

Acids, Bases, & Salts

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Soluble and insoluble salts

- Salts are ionic compounds. Most salts, with a few exceptions, are soluble in water.

Chloride salts Cl^-



All are **soluble**
except

- AgCl
- PbCl_2

Sulfate salts SO_4^{2-}



All are **soluble**
except

- BaSO_4
- PbSO_4
- CaSO_4

Carbonates CO_3^{2-}



All are **insoluble**
except

- Na_2CO_3
- K_2CO_3
- $(\text{NH}_4)_2\text{CO}_3$

Na^+ , K^+ , NH_4^+ , NO_3^-



All are **soluble**
in water

Practice 1

► Write the formulae of the following salts and classify them as soluble or insoluble salts in water.

- | | | |
|-------------------------|----------------------------|-----------|
| 1. Barium chloride, | BaCl_2 | Soluble |
| 2. Barium sulfate, | BaSO_4 | Insoluble |
| 3. Calcium nitrate, | $\text{Ca}(\text{NO}_3)_2$ | Soluble |
| 4. Lead(II) chloride, | PbCl_2 | Insoluble |
| 5. Iron(II) sulfate, | FeSO_4 | Soluble |
| 6. Magnesium carbonate, | MgCO_3 | Insoluble |
| 7. Potassium carbonate, | K_2CO_3 | Soluble |
| 8. Silver chloride, | AgCl | Insoluble |
| 9. Zinc chloride | ZnCl_2 | Soluble |

Methods of preparing salts

Q1. Is the salt to be prepared soluble in water?

No

Precipitation method

2 aqueous solutions

Yes

Q2. Is the salt to be prepared
S.P.A. salts or group I metals
Salts?

S.P.A. salts
Sodium Na^+ ,
Potassium K^+ ,
Ammonium NH_4^+

No

Acid + excess solids

- Acid + excess metals
(excluding **K, Na, Ca**, **Cu, Ag**)
highly reactive **unreactive**
- Acid + excess insoluble carbonates
- Acid + excess insoluble bases
(metal oxides or metal hydroxides)

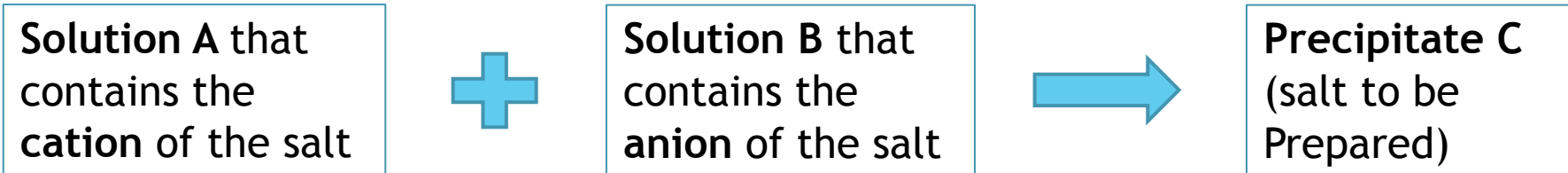
Yes

Titration method

- Acid + alkali
- Acid + soluble carbonates

Preparation of insoluble salts

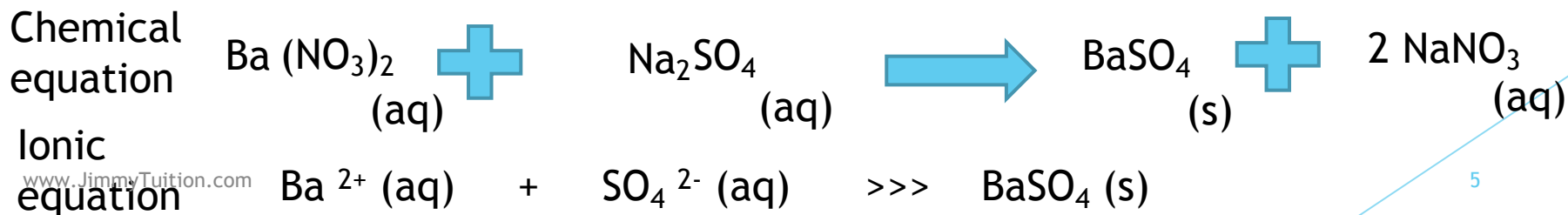
- ▶ All insoluble salts can be prepared by **precipitation method**.
- ▶ To prepare an insoluble salt, mix a solution that contains the cation (positive ion) of the salt with another solution that contains the anion (negative ion) of the salt.



Solution A - use a soluble salt that contains the cation. A suitable salt is the **nitrate salt** because all nitrate salts are soluble in water.

Solution B - use a **sodium salt** that contains the anion because all sodium salts are soluble in water. An acid that contains the anion can be also used.

Example: Preparation of **barium sulfate**



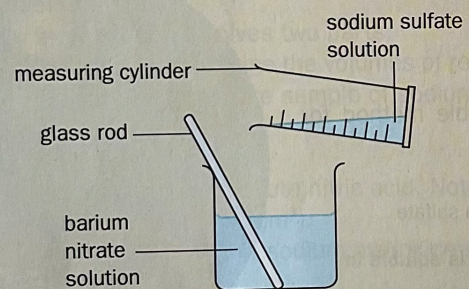
Precipitation method

Aim

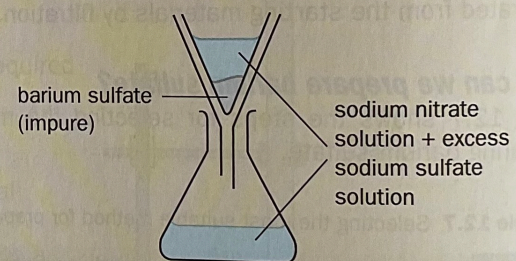
To prepare barium sulfate by precipitation

Procedure

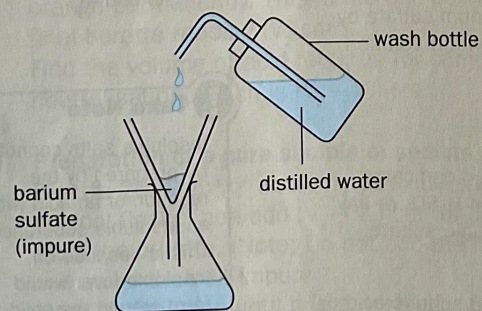
1. Pour about 50 cm³ of barium nitrate solution into a small beaker. Add sodium sulfate solution (in excess) and stir until no more precipitate forms.



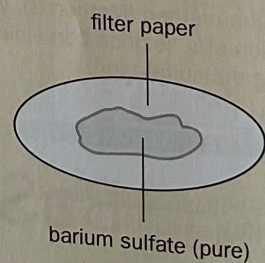
2. Filter to collect the precipitate.



3. Wash the precipitate with a little distilled water to remove impurities.



4. Allow the precipitate to dry on a piece of filter paper.



Titration method (SPA salts or group I metals salts)

- ▶ Sodium, potassium and ammonium salts (and group I metals salts) are prepared using the titration method.
- ▶ Example: preparation of potassium nitrate KNO_3 from potassium hydroxide and nitric acid.

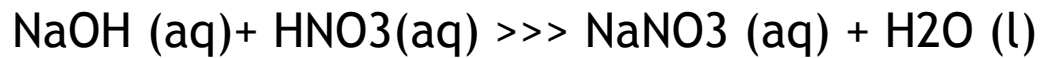
Stage 1: **Titration**

A titration is carried out to determine the actual volume ($V \text{ cm}^3$) of dilute nitric acid required to neutralize 25 cm^3 of sodium hydroxide solution. In this experiment, **an indicator is added to detect the end-point.**

Stage 2: **Neutralization**

$V \text{ cm}^3$ of nitric acid is added to neutralize 25 cm^3 of sodium hydroxide solution. In this experiment, **no indicator is used** as this would contaminate the salt produced.

Titration method



Aim

To prepare sodium nitrate by titration

Procedure

This investigation involves two parts:

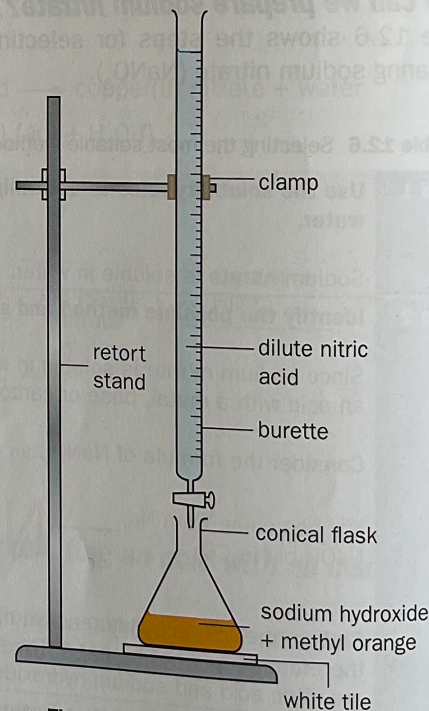
- (a) Titration to determine the volumes of reactants required
- (b) Preparation of a pure sample of sodium nitrate

(a) Titration

1. Fill a burette with dilute nitric acid. Note the initial burette reading ($V_1 \text{ cm}^3$).
2. Pipette 25.0 cm^3 of sodium hydroxide solution into a conical flask.
3. Add one or two drops of methyl orange (indicator) to the sodium hydroxide solution. The solution turns yellow (Figure 12.5).
4. While swirling the conical flask, add dilute nitric acid from the burette slowly until the solution just turns orange permanently. This is the end-point. Record the final burette reading ($V_2 \text{ cm}^3$).
5. Find the volume of acid required for complete neutralisation, which is $(V_2 - V_1) \text{ cm}^3$.

(b) Preparation of a pure sample of sodium nitrate

1. Pipette 25.0 cm^3 of sodium hydroxide solution into a conical flask. Then add $(V_2 - V_1) \text{ cm}^3$ of dilute nitric acid from the burette. (Note: Do not add the indicator as it will make the salt impure.)
2. Heat the solution until it is saturated.
3. Allow the saturated solution to cool so that the salt can crystallise.
4. Filter to collect the crystals. Then, wash the crystals with a little cold water to remove impurities. Dry the crystals between a few sheets of filter paper.



▲ Figure 12.5 Titration of sodium hydroxide with dilute nitric acid

Acid + excess solids (soluble but not SPA salts)

▶ Step 1: Dissolving

Add **excess** solid (insoluble base, insoluble carbonate or metal) to the acid in the beaker. Stir to dissolve the solid.

▶ Step 2: Filtering

Filter to remove the excess solid. Collect the filtrate (salt solution) in an evaporating dish.

▶ Step 3: Concentrating

Evaporate the salt solution by heat to obtain a saturated solution.

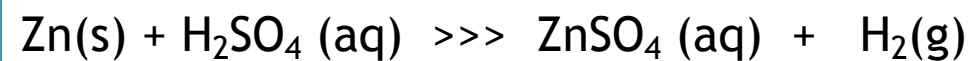
▶ Step 4: Crystallizing

When the hot, saturated solution is left to cool, crystals of salt are formed.

▶ Step 5: Filtering

Filter to remove the salt crystals in the residue. Then wash the crystals with a little cold distilled water to remove impurities. Dry the crystals between few sheets of filter paper.

Acid + excess solids

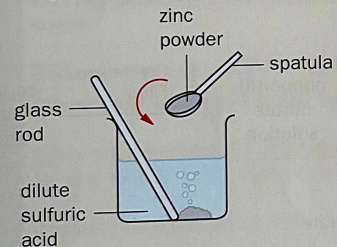


Aim

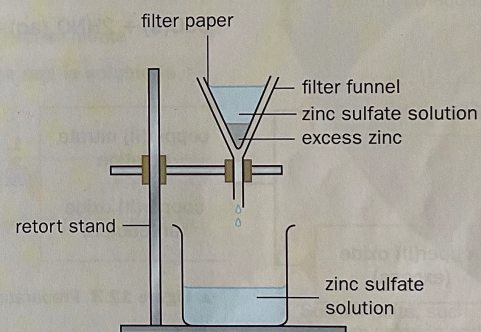
To prepare zinc sulfate from the reaction of an acid with a metal

Procedure

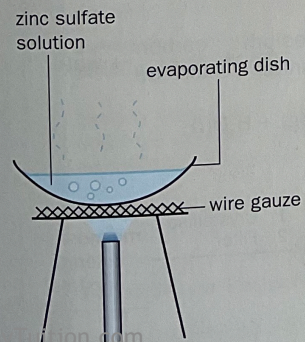
1. Fill half a beaker with dilute sulfuric acid. With constant stirring, add zinc powder until no more reaction occurs with the acid or no more effervescence is observed. (Effervescence is the release of gas bubbles due to a chemical reaction in the liquid.)



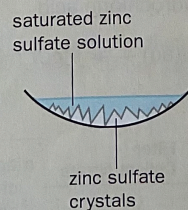
2. Filter to remove the excess (unreacted) zinc powder. Collect the filtrate. This is zinc sulfate solution.



3. Heat the filtrate until it is saturated.



4. Allow the saturated solution to cool so that the salt can crystallise.



5. Filter to collect the crystals. Then wash the crystals with a little cold water to remove impurities. Dry the crystals between a few sheets of filter paper.

