2CO_3) solution will be
(a) 7 (b) > 7
(c) < 7 (d) 1

5. Change of $Na_2CO_3.10H_2O$ to $Na_2CO_3.H_2O$ on exposure to air is called
(a) efflorescence (b) effervescence
(c) fluorescence (d) luminescence

6. Which of the following is a strong base?
(a) Ammonium hydroxide
(b) Sodium hydroxide
(c) Magnesium hydroxide
(d) Copper hydroxide

7. Which of the following is not a base?
(a) KOH (b) ZnO
(c) $Al(OH)_3$ (d) NaCl

8. Acetic acid is a weak acid because
(a) its aqueous solution is acidic
(b) it is highly ionized
(c) it is weakly ionized
(d) it contains - COOH group

9. Partial neutralization of a polybasic acid gives
(a) acid salt (b) basic salt
(c) normal salt (d) double salt

10. Which of the following can form more than one acid salt?
(a) CH_3COOH (b) H_3PO_4
(c) CH_3CH_2COOH (d) ZnO

11. A solution turns blue litmus red. The pH of the solution is probably
(a) 8 (b) 10
(c) 12 (d) 6

12. The type of medicine used to treat indigestion is
(a) antihistamine (b) sulpha drug
(c) antacid (d) antibiotic

13. Washing soda has the formula
(a) $Na_2CO_3.7H_2O$ (b) $Na_2CO_3.10H_2O$
(c) $Na_2CO_3.H_2O$ (d) Na_2CO_3

14. Which of the following acid is present in vinegar?
(a) Lactic acid (b) Malic acid
(c) Acetic acid (d) Tartaric acid

15. Basic salts are formed by neutralization of
(a) strong acid and strong base
(b) strong acid and weak base
(c) weak acid and weak base
(d) strong base and weak acid

16. When bitten by an ant, the sting causes irritation due to the presence of
(a) a base in the sting
(b) formic acid in the sting
(c) poisonous chemicals (d) both (a) and (b)

17. Plaster of Paris is obtained
(a) by adding water to calcium sulphate
(b) by adding sulphuric acid to calcium hydroxide
(c) by heating gypsum to a very high temperature
(d) by heating gypsum to 120° C

18. Which of the following is 'quick lime'?
(a) CaO (b) $Ca(OH)_2$
(c) $CaCO_3$ (d) $CaCl_2.6H_2O$

19. Which of these choices is considered to be a Bronsted-Lowry base?
(a) Proton donor (b) Proton acceptor
(c) Electron acceptor (d) None of these

20. In the reaction, $CO_3^{2-} H_2O \rightarrow HCO_3^- + OH^-$ water is a
(a) Bronsted acid (b) Bronsted base

(c) conjugate acid (d) conjugate base

21. A solution reacts with crushed egg-shells to give a gas that turns lime-water milky. The solution contains
(a) NaCl (b) HCl
(c) Lid (d) KCl

22. Which of the following statement is not correct?
(a) Acids turn blue litmus solution to red.
(b) Raw onion can be used as an olfactory indicator to check acid or base.
(c) Bases are sour in taste.
(d) Vanilla essence does not give odour in strongly basic solution.

23. Baking powder contains sodium hydrogen carbonate and
(a) tartaric acid (b) washing soda
(c) calcium chloride (d) acetic acid

24. Lime reacts with water to give
(a) $Ca(OH)_2$ (b) $CaCl_2$
(c) $CaOCl_2$ (d) CaO

25. Plaster of Paris hardens by
(a) giving off CO_2
(b) changing into $CaCO_3$
(c) combining with water
(d) giving out water

26. The difference of water molecules in gypsum and Plaster of Paris is
(a) 5/2 (b) 2
(c) 1/2 (d) 3/2

27. The pH of a solution of hydrochloric acid is 4. The molarity of solution is
(a) 4.0 (b) 0.4
(c) 0.0001 (d) 0.04

28. When water is added to quick lime, the reaction is
(a) explosive (b) endothermic
(c) exothermic (d) photochemical

29. Bleaching powder gives smell of chlorine because it
(a) is unstable
(b) gives chlorine on exposure to atmosphere
(c) is a mixture of chlorine and slaked lime
(d) contains excess of chlorine

30. Which of the following salts on dissolving in water will give a solution with pH less than 7 at 298 K?
(a) KCN (b) CH_3COONa
(c) NaBr (d) NH_4Cl

31. Which of the following is incorrectly matched?
(a) Tomato - tartaric acid
(b) Ant sting - methanoic acid
(c) Citrus fruit - citric acid
(d) Curd - lactic acid

32. The solution with the lowest concentration of H^+ ion is
(a) pH = 7 (b) pH = 8.6
(c) pH = 2.0 (d) pH = 6.8

33. The incorrect statement about acids is
(a) they give H^+ ion in water
(b) they are sour in taste
(c) they turn blue litmus red
(d) they give pink colour with phenolphthalein

34. If tartaric acid is not added in baking powder, the cake will taste bitter due to the presence of
(a) sodium hydrogen carbonate
(b) sodium carbonate
(c) carbon dioxide
(d) some unreacted tartaric acid

35. Soda-acid fire extinguisher extinguishes the fire by
(a) cutting the supply of air
(b) removing the combustible substance
(c) raising the ignition temperature
(d) none of these

36. Acids like lactic acid, uric acid which are obtained usually from plants and animals
(a) organic acid (b) inorganic acid
(c) oxy acid (d) hydra acid

37. Choose one example of inorganic acid (minera acid) from the following.
(a) Oxalic acid (b) Acetic acid
(c) Nitric add (d) Formic acid

38. Which of the following statements is true regarding acids and bases?
(a) Adds and bases don't react with each other.
(b) Acids mixed with bases neutralize each other.
(c) Acids mixed with bases make stronger acids.
(d) Adds mixed with bases make weaker acids.

39. Which gas is evolved when acids react with metal carbonates?
(a) CO_2 (b) H_2
(c) NH_3 (d) O_2

40. Which acid is used in flavoured drinks?
(a) Boric acid (b) Carbonic acid
(c) Sulphuric add (d) Oxalic acid

41. Sour milk contains
(a) lactic acid (b) acetic acid
(c) tartaric add (d) citric add

42. What will be the pH value of a solution if salt of a strong acid and weak base undergoes hydrolysis?
(a) pH = 7 (b) pH > 7
(c) pH < 7 (d) pH = 1

43. pH is a measure of .... ions in a solution.
(a) hydrogen (b) hydroxide

(c) ammonium (d) carbonium

44. On diluting solution of pH of 4, its pH will
(a) remain same (b) increase
(c) decrease
(d) undergo a chemical change.

45. The equation between an add and a base is $XOH + HY \rightarrow XY + H_2O$ which of the following is the cation part of salt?
(a) X (b) OH
(c) H (d) Y

46. Why should Plaster of Paris be stored in a moisture proof container?
(a) On mixing with water it changes into a hard solid.
(b) On mixing with water it becomes diluted
(c) It evaporates in moisture
(d) It breaks into its component in water.

47. If pH of solution is 13, it means that it is
(a) weakly acidic (b) weakly basic
(c) strongly acidic (d) strongly basic

48. Which of the following metals can displace hydrogen from the aqueous solution of sodium hydroxide?
(a) Mg (b) Cu
(c) Al (d) Ag

49. An aqueous solution with pH = zero is
(a) acidic (b) alkaline
(c) neutral (d) amphoteric

50. Two solutions A and B were found to have pH value of 6 and 8 respectively. The inference which can be drawn is that
(a) the acid strength of the solution A is higher than that of B
(b) A is an add while B is a base
(c) both are add solutions
(d) both are base solutions.

51. Acetic add 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
(a) solid X is sodium hydroxide and the.gas evolved is CO_2
(b) solid X is sodium bicarbonate and the gas evolved is CO_2
(c) solid X is sodium acetate and the gas evolved is CO_2
(d) solid X is sodium chloride and the gas evolved is CO_2.

52. 'Alum' is an example of
(a) single salt (b) double salt
(c) acids (d) none of these

53. Which of the following is not an acidic salt?
(a) $CuSO_4$ (b) Na_2CO_3
(c) $ZnSO_4$ (d) NH_4NO_3

54. Arrhenius acid gives
(a) H^+ in water (b) OH^- in water
(c) both (a) and (b) (d) none of these

55. 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
(a) changed to red
(b) changed first to red and then to blue
(c) changed blue to colourless
(d) remained blue in both the solutions

56. $CuO + (X) \rightarrow CuSO_4 + H_2O$. Here (X) is
(a) $CuSO_4$ (b) HCl
(c) H_2SO_4 (d) HNO_3

57. In a solution of pH = 5, more add is added in order to reduce the pH = 2. The increase in hydrogen ion concentration is
(a) 100 times (b) 1000 times
(c) 3 times (d) 5 times

58. How many litres of water has evaporated on concentrating 10 litres of H_2SO_4 such that its pH decreases from 6 to 5?
(a) 9 (b) 7
(c) 5 (d) 10

59. Which of the following is an example of a basic buffer?
(a) $NH_4OH + NH_4Cl$
(b) $CH_3COOH + CH_3COONa$
(c) $CH_3COONH_4 + CH_3COOH$
(d) $CH_3COONH_4 + NH_4OH$

60. Which set of acids is solid in nature?
(a) Boric acid, oxalic add
(b) Acetic acid and boric acid
(c) Formic add and oxalic add
(d) Formic add and acetic acid

61. Which acids are highly corrosive in nature?
(a) Acetic add and oxalic add
(b) Acetic add and sulphuric add
(c) Sulphuric add and nitric add
(d) Carbonic acid and acetic acid

62. Which of the following does not give H^+ ions in aqueous solution?
(a) H_2CO_3 (b) C_2H_5OH
(c) CH_3COOH (d) H_3PO_4

63. For dilution of concentrated acid we should add
(a) water into concentrated acid
(b) concentrated add into water
(c) first water into acid and then more acid
(d) both (a) and (b) are correct

64. When sodium chloride reacts with sulphuric acid, a gas is evolved which gives dense white fumes with ammonia. Which is the gas evolved?
(a) HCl (b) NH_4Cl
(c) NH_4OH (d) $(NH_4)_2SO_4$

65. When two molecules of NaOH react with one molecule of sulphuric acid, one molecule of .... and.......... molecules of water are formed. '
(a) sodium sulphate, 2
(b) sodium sulphite, 2
(c) sodium sulphate, 1
(d) sodium sulphite, 1

66. Phenolphthalein is
(a) yellow in acidic medium, pink in basic medium
(b) pink in acidic medium, colourless in basic medium
(c) colourless in acidic medium, pink in basic medium
(d) pink in acidic medium, yellow in basic medium

67. The substances whose odour change in acidic and basic solutions are known as
(a) olfactory indicators
(b) add base indicators
(c) visual indicators
(d) all of these

68. Which is not a dibasic acid?
(a) Carbonic add (H_2CO_3)
(b) Sulphurous add (H_2SO_3)
(c) Formic acid (HCOOH)
(d) Oxalic add [$(COOH)_2$]

69. One molecule of Aluminium hydroxide will require how many molecules of dil HCl for complete neutralization?
(a) 1 (b) 2
(c) 3 (d) 4

70. When ferrous hydroxide reacts with hydrochloric acid, which salt is produced?
(a) $FeCl_3$ (b) $FeCl_2$
(c) $FeCl_4$ (d) FeCl

71. Aqueous solution of copper sulphate reacts with aqueous ammonium hydroxide solution to give
(a) brown ppt. (b) pale blue ppt.
(c) white ppt. (d) green ppt

72. Carbon tetrachloride is an example of
(a) strong electrolyte (b) weak electrolyte
(c) non electrolyte (d) electrolyte.

73. 10 mL of a solution of NaOH is found to be completely neutralized by 8 mL of a given solution of HCl. If we take 20 mL of the same solution of NaOH, the amount of HCl required to neutralize it will be
(a) 4 mL (b) 8 mL
(c) 12 mL (d) 16 mL

74. Which one of the following is a strong electrolyte?
(a) Carbon disulphide
(b) Ammonium hydroxide
(c) Sodium chloride
(d) Water

75. Mark the correct statement.
(a) Both bases and alkalies are soluble in water.
(b) Alkalies are soluble in water but all bases are not.
(c) C_2H_5OH is a base because it has OH group.
(d) Bases are soluble in water but alkalies are not.

76. The concentration of hydroxide [OH^-] in neutral water at 25°C in mol/L is
(a) 7 (b) 10^{-7}
(c) 14 (d) 10^{-14}

77. The expression for the pH of a solution is given by
(a) pH = $-\log\frac{1}{[H^+]}$ (b) pH = log $[H^+]$
(c) $\log\frac{1}{[H^+]}$ (d) pH= $[H^+]$

78. 10^{-6} M HCl is diluted to 100 times. Its pH is
(a) 6.0 (b) 8.0
(c) 6.95 (d) 9.5

79. Which salt can be classified as an acid salt
(a) Na_2SO_4 (b) $BiOCl$
(c) $Pb(OH)Cl$ (d) Na_2HPO_4

80. pH of blood is maintained constant by mechanism of
(a) common ion effect (b) buffer
(c) solubility (d) all of these

81. The species among the following, which can act as an acid and a base is
(a) HSO_4^- (b) SO_4^{2-}
(c) H_3O^+ (d) Cl^-

82. What is the term for the positive and negative ions of a compound breaking apart in solution?
(a) Conglomeration (b) Oxidation
(c) Dissociation (d) None of the above

83. In the reaction
$HNO_{3(aq)} + H_2O_{(l)} \rightarrow H3O^+ + NO_3^-$ the nitrate is the
(a) Bronsted acid (b) Bronsted base
(c) conjugate acid (d) conjugate base

84. Plaster of Paris $\left(CaSO_4.\frac{1}{2}H_2O\right)$ on mixing with water sets to form
(a) $CaSO_4.H_2O$ (b) $CaSO_4.1\frac{1}{2}H_2O$
(c) $CaSO_4.2H_2O$ (d) $CaSO_4.2\frac{1}{2}H_2O$

85. The soil for healthy growth of plants should be
(a) highly acidic

(b) highly alkaline
(c) neither alkaline nor highly acidic
(d) either acidic or highly alkaline

86. On electrolysis of brine solution, the products formed are
(a) sodium and chlorine
(b) hydrogen, chlorine and oxygen
(c) hydrogen, chlorine and sodium hydroxide
(d) sodium hydroxide, chlorine and oxygen

87. When dilute hydrochloric acid is added to granulated zinc placed in a test tube, the observation made is that
(a) the surface of the metal turns shining
(b) the reaction mixture turns milky
(c) odour of chlorine is observed
(d) a colorless and odorless gas is evolved with bubbles

88. Moist sodium bicarbonate was placed on a strip of pH paper. The colour of the strip
(a) turned blue (b) did not change
(c) turned green (d) turned light pink

89. The colour of the pH strip turned red when it was dipped in a sample. The sample could be
(a) dilute sodium bicarbonate solution
(b) tap water
(c) dilute sodium hydroxide solution
(d) dilute hydrochloric acid

90. Iron filings were added to solution of copper sulphate. After 10 minutes, it was observed that the blue colour of the solution changed and layer got deposited on iron filings. The colour of the solution and that of the layer would respectively be
(a) yellow and green
(b) brown and blue
(c) red and greenish blue
(d) green and reddish brown

91. Write the net ionic equation for the reaction of sodium hydroxide with hydrochloric acid.
(a) $Na^+ + Cl^- \rightarrow NaCl$
(b) $Na^+ + Cl^- + H^+ + OH^- \rightarrow NaCl + H_2O_{(l)}$
(c) $H^+ + OH^- \rightarrow H_2O_{(l)}$
(d) none of these

92. What is the term for a water molecule that gains an extra hydrogen ion?
(a) hydroxium ion (b) Hydronium ion
(c) hydroxide ion (d) none of the above

93. Which of the following compounds is neutral to litmus?
(a) $NaNO_3$ (b) $CuSO_4.5H_2O$
(c) $NaHCO_3$ (d) $Ca(OH)_2$

94. A compound whose aqueous solution will have the highest pH is
(a) NaCl (b) Na_2CO_3
(c) NH_4Cl (d) $NaNO_3$

95. pH + pOH equals
(a) zero (b) fourteen
(c) a negative number (d) infinity

FILL IN THE BLANKS

1. Plaster of Paris is obtained by heating ....
2. Chemical formula of Plaster of Paris is........
3. Chemical formula of bleaching powder is ....
4. Brine is a saturated solution of.......
5. A salt is made when the .... in an acid is replaced by a ....
6. An acidic solution contains .... ions while a basic solution contain .... ions.
7. The weaker is the acid, greater is the base strength of its ....
8. When an acid react with a metal............ gas is evolved and a corresponding............ is formed.
9. Anhydrous sodium carbonate is commonly known as ....
10. Acid-base indicators are dyes or mixture of dyes which are used to indicate the presence of .... and ....
11. Strong acids are essentially ....% ionized in aqueous solution whereas weak acids are ....ionized.
12. When ammonium chloride is heated with caustic soda, the gas evolved is ....
13. A base which is not a metallic oxide or hydroxide is ....
14. The colour of phenolphthalein in acidic medium is......
15. ENO salt contains......... and is........... in nature.
16. An acid used in lead storage batteries is.........
17. An alkali reacts with an .... to give a ....
18. All acids have a pH........... than 7.
19. The strength of an acid or alkali can be tested by using a scale called the..........
20. An acid that contains more than one acidic hydrogen atoms called a............
21. Chlorine produced from bleaching powder when it is treated with excess of hydrochloric acid, is called............

TRUE OR FALSE

1. The hydronhun ion is the strongest acid that can exist in aqueous solution.
2. Acidic and basic solutions in water conduct electricity because they produce hydrogen and hydroxide ions respectively.

3. Living beings carry out their metabolic activities at a very high pH.

4. Mixing concentrated acids or bases with water is a highly endothermic reaction.

5. The colour of caustic soda turns pink when phenolphthalein is added to it.

6. Bleaching powder cannot be used for disinfecting drinking water.

7. An aqueous solution is one that has compound dissolved in water.

8. Washing soda on reaction with dilute HCl liberates carbon dioxide in water.

9. Dilution of an acid decreases H^+ concentration.

10. Calcium hydroxide is used to make soaps.

11. Gastric juice contains hydrochloric acid.

12. Vinegar contains citric acid.

13. Carbonic acid is a weak acid.

14. Basicity of acetic acid (CH_3COOH) is four.

15. Anhydrous sodium carbonate is known as washing soda.

16. Formic acid is a weak acid.

17. The solution of a weak acid and a strong base is alkaline.

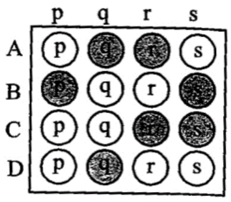
18. The pH of a solution is 10. It is likely to be acidic in nature.

19. An antacid is used to treat indigestion.

20. Nettle sting produces methanoic acid.

Matrix Match Type

In this section, each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in Column-I have to be matched with statements (p, q, r, s) in Column-II. The answers to these questions have to be appropriately bubbled as illustrated in the following example. If the correct matches are A-q, A-r, B-p, B-s, C-r, C-s and D-q, then the correctly bubbled matrix will look like as shown.



1.

Column I	Column II
(A) HCl	(p) Strong acid
(B) HCN	(q) Weak add
(C) NaOH	(r) Weak base
(D) NH_4OH	(s) Strong base.

2.

Column I	Column II
(A) KNO_3	(p) Nitric acid, silver hydroxide
(B) $AgNO_3$	(q) Hydrochloric acid, Magnesium hydroxide
(C) $MgCl_2$	(r) Carbonic acid, Ammonium hydroxide
(D) $(NH_4)_2CO_3$	(s) Nitric acid, Potassium hydroxide

3.

Column I	Column II
(A) Acid-base indicator	(p) Na_2SO_4
(B) Acid used in soft drinks	(q) Phenolphthalein
(C) Salt formed by neutralization of strong acid and weak base	(r) Carbonic acid
(D) Salt whose aqueous solution is neutral	(s) $CuSO_4$

4.

Column I Solution	Column II pH
(A) Vinegar	(p) 6.8
(B) Milk	(q) 7.4
(C) Human blood	(r) 2.4 - 3.4
(D) Lime water	(s) 10.5

5.

Column I Anhydrous salt .	Column II Water of Crystallization
(A) $CuSO_4$	(p) $5H_2O$
(B) $CuSO_4$	(q) $10H_2O$
(C) $FeSO_4$	(r) $2H_2O$
(D) Na_2SO_4	(s) $NaHCO_3$

6.

Column I	Column II
(A) Baking soda	(p) $NaCl$
(B) Washing soda	(q) $NaOH$
(C) Caustic soda	(r) Na_2CO_3
(D) Common salt	(s) $NaHCO_3$

7.

Column I	Column II
(A) Simple buffer	(p) $CH_3COONa+CH_3COOH$
(B) Acidic buffer	(q) NH_4OH+NH_4Cl
(C) Basic buffer	(r) CH_3COONH_4
(D) Basic solution	(s) CH_3COONa

8.

Column I	Column II
(A) Mono basic	(p) KOH
(B) Dibasic	(q) $Ca(OH)_2$
(C) Diacidic	(r) H_2SO_4
(D) Mono acidic	(s) HNO_3

9. **Column I** **Column II**

Salt solution	pH
(A) Na_2SO_4	(p) < 7
(B) NH_4Cl	(q) 7
(C) Na_2CO_3	(r) = 7
(D) CH_3COONH_4	(s) > 7

10.

Column I	Column II
(A) Metal + acid	(p) Water
(B) Acid + base	(q) Hydronium ion
(C) Metal carbonate + acid	(r) Hydrogen gas
(D) Acid + water .	(s) Carbon dioxide.

ASSERTION & REASON QUESTIONS

Directions: In each of the following questions, a statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements, mark the correct answer as

(a) If both assertion and reason are true and reason is the correct explanation of assertion

(b) If both assertion and reason are true but reason is not the correct explanation of assertion

(c) If assertion is true but reason is false

(d) If assertion is false but reason is true.

1. **Assertion:** Phenolphthalein is an acid-base indicator.
Reason: In acid-base titration, it is used as an indicator.

2. **Assertion:** pH of our body is about 7.4 and it remains almost constant inspite the variety of foods we eat.
Reason: Blood is a buffer.

3. **Assertion:** pH of ammonium nitrate solution is acidic.
Reason: Solution of a salt of weak base and strong acid is acidic.

4. **Assertion:** pH = 7 signifies pure water.
Reason: At this Ph, $[H^+]=[OH^-]=10^{-7}$.

5. **Assertion:** A solution of pH = 1 has hydrogen ion concentration 3 times than that of solution of pH = 3.
Reason: pH = $\log\frac{1}{[H_2O^+]}$.

6. **Assertion:** Strength of the acid or the base increases with dilution.
Reason: Iionization of an acid or a base increases with dilution.

7. **Assertion:** When rain is accompanied by a thunderstorm, the collected rain water will have pH value slightly lower than that of rain water without thunderstorm.
Reason: Temperature increases due to thunderstorm and so $[H^+]$ increases.

8. **Assertion:** A buffer solution controls the change in pH value on addition of small amount of acid or base to it.
Reason: pH value of buffer solution remains same on dilution or on keeping for long,

9. **Assertion:** Acetic acid does not act as an acid in benzene solution.
Reason: Benzene does not accept proton.

10. **Assertion:** H_3PO_4 and H_2SO_4 are known as polybasic acids.
Reason: They have two or more than two protons per molecule of the acid.

11. **Assertion:** pH of 10 M HCl aqueous solution is less than 1.
Reason: pH is negative logarithm of concentration.

12. **Assertion:** When a smaller amount of sodium acetate is added to a dilute solution of acetic acid, pH of the solution is not affected.
Reason: Buffer solutions have a definite pH.

13. **Assertion:** Ammonia is a base.
Reason: It does not contain OH⁻ ions.

14. **Assertion:** Calcium sulphate semi hydrate, $CaSO_4.\frac{1}{2}H_2O$ is called plaster of Paris.
Reason: Plaster of Paris is used for producing moulds for pottery and ceramics and casts of statues and buses.

15. **Assertion:** Bleaching powder reacts with dilute acids to evolve chlorine.
Reason: The chlorine liberated by the action of dilute acids on bleaching powder is called available chlorine.

PASSAGE

PASSAGE 1: The following reactions are occurring in a process used for manufacture of sodium carbonate.

(A) $\xrightarrow{Heat}$ (B) $+CO_2$

(B) $+H_2O\rightarrow$ (C)

(C) $+NH_4Cl\rightarrow$ (D) (a gas which is soluble in water)

(D) $+H_2O\rightarrow$ (E) solution

(E) $+CO_2\rightarrow$ (F)   (F) $+NaCl\rightarrow$ (G) + (H)

(G) $\xrightarrow{Heat} Na_2CO_3+CO_2+H_2O$

Answer the following questions:

1. The name of the process is
(a) Solvay (b) Salt cake
(c) Haber (d) Chlor-alkali

2. (A) is
(a) $Ca(HCO_3)_2$ (b) $NaHCO_3$
(c) $CaCO_3$ (d) $Ca(OH)_2$

3. (C) is
(a) $Ca(OH)_2$ (b) $NaOH$
(c) CaO (d) $CaCO_3$

4. (E) is
(a) $NaOH$ (b) $NaCl$
(c) NH_4OH (d) NH_4Cl

5. (F) is
(a) NH_4HCO_3 (b) Na_2CO_3
(c) $NaHCO_3$ (d) $(NH_4)_2CO_3$

6. (G) is
(a) $NaCl$ (b) NH_4Cl
(c) NH_4OH (d) $NaHCO_3$

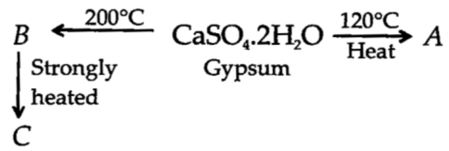
PASSAGE 2: A solid compounds X on heating gives CO_2 gas and a solid residue. The residue mixed with water forms Y. On passing an excess of CO_2 through Y in water a clear solution Z is obtained.

1. Identify the compound X.
(a) $CaCO_2$ (b) Na_2CO_3
(c) CaO (d) $Ca(OH)_2$

2. Identify the compound Y.
(a) $CaCl_2$ (b) CaO
(c) $Ca(OH)_2$ (d) CO_2

3. Identify the compound Z.
(a) $Ca(HCO_3)_2$ (b) $Ca(OH)_2$
(c) $CaCO_3$ (d) CaO

PASSAGE 3:



1. A is
(a) plaster of Paris (b) dead burnt plaster
(c) lime (d) lime water

2. B is
(a) dead burnt plaster (b) lime
(c) limestone (d) plaster of Paris

3. C is
(a) anhydrous calcium sulphate
(b) lime (c) plaster of Paris
(d) dead burnt plaster

PASSAGE 4: A strong acid or strong base means 100% ionization. That means, the H^+ concentration of a strong acid is equal to concentration of the acid. After all the acid dissociates, there will be no acid molecules. Similarly for a strong base OH^- concentration is equal to the concentration of base. It is possible to reach a pH value of zero for an acid. For calculating pH of a base, pOH value can be calculated first and then going to pH. The point to be kept in mind for such calculations is the relation pH + pOH = 14.

1. The $[OH^-]$ in a solution is measured to be M. What is pOH of the solution?
(a) 3 (b) 1
(c) 2 (d) 0.01

2. What is the pH of a 1.00 M solution of HBr?
(a) 1 (b) 13
(c) 0.00 (d) 14

3. What is the pH of a 0.050 M solution of KOH?
(a) 12.70 (b) 1.30
(c) 5 (d) 9

4. What is the pH of 0.100 M solution of HCl?
(a) 1 (b) 0.01
(c) 0.1 (d) 0.001

PASSAGE 5: A compound X of sodium forms a white powder. It is a constituent of baking powder and used in some antacids. When heated it gives a compound Y which is anhydrous and absorbs water to become hydrated salt. When kept open in air Y looses water molecules in a process called efflorescence. When dissolved in water it forms a strong base and a weak acid Z.

Answer the following questions.

1. What is Y?
(a) $NaHCO_3$
(b) Na_2CO_3
(c) $Na_2CO_3.10H_2O$
(d) $NaCl$

2. What happens when sodium carbonate decahydrate is exposed to air?
(a) It loses one molecule.
(b) It loses ten molecules of water.
(c) It loses nine molecules.
(d) It dissociates to give CO_2.

3. What is the nature of the solution formed by dissolving Y in water?
(a) Alkaline
(b) Acidic
(c) Neutral
(d) It remains insoluble

4. Identify Z.
(a) CO_2 (b) H_2CO_3
(c) NaOH (d) H_2O

SUBJECTIVE PROBLEMS

VERY SHORT ANSWER TYPE QUESTIONS

1. Name two substances from daily life which contain acid and two substances which contain base.
2. Name one antacid commonly used.
3. Can we use Na_2CO_3 as antacid?
4. Can we use NaOH as antacid?
5. Name flowers whose colour or petals can be used as indicator.
6. What are olfactory indicators? Give one example.
7. Can vanilla essence act as indicator? Why?
8. What is the colour of phenolphfhalein in NaOH?
9. What is the colour of methyl orange in NaOH?
10. Which gas bums with pop sound?
11. Why does HNO_3 not liberate hydrogen gas with most of the metals?
12. Will acetic acid liberate hydrogen gas with zinc metal?
13. Why certain metals displace hydrogen from dilute acids?
14. Name two metals which displace H_2 with very dilute HNO_3 (5%).
15. Which gas is evolved when metal carbonates or metal hydrogen carbonate reacts with dilute acids?
16. Why does CO_2 turns lime water milky?
17. What is lime water?
18. Which metal oxide reacts with dil. H_2SO_4 to form blue colour?
19. Which colour is obtained when CuO reacts with conc. HCl?
20. What happens when CO_2 gas is passed through KOH solution?
21. Does dry $HCl_{(g)}$ turn blue litmus red?
22. Does NaOH solution contain H^+?
23. Is H_2O acidic, basic or neutral?
24. What is conc. of OH^- ions in solution with pH=13?
25. What is pH of our stomach?
26. Is toothpaste acidic, basic or neutral?
27. Why is NaCI called salt?
28. KCN is salt of which acid and base?
29. What is the colour of pH paper in NaCl solution?
30. How do we prepare NaOH from NaCI?
31. What is the common name of $CaOCl_2$?
32. Why does bleaching powder act as bleaching agent?
33. Why does bleaching powder act as disinfectant?
34. Why are bread, biscuits fluffy?
35. Which of the following is gypsum and which one is plaster of Paris?

    (i) $CaSO_4.\frac{1}{2}H_2O$ (ii) $CaSO_4.2H_2O$
36. Write the equation to show formation of plaster of Paris?
37. What do you call the property of loosing water of crystallization?
38. Name the two main constituent of baking powder.
39. Name the acids and bases from which the following salts are obtained :

    (i) Sodium acetate

    (ii) Ammonium carbonate.
40. How will you treat the bee sting?
41. What is a universal indicator?
42. What is the effect of dilution on H^+ ion concentration of an acid?
43. Solution A gives pink colour when a drop of phenolphthalein indicator is added to it. Solution B gives red colour when a drop of methyl orange is added to it. What are types of solutions A and B and what type of pH would they have?
44. Name the gas evolved when dilute HCl reacts with sodium hydrogen carbonate. How is it recognized?
45. What is dead burnt plaster?
46. What is the difference between washing soda and soda ash?
47. What is me action of sulphuric acid on bleaching powder?
48. Why is potassium iodide added into common salt to use it as table salt?

SHORT ANSWER TYPE QUESTIONS

1. What happens when:

    (a) CO_2 is passed through lime water in limited amount

    (b) CO_2 is passed through lime water in excess
2. What is the difference between a base and an alkali?
3. What precaution must be taken while diluting a concentrated acid?
4. Crystals of copper sulphate are heated in a test tube for some time.

    (a) What is the colour of copper sulphate crystals?

    (i) Before heating (ii) After heating

    (b) What is the source of liquid droplets seen on the inner upper side of the test tube during the heating process?
5. Ammonia is also considered as a base although it does not contain hydroxyl ion. Why?

6. (a) Name the products formed when sodium hydrogen carbonate is heated.
(b) Write the chemical equation for the reaction involved in the above.

7. Name the four chemicals which can be obtained from common salt.

8. How is bleaching powder prepared? Why does bleaching powder:
(a) Smell strongly of chlorine?
(b) Not dissolve completely in water?

9. Write the chemical formula for washing soda. How can it be obtained from baking soda? Describe a household application of washing soda.

10. What is the chemical name of baking soda? What happen when it is heated? Write two uses of baking soda.

11. A yellowish-white powder which smells of chlorine readily loses chlorine on exposure to air, it is also used for bleaching cotton and for disinfecting water.
(a) Identify the yellowish white powder compound.
(b) Write balanced chemical equation representing the reaction involved in its manufacture.

12. How is plaster of Paris prepared? Why is plaster of Paris stored in an airtight container?

13. What is the role of acid in our stomach? Why pain occurs in the stomach during indigestion? What is done to get rid of this pain?

14. Although acetic acid is highly soluble in water but still it is a weak acid. Explain why?

15. Dry hydrogen chloride gas does not turn blue litmus red whereas hydrochloric add does. Give one reason.

16. Give reason why?
(i) It is recommended that the acid should be added to water and not water to the acid?
(ii) Compounds like alcohol and glucose do not show acidic behaviour although they contain hydrogen in them?

17. Answer the following:
(i) Why is plaster of Paris written as $CaSO_4.1/2\ H_2O$? How is it possible to have half a water molecule attached to $CaSO_4$?
(ii) Why is sodium hydrogen carbonate an essential ingredient in antacids?
(iii) When electricity is passed through an aqueous solution of sodium chloride, three products are obtained. Why is the process called chlor-alkali?

18. What is the pH of a 10^{-6} M sodium hydroxide solution?

19. 0.02 mole of hydrochloric acid (HCl) is added to water to prepare 2.0 L of solution. Calculate the pH of this hydrochloric acid solution.

20. Write balanced acid-base neutralization reactions that would lead to formation of the following salts or acid salts.
(a) $CaBr_2$ (b) $Sr(ClO_2)_2$
(c) $Ba(HS)_2$ (d) Li_2S

21. A tarnished copper vessel begins to shine again when rubbed with lemon. Why?

22. Why does a stain of curry on a white cloth become reddish brown when soap is scrubbed on it and turns yellow again when the cloth is washed with plenty of water?

23. What is meant the term 'pH of a solution'? The pH of gastric juices extracted from the stomach of two persons A and B were found to be 1 and 3 respectively. The stomach juice of which person is more acidic?

24. Concentrated basic solutions have greater pH. Explain.

25. Why is N_2SO_3 more soluble in cold drinks than in water?

26. A substance X is used as a building material and is insoluble in water. When reacted with dilute HCl, it produces a gas which turns lime water milky. Predict the substance. Write the chemical equations involved.

27. Why do we feel a burning sensation in the stomach when we overeat? What is the medicine used called? Give one example.

28. What is the difference between a base and alkali? Explain with suitable examples.

29. On adding dilute hydrochloric acid to copper oxide powder, the solution formed is blue-green. Predict the new compound formed which imparts a blue- green colour to the solution.

LONG ANSWER TYPE QUESTIONS

1. Name the raw materials that are required for the manufacture of washing soda by Solvay process. Describe the chemical reactions involved in the purpose.

2. What is observed when (i) dilute sulphuric acid is added to solid sodium carbonate, (ii) hot concentrated sulphuric acid is added to sulphur, (iii) sulphur dioxide is passed through lime water? Also write chemical equations to represent the chemical reaction taking place in each case.

3. Write the balanced molecular, total ionic, and net ionic equations illustrating the reaction of mol of H_3SO_4 with 1 mol of Ca(OH)$_2$.

4. Write any three chemical properties of acids.

5. Complete the following equations:

(i) $NaHCO_3 \xrightarrow{heat}$

(ii) $CaSO_4.2H_2O \xrightarrow[373K]{heat}$

(iii) $Na_2CO_3.10H_2O \xrightarrow{air}$

(iv) $CuSO_4.5H_2O \xrightarrow{heat}$

Identify the compound of calcium which is

6. Identify the compound of calcium which is yellowish white powder and is used for disinfecting drinking water. How is it manufactured? Write the chemical equation for the reaction involved. What happens when it is left exposed to air?

7. Identify two salts among the following whose solution can generate a pH greater than 7.

(i) K_2S (ii) NH_4Cl

(iii) KNO_3 (iv) $CaCO_3$

8. Find the pH of the solution formed by the addition of 36.5 g of HC1 and 40 g of NaOH.

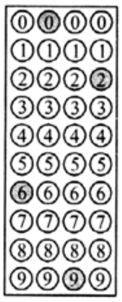
9. Find the nature of the solution, in the following cases.

(a) $[H^+]$ (b) pH = 6

(c) pOH = 7

INTEGER ANSWER TYPE

This section contains 5 questions. The answer to each of the questions is a single digit integer, ranging from 0 to 9. If the correct answers to question number X, Y, Z and W (say) are 6, 0, 9 and 2 respectively, then the correct darkening of bubbles will look like the following.



1. 50 mL of 0.2 mL HCl is added to 30 mL of 0.1M KOH solution. The pH of the solution is

2. Equal volumes of solutions with pH = 4 and pH = 10 are mixed. The pH of the resulting solution is

3. A solution of HCl has a pH = 5. If one mL of it is diluted to 1 litre. The pH of resulting solution will be

4. The pH of 10^{-5} M NaOH solution is

5. 50 mL of 0.2N H_2SO_4 were added to 100 mL of 0.2 N HNO_3. Then the solution is diluted to 300 mL. The pH of the solution is

ANSWER – KEY

Multiple Choice Questions

1. B	**2.** A	**3.** C	**4.** B	**5.** A	**6.** B	**7.** D
8. C	**9.** A	**10.** B	**11.** D	**12.** C	**13.** B	**14.** C
15. D	**16.** B	**17.** D	**18.** A	**19.** B	**20.** A	**21.** B
22. C	**23.** A	**24.** A	**25.** C	**26.** D	**27.** C	**28.** C
29. B	**30.** D	**31.** A	**32.** B	**33.** D	**34.** B	**35.** A
36. A	**37.** C	**38.** B	**39.** A	**40.** B	**41.** A	**42.** C
43. A	**44.** B	**45.** A	**46.** A	**47.** D	**48.** C	**49.** A
50. B	**51.** B	**52.** B	**53.** B	**54.** A	**55.** B	**56.** C
57. B	**58.** A	**59.** A	**60.** A	**61.** C	**62.** B	**63.** B
64. A	**65.** A	**66.** C	**67.** A	**68.** C	**69.** C	**70.** B
71. B	**72.** C	**73.** D	**74.** C	**75.** B	**76.** B	**77.** C
78. C	**79.** D	**80.** B	**81.** A	**82.** C	**83.** D	**84.** C
85. C	**86.** C	**87.** D	**88.** A	**89.** D	**90.** D	**91.** C
92. B	**93.** A	**94.** B	**95.** B			

Fill in the Blanks

1. gypsum	**2.** $CaSO_4.\frac{1}{2}H_2O$
3. $CaOCl_2$	**4.** sodium chloride
5. hydrogen, cation (or metal ion)	
6. H_3O^+ or H^+, OH^-	**7.** Conjugate base
8. Hydrogen, salt	**9.** soda ash
10. acids, bases	**11.** 100, partially
12. ammonia	**13.** ammonium hydroxide
14. colourless	**15.** $NaHCO_3$, basic
16. sulphuric acid	**17.** acid, salt
18. less	**19.** pH scale
20. polyprotic acid.	**21.** available chlorine

Fill in the Blanks

1. True	**2.** True
3. False	**4.** False
5. True	**6.** False
7. True	**8.** True
9. True	**10.** False
11. True	**12.** False
13. True	**14.** False
15. False	**16.** True
17. True	**18.** False
19. True	**20.** True

Matrix Match Type

1.	A→p; B→q; C→s; D→r
2.	A→s; B→p; C→q; D→r
3.	A→q; B→r; C→s; D→p
4.	A→r; B→p; C→q; D→s
5.	A→r; B→p; C→s; D→q
6.	A→s; B→r; C→q; D→p
7.	A→r; B→p; C→q; D→s
8.	A→s; B→r; C→q; D→p
9.	A→q; B→p; C→s; D→r
10.	A→r; B→p; C→s; D→p

Assertion & Reason

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

Passage – 1

1. A	**2.** C	**3.** A	**4.** C	**5.** A	**6.** D

Passage – 2

1. A	**2.** C	**3.** A

Passage – 3

1. A	**2.** A	**3.** B

Passage – 4

1. A	**2.** C	**3.** A	**4.** A

Passage – 5

1. C	**2.** B	**3.** A	**4.** B

Integer Answer Type

1. 1	**2.** 7	**3.** 8	**4.** 9	**5.** 1