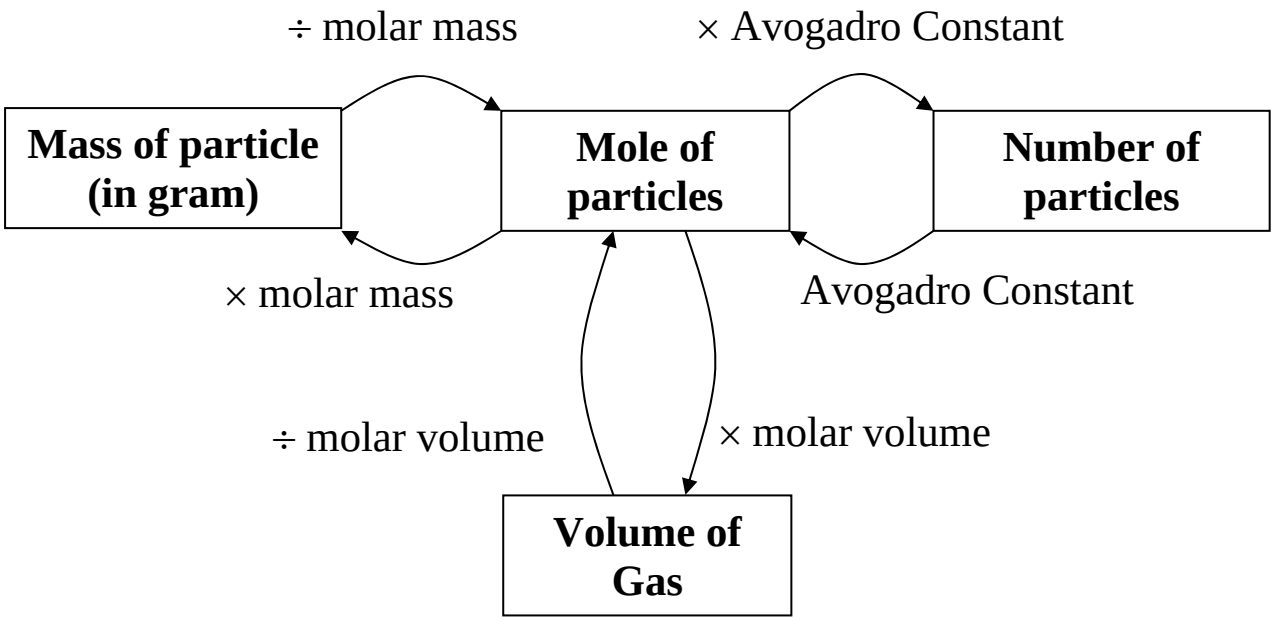
Short Notes: Form 4 Chemistry
Chemical Formulae and Equation

Calculation

For Solid, liquid or gas	**For gas (only)**
$\text{number of mole} = \frac{\text{mass of subtance}}{\text{molar mass}}$ Molar mass = RAM/RMM/RFM in gram	$\text{number of mole} = \frac{\text{volume of gas}}{\text{molar volme}}$ Molar volume = $24dm^3$ at room temperature Molar volume = $22.4dm^3$ at s.t.p.
For Solution	**For quantity of particle(atom,molecule,ion)**
$\text{number of mole} = \frac{MV}{1000}$ M = molarity V = Volume of solution in cm^3	$\text{number of mole} = \frac{\text{quantity of particle}}{6.02\times10^{23}}$

Summary



Chemical Formula

Cation (Positive Ions)

Ion	Symbol	Ion	Symbol	Ion	Symbol
Potassium	K^+	Calcium	Ca^{2+}	Aluminium	Al^{3+}
Sodium	Na^+	Magnesium	Mg^{2+}	Iron (III)	Fe^{3+}
Lithium	Li^+	Zinc	Zn^{2+}	Chromium(III)	Cr^{3+}
Hydrogen	H^+	Barium	Ba^{2+}		
Argentums(I)	Ag^+	Iron (II)	Fe^{2+}		
Mercury(I)	Hg^+	Tin (II)	Sn^{2+}		
Ammonium	NH_4^+	Lead(II)	Pb^{2+}		
		Copper(II)	Cu^{2+}		
		Manganese(II)	Mn^{2+}		

Anion (Negative Ions)

Ion	Symbol	Ion	Symbol	Ion	Symbol
Oxide	O^{2-}	Hydroxide	OH^-	Ethanoate	CH_3COO^-
Fluoride	F^-	Sulphate	SO_4^{2-}	Manganate(VII)	MnO_4^-
Chloride	Cl^-	Nitrate	NO_3^-	Dichromate(VI)	$Cr_2O_7^{2-}$
Bromide	Br^-	Carbonate	CO_3^{2-}	Phosphate	PO_4^{3-}
Iodide	I^-			Thiosulphate	$S_2O_3^{2-}$

Formulae for Certain Molecule

Karbon monoxide	CO	Ammonia	NH_3
Carbon dioxide	CO_2	water	H_2O
Nitrogen monoxide	NO	Hydrogen chloride	HCl
Nitrogen dioxide	NO_2	Tetrachloromethane	CCl_4
Sulphur dioxide	SO_2	Glucose	$C_6H_{12}O_6$
Sulphur trioxide	SO_3	Hydrogen bromide	HBr
Fluorine	F_2	Hydrogen iodide	HI
Bromine	Br_2	Hydrogen sulphide	H_2S
Chlorine	Cl_2	Ethanol	C_2H_5OH
Iodine	I_2	Ethanoic Acid	CH_3COOH

Periodic Table

Reaction of Group 1 Elements

1. **Reaction with Oxygen**
   The entire group 1 metal can react with oxygen to form metal oxide.

$$4Li + O_2 \longrightarrow 2Li_2O$$
$$4Na + O_2 \longrightarrow 2Na_2O$$
$$4K + O_2 \longrightarrow 2K_2O$$

   The metal oxide of group 1 elements can dissolve in water to form alkali (hydroxide) solution

$$Li_2O + H_2O \longrightarrow 2LiOH$$
$$Na_2O + H_2O \longrightarrow 2NaOH$$
$$K_2O + H_2O \longrightarrow 2KOH$$

2. **Reaction with halogen (Chlorine)**

$$2Li + Cl_2 \longrightarrow 2LiCl$$
$$2Na + Cl_2 \longrightarrow 2NaCl$$
$$2K + Cl_2 \longrightarrow 2KCl$$

3. **Reaction with water**
   The entire group 1 metal can react with water to produce alkali (hydroxide) solution and hydrogen gas.

$$2Li + 2H_2O \longrightarrow 2LiOH + H_2$$
$$2Na + 2H_2O \longrightarrow 2NaOH + H_2$$
$$2K + 2H_2O \longrightarrow 2KOH + H_2$$

Reaction of Group 17 Elements

1. **React with water**

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$
$$Br_2 + H_2O \longrightarrow HBr + HOBr$$
$$I_2 + H_2O \longrightarrow HI + HOI$$

2. **React with Sodium Hydroxide**

$$\mathbf{Cl_2 + 2NaOH \longrightarrow NaCl + NaOCl + H_2O}$$
$$\mathbf{Br_2 + 2NaOH \longrightarrow NaBr + NaOBr + H_2O}$$
$$\mathbf{I_2 + 2NaOH \longrightarrow NaI + NaOI + H_2O}$$

3. **React with Iron**

$$3Cl_2 + 2Fe \longrightarrow 2FeCl_3$$
$$3Br_2 + 2Fe \longrightarrow 2FeBr_3$$
$$3I_2 + 2Fe \longrightarrow 2FeI_3$$

Preparation of Chlorine Gas

$$2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$$

Electrochemistry

Electrolyte

Ionisation of Electrolyte
Ionisation of Molten Compound

$$PbBr_2 \longrightarrow Pb^{2+} + Br^-$$
$$NaCl \longrightarrow Na^+ + Cl^-$$
$$Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$$

Ionisation of Aqueous Solution

$NaCl \longrightarrow Na^+ + Cl^-$ $H_2O \longrightarrow H^+ + OH^-$	$HCl \longrightarrow H^+ + Cl^-$ $H_2O \longrightarrow H^+ + OH^-$	$CuSO_4 \longrightarrow Cu^{2+} + SO_4^{2-}$ $H_2O \longrightarrow H^+ + OH^-$

Discharge of Positive Ion	**Discharge of Negative Ion**
$Na^+ + e \longrightarrow Na$ **Observation:** Grey deposit is formed. $Al^{3+} + 3e \longrightarrow Al$ **Observation:** Grey deposit is formed. $Pb^{2+} + 2e \longrightarrow Pb$ **Observation:** Grey deposit is formed. $Cu^{2+} + 2e \longrightarrow Cu$ **Observation:** Brown deposit is formed. $Ag^+ + e \longrightarrow Ag$ **Observation:** Silver deposit is formed. $2H^+ + 2e \longrightarrow H_2$ **Observation:** Gas bubble is formed. A 'pop' sound is produced when a lighted splinter is placed near the mouth of the test tube.	$2Cl^- \longrightarrow Cl_2 + 2e$ **Observation:** Bubbles of pungent yellowish green gas are produced. The gas turns moist litmus paper to red and then bleaches it. $2Br^- \longrightarrow Br_2 + 2e$ **Observation:** Molten electrolyte: Brown colour gas is produced. Aqueous solution: Light brown solution is formed. $2I^- \longrightarrow I_2 + 2e$ **Observation:** Molten electrolyte: Brown colour gas is produced. Aqueous solution: Light brown solution is formed. The solution turns blue when a few drops of starch solution is added in. $4OH^- \longrightarrow O_2 + 2H_2O + 4e$ **Observation:** Gas bubble is formed. Gas produces light up a wooden splinter.

Acid and Base

Ionisation of Acid

Hydrochloric Acid

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

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

Nitric Acid

$HNO_3 \longrightarrow H^+ + NO_3^-$

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$

Sulphuric Acid

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

$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^+ + SO_4^{2-}$

Ethanoic Acid

$CH_3COOH \longrightarrow H^+ + CH_3COO^-$

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

Chemical Properties of Acid

Acid + Reactive Metal $\longrightarrow$ Salt + H_2

Example:

$2HCl + Zn \longrightarrow ZnCl_2 + H_2$

$6HNO_3 + 2Fe \longrightarrow 2Fe(NO_3)_3 + 3H_2$

$H_2SO_4 + Pb \longrightarrow PbSO_4 + H_2$

$6CH_3COOH + 2Al \longrightarrow 2Al(CH_3COO)_3 + 3H_2$

Acid + Metal Oxide $\longrightarrow$ Salt + H_2O

Example:

$2HCl + ZnO \longrightarrow ZnCl_2 + H_2O$

$2HNO_3 + MgO \longrightarrow Mg(NO_3)_2 + H_2O$

$H_2SO_4 + CuO \longrightarrow CuSO_4 + H_2O$

$2CH_3COOH + Na_2O \longrightarrow 2CH_3COO^-Na^+ + H_2O$

Acid + Metal Hydroxide $\longrightarrow$ Salt + H_2O

Example:

$2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$

$HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$

$H_2SO_4 + 2NH_4OH \longrightarrow (NH_4)_2SO_4 + 2H_2O$ or $H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2SO_4$

$CH_3COOH + KOH \longrightarrow CH_3COO^-K^+ + H_2O$

Acid + Metal Carbonate $\longrightarrow$ Salt + CO_2 + H_2O

Example:

$2HCl + ZnCO_3 \longrightarrow ZnCl_2 + CO_2 + H_2O$

$2HNO_3 + CaCO_3 \longrightarrow Ca(NO_3)_2 + CO_2 + H_2O$

$H_2SO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + CO_2 + H_2O$

$2CH_3COOH + MgCO_3 \longrightarrow Mg(CH_3COO)_2 + CO_2 + H_2O$

Salt

Solubility of Salt

Salt	Solubility
Salt of potassium, sodium and ammonium	All are **soluble** in water
Salt of nitrate	All are **soluble** in water
Salt of sulphate	Mostly **soluble** in water except: (**P**b) Lead sulphate (**B**a) Barium sulphate (**C**a) Calcium sulphate
Salt of chloride	Mostly **soluble** in water except: (**P**b) Lead chloride (**A**g) silver chloride (**H**g) mercury chloride
Salt of carbonate	Mostly **insoluble** in water except: Potassium carbonate Sodium carbonate Ammonium carbonate
Oxide and Hydroxide	**Solubility**
Oxide	Mostly **insoluble** in water except: K_2O and Na_2O.
Hydroxide	Mostly **insoluble** in water except: NH_4OH, KOH and NaOH

Preparation of Salt

Preparation of Soluble Salt

Salt of Potassium, Sodium and Ammonium

Acid + Alkali $\longrightarrow$ Salt + Water

Example: Preparation of Sodium Chloride (NaCl)

$HCl + NaOH \longrightarrow NaCl + H_2O$

Salt of non-Potassium, Sodium and Ammonium

Acid + Reactive metal $\longrightarrow$ Salt + Hydrogen Gas
Acid + Metal Oxide $\longrightarrow$ Salt + Water
Acid + Metal Carbonate $\longrightarrow$ Salt + Water + Carbon Dioxide

Example: Preparation of Zinc Sulphate ($ZnSO_4$)

$H_2SO_4 + Zn \longrightarrow ZnSO_4 + H_2$
$H_2SO_4 + ZnO \longrightarrow ZnSO_4 + H_2O$
$H_2SO_4 + ZnCO_3 \longrightarrow ZnSO_4 + H_2O + CO_2$

Preparation of Insoluble Salt

Ionic Precipitation

Insoluble salts can be made by double decomposition. This involves mixing a solution that contains its positive ions with another solution that contains its negative ions.

Example: Preparation of Silver Nitrate

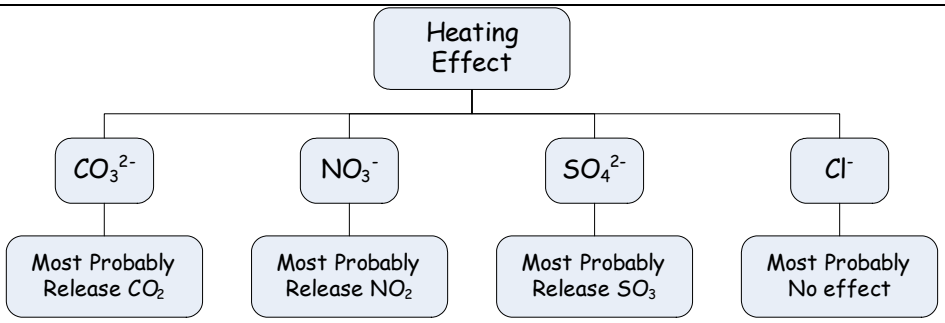
$$AgNO_{3\,(aq)} + NaCl_{\,(aq)} \longrightarrow AgCl_{\,(s)} + NaNO_{3\,(aq)}$$

$$Ag^{+}_{\,(aq)} + C1^{-}_{\,(aq)} \longrightarrow AgCl_{\,(s)} \qquad \text{(ionic equation)}$$

Colour of Salt

Salt or metal oxide	Solid	Aqueous solution
Salt of: Sodium, Calcium, Magnesium, Aluminium, zinc, Lead, ammonium Chloride, sulphate, nitrate, carbonate	White	Colourless
Salt of Copper(II).- Copper(II) Carbonate Copper(II) sulphate, Copper(II) nitrate, Copper(II) chloride Copper(II) oxide	 Green Blue Black	 Insoluble Blue Insoluble
Salt of Iron (II) Iron(II) sulphate; Iron(II) nitrate; Iron(ID chloride	Green	Green
Salt of Iron (III). Iron(III) sulphate; Iron(III) nitrate; Iron(III) chloride	Brown	Brown
Lead Iodide	Yellow	Insoluble
Lead Chloride	White	Insoluble
Zink oxide	Yellow when it is hot and white when it is cold.	Insoluble
Lead(II) oxide-	Brown when it is hot and yellow when it is cold.	Insoluble
Magnesium oxide, Aluminium oxide	White	Insoluble
Potassium oxide, Sodium oxide, Calcium oxide	White	Colourless

Heating effect on Salt



Heating Effect on Carbonate Salt

Carbonate Salt	Equation of The Reaction
Potassium carbonate Sodium carbonate	Not decomposible
Calcium carbonate Magnesium carbonate Aluminium carbonate Zinc carbonate Iron (III) carbonate Lead(II) carbonate Copper(II) carbonate	$CaCO_3 \longrightarrow CaO + CO_2$ $MgCO_3 \longrightarrow MgO + CO_2$ $Al_2(CO_3)_3 \longrightarrow Al_2O_3 + 3CO_2$ $ZnCO_3 \longrightarrow ZnO + CO_2$ $Fe_2(CO_3)_3 \longrightarrow Fe_2O_3 + 3CO_2$ $PbCO_3 \longrightarrow PbO + CO_2$ $CuCO_3 \longrightarrow CuO + CO_2$
Mercury(II) carbonate Silver(I) carbonate	$2HgCO_3 \longrightarrow 2Hg + 2CO_2 + O_2$ $2Ag_2CO_3 \longrightarrow 4Ag + 2CO_2 + O_2$
Ammonium carbonate	$(NH_4)_2CO_3 \longrightarrow NH_3 + CO_2 + H_2O$

Heating Effect on Nitrate Salt

Nitrate Salt	**Equation of The Reaction**
Potassium nitrate Sodium nitrate	$2KNO_3 \longrightarrow 2KNO_2 + O_2$ $2NaNO_3 \longrightarrow 2NaNO_2 + O_2$
Calcium nitrate Magnesium nitrate Aluminium nitrate Zink nitrate Iron (III) nitrate Lead(II) nitrate Copper(II) nitrate	$2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$ $Mg(NO_3)_2 \longrightarrow 2MgO + 4NO_2 + O_2$ $4Al(NO_3)_3 \longrightarrow 2Al_2O_3 + 12NO_2 + 3O_2$ $Zn(NO_3)_2 \longrightarrow 2ZnO + 4NO_2 + O_2$ $4Fe(NO_3)_3 \longrightarrow 2Fe_2O_3 + 12NO_2 + 3O_2$ $Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ $Cu(NO_3)_2 \longrightarrow 2CuO + 4NO_2 + O_2$
Mercury(II) nitrate Silver(I) nitrate	$Hg(NO_3)_2 \longrightarrow Hg + 2NO_2 + O_2$ $2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$
Ammonium nitrate	$NH_4NO_3 \longrightarrow N_2O + 2H_2O$

[NOTES: Nitrogen dioxide, NO_2 is acidic gas and is brown in colour.]

Heating effect on sulphate salt	**The heating effect on chloride salts**
Most sulphate salts do not decompose by heat. Only certain sulphate salts are decomposed by heat when heated strongly. Zinc sulphate, Copper (II) sulphate, Iron (III) sulphate $ZnSO_4 \longrightarrow ZnO + SO_3$ $CuSO_4 \longrightarrow CuO + SO_3$ $2Fe_2(SO_4)_3 \longrightarrow Fe_2O_3 + SO_2 + SO_3$ Ammonium sulphate $(NH_4)_2SO_4 \longrightarrow 2NH_3 + H_2SO_4$	All chloride salts are not decomposable by heat except ammonium chloride. Example: $NH_4Cl \longrightarrow NH_3 + HCl$

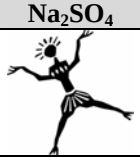
Identification of Gases

Gasses	**Characteristics**
Oxygen	Rekindle glowing splinter.
Hydrogen	Explode with a 'pop' sound when brought close to a lighted splinter.
Carbon Dioxide	Turns lime water chalky.
Chlorine	Bleach moist litmus paper.
Ammonia	Pungent smell. Turn moist red litmus paper to blue. Produces white fume when reacts with concentrated hydrochloric Acid.
Sulphur Dioxide	Pungent smell. Bleach the purple colour of potassium manganate(VII). Turn moist blue litmus paper to red.
Nitrogen Dioxide	Pungent smell. Brown in colour. Turn moist blue litmus paper to red.

Qualitative analysis
Identification of Anions (Negative ions)

	Diluted HCl or diluted HNO_3 or diluted H_2SO_4	**BaCl (aq) or $Ba(NO_3)_2$ (aq) follow by diluted HCl/HNO_3**	**$AgNO_3$ follow by diluted HNO_3.**	**Brown Ring Test (+ $FeSO_4$ (aq) + concentratedH_2SO_4**
CO_3^{2-}	Carbon Dioxide is released.	White precipitate is formed. It is soluble in diluted HCl/HNO_3	White precipitate is formed. It is soluble in diluted HNO_3	-
SO_4^{2-}	-	White precipitate is formed. It is **NOT** soluble in diluted HCl/HNO_3	-	-
Cl^-	-	-	White precipitate is formed. It is **NOT** soluble in diluted HNO_3	-
NO_3^-	-	-	-	Formation of Brown Ring

Idendification of cation

	NaOH(ak)	NH_3(ak)	HCl or NaCl	H_2SO_4 or Na_2SO_4	Na_2CO_3	KI
Na^+						
Ca^{2+}	White precipitate.			White precipitate is produced.	White precipitate is produced.	
Mg^{2+}	White precipitate is produced.	White precipitate is produced.			White precipitate is produced.	
Al^{3+}	White precipitate is produced. Dissolve in excess NaOH solution.	White precipitate is produced.			White precipitate is produced.	
Zn^{2+}	White precipitate is produced. Dissolve in excess NaOH solution.	White precipitate is produced. Dissolve in excess NH_3 solution.			White precipitate is produced.	
Pb^{2+}	White precipitate is produced. Dissolve in excess NaOH solution.	White precipitate is produced.	White precipitate is produced. Dissolve in hot water	White precipitate is produced.	White precipitate is produced.	Yellow precipitate is produced. Dissolve in hot water
Fe^{2+}	Dirty green precipitate is produced.	Dirty green precipitate is produced.			Green precipitate is produced.	
Fe^{3+}	Red brown precipitate is produced.	Red brown precipitate is produced.			Brown precipitate is produced.	A red brown solution formed.
Cu^{2+}	Blue precipitate is produced.	Blue precipitate is produced. Dissolve in excess NH_3 solution and form a blue solution.			Blue precipitate is produced.	White precipitate form in brown solution
NH_4^+						

 = No changes is observed

Distibguish Iron(II) and Iron(III)

Reagent	Observation	Ion presents
Solution of potassium hecxacianoferate(II)	Light blue precipitate	Fe^{2+}
	Dark Blue precipitate	Fe^{3+}
Solution of potassium hecxacianoferate(III)	Dark blue precipitate	Fe^{2+}
	Greenish brown solution	Fe^{3+}
Solution of potassium Thiocyanate(II)	Pinkish solution	Fe^{2+}
	Blood red solution	Fe^{3+}

Manufactured Substances in Industry

Contact Process (Making Sulphuric Acid)

Stage 1: Formation of SO_2

Combustion of Sulphur

$$S_{(s)} + O_2\ (g) \longrightarrow SO_{2\ (g)}$$

or

Heating of metal sulphide such as lead(II) sulphide

$$2PbS_{(s)} + 3O_{2(g)} \longrightarrow 2PbO_{(s)} + 2SO_{2(g)}$$

or

Combustion of hiydrogen sulphide

$$2H_2S_{(g)} + 3O_{2(g)} \longrightarrow 2SO_{2(g)} + 2H_2O_{(ce)}$$

Stage 2: Formation of SO_3

$$2SO_{2\ (g)} + O_{2\ (g)} \longrightarrow 2SO_{3\ (g)}$$

Catalyst: **vanadium(V) oxide**
Temperature: **450°C**
Pressure: **2-3 atmospheres**

Stage 3 Formation of oleum $H_2S_2O_7$

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

Stage 4:Formation of Sulphuric acid

$$H_2S_20_{7\ (1)} + H_2O_{\ (1)} \longrightarrow 2H_2SO_{4(aq)}$$

Haber Process (Making Ammonia)

Sources of the raw material

Hydrogen	1. Reaction between steam and heated coke $H_2O + C \longrightarrow CO + H_2$ **2. Reaction between steam and natural gas.** $\mathbf{2H_2O + CH_4} \longrightarrow CO_2 + 4H_2$
Nitrogen	From distillation of liquid air.

The reaction

1. Ammonia is made by the Haber process from nitrogen and hydrogen:

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g); \Delta H = -92 \text{ kJ mo1}^{-1}$$

Catalyst: Iron
Promoter: Aluminium oxide
Temperature: 450 °C
Pressure: 200-1000 atm