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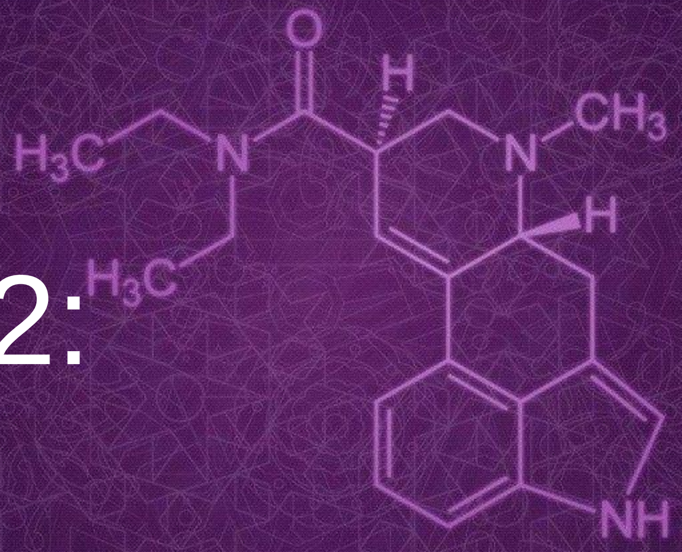
TOPIC 7.2: SALTS



THE ABOUT

CHAPTER ANALYSIS

TIME

- Complex chapter
- Salt preparation requires high level of mastery

EXAM

- Usually tested in Section A or B
- Requires strong knowledge from Acid & Bases
- Very important chapter for Qualitative Analysis

WEIGHTAGE

- Light-Medium overall weightage
- Constitute to **3.5%** of marks for past 5 year papers

KEY CONCEPT

OXIDES
NEUTRALISATION
APPLICATION OF NEUTRALISATION

4 TYPES OF OXIDES

SUMMARY TABLE

OXIDES

Oxides	Basic Oxide	Acidic Oxide	Amphoteric Oxide	Neutral Oxide
Element type	Metal oxides	Non-metal oxides	Some metal oxides	Some non-metal oxides
Chemical properties	Behave like an alkali	Behave like an acid	Behave like an acid or an alkali	Does not react
Reactions	Neutralisation (with an acid)	Neutralisation (with an alkali)	React with both acid or alkali	Does not react
Examples	- Sodium oxide - Potassium oxide - Magnesium oxide - Calcium oxide	- Carbon dioxide - Sulfur dioxide - Sulfur trioxide - Phosphorus (V) oxide	- Aluminium oxide, Al_2O_3 - Lead (II) oxide, PbO - Zinc oxide, ZnO	- Water, H_2O - Carbon monoxide, CO - Nitrogen monoxide, NO

BASIC OXIDES

Basic oxides are **metal oxides.**

Basic oxides are also known as **'base'.**

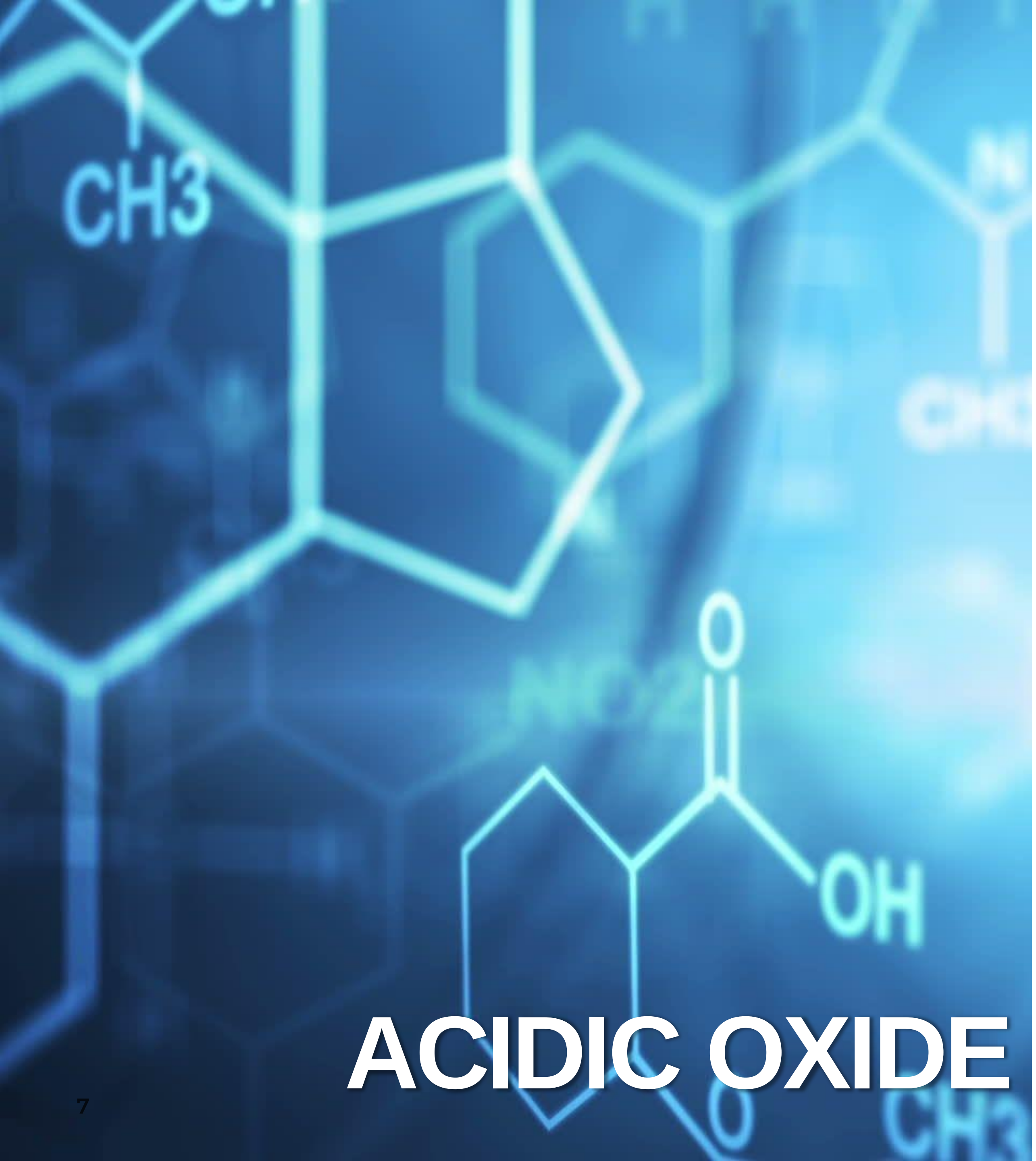
Soluble basic oxides are known as '**alkaline**'.

Basic oxides react with an acid to produce salt & water.

ACID + BASE → SALT + WATER

Examples of basic oxides:
(all Group I & II elements)

- Sodium oxide
- Potassium oxide
- Magnesium oxide
- Calcium oxide



ACIDIC OXIDE

ACIDIC OXIDES

Acidic oxides are **non-metal oxides.**

Acidic oxides react with water to produce acid.

(Acidic oxides need to dissolve in water to turn into an acid, which then has its acidic properties)

ACIDIC OXIDE + WATER → ACID

For example, sulfuric acid is formed from sulfur trioxide.

$$SO_3 + H_2O \rightarrow H_2SO_4$$

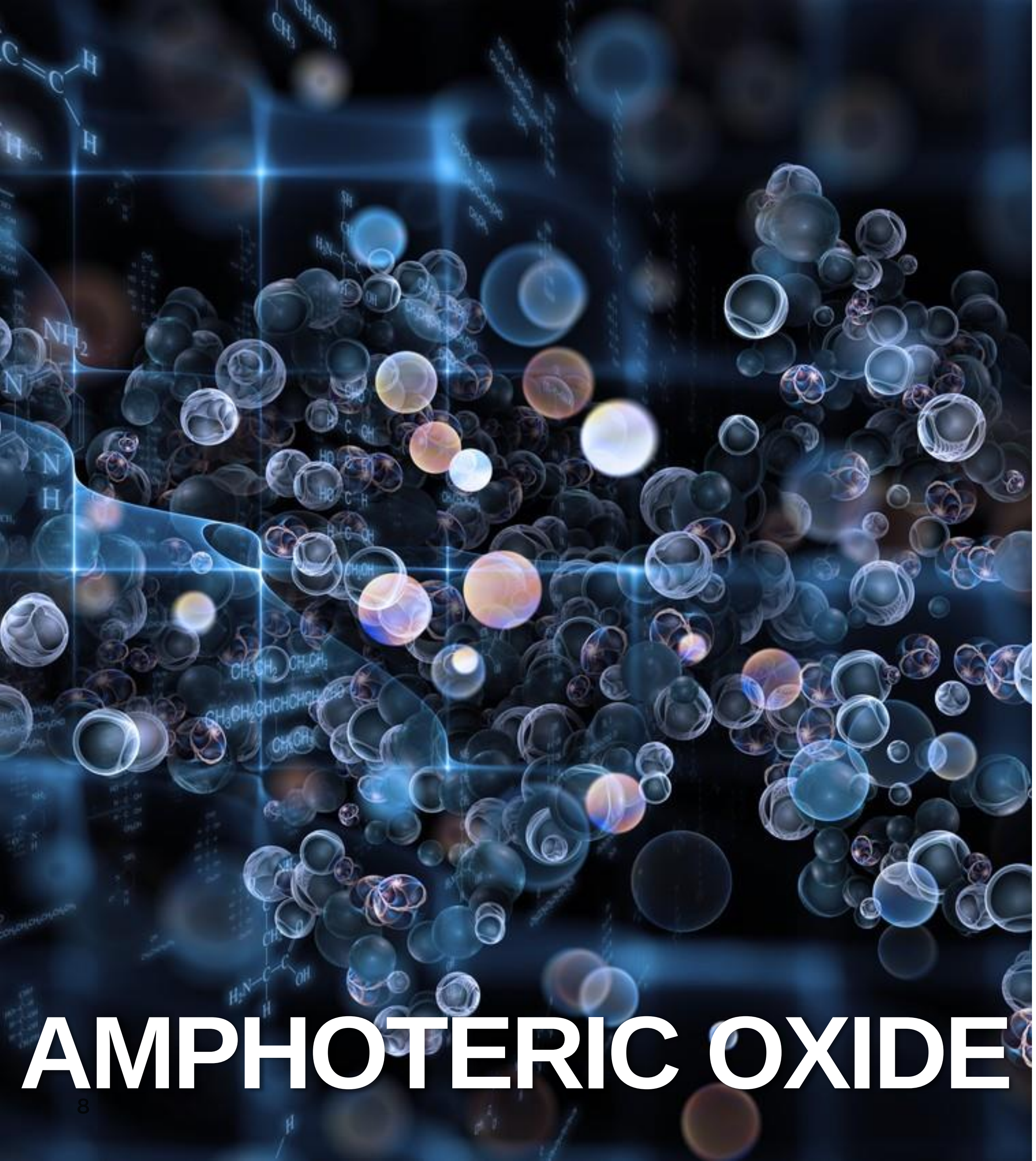
Similar to an acid, acidic oxides will react with alkaline* to undergo a neutralisation reaction.

ACIDIC OXDE + ALKALINE → SALT + WATER

Examples of acidic oxides:
(most non-metal elements)

- Carbon dioxide
- Sulfur dioxide
- Sulfur trioxide
- Phosphorus (V) oxide

*Acidic oxides can react with alkaline directly as alkaline is aqueous and contains water, which allow the acidic properties of the acidic oxide to emerge.



AMPHOTERIC OXIDES

There are 3 amphoteric oxides:

1) **Aluminium oxide, Al_2O_3**
2) **Lead (II) oxide, PbO**
3) **Zinc oxide, ZnO**

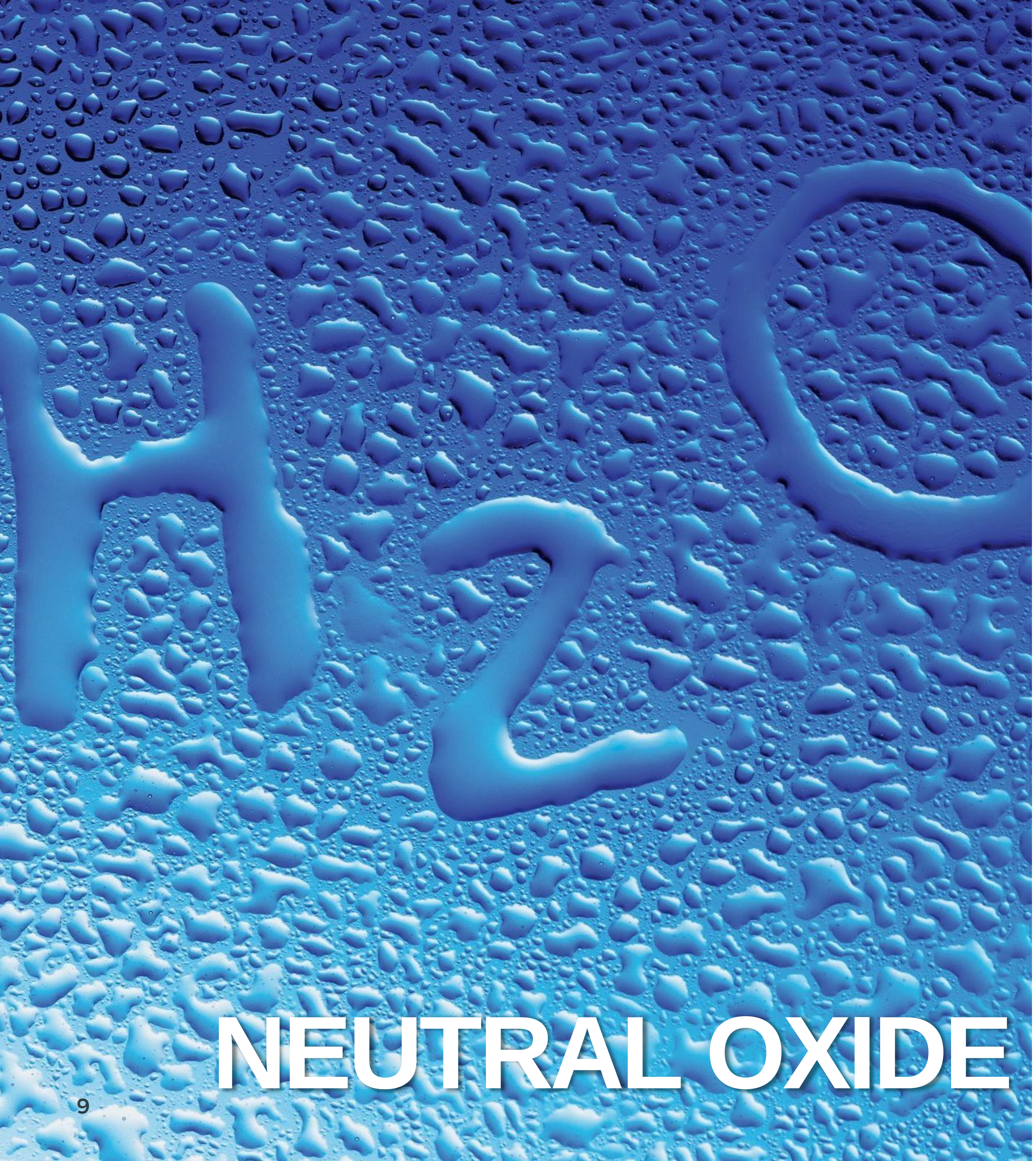
Amphoteric oxides are oxides which can behave like an acid or an alkali.

For example,

$$Al_2O_3\,(s) + 6HCl\,(aq) \rightarrow 2AlCl_3\,(aq) + 3H_2O\,(l)$$

$$Al_2O_3\,(s) + 2NaOH\,(aq) \rightarrow 2NaAlO_2\,(aq) + H_2O\,(l)$$

As seen from the above equation, ***Al_2O_3*** can **act as a base when reacting when an acid** or **act as an acid when reacting with a base.**



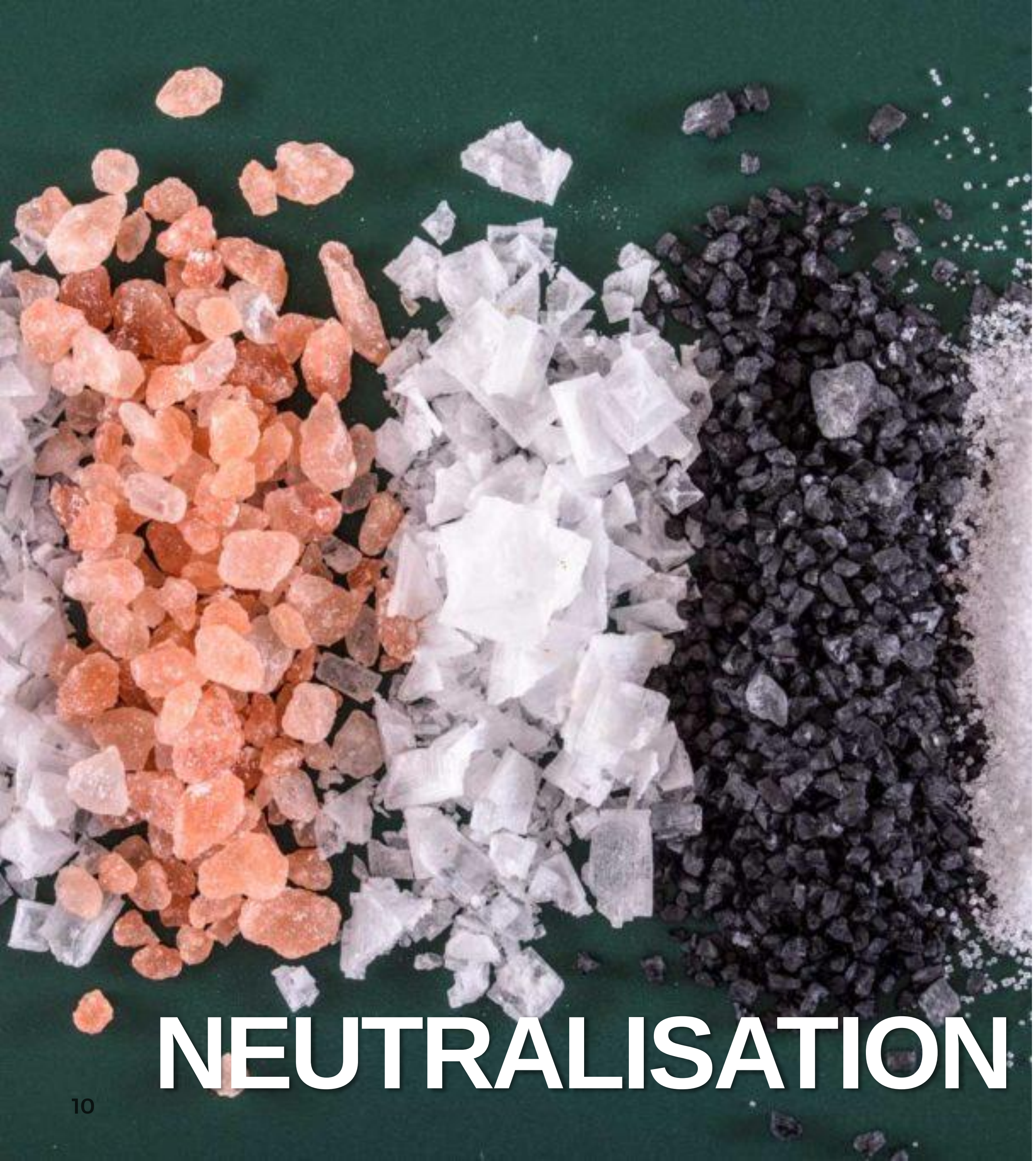
NEUTRAL OXIDE

<u>NEUTRAL OXIDES</u>

There are 3 neutral oxides:

1) **Water, H_2O**
2) **Carbon monoxide, CO**
3) **Nitrogen monoxide, NO**

Neutral oxides do not have any acidic or alkali properties and does not undergo neutralisation to form salts.



NEUTRALISATION

Neutralisation is the process where acid reacts with a base to produce salt & water.

ACID + BASE → SALT + WATER

APPLICATION

- Regulating the pH of soil

To ensure the optimal pH for growth of plants, farmers will add bases like slaked lime (calcium hydroxide) or quicklime (calcium oxide) to the soil when its acidic.

To reduce alkalinity, farmers will add compost which consists of decaying plant matter. During decomposition, carbon dioxide gas is given off which dissolves in water to give carbonic acid (H_2CO_3).

- **Treating indigestion**

Overeating can cause the overproduction of hydrochloric acid by our stomach walls, causing indigestion.

A common example of an antacid is magnesium hydroxide, which reacts with hydrochloric acid to give magnesium chloride (salt) and water, neutralising the acid in the stomach.

- **Toothpaste**

Bacteria on our teeth produce acids when they digest the sugars in food. Acid can corrode our teeth and cause tooth decay.

Toothpastes contain magnesium hydroxide and are alkaline. The bases in toothpaste also help to remove bacteria & neutralise the acids.

KEY CONCEPT

SALT SOLUBILITY TABLE
ACID + EXCESS INSOLUBLE SUBSTANCE
TITRATION
PRECIPITATION

SUMMARY TABLE

SALT SOLUBILITY TABLE

	Soluble salts	Insoluble salts
SPA - Sodium - Potassium - Ammonium	**ALL**	**NONE**
Nitrates	**ALL**	**NONE**
Chlorides	**ALL except**	Lead(II) chloride, $PbCl_2$ Silver chloride, AgCl
Sulfates	**ALL except**	Lead(II) sulfate, $PbSO_4$ Barium sulfate, $BaSO_4$ Calcium sulfate, $CaSO_4$
Carbonates	**SPA salts**	**ALL except**
Oxides & Hydroxides	**Group I & some Group II elements**	**ALL except**

SPAN
Anything with sodium, potassium, ammonium or is a nitrate are definitely soluble.

PRINCIPLE OF ACCOUNTANCY
P, A
Pb, Ag

3 SCIENCE SUBJECTS
Physics, Biology, Chemistry
P, B, C
Pb, Ba, Ca

All **Group I metals** form soluble salts.
(Sodium, Potassium...)

Ca (oxide / hydroxide) are *slightly soluble.*

*Find your own method for memorising. Make your life easier by finding a methodology that works for you!

*If you find the next couple of slides too complicated, feel free to skip to SLIDE 20.

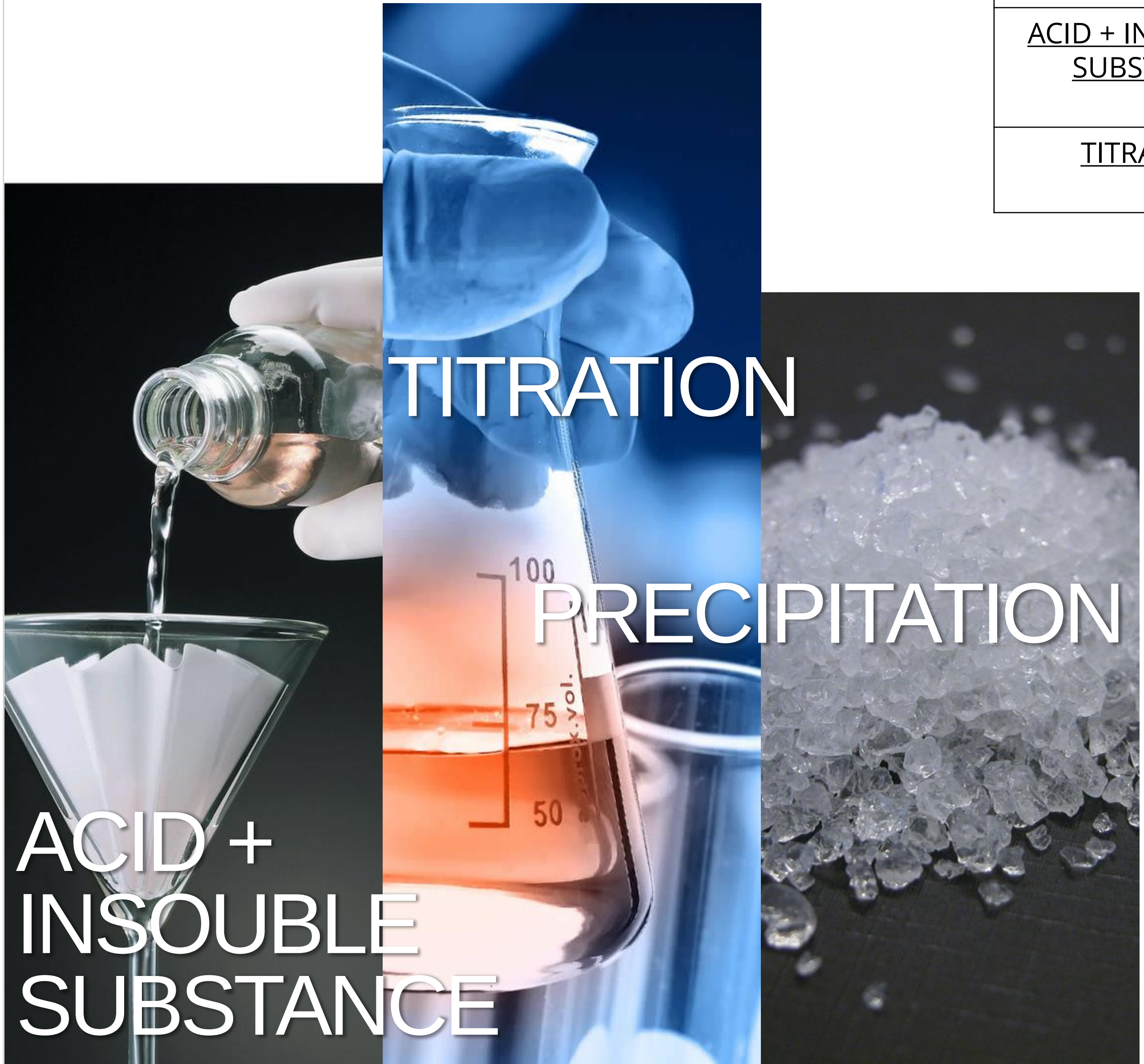
Due to the seemingly complex nature of salt preparation, many students opt to memorise the procedure for salt preparation and attempt regurgitate the content in exams.

While that might work to an extent, they will not be able to solve application questions and might remember some parts wrongly.

In this upcoming section, I will attempt to break down the logic behind salt preparation and show you ***why you do not need to memorise anything once you have understood salt preparation***.

UNDERSTANDING SALT PREPARATION VS MEMORISING

NAME	REACTION
<u>PRECIPITATION</u>	SOLUBLE + SOLUBLE → **INSOLUBLE SALT**
<u>ACID + INSOLUBLE SUBSTANCE</u>	SOLUBLE + INSOLUBLE → **SOLUBLE SALT**
<u>TITRATION</u>	SOLUBLE + SOLUBLE → **SOLUBLE SALT**



3 methods

There are only 3 ways to prepare a salt.

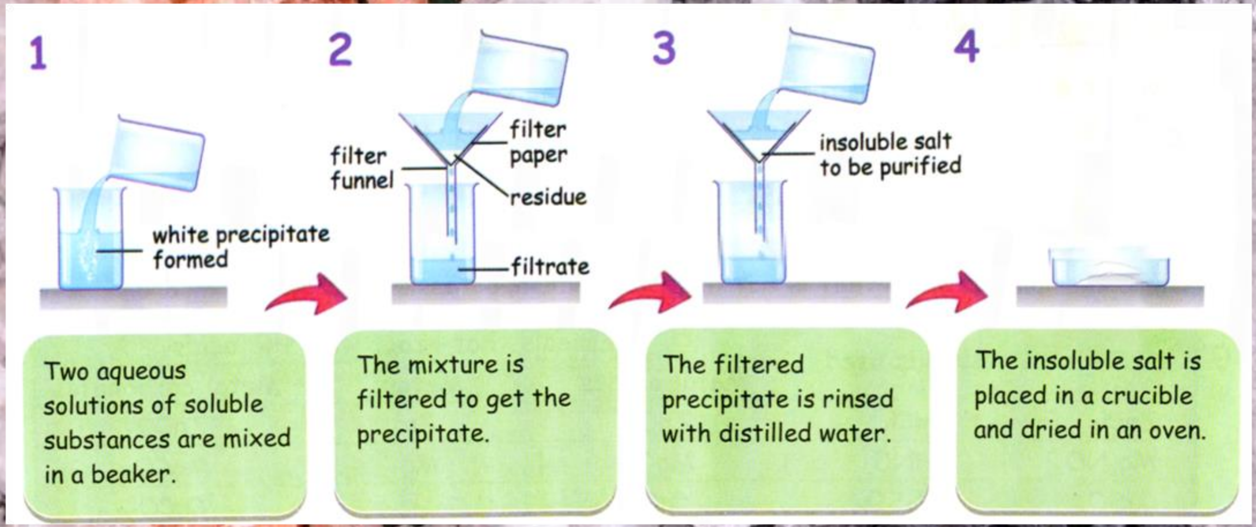
Choosing which method to use depends on the **solubility of the salt** and the **solubility of the reagents.**

Use the table above to see how each preparation method is different!

SUMMARY TABLE

SALT PREPARATION

PREPARATION METHOD	PRECIPITATION	TITRATION	ACID + INSOLUBLE SUBSTANCE
SOLUBILITY OF SALT (Product in reaction)	INSOLUBLE	SOLUBLE	SOLUBLE
Common elements' salt	**ALL INSOLUBLE SALTS**	**Group I salts / SPA salts**	- **Group II salts** - **Group III salts** - **Transition metal salts** - **Unreactive metal salts**
EXAMPLE OF SALTS	-All carbonates except SPA - Silver Chloride - Lead Chloride - Barium Sulfate - Calcium Sulfate - Lead Sulfate - Group II oxides/ hydroxides	- Sodium nitrate - Potassium chloride - Sodium sulfate - Potassium carbonate	- Magnesium sulfate - Aluminium nitrate - Zinc chloride - Iron sulfate - Lead nitrate - Copper chloride
REASONING (MOST IMPORTANT)	Mix 2 soluble reactants that contain the correct ions. Get an insoluble salt as the **only solid in the reacting solution** and collect using filtration.	Reactants are soluble. So is the product. The only way to get a pure substance is to find the **exact volume to react through titration.**	Use **excess of the insoluble** to is ensure that **all the acid is fully reacted.** The **only liquid in the resultant solution is the soluble salt.**
CHEMICAL EQUATION (Example)	*barium nitrate + sodium sulfate →* ***barium sulfate*** *(insoluble) + sodium nitrate* (salt collected using filtration) *SOLUBLE + SOLUBLE → INSOLUBLE SALT*	*sodium hydroxide+ sulfuric acid →* ***sodium sulfate*** *(soluble) + water* (neutralisation reaction) (water removed through crystallisation) *SOLUBLE + INSOLUBLE → SOLUBLE SALT*	*acid + carbonate → salt + water + carbon dioxide gas* *(water removed through crystallisation)* *acid + base → salt + water* *(water removed through crystallisation)* *acid + metal → salt + hydrogen gas* *SOLUBLE + INSOLUBLE → SOLUBLE SALT*



PRECIPITATION

PRECIPITATION

The aqueous solutions of two appropriate soluble salts are mixed.

One salt must contain the cation needed while the other must contain the anion needed.

The **desired salt** produced by the reaction must be **insoluble.**

Other products formed by the reagent must be soluble.

When the two solutions are mixed, the ions in the solution mix. The insoluble salt will precipitate out and can be filtered out and washed with distilled water to obtain a pure sample.

Both reactants used must to be soluble in order to isolate the precipitate.

The last step for preparation of insoluble salt consists of filtering, washing with distilled water and drying with filter paper.

This step ensures that there are no impurities adhering to the salt obtained.

Steps:
1) Mix the 2 reactants.
2) Filter and collect residue.
3) Wash & dry with filter paper.

ACID + INSOLUBLE SUBSTANCE

React excess of insoluble substance (metal, carbonate, oxide/hydroxide) **with acid**.

We have to add **excess of our insoluble substance to ensure that all the acid is fully reacted** such that the filtrate that we collect is a pure sample of the soluble salt.

Ensure that the insoluble substance contain the cation that you need and the acid contains the anion needed.

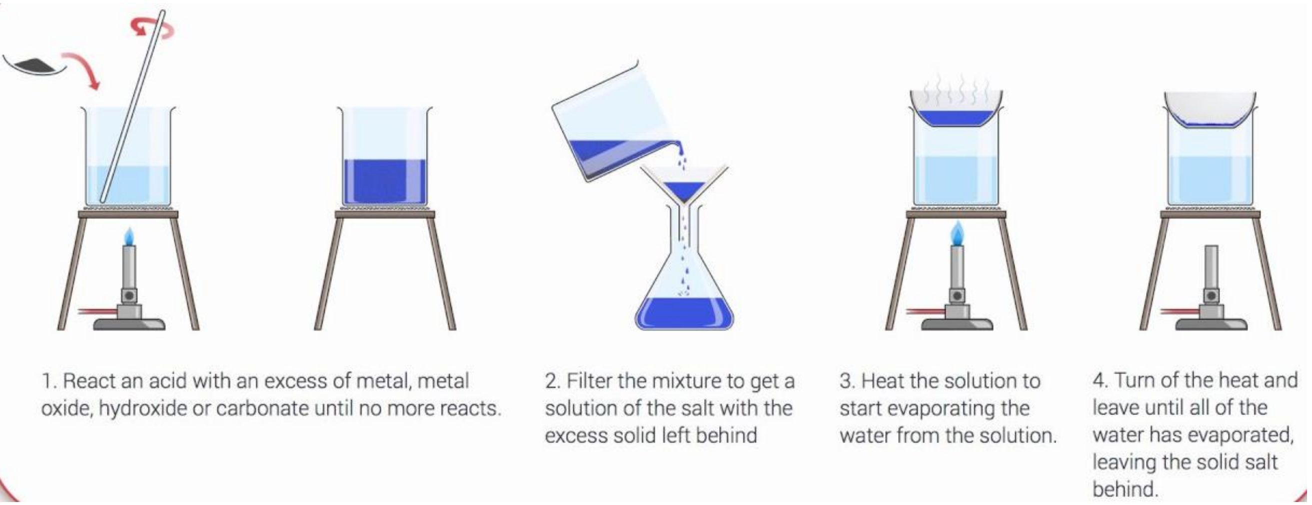
To **remove the excess metal, filter the solution and collect the filtrate (soluble salt).**

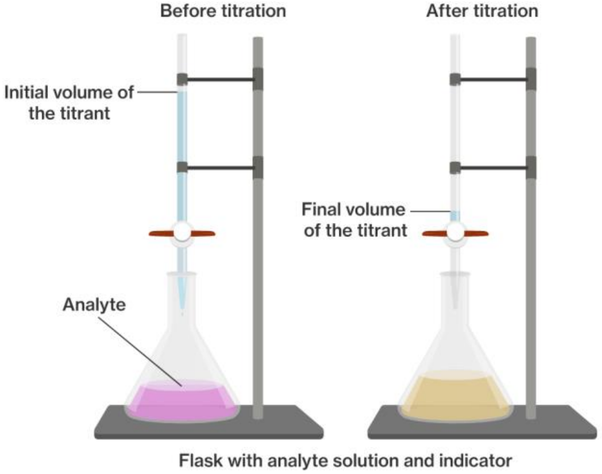
Heat the filtrate until a hot saturated solution of the salt is obtained. Salt crystals will appear when the solution cools.

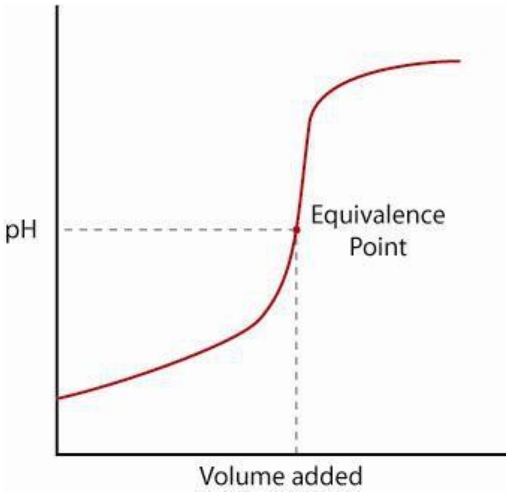
Filter the resultant mixture to obtain the crystals.

The crystals can then be purified by washing them with a little cold distilled water and dried between sheets of dry filter paper.

Steps:
1) Mix the 2 reactants.
2) Filter and collect filtrate.
3) Heat till saturation & allow to cool. Crystals will form.
4) Filter to collect crystals.
5) Wash & dry with filter paper.







TITRATION

TITRATION

Soluble salts can also be prepared by reacting an acid with an alkali. However, there is **no easy way of separating the different solutions as they are all mixed together.**

The solution to this problem is to know the **exact amount of alkali needed to react with a fixed amount of acid.**

1) Using a pipette, transfer 25.0 cm^3 of dilute acid into a conical flask.

2) Add a few drops of indicator to the acid. (phenolphthalein is colourless in acidic solutions)

3) Fill a burette with dilute alkali. Record the initial burette reading. Slowly release the dilute alkali into the conical flask until a change in colour of the solution. (the last drop caused the solution to turn pink as the solution became alkaline after all the acid has been neutralised)

4) Record the final burette reading. The difference between the initial and final reading gives the volume of alkali needed to completely neutralise the acid.

5) Repeat the experiment with the same amount of acid & alkali, but without adding the indicator. The flask now contains only the soluble salt and water.

6) Pour the solution into an evaporating dish. Heat the solution until a hot saturated solution is obtained.

7) Allow the solution to cool and for crystals to form. Filter and collect the crystals. Dry the crystals between sheets of dry filter paper.

3 methods

There are only 3 ways to prepare a salt.

Choosing which method to use depends on the **solubility of the salt** and the **solubility of the reagents.**

Is everything clearer now? Hopefully lel.

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