ACIDS, BASES AND SALTS

Definition of an acid	***What causes the acidic properties of acids?***
An acid is a compound which when dissolved in water produces hydrogen ions as the only positively charged ions	The hydrogen ions (H^+) cause the acidic properties and these are formed in the presence of water.

Another term to refer to an acid	***Why an acid is also called a proton donor?***
An acid is called a proton donor	It's because an acid provides protons or hydrogen ions (H^+) to other substances during the reaction.

Substance to which an acid provides protons	***A base is then called***	***Why the base is called a proton acceptor?***	***Equation for the reaction between acid and base***
BASE	PROTON ACCEPTOR	Because the base accepts hydrogen ions from acids	$H^+_{(aq)} + \bar{O}H_{(aq)} \rightarrow H_2O_{(l)}$

Common laboratory acids		***These three common laboratory acids are also called***	***Why these acids are also called mineral acids?***
Hydrochloric acid	HCl	MINERAL ACIDS	They are derived from mineral salts ie *chlorides* for HCl, *sulphates* for H_2SO_4 and *nitrates* for HNO_3
Sulphuric acid	H_2SO_4		
Nitric acid	HNO_3		

Other mineral acids known		***Mineral salts from which the acid is derived***	***Organic acids known***	***Naturally occurring acids***
Sulphurous acid	H_2SO_3	Derived from sulphites	Ethanoic acid (CH_3COOH)	CITRIC ACID from lemons
Carbonic acid	H_2CO_3	Derived from carbonates		TARTARIC ACID from grapes
Phosphoric acid	H_3PO_4	Derived from phosphates		ACETIC ACID from vinegar
Nitrous acid	HNO_3	Derived from nitrites	Methanoic acid (HCOOH)	LACTIC ACID from sour milk
				Hydrochloric acid from digestive juices

Whenever an acid is dissolved in water, it produces	***Term given to the number of hydrogen ions produced by one molecule of an acid***	***Definition of basicity of an acid***
HYDROGEN IONS	BASICITY OF AN ACID	BASICITY of an acid is the number of hydrogen ions produced by one molecule of an acid in aqueous solution.

Basicity can also be defined as	***Categorization of acids depending on basicity***
BASICITY of an acid is the <u>number of hydrogen ions</u> produced by <u>one molecule</u> of an acid <u>when dissolved in water.</u>	Monobasic acids
	Dibasic acids
	Tribasic acids

Definition of	***Its basicity***	***Examples of acids***	***Ionization equations of acids***
<u>**Monobasic acid**</u> *is an acid whose one molecule produces one hydrogen ion when dissolved in water.* OR <u>**Monobasic acid**</u> *is an acid whose one molecule produces one hydrogen ion when in aqueous solution.*	Basicity of monobasic acids is **ONE**	Nitric acid	$HNO_{3(aq)} \rightarrow H^{+}_{(aq)} + NO^{-}_{3(aq)}$
		Hydrochloric acid	$HCl_{(aq)} \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$
		Nitrous acid	$HNO_{2(aq)} \rightarrow H^{+}_{(aq)} + NO^{-}_{2(aq)}$
		Ethanoic acid	$CH_3COOH_{(aq)} \rightarrow H^{+}_{(aq)} + CH_3COO^{-}_{(aq)}$
		Hypochlorous acid	$HOCl_{(aq)} \rightarrow H^{+}_{(aq)} + OCl^{-}_{(aq)}$
		Methanoic acid	$HCOOH_{(aq)} \rightarrow H^{+}_{(aq)} + HCOO^{-}_{(aq)}$
		Have general formula of **HX**	
<u>**Dibasic acid**</u> *is an acid whose one molecule produces two hydrogen ions when dissolved in water.* OR <u>**Dibasic acid**</u> *is an acid whose one molecule produces two hydrogen ions when in aqueous solution.*	Basicity of Dibasic acids is **TWO**	Sulphuric acid	$H_2SO_{4(aq)} \rightarrow 2H^{+}_{(aq)} + SO_4{}^{2-}{}_{(aq)}$
		Carbonic acid	$H_2CO_{3(aq)} \rightleftharpoons 2H^{+}_{(aq)} + CO_3{}^{2-}{}_{(aq)}$
		Sulphurous acid	$H_2SO_{3(aq)} \rightleftharpoons 2H^{+}_{(aq)} + SO_3{}^{2-}{}_{(aq)}$
		Have general formula of **H_2X**	*The double half arrows ($\rightleftharpoons$) imply that the ionization of such an acid is reversible.* *Double half arrows ($\rightleftharpoons$) mainly apply to weak acids*
<u>**Tribasic acid**</u> *is an acid whose one molecule produces three hydrogen ions when dissolved in water.* OR <u>**Tribasic acid**</u> *is an acid whose one molecule produces three hydrogen ions when in aqueous solution.*	Basicity of Tribasic acids is **THREE**	Phosphoric acid	$H_3PO_{4(aq)} \rightleftharpoons 3H^{+}_{(aq)} + PO_4{}^{3-}{}_{(aq)}$
		Have general formula of **H_3X**	***Important note on basicity of an acid*** Basicity of an acid is not necessarily the number of hydrogen atoms contained in one molecule of the acid. Basicity refers to the number of hydrogen atoms capable of ionization in an acid for example; In CH_3COOH, its only one hydrogen atom that can ionize. The other three hydrogen atoms are incapable of ionization, THUS CH_3COOH has ***basicity of 1***

TYPE OF ACIDS	**DEFINITION 1**	**DEFINITION 2**
Strong acids	A strong acid is an acid which when dissolved in water produces ALL the hydrogen ions it contains.	A strong acid is an acid which completely ionizes in dilute solution.
Weak acids	A weak acid is an acid which when dissolved in water produces PART of the hydrogen ions it contains.	A weak acid is an acid which only slightly ionizes in dilute solution.

Examples of strong acids	***Ionization equation for the acid when dissolved in water***
Hydrochloric acid	$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$
Sulphuric acid	$H_2SO_{4(aq)} \longrightarrow 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$
Nitric acid	$HNO_{3(aq)} \longrightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$

Examples of weak acids	***Ionization equation for the acid when dissolved in water***
carbonic acid	$H_2CO_{3(aq)} \rightleftharpoons 2H^+_{(aq)} + CO_3^{2-}{}_{(aq)}$
phosphoric acid	$H_3PO_{4(aq)} \rightleftharpoons 3H^+_{(aq)} + PO_4^{3-}{}_{(aq)}$
Ethanoic acid	$CH_3COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-_{(aq)}$
Methanoic acid	$HCOOH_{(aq)} \rightleftharpoons H^+_{(aq)} + HCOO^-_{(aq)}$

PROPERTIES OF ACIDS

PHYSICAL PROPERTIES

Physical properties of acids are those properties of acids that can be seen, felt and smelt.

1. Have a sour and sharp taste

2. Acids change colour of indicators.

   Definition of an indicator

   An indicator is a substance that has different colours in acidic and alkaline solutions.

Indicator	***Colour in acidic solution***	***Colour in alkaline solution***
Phenolphthalein	Colourless	Pink
Methyl orange	Pink	Yellow
Red litmus	Red	Blue
Blue litmus	Red	Blue

3. Dilute acids are colourless solutions.

4. Concentrated acids are oily liquids eg concentrated sulphuric acid.

CHEMICAL PROPERTIES

Chemical properties of acids are those properties of acids when they are involved in chemical reactions.

1. ***Reaction with carbonates and hydrogencarbonates.***

Observation made	Products of reaction		
Effervescence of a colourless gas that turns lime- water milky.	SALT	WATER	Carbon dioxide

Examples illustrated by equations

$Na_2CO_{3(s)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

$K_2CO_{3(s)} + 2HCl_{(aq)} \longrightarrow 2KCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

2. ***Reaction with oxides and hydroxides***

Products of the reaction	
SALT	WATER

Examples illustrated by equations

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

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

3. ***Reaction with metals***

Observation made	***Products of reaction***	
Effervescence of a colourless gas that burns with a pop sound.	SALT	Hydrogen

Examples illustrated by equations

$Mg_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_{2(g)}$

STATEMENT(S)		REASON(S)
When a piece of aluminium foil is placed in a test tube containing cold dilute hydrochloric acid, no reaction occurs.	BECAUSE	A thin protective layer forms on aluminium as soon as the metal is exposed to moist air, which prevents any reaction.
When a piece of aluminium foil is placed in a test tube containing cold dilute sulphuric acid, no reaction occurs.	BECAUSE	A thin protective layer forms on aluminium as soon as the metal is exposed to moist air, which prevents any reaction.
If a piece of aluminium foil is placed in a test tube containing warm acid, a reaction occurs after a short while.	BECAUSE	The oxide layer on aluminium dissolves in the warm acid exposing the metal which reacts with the acid.
Copper does not liberate hydrogen with dilute acids.	BECAUSE	Copper is below hydrogen in the electrochemical series, thus cannot displace it from dilute acids.
Nitric acid does not liberate hydrogen with nitric acid except magnesium.	BECAUSE	Nitric acid is a strong oxidizing agent. It oxidizes the hydrogen formed immediately into water.

NOTE;
Magnesium only reacts with nitric acid when it is very dilute.

$Mg_{(s)} + 2HNO_{3(aq)} \longrightarrow Mg(NO_3)_{2(aq)} + H_{2(g)}$

BASES AND ALKALIS

Definition of a base	***In general terms, bases are;***	***A reaction where an acid reacts with a base is called***
A base is a substance which reacts with an acid to form a salt and water only.	Oxides of metals Hydroxides of metals Ammonium hydroxide	NEUTRALIZATION REACTION

Definition of neutralization;
Neutralization is a reaction in which an acid reacts with a base to form a salt and water only.

Many bases exist but only a few are soluble in water

Examples of bases that are soluble in water		These soluble bases are called	Alkalis are also called
Sodium hydroxide	$NaOH$	ALKALIS	SOLUBLE BASES
Potassium hydroxide	KOH		
Calcium hydroxide	$Ca(OH)_2$		
Aqueous ammonia	NH_4OH	Alkalis are categorized into STRONG and WEAK alkalis	

Definition of alkalis;
Alkalis are substances which when dissolved in water produce hydroxide ions as the only negatively charged ions.

TYPES OF ALKALIS

STRONG ALKALIS	WEAK ALKALIS
These are electrovalent compounds that completely ionize in both aqueous solution and in solid state.	These are covalent compounds that partly ionize in aqueous solution and their ionization is reversible.
<u>**Examples of strong alkalis**</u> 1. Sodium hydroxide solution $NaOH_{(aq)} \longrightarrow Na^{+}_{(aq)} + \overline{O}H_{(aq)}$ 2. Potassium hydroxide solution $KOH_{(aq)} \longrightarrow K^{+}_{(aq)} + \overline{O}H_{(aq)}$ 3. Calcium hydroxide solution $Ca(OH)_{2(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2\overline{O}H_{(aq)}$	<u>**Example of weak alkalis**</u> 1. Aqueous ammonia It is also called <u>*ammonia solution*</u> Aqueous ammonia is also called <u>*ammonium hydroxide solution*</u> $NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4{}^{+}{}_{(aq)} + \overline{O}H_{(aq)}$

PROPERTIES OF ALKALIS	
Physical properties	**Chemical properties**
Have a bitter taste	React with acids to form a salt and water only $NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$
Have a soapy feeling to touch Change colours of indicators Form colourless solutions	Alkalis precipitate insoluble metallic hydroxides from solutions of their salts. $2NaOH_{(aq)} + Pb(NO_3)_{2(aq)} \longrightarrow Pb(OH)_{2(s)} + 2NaNO_{3(aq)}$

COLOUR OF METAL HYDROXIDES

Metal hydroxide	***Colour***
Potassium hydroxide	White
Sodium hydroxide	White
Calcium hydroxide	White
Magnesium hydroxide	White
Zinc hydroxide	White
Aluminium hydroxide	White
Lead (ii) hydroxide	White
Copper (ii) hydroxide	Blue
Iron (ii) hydroxide	Green
Iron (iii) hydroxide	Brown

pH SCALE OF ACIDITY AND ALKALINITY

pH scale	*pH is related to*	*pH number*
Is a scale of numbers from 1 to 14, to express acidity and alkalinity	HYDROGEN ION concentration in solution	Is a measure of the hydrogen ion concentration

APPROXIMATE pH VALUES OF COMMON SOLUTIONS				
pH 1	pH 2 – pH 6	pH 7	pH 8 – pH 13	pH 14
Strong acid	*Weak acid*	*Neutral*	*Weak alkali*	*Strong alkali*
Dilute sulphuric acid	Lemon juice (pH 2)	Sodium chloride	Baking powder (pH 9)	Sodium hydroxide
Dilute nitric acid	Sour milk (pH 5)	Pure water	Wood ash (pH 10)	Potassium hydroxide

NOTE **1**	Acidic solutions have pH values less than seven. The smaller the pH value, the more acidic the solution is ie the larger the concentration of hydrogen ions.
NOTE **2**	When distilled water is added to an acid, the pH value of the acid increases towards seven. The solution becomes less acidic.
NOTE **3**	Water and other solutions have a pH of seven.
NOTE **4**	Any solution of pH greater than seven is alkaline. The higher the pH value, the more alkaline the solution is ie the larger the concentration of hydroxyl or hydroxide ions.
NOTE **5**	When distilled water is added to an alkaline solution, the pH value of the alkali decreases towards seven. The solution becomes less alkaline.

UNIVERSAL INDICATOR

Definition	*Forms in which universal indicator occurs*	*Uses of universal indicator*
Universal indicator is a mixture of indicators.	✓ In solution form ✓ In paper form	Determines whether the solution is acidic or alkaline. Used to determine the degree of acidity and alkalinity.

pH scale	1 -2	3	4	5	6 - 8	9 - 10	11 - 12	13 - 14
Colour	Red	Pink	Brown	Yellow	Green	Blue	Indigo	Violet

SIGNIFICANCE OF pH MEASUREMENTS
1. It helps to know that the final product in soap industry is neutral.
2. Too acidic soils are harmful in agriculture, and this can be determined by measuring the pH of the soil.
3. Various drugs are prepared at pHs which must be determined

SALTS

DEFINITION OF SALT	TYPES OF SALTS	
A salt is a substance formed when <u>all</u> or <u>part</u> of the replaceable hydrogen of an acid is replaced by a metal or metallic radical.	Acid salts	Normal salts

Definition of normal salt	***Definition of acid salt***
A normal salt is a salt formed when all the replaceable hydrogen of an acid is replaced by a metal or metallic radical.	An acid salt is a salt formed when part of the replaceable hydrogen of an acid is replaced by a metal or metallic radical.
Examples of normal salts	***Examples of acid salts***
✓ Sodium sulphate	✓ Calcium hydrogencarbonate
✓ Sodium carbonate	✓ sodium hydrogencarbonate
✓ Potassium nitrate	✓ Calcium hydrogensulphate
✓ Potassium sulphate	✓ Potassium hydrogencarbonate
✓ Calcium nitrate	✓ Calcium hydrogenphosphate
✓ Aluminium sulphate	✓ Magnesium hydrogencarbonate
Formation of a normal salt	***Formation of an acid salt***
Zinc granules reacting with dilute sulphuric acid. $Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$	Sodium chloride reacting with concentrated sulphuric acid. $H_2SO_{4(l)} + NaCl_{(s)} \longrightarrow NaHSO_{4(aq)} + HCl_{(g)}$

STATEMENT(S)		**REASON(S)**
Monobasic acids do not form acid salts	BECAUSE	Monobasic acids contain only one atom of replaceable hydrogen per acid molecule.
Sodium ethanoate, CH_3COONa is a normal salt.	BECAUSE	The hydrogen it contains does not form ions and cannot be replaced by a metal

TYPES OF SALTS AND ACIDS FROM WHICH THEY ARE FORMED		
ACID	TYPE OF SALT	EXAMPLE OF THE SALT
Sulphuric acid	Sulphates	Iron (ii) sulphate
Hydrochloric acid	Chlorides	Sodium chloride
Carbonic acid	Carbonates	Potassium carbonate
Nitric acid	Nitrates	Calcium nitrate
Sulphuric acid	hydrogencarbonates	Sodium hydrogencarbonate

CATEGORIZING SALTS DEPENDING ON THEIR SOLUBILITY IN WATER			
SOLUBLE SALTS		INSOLUBLE SALTS	
Soluble salts are salts which completely dissolve in water to form a solution.		Insoluble salts are salts which do not dissolve completely in water and they form a residue when filtered.	
Soluble salts are usually prepared by methods which involve crystallization.		Insoluble salts are usually prepared by methods which involve precipitation (double decomposition)	
Crystallization is a process by which a solution is saturated by evaporating some of the solvent,		Precipitation is a process where an insoluble solid is formed when two aqueous solutions are mixed together.	
On cooling, the excess salt dissolved in the hot solution is deposited as crystals.		The insoluble salt is formed as a precipitate in an aqueous solution which is filtered off, washed and dried.	
A crystal is a solid that has solidified in a definite regular shape		A precipitate is an insoluble solid that separates from the solution.	
EXAMPLES OF SOLUBLE SALTS	**COLOUR**	**EXAMPLES OF INSOLUBLE SALTS**	**COLOUR**
Lead (ii) nitrate	White	Lead (ii) carbonate	White
Copper (ii) sulphate	Blue	Copper (ii) carbonate	Green
Copper (ii) nitrate	Blue	Lead (ii) sulphate	White
Iron (ii) sulphate	Green	Iron (ii) carbonate	Green
Iron (ii) chloride	Green	Barium sulphate	White
Iron (ii) nitrate	Green	Calcium sulphate (slightly soluble in water)	White
Iron (iii) sulphate	Brown/ yellow	Silver chloride	White
Iron (iii) chloride	Brown/ yellow	Magnesium carbonate	White
Iron (iii) nitrate	Brown/ yellow	Zinc carbonate	White
Formation of zinc sulphate $Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$		*Formation of zinc carbonate by precipitation* $Na_2CO_{3(aq)} + ZnCl_{2(aq)} \longrightarrow NaCl_{(aq)} + ZnCO_{3(s)}$	
Formation of zinc sulphate $CuO_{(s)} + H_2SO_{4(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}$		*Formation of copper (ii) carbonate by precipitation* $Na_2CO_{3(aq)} + CuSO_{4(aq)} \longrightarrow CuCO_{3(s)} + Na_2SO_{4(aq)}$	

SOLUBLE SALTS	**INSOLUBLE SALTS**
ALL Sodium salts	
ALL potassium salts	
ALL ammonium salts	
ALL NITRATES form soluble salts	***NO Nitrate salt is insoluble***
ALL sulphates ***Except***	Lead (ii) sulphate Barium sulphate Calcium sulphate
ALL chlorides ***Except***	Lead (ii) chloride (soluble in hot water) Sliver chloride Mercury (i) chloride
Sodium carbonate Potassium carbonate Ammonium carbonate	***Except*** ALL CARBONATES are insoluble

PREPARATION OF SOLUBLE SALTS BY

1. ACTION OF AN ACID ON A METAL

General equation	Metal + Acid $\longrightarrow$ Salt + Hydrogen	
This method is not suitable for preparation of salts of highly reactive metals for example; • *Potassium* • *Sodium* • *Calcium*	BECAUSE	The metals of potassium, sodium and calcium react explosively with dilute acids

This method is only used to prepare salts of less reactive metals such as

- *Aluminium*
- *Zinc*
- *Magnesium*
- *Iron*

Magnesium sulphate can be prepared by using magnesium and dilute sulphuric acid

$$Mg_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_{2(g)}$$

Iron (ii) sulphate can be prepared by using iron filings and dilute sulphuric acid

$$Fe_{(s)} + H_2SO_{4(aq)} \longrightarrow FeSO_{4(aq)} + H_{2(g)}$$

EXPERIMENT: ***<u>Preparation of zinc sulphate crystals</u>***

- ✓ Dilute sulphuric acid is poured in a beaker and granulated zinc is added.
- ✓ Effervescence occurs
- ✓ If the reaction is slow, a little copper (ii) sulphate solution is added as a catalyst and the reactants are warmed gently.

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

- ✓ When the reaction stops, more zinc is added to make sure that the acid is not left in considerable amounts.
- ✓ Excess zinc granules are filtered off.
- ✓ The filtrate is gently heated in an evaporating dish to boil off some water until crystals begin to form, when the filtrate cools, on a glass rod, which is dipped into the filtrate at regular intervals.
- ✓ The crystals are filtered off and then pressed gently between filter papers to dry.

PREPARATION OF SOLUBLE SALTS BY	
2. ACTION OF AN ACID ON SOLUBLE HYDROXIDE OR CARBONATE	
This method is used to prepare salts of potassium, sodium and ammonium	
PREPARATION OF;	***(i) Potassium chloride*** $KOH_{(aq)} + HCl_{(aq)} \longrightarrow KCl_{(aq)} + H_2O_{(l)}$ $K_2CO_{3(aq)} + 2HCl_{(aq)} \longrightarrow KCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(ii) Sodium nitrate $NaOH_{(aq)} + HNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + H_2O_{(l)}$ $Na_2CO_{3(aq)} + 2HNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(iii) Ammonium chloride $NH_4OH_{(aq)} + HCl_{(aq)} \longrightarrow NH_4Cl_{(aq)} + H_2O_{(l)}$ $(NH_4)_2CO_{3(aq)} + 2HCl_{(aq)} \longrightarrow 2NH_4Cl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(iv) Ammonium sulphate $2NH_4OH_{(aq)} + H_2SO_{4(aq)} \longrightarrow (NH_4)_2SO_{4(aq)} + H_2O_{(l)}$ $(NH_4)_2CO_{3(aq)} + H_2SO_{4(aq)} \longrightarrow (NH_4)_2SO_{4(aq)} + H_2O_{(l)} + CO_{2(g)}$

EXPERIMENT: *Preparation of sodium sulphate crystals*

- ✓ A known volume of sodium hydroxide solution is pipetted into a conical flask and 2 drops of phenolphthalein added.
- ✓ Dilute sulphuric acid is added from the burette to conical flask at intervals until the colour of the indicator changes to pink.

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

- ✓ Having noted the volume of the acid used, the solution is poured away as the indicator would colour the salt obtained from it.
- ✓ The whole process is repeated using the same volume of the solution of sulphuric acid and sodium hydroxide solution without adding the indicator.
- ✓ The solution is evaporated until it forms crystals when it cools, on a clean glass rod, which is dipped into the solution at regular intervals.
- ✓ The crystals are filtered off and then pressed gently between filter papers to dry.

PREPARATION OF SOLUBLE SALTS BY	
3. ACTION OF AN ACID ON INSOLUBLE OXIDES OR HYDROXIDES	
This method is used to prepare Magnesium sulphate, zinc sulphate and lead (ii) nitrate	
PREPARATION OF;	***(i) Magnesium sulphate*** $MgO_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_2O_{(l)}$ $Mg(OH)_{2(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_2O_{(l)}$
	(ii) Zinc sulphate $ZnO_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_2O_{(l)}$ $Zn(OH)_{2(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_2O_{(l)}$
	(iii) Lead (ii) nitrate $PbO_{(s)} + HNO_{3(aq)} \longrightarrow Pb(NO_3)_{2(aq)} + H_2O_{(l)}$ $Pb(OH)_{2(s)} + HNO_{3(aq)} \longrightarrow Pb(NO_3)_{2(aq)} + H_2O_{(l)}$

EXPERIMENT: *Preparation of copper (ii) sulphate crystals*

- ✓ Copper (ii) oxide is added to a beaker of warm dilute sulphuric acid and the mixture stirred gently.
- ✓ More of the oxide is added, little at a time until no more reacts, showing that all the acid has been neutralized.

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

- ✓ Excess copper (ii) oxide is filtered off and the filtrate evaporated until crystals begin to form when it cools, on a clean glass rod, which is dipped into the filtrate at regular intervals
- ✓ The crystals are filtered off and then pressed gently between filter papers to dry.

PREPARATION OF SOLUBLE SALTS BY	
4. ACTION OF AN ACID ON SOLUBLE INSOLUBLE CARBONATES	
The salts of copper (ii) sulphate, copper (ii) nitrate, magnesium sulphate, zinc sulphate, calcium chloride and calcium nitrate are prepared by this method.	
Calcium chloride and calcium nitrate are deliquescent and do not form crystals. Their solutions must be evaporated to dryness	
PREPARATION OF;	***(i) Copper (ii) sulphate*** $CuCO_{3(s)} + H_2SO_{4(aq)} \longrightarrow CuSO_{4\,(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(ii) Copper (ii) nitrate $CuCO_{3(s)} + 2HNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(iii) Magnesium sulphate $MgCO_{3(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4\,(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(iv) Zinc sulphate $ZnCO_{3(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4\,(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(v) Calcium (ii) nitrate $CaCO_{3(s)} + 2HNO_{3(aq)} \longrightarrow Ca(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$
	(vi) Calcium chloride $CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

EXPERIMENT: *Preparation of lead (ii) nitrate crystals*

- ✓ Lead (ii) carbonate is added little at a time to dilute nitric acid in a beaker.
- ✓ Effervescence occurs as carbon dioxide is evolved.
- ✓ More carbonate is added until no more reacts, showing that all the acid has reacted.

$$PbCO_{3(s)} + 2HNO_{3(aq)} \longrightarrow Pb(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

- ✓ The excess carbonate is filtered off and the filtrate evaporated until crystals begin to form when it cools, on a clean glass rod, which is dipped into the filtrate at regular intervals.
- ✓ The crystals are filtered off and then pressed gently between filter papers to dry.

5. **PREPARATION OF SALTS BY DIRECT SYNTHESIS**	
Salts to which this method applies	APPLIES to both _soluble_ and _insoluble_ salts
Another name for this method	Direct synthesis
Salts prepared by direct synthesis	Used to prepare binary salts, for example; ✓ *Chlorides eg anhydrous iron (iii) chloride* ✓ *Bromides eg aluminium bromide* ✓ *Sulphides eg iron (ii) sulphide*
Definition of direct synthesis	*Direct synthesis is the method of preparing soluble and insoluble salts directly from their elements.*

PREPARATION OF ANHYDROUS IRON (III) CHLORIDE	
Conditions for the reaction	▪ Dry chlorine gas ▪ Heating is required
Equation for the reaction	$2Fe_{(s)} + 3Cl_{2(g)} \longrightarrow 2FeCl_{3(s)}$
Colour of iron (iii) chloride	BROWN

PREPARATION OF ALUMINIUM CHLORIDE	
Conditions for the reaction	▪ Dry chlorine gas ▪ Heating is required
Equation for the reaction	$2Al_{(s)} + 3Cl_{2(g)} \longrightarrow 2AlCl_{3(s)}$
Colour of aluminium chloride	WHITE

PREPARATION OF IRON (II) SULPHIDE	
Conditions for the reaction	▪ Heating is required
Observation made	The mixture glows when heated forming a black solid.
Equation for the reaction	$Fe_{(s)} + S_{(g)} \longrightarrow FeS_{(s)}$
Colour of iron (ii) sulphide	BLACK

6. PREPARATION OF INSOLUBLE SALTS BY PRECIPITATION	
Method also called	Double decomposition reaction
What is involved in this method?	In this method, two soluble salts are mixed together to give a mixture of a soluble salt and an insoluble salt (precipitate)
PREPARATION OF	*(i) Barium sulphate* $BaCl_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$
	(ii) *Lead (ii) chloride* (It is soluble in hot water) $Pb(NO_3)_{2(aq)} + NaCl_{(aq)} \longrightarrow PbCl_{2(s)} + 2NaNO_{3(aq)}$
	(iii) Calcium carbonate $CaCl_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaCl_{(aq)}$
	(iv) Lead (ii) bromide $Pb(NO_3)_{2(aq)} + 2NaBr_{(aq)} \longrightarrow PbBr_{2(s)} + 2NaNO_{3(aq)}$
	(v) Calcium sulphate $Ca(NO_3)_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow CaSO_{4(s)} + 2NaNO_{3(aq)}$

EXPERIMENT: *Preparation of lead (ii) sulphate crystals*

- ✓ Dilute sulphuric acid is added to warm lead (ii) nitrate solution in a beaker and the mixture is stirred.
- ✓ The white precipitate formed is heated to enable rapid filtration.
- ✓ After filtration, the precipitate is washed several times with hot distilled water to remove soluble impurities.
- ✓ The precipitate is allowed to dry on a filter paper.

$$Pb(NO_3)_{2(aq)} + H_2SO_{4(aq)} \longrightarrow PbSO_{4(s)} + 2HNO_{3(aq)}$$

NOTE; SODIUM SULPHATE solution may be used instead of SULPHURIC ACID

$$Pb(NO_3)_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow PbSO_{4(s)} + 2NaNO_{3(aq)}$$

HYDROLYSIS OF SALTS

Why does a solution of potassium carbonate show basic characteristics?	This is because when in aqueous solution, potassium carbonate hydrolyses in water to form a mixture of a strong alkali (KOH) and a weak acid (H_2CO_3). The resultant solution is alkaline because the concentration of hydroxyl ions from the strong alkali is greater than the concentration of hydrogen ions from the weak acid. The strong alkali completely ionizes in solution and the weak acid under goes incomplete ionization.
Equation for the reaction	$K_2CO_{3(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_2CO_{3(aq)}$

Why does a solution of ammonium chloride show acidic characteristics?	This is because when in aqueous solution, ammonium chloride hydrolyses in water to form a mixture of a strong acid (HCl) and a weak alkali (NH_4OH). The resultant solution is acidic because the concentration of hydrogen ions from the strong acid is greater than the concentration of hydroxyl ions from the weak alkali. The strong acid completely ionizes in solution and the weak alkali under goes incomplete ionization.
Equation for the reaction	$NH_4Cl_{(s)} + 2H_2O_{(l)} \longrightarrow NH_4OH_{(aq)} + HCl_{(aq)}$

REACTIONS FOR IONIC SALTS

When an ionic salt dissolves in water, its ions separate into free ions. For example; when zinc sulphate is dissolved in water, zinc ions (Zn^{2+}) and sulphate ions (SO_4^{2+})

IONIC EQUATIONS

Ionic equations describe chemical changes by showing only the reacting ions.

Three steps are followed when writing ionic equations;

STEP 1	Write the formal equation.
STEP 2	Write down all the ions in the equation.
STEP 3	The ionic equation is written by omitting the identical ions which appear on both sides of the equation.

Important notes to take;

NOTE 1	Gases do not ionize.
NOTE 2	Solids do not ionize. (Precipitates do not ionize)
NOTE 3	Water does not ionize.
NOTE 4	*Only aqueous solutions ionize.*

EXERCISE

Write ionic equations for the following reactions

i) *Copper (ii) sulphate solution is added to sodium carbonate solution*

ii) *Sodium hydroxide solution is added to lead (ii) nitrate solution*

iii) *Zinc powder is added to copper (ii) sulphate solution*

iv) *Chlorine gas is passed through a solution of iron (ii) chloride*

v) *Dilute hydrochloric acid is added to solid calcium carbonate*

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