# 7 The chemistry and uses of acids, bases and salts

**Content**

7.1 The characteristic properties of acids and bases

7.2 Preparation of salts

7.3 Properties and uses of ammonia

7.4 Sulfuric acid

**Learning outcomes**

*Candidates should be able to:*

**7.1 The characteristic properties of acids and bases**

*(a)* describe the meanings of the terms acid and alkali in terms of the ions they contain or produce in aqueous solution and their effects on Universal Indicator paper

*(b)* describe how to test hydrogen ion concentration and hence relative acidity using Universal Indicator paper and the pH scale

*(c)* describe the characteristic properties of acids as in reactions with metals, bases and carbonates

*(d)* describe qualitatively the difference between strong and weak acids in terms of the extent of dissociation

*(e)* describe neutralisation as a reaction between hydrogen ions and hydroxide ions to produce water, $H^+ + OH^- \rightarrow H_2O$

*(f)* describe the importance of controlling the pH in soils and how excess acidity can be treated using calcium hydroxide

*(g)* describe the characteristic properties of bases in reactions with acids and with ammonium salts

*(h)* classify oxides as acidic, basic or amphoteric, based on metallic/non-metallic character

**7.2 Preparation of salts**

*(a)* describe the techniques used in the preparation, separation and purification of salts as examples of some of the techniques specified in Section 1.2(a)

(methods for preparation should include precipitation and titration together with reactions of acids with metals, insoluble bases and insoluble carbonates)

*(b)* describe the general rules of solubility for common salts to include nitrates, chlorides (including silver and lead), sulfates (including barium, calcium and lead), carbonates, hydroxides, Group I cations and ammonium salts

*(c)* suggest a method of preparing a given salt from suitable starting materials, given appropriate information

*(d)* describe the meanings of the terms hydrated, anhydrous and water of crystallisation

**7.3 Properties and uses of ammonia**

*(a)* describe the use of nitrogen, from air, and hydrogen, from cracking hydrocarbons, in the manufacture of ammonia

*(b)* state that some chemical reactions are reversible (e.g. manufacture of ammonia)

*(c)* describe and explain the essential conditions for the manufacture of ammonia by the Haber process

*(d)* describe the use of nitrogenous fertilisers in promoting plant growth and crop yield

*(e)* compare nitrogen content of salts used for fertilisers by calculating percentage masses

*(f)* describe eutrophication and water pollution problems caused by nitrates leaching from farm land and explain why the high solubility of nitrates increases these problems

*(g)* describe the displacement of ammonia from its salts and explain why adding calcium hydroxide to soil can cause the loss of nitrogen from added nitrogenous fertiliser

### 7.4 Sulfuric acid

*(a)* describe the manufacture of sulfuric acid from the raw materials sulfur, air and water in the contact process

*(b)* state the use of sulfur dioxide as a bleach, in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria)

*(c)* state the uses of sulfuric acid in the manufacture of detergents and fertilisers, and as a battery acid

# Acids and Bases

**Acids:-** Those substances which produce $H^+$ in their aqueous solution are called acids, e.g;

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

Hydrogen chloride gas → Hydrochloric acid

$$HNO_{3(l)} + H_2O_{(l)} \longrightarrow H^+_{(aq)} + NO_3^{-1}{}_{(aq)}$$

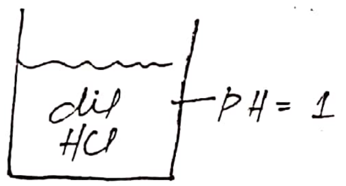
Hydrogen nitrate → nitric acid

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

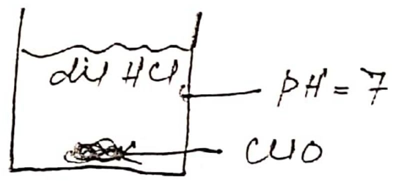
Hydrogen sulphate → Sulphuric acid

**Bases:-** Those substances which can neutralise acids are called Bases.

All metal oxides, metal hydroxide and metal carbonates are Bases, e.g; $Na_2O$, $NaOH$, $Na_2CO_3$, $FeO$, $Fe(OH)_2$, $FeCO_3$, $CuO$, $Cu(OH)_2$, $CuCO_3$ etc




Before adding CuO (excess)




After adding CuO

**Alkalis:-** water soluble bases are called alkalis.

⇒ Common alkalis include

⇒ oxides, hydroxides and carbonates of group I

⇒ oxides and hydroxides of group II

⇒ Ammonium hydroxide and ~~ammonium~~ carbonate.

**Definition of alkalis:-** Those substances which produce hydroxide ions ($O\bar{H}$) in their aqueous solution are called alkalis e.g;

$NaOH_{(s)} + H_2O_{(l)} \longrightarrow Na^+_{(aq)} + O\bar{H}_{(aq)}$

$KOH_{(s)} + H_2O_{(l)} \longrightarrow K^+_{(aq)} + O\bar{H}_{(aq)}$

$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2Na^+_{(aq)} + 2O\bar{H}_{(aq)}$

$K_2O_{(s)} + H_2O_{(l)} \longrightarrow 2K^+_{(aq)} + 2O\bar{H}_{(aq)}$

$Mg(OH)_{2(s)} + H_2O_{(l)} \longrightarrow Mg^{+2}_{(aq)} + 2O\bar{H}_{(aq)}$

$Ca(OH)_{2(s)} + H_2O_{(l)} \longrightarrow Ca^{+2}_{(aq)} + 2O\bar{H}_{(aq)}$

$NH_{3(g)} + H_2O_{(l)} \longrightarrow NH_4^+{}_{(aq)} + O\bar{H}_{(aq)}$

$NH_4OH_{(aq)}$ or aqueous $NH_3 \longrightarrow NH_4^+{}_{(aq)} + O\bar{H}_{(aq)}$

## Physical properties of acids and of alkalis

| Acids | Alkalis |
|---|---|
| ⇒ Sour in taste | Bitter in taste / soapy to |
| ⇒ Corrosive in nature | Corrosive in nature |
| ⇒ aqueous solution conduct electricity due to the presence of freely moving ions, called electrolyte | Electrolytes |
| | " |
| ⇒ have pH below 7 | " |
| | have pH greater than 7 |

| Acids | Alkalis |
|---|---|
| turn blue litmus red | turn red litmus blue |
| phenolphthalene remains colourless | turns pink |
| methyl orange turns red | turns yellow |
| Universal indicator (PH paper) or pH solution turns red in strong acids and orange in weak acids | turns blue in strong alkalis and greenish in weak alkalis |

## Chemical properties of acids

(i) Reaction with metals

Metal + Acid ⟶ Salt + Hydrogen

| | | |
|---|---|---|
| Pakistan | K | React violently with acids, their reaction must be avoided |
| steel | Na | |
| covers | Ca | |
| many | Mg | React moderately with acids |
| Acres | Al | |
| Zameen | Zn | |
| its | Fe | |
| loss | Pb | |
| has | H | |
| Caused | Cu | Can't react with dil acids as they are less reactive than hydrogen |
| many | Hg | |
| serious | Ag | |
| Govt | Au | |
| Problems | Pt | |

$Mg + HCl \rightarrow MgCl_2 + H_2 \uparrow$

$Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2 \uparrow$

$Zn + HNO_3 \rightarrow Zn(NO_3)_2 + H_2 \uparrow$

$Fe + HCl \rightarrow FeCl_2 + H_2 \uparrow$

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2 \uparrow$

### Observations

⇒ Bubbles are seen

⇒ metal decreases in size

⇒ with Iron colourless solution of acids turns green

### Important

Iron when reacts with acids, it form salts with +2 valency

## (2) Reaction with metal carbonates (Bases)

(Neutralisation reaction)

Metal Carbonate + Acid $\rightarrow$ Salt + water + Carbon...

$Na_2CO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

Observation: Carbonate decreases in size, bubbles are seen

$MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + H_2O + CO_2$

$ZnCO_3 + HNO_3 \rightarrow Zn(NO_3)_2 + H_2O + CO_2$

$CuCO_3 + HCl \rightarrow CuCl_{2(aq)} + H_2O + CO_2$

colourless — Blue solution

$FeCO_3 + H_2SO_4 \rightarrow FeSO_{4(aq)} + H_2O + CO_2$

colourless — green solution

$Fe_2(CO_3)_3 + HNO_3 \rightarrow Fe(NO_3)_{3(aq)} + H_2O + CO_2$

colourless — reddish Brown

## (3) Reaction with metal oxide (Bases)

(Neutralisation reaction)

Metal oxide + Acid $\rightarrow$ salt + water

$K_2O + HCl \rightarrow KCl + H_2O$

metal oxide decreases in size

$CaO + HCl \rightarrow CaCl_2 + H_2O$

$FeO + HCl \rightarrow FeCl_2 + H_2O$

colourless solution turns green

$Fe_2O_3 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2O$

colourless solution turns reddish brown

$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

Black solid — colourless solution turns Blue

Scanned by CamScanner

## (4) Reaction with metal hydroxide (Bases)
(Neutralisation reaction)

Metal hydroxide + Acid ⟶ Salt + water

Soluble Bases / alkalis:

$NaOH + HCl \longrightarrow NaCl + H_2O$

$KOH + H_2SO_4 \longrightarrow K_2SO_4 + H_2O$

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

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

$NH_4OH + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + H_2O$

Insoluble Bases:

$Zn(OH)_2 + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

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

$Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4 + H_2O$

## Chemical properties of Bases

### (i) Reaction with ammonium salts
(Neutralisation reaction)

Ammonium salt + Base $\xrightarrow{Heat}$ Salt + water + Ammonia gas

$NH_4Cl_{(s)} + NaOH_{(s)} \xrightarrow{Heat} NaCl_{(s)} + H_2O_{(l)} + NH_{3(g)}$

or

$NH_4Cl_{(aq)} + NaOH_{(aq)} \xrightarrow{Heat} NaCl_{(aq)} + H_2O + NH_{3(g)}$

$NH_4NO_3 + KOH \xrightarrow{Heat} KNO_3 + H_2O + NH_3$

$(NH_4)_2SO_4 + Mg(OH)_2 \xrightarrow{Heat} MgSO_4 + H_2O + NH_3$

Ammonium salts release hydrogen so show acidic character.

## (12) Reaction with Carbon dioxide gas (Neutralisation reaction)

Metal oxide + $CO_2$ ⟶ metal carbonate (salt)
Metal hydroxide + $CO_2$ ⟶ metal carbonate + water

$Na_2O + CO_2 \longrightarrow Na_2CO_3$

$NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$
Base acid salt water

$CaO + CO_2 \longrightarrow CaCO_3$
lime

$Ca(OH)_{2(aq)} + CO_2 \longrightarrow CaCO_{3(s)} + H_2O_{(l)}$
↑ lime water turns milky

## Use of lime or limewater in agriculture

Lime or lime water being basic in nature neutralise excessive acidity of the soil which is caused by the excessive use of fertilizers this increases the pH of the soil.

$CaO + H_2O \longrightarrow Ca(OH)_{2(aq)}$
lime limewater

⇒ lime water is also used to white wash building

## Strong and weak acids

| Strong acids | Weak acids |
|---|---|
| ⇒ are completely ionised in water | partially ionised |
| ⇒ greater number of $H^+$ in water | lesser number of $H^+$ in |
| ⇒ pH from 0-2 | pH from 3 to 6.9 |

| Strong acids | Weak acids |
|---|---|
| ⇒ Ionise in water irreversibly | Ionise reversibly |
| $HCl + H_2O \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$ | $H_2CO_3 + H_2O \rightleftharpoons 2H^+_{(aq)} + CO_3^{-}{}_{(aq)}$ |
| ⇒ Examples $HCl$, $HNO_3$ and $H_2SO_4$ | Carbonic acid, phosphoric acid, ethanoic acid etc |

## Strong and weak alkalis

| Strong alkalis | Weak alkalis |
|---|---|
| ⇒ are completely ionised in water | partially ionise |
| ⇒ produce greater number of $OH^-$ | lesser number of $OH^-$ |
| ⇒ ionise irreversibly in water | ionise reversibly |
| $NaOH_{(s)} + H_2O \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$ | $Mg(OH)_{2(s)} + H_2O \rightleftharpoons Mg^{+2}_{(aq)} + 2OH^-_{(aq)}$ |
| $KOH + H_2O \longrightarrow K^+ + OH^-$ | $NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$ |
| ⇒ pH from 11 to 14 | pH from 7.1 to 10 |
| ⇒ Example, group I oxides and hydroxide $NaOH$, $Na_2O$, $K_2O$, $KOH$ | ⇒ Examples $Mg(OH)_2$, $Ca(OH)_2$, $NH_4OH$ |

## Acidity needs water

| Test | HCl in water | HCl in Benzene |
|---|---|---|
| Blue litmus | turns red | No change |
| Mg metal | Bubbles | No bubbles |
| Electricity | pass | don't pass |

**Reason:** Acids ionise only in water, same is true for alkalis, produce $H^+$ and $OH^-$ respectively only in water.

# Types of Oxides

## Basic oxides

⇒ oxides which neutralise acids

⇒ metal oxides are basic

e.g; $Na_2O$, $MgO$, $CaO$, $FeO$, $CuO$

$MgO + HCl \rightarrow MgCl_2 + H_2O$

$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

## Acid oxides

⇒ oxides which neutralise Bases

⇒ non metallic oxides are acidic

e.g; $CO_2$, $SO_2$, $SO_3$, $NO_2$, $P_2O_3$, $P_2O_5$

$NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

$CaO + CO_2 \rightarrow CaCO_3$

## Amphoteric oxides

⇒ oxides which neutralise acids and Bases both

⇒ PZA oxides → $PbO$, $ZnO$, $Al_2O_3$

$ZnO + HCl \rightarrow ZnCl_2 + H_2O$
(Base, Acid, Salt, water)

$ZnO + NaOH \rightarrow Na_2ZnO + H_2O$
(Acid, Base, Salt)

## Neutral oxides

⇒ neither acidic nor Basic

⇒ $H_2O$, $CO$

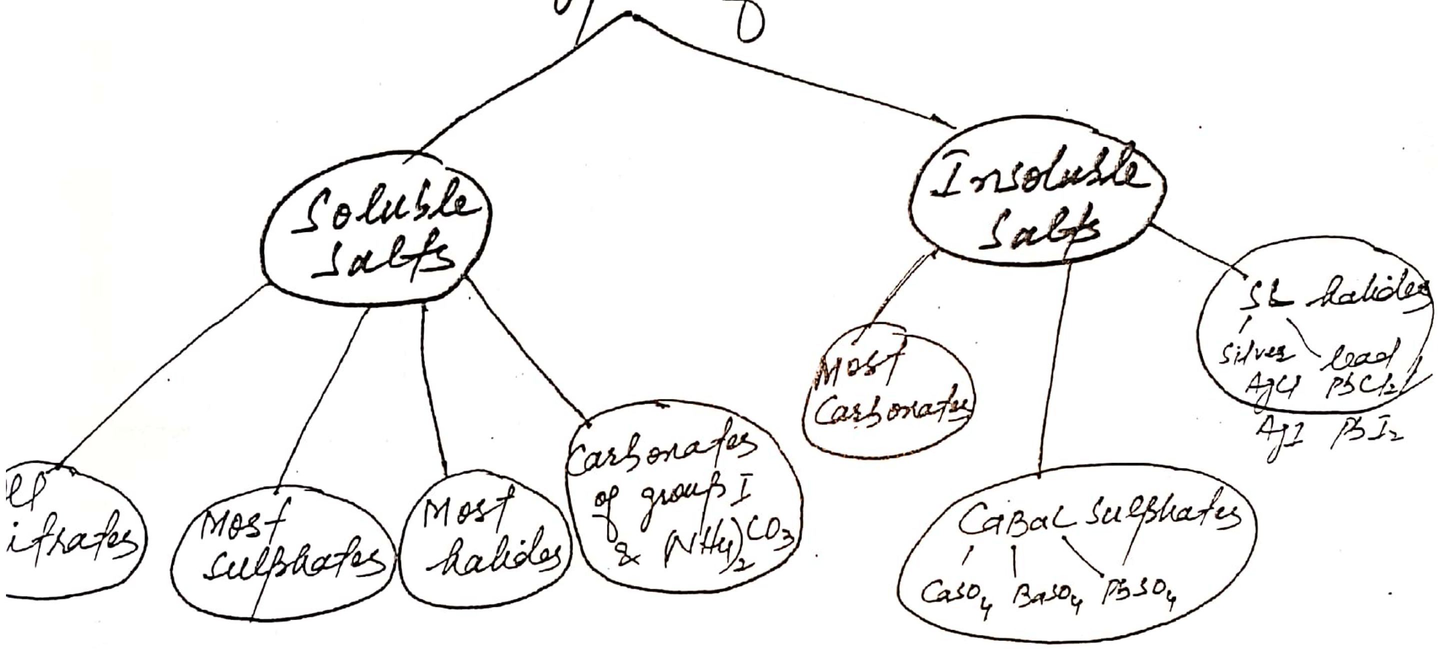
# Salts

Salts are produced when hydrogen of an acid is completely or partially replaced by a metal.

=> Compounds in which any metal or ammonium is bonded with chloride, Bromide, iodide, fluoride, sulphate, nitrate, phosphate, carbonate etc

=> In short metals and ammonium "ide", "ite" and "ate" are salts

## Types of Salts




**Halides:-** Salts of halogens are called halides e.g; $NaCl$, $KCl$, $AgCl$, $AgBr$, $AgI$, $PbCl_2$ etc

**Important:-** All group I and all ammonium salts are water soluble.

# Preparation of Soluble salts

**Method:** crystallisation

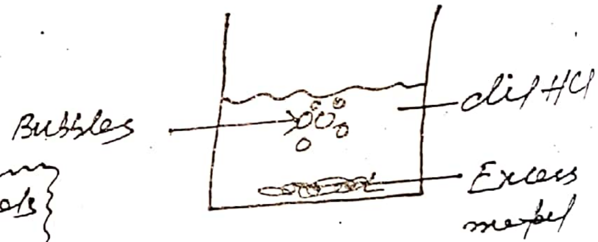
## (1) Preparation of soluble salts by the reaction of reactive metals with dil. acids

⇒ K, Na and Ca should not be used to react with acids because they react violently with acids.

⇒ Metals present below hydrogen in the reactivity series e.g; Cu, Hg, Ag, Au and Pt can't react with dil acids.

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

Suitable metals: Mg, Al, Zn, Fe




⇒ Lead can react with acids but with $H_2SO_4$ and HCl, it forms insoluble $PbSO_4$ and $PbCl_2$ respectively.

⇒ Lead forms soluble salt only when it reacts with nitric acid, then it forms soluble $Pb(NO_3)_2$.

**Endpoint:-** when no more bubbles are seen.

**Filteration:-** to remove unreacted metal.

**Evaporation:-** Filtrate is evaporated by heating over water bath till crystals appear, stop heating.

⇒ Allow solution to cool at room temperature.

⇒ separate crystals by filteration, wash them with cold water and then dry over filter paper.

## (ii) Preparation of Soluble salt by the reaction of metal carbonate with acids

✗ $K_2CO_{3(s)}$ + HCl ⟶ KCl + $H_2O$ + $CO_2$

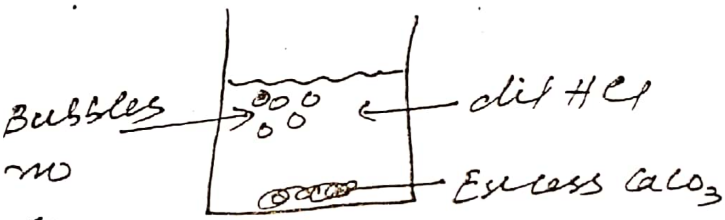
✗ $Na_2CO_{3(s)}$ + HCl ⟶ NaCl + $H_2O$ + $CO_2$

soluble metal carbonate should not be used because they dissolve in water and contaminate the salt.

✓ $CaCO_3$ + HCl ⟶ $CaCl_{2(aq)}$ + $H_2O$ + $CO_2$ ✓

✗ $CaCO_3$ + $H_2SO_4$ ⟶ $CaSO_{4(s)}$ + $H_2O$ + $CO_2$

Because $CaSO_4$ is insoluble sulphate




Endpoint:- when no more bubbles are seen

Filteration:- to remove unreacted $CaCO_3$.

Evaporation:- Same, as mentioned on a previous page.

## (iii) Preparation of a Soluble salt by the reaction of metal oxide with acids

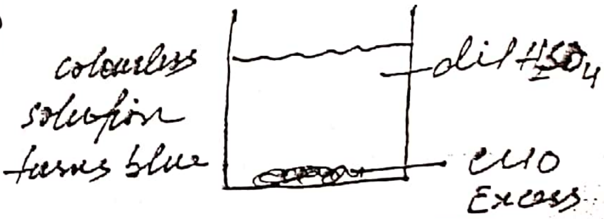
✗ $K_2O$ + HCl ⟶ KCl + $H_2O$

✗ $Na_2O$ + HCl ⟶ NaCl + $H_2O$

✗ MgO + HCl ⟶ $MgCl_2$ + $H_2O$

✗ CaO + HCl ⟶ $CaCl_2$ + $H_2$

Soluble metal oxides, dissolve and contaminate the salt.




Filteration:- to remove unreacted metal oxide

Evaporation :- same as mentioned for the first method, but this time extra care should be done to prevent solution from dryness, otherwise blue crystals of $CuSO_4 \cdot 5H_2O$ damage to white powder $CuSO_4$.

$$CuSO_4 \cdot 5H_2O \xrightarrow{Heat} CuSO_4 + 5H_2O$$

Blue crystals — white powder

hydrate of copper(II) sulphate — anhydrous copper(II) sulphate

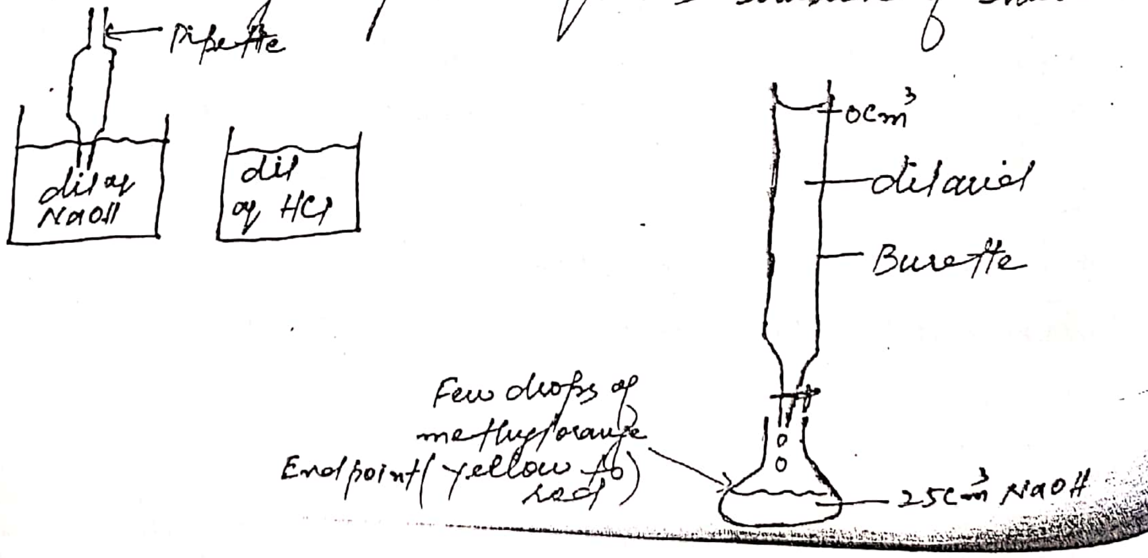
$$CuSO_4 \xrightarrow{Heat} CuO_{(s)} + SO_{3(g)}$$

white powder — Black solid

Preparation of a soluble salt by the reaction of a soluble bases with acid

Method or Technique :- Titration

Soluble bases e.g; $Na_2O$, $NaOH$, $Na_2CO_3$ are always made to react with acids by the method of titration by using the aqueous solution of soluble base.



when solution in conical flask is evaporated by heating over a water bath in an evaporating dish, coloured crystals are obtained due to the presence of indicator.

## How to get rid of indicator

**Method 1:-** Perform titration first with indicator and then without indicator but using the same volume of acids and alkalis each time, then evaporate solution by heating over water bath till - - - - - - - - - - - - - - - - - - - - - - - - -

**Method 2:-** Perform titration using indicator till the end point, then boil solution for 5 to 10 minutes after adding charcoal as colour absorbant. Filter solution to remove charcoal.
Evaporate solution by heating - - - - - - - - - - -

## Preparation of insoluble salts

**Method:-** Precipitation
An insoluble salt is prepared by reacting two soluble compounds. For example

$AgCl$

$$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow \underset{\text{white ppt}}{AgCl_{(s)}} + NaNO_{3(aq)}$$

Precipitates are separated by filtration, washed with cold water and dry over filter paper.

**Important point:** For the preparation of insoluble salts, the compounds to be selected should be "nitrate" and a "group I compounds" because they are always water soluble.

For example $CaSO_4$

$$Ca(NO_3)_{2\,(aq)} + Na_2SO_{4\,(aq)} \longrightarrow \underset{\text{white ppt}}{CaSO_{4\,(s)}} + 2NaNO_{3\,(aq)}$$

**Ionic equation**

$$Ca^{+2}_{(aq)} + 2NO_{3\,(aq)}^{-} + 2Na^{+}_{(aq)} + SO_{4\,(aq)}^{-2} \longrightarrow CaSO_{4\,(s)} + 2Na^{+}_{(aq)} + 2NO_{3\,(aq)}^{-}$$

$$\boxed{Ca^{+2}_{(aq)} + SO_{4\,(aq)}^{-2} \longrightarrow CaSO_{4\,(s)}}$$ Ionic equation

**Preparation of $ZnCO_3$ and Ionic equation**

$$Zn(NO_3)_{2\,(aq)} + Na_2CO_{3\,(aq)} \longrightarrow ZnCO_{3\,(s)} + 2NaNO_{3\,(aq)}$$

$$Zn^{+2}_{(aq)} + 2NO_{3\,(aq)}^{-1} + 2Na^{+}_{(aq)} + CO_{3\,(aq)}^{-2} \longrightarrow ZnCO_{3\,(s)} + 2Na^{+}_{(aq)} + 2NO_{3\,(aq)}^{-}$$

$$\boxed{Zn^{+2}_{(aq)} + CO_{3\,(aq)}^{-2} \longrightarrow ZnCO_{3\,(s)}}$$ Ionic equation

## Direct method of writing ionic equation

⇒ Always balance the simple equation

$$Ca(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaNO_{3(aq)}$$

⇒ Cancel those substances which are common at both sides and which states are same at both sides

$$Ca(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaNO_{3(aq)}$$

⇒ Write remaining parts (substances) in their ionic form..

$$Ca^{+2}_{(aq)} + CO_{3(aq)}^{-2} \longrightarrow CaCO_{3(s)}$$ Ionic equation

## Balancing of Ionic equation

An ionic equation is considered balanced if it is balanced not only with respect to atoms but also with respect to charges.

## Types of Ionic equation

(i) Ionic equations contain charge particles only at one side of equation

In such equations charge is balanced by

using electrons. e.g;

$$H_2 + O\bar{H} \longrightarrow H_2O$$

Balance atoms first

$$H_2 + 2O\bar{H} \longrightarrow 2H_2O$$

Left side contains (−2) charge, so 2 electrons should be written side to keep charges equal.

$$\boxed{H_2 + 2O\bar{H} \longrightarrow 2H_2O + 2\bar{e}}$$ — Balanced Ionic equation

Similarly

$$O_2 + H_2O \longrightarrow O\bar{H}$$

Balance atoms $$O_2 + 2H_2O \longrightarrow 4O\bar{H}$$

Balance charges $$O_2 + 2H_2O + 4\bar{e} \longrightarrow 4O\bar{H}$$

More examples

$$N\bar{O}_3 + H^+ \longrightarrow N_2 + H_2O$$

Balanced $$2N\bar{O}_3 + 12H^+ + 10\bar{e} \longrightarrow N_2 + 6H_2O$$

(2) Ionic equations containing charge parti at both sides of equation

In such ionic equations, charges are balanced without using electrons, only using multiplication method.

(ii) $Cu + H^{+} + O_2 \longrightarrow Cu^{+2} + H_2O$

Balance atoms $Cu + 4H^{+} + O_2 \longrightarrow Cu^{+2}_{(aq)} + 2H_2O$

Balance charge by multiplying copper by (2) both sides

Balanced equation $\boxed{2Cu + 4H^{+} + O_2 \longrightarrow 2Cu^{+2} + 2H_2O}$

Solve following equation

$Fe^{+2} + H^{+} + O_2 \longrightarrow Fe^{+3} + H_2O$

Balance atoms $Fe^{+2} + 4H^{+} + O_2 \longrightarrow Fe^{+3} + 2H_2O$

charges will be balanced by multiplying iron by (4) both sides

Balanced equation $\boxed{4Fe^{+2} + 4H^{+} + O_2 \longrightarrow 4Fe^{+3} + 2H_2O}$

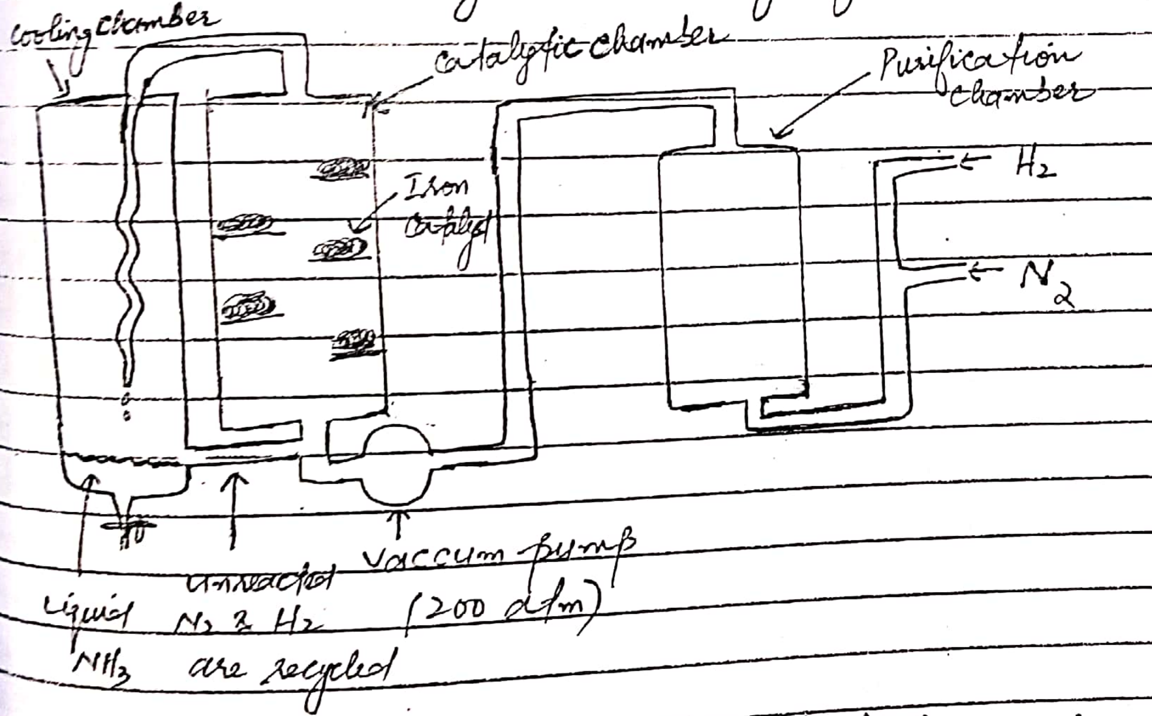
# Ammonia and its uses

## Manufacture of Ammonia by Haber's process

In the industry ammonia is manufactured by Haber's process which is represented by the following equation.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow[450^\circ C / 200 atm]{Fe} 2NH_3 \; -\Delta H$$

| Raw material | Source |
| --- | --- |
| $N_2$ | By the fractional distillation of air |
| $H_2$ | By the cracking of oil |




## Factors affecting yield of Ammonia

### Concentration of reactants & products

Percentage yield of ammonia can be increased by keeping the continuous supply of $N_2$ & $H_2$

and by continuously removing ammonia from the reaction mixture.

## Effect of pressure

High pressure of 200 atm increases the yield of ammonia by shifting dynamic equilibrium towards the product side as there are lesser number of moles towards product side.

## Effect of temperature

High temperature of 450°c decreases the yield of ammonia by shifting dynamic equilibrium towards the backward direction as the forward is exothermic.
But this high temperature is maintained to keep the rate of reaction higher.

## Uses of ammonia

⇒ Ammonia is used in the manufacture of explosives.

⇒ Ammonia is used in the manufacture of nitrogenous fertilisers e.g. ammonium nitrate ($NH_4NO_3$), Ammonium sulphate ($(NH_4)_2SO_4$), ammonium phosphate ($(NH_4)_3PO_4$) and urea $(NH_2)_2CO$.

Scanned by CamScanner

## Purpose of adding nitrogenous fertilisers in the soil

They are added to replace nitrogen in the soil which is used up by plants to make proteins.

## Preparation of fertilisers and percentage of nitrogen

| | % of Nitrogen |
|---|---|
| $NH_3 + HNO_3 \rightarrow NH_4NO_3$ | $\frac{28}{80} \times 100 = 35\%$ |
| $NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ | $\frac{28}{132} \times 100 = 21.21\%$ |
| $NH_3 + H_3PO_4 \rightarrow (NH_4)_3PO_4$ | $\frac{42}{149} \times 100 = 28.19\%$ |
| $(NH_2)_2CO$ urea | $\frac{28}{60} \times 100 = 46.67\%$ |

So urea is the best nitrogenous fertiliser as it has greater percentage of nitrogen.

## Most essential needed by plants

N P K are the most essential elements

N → Nitrogen, P → phosphorus, K → potassium

## Least essential elements for plants

Calcium, Magnesium and Sulphur are the least essential elements needed by plants.

# Harmful effect of fertilisers

Fertilisers are acidic in nature, so acidity of the soil is increased and pH of the soil is decreased.

## Use of lime or lime water to decrease the acidity of the soil

Lime CaO or lime water $Ca(OH)_2$ which are alkaline in nature is added in the soil to decrease the acidity of the soil and to increase its pH value but this releases $NH_3$ gas, as a result nitrogen content of the soil is decreased.

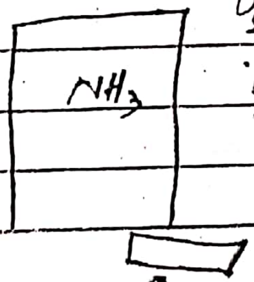
$$CaO + NH_4NO_3 \longrightarrow Ca(NO_3)_2 + H_2O + NH_3\uparrow$$

$$Ca(OH)_2 + (NH_4)_2SO_4 \longrightarrow CaSO_4 + H_2O + 2NH_3\uparrow$$

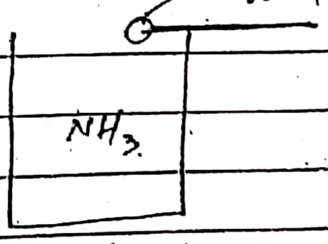
## Test for $NH_3$ gas

(i) $NH_3$ gas turns damp litmus blue

(ii) White fumes of $NH_4Cl$ are seen when a stirrer soaked in HCl is brought near $NH_3$ gas.




stirrer soaked in HCl (aq)




damp litmus blue

white fumes of $NH_4Cl$ are seen

# Manufacture of sulphuric acid by contact process

In the industry sulphuric acid is manufactured by contact process.

Raw materials

Sulphur
concentrated $H_2SO_4$
water

## Following steps are involved

(i) Burning of sulphur

$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)} \quad -\Delta H$$

(ii) Purification of $SO_2$ and Air

To remove impurities which can cause poisoning of catalyst.

(iii) oxidation of $SO_2$ to $SO_3$ (Most important step)

$$2SO_2 + O_2 \xrightarrow[450^\circ C\,/\,2\text{-}3\ atm]{\text{vanadium (V) oxide}} 2SO_3 \quad -\Delta H$$

(iv) Formation of Oleum

$$SO_{3(g)} + H_2SO_{4\,(conc)} \longrightarrow H_2S_2O_{7(l)}$$

oleum or fuming sulphuric acid

(v) Formation of $H_2SO_4$

$$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$$

Scanned by CamScanner

## Some important questions

Q:- Why a lower pressure of 1-3 atm used in the oxidation of $SO_2$ to $SO_3$ as compared to a very high pressure of 200 atm in the manufacture of ammonia?

Ans:- High pressure will not be as effective in the oxidation of $SO_2$ to $SO_3$ as compared to $NH_3$ due to the lesser difference of moles between reactant and products.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

4 mole → 2 mole

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

3 mole → 2 mole

2nd answer:- Lower pressure will keep process economical.

3rd answer:- High pressure will be risky because $SO_2$ and $SO_3$ are very corrosive.

Q:- Why a direct reaction of $SO_3$ with water to form $H_2SO_4$ is avoided?

$$SO_3 + H_2O \longrightarrow H_2SO_4 \quad -\Delta H$$

Ans:- This reaction is dangerously exothermic and will cause explosion.

## Uses of $SO_2$

=> used as a preservative in jams, jellies and marmalads.
=> As bleaching agent to bleach wood pulp in the manufacture of paper.
=> To sterelise baby bottles.

Reason
$SO_2$ is a very good reducing agent. It oxidises itself and does not let bacteria to multiply by not allowing oxygen to reach bacteria.

## Uses of sulphuric acid

=> In the manufacture of detergents.
=> In the manufacture of fertiliser e.g. ammonium sulphate $(NH_4)_2SO_4$
=> As an electrolyte in car batteries.

Tuesday 25th January, 2011

## Lab Activity

**Objective:** To perform acid-base titrations.

**Required:**
- a burette
- a pipette.
- conical flask.
- a beaker.
- dillute Sodium hydroxide ($NaOH$)
- dillute hydrochloric acid ($HCl$)

**Method:** 1) Take the acid ($HCl$) in a conical flask. Add this in the burette. ($25\,cm^3$)

2) Use the pipette to take $25\,cm^3$ of dillute $NaOH$ in a beaker.

3) Place the beaker under the burette, that is fixed is a retort stand.

4) Add few drops of methyl orange solution to the beaker.

**Observations:** At the end point the yellow colour of the solution in the beaker beaker becomes red.

**Method:** 1) Repeat the same experiment one more time after ~~removing the solution~~ from the beaker and taking a fresh solution of dillute $NaOH$.

2) Do the same experiment, but by using

Phenophthalin as the indicator.

Conclusion:-

| Methyl Orange | | Phenophthalin | |
|---|---|---|---|
| Experiment 1 | Experiment 2 | Experiment 1 | Experiment 2 |
| → 20.9 $cm^3$ acid | 21.3 $cm^3$ acid | 18.5 $cm^3$ acid | 19.2 $cm^3$ of acid |
| (dillute alkali | (dillute HCL) | (dillute HCL) | (dillute HCl) |
| → nuetralises | nuetralises | nuetralises | nuetralises |
| 25 $cm^3$ of alkali | 25 $cm^3$ of alkali | 25 $cm^3$ of alkali | 25 $cm^3$ of alkali |
| (dillute NaOH) | (dillute NaOH) | (dillute NaOH) | (dillute NaOH) |

Colour changes: 1) Yellow to Red (Methyl Orange)
2) Purple to Colourless (Phenophthalin)

# Lab Activity

Objective: To carry out various tests on different solutions, thus determine whether they are acidic, alkaline or neutral.

| Solution | Litmus Paper (Result) | pH Paper (Result) | Phenophthalene (Result) | Methyl Orange (Result) | Magnesium Piece | $Na_2CO_3$ |
|---|---|---|---|---|---|---|
| A | Red | 1 | Colourless | Red | More bubbles (faster reaction) | More bubbles (faster reaction) |
| B | Red | 3 | Colourless | Red | Less bubbles (slower reaction) | Less bubbles (slower reaction) |
| C | No change | 7 | Colourless | Orange (no change) | — | — |
| D | Blue | 10 | Purple | Yellow | — | — |
| E | Blue | 11 | Purple | Yellow | — | — |
| F | Blue | 13 | Purple | Yellow | — | — |

Good
11/01/2012

15