SOLUBILITY RULES OF SALTS

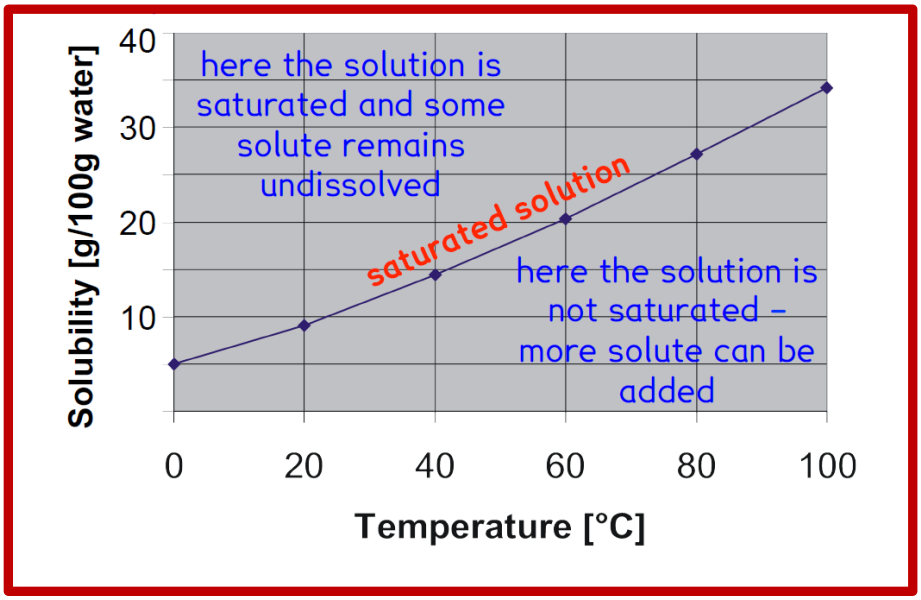
- Reactions of (acidic, basic, neutral).

Solubility

- It is not as simple as substances being ‘soluble’ or ‘insoluble’ – we need to know how soluble they are, and understand how their solubility changes with temperature.
- The solubility of a substance is defined as the maximum mass (in g) of that substance that will dissolve in 100ml of water. Especially, this depends on the temperature of the water. so that, is the ability of a solid, liquid, or gaseous chemical substance (referred to as the solute) to dissolve in solvent (usually a liquid) and form a solution.
- A solution is saturated when it contains the maximum mass of the solute that can dissolve at that temperature.
- If we add more solute to a saturated solution, it won’t dissolve.

Solubility Curves

These show how the solubility of a substance varies with temperature.



Using Solubility Curves

i) What is the lowest temperature at which we can dissolve 20g of the solute in 100g of water?

Answer / 60°C

ii) How much solute will dissolve in 100g of water at 40°C?

Answer / 15g

iii) How much solute will dissolve in 50g of water at 60°C?

Answer / 20g in 100ml water, so 10g in 50ml water

iv) What is the lowest temperature required to dissolve 30g of solute in 200ml of water?

Answer / Same as 15g in 100ml water so 40°C

v) 27g of solute is dissolved in 100ml of water at 80°C to make a saturated solution. The solution is cooled to 20°C (room temperature).

- **What would you observe?**

Answer/ crystals of the solute would form

- **What mass of solute would remain dissolved?**

Answer/ 9g≈

- **What mass of crystals would form?**

Answer/ 27-9 = 18g≈

- **How would you separate the crystals from the remaining solution?**

Answer/ Filtering

- **After removing the crystals, is the remaining solution still saturated?**

Answer/ Yes

❖ Making salts

The methods for making different salts depend on the solubility of the salt in water. We need to be able predict if a salt will be soluble:

Solubility Rules for ionic compounds in water

1. sodium, potassium and ammonium salts are soluble
2. all nitrates are soluble
3. chlorides are soluble **except silver and lead (II) chlorides**
4. sulphates are soluble **except barium, calcium and lead (II)**
5. calcium hydroxide is slightly soluble
6. predict that other ionic compounds are insoluble

Investigating solubility practically

Method:

1. Add known mass of solute and known volume of water in a boiling tube.
2. Calculate solubility (g of solute per 100ml of water) when this forms a saturated solution.
3. Heat mixture in hot water bath until all the solute dissolves.
4. Cool in an ice bath until crystals just start to appear – record temperature.
5. Add known volume of water to the boiling tube.
6. Repeat steps 2 – 5 until sufficient points have been obtained to plot solubility curve.

Use this method to plot a solubility curve for ammonium chloride, starting with 2.6g of solute and 4ml of water, and adding 1ml each time.

Methods for making salts

A salt is made when the hydrogen ions in an acid are **replaced** by metal ions (or ammonium ions).

The name of the salt begins with the name of the metal, followed by a name reflecting the acid it was made from:

e.g

sodium chloride

(NaCl)

from hydrochloric acid

(HCl)

magnesium sulphate

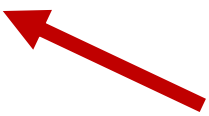
($MgSO_4$)

from sulphuric acid

(H_2SO_4)

potassium nitrate

(KNO_3)



from nitric acid

(HNO_3)

There are two methods for making a salt – which one we use depends on whether the salt we want to make is soluble or insoluble **(use the solubility rules)**.

In both cases, the method is designed so that:

- ❖ we can tell when the reaction is complete
- ❖ we can remove unreacted reactants
- ❖ we can remove any products we don't want
- ❖ so, we obtain a clean, dry, pure sample of our salt

The techniques we will need are:

- ❖ removing a solid from a solution
- ❖ removing the solvent (water) from a solution

Method for making soluble salts

Choose a solid reactant that will react with an acid to make the salt we want. This is likely to be:

- A **metal** e.g. Mg, Zn, Fe

Reaction: **metal + acid → salt + hydrogen**

- A **metal oxide** e.g. CuO

Reaction: **metal + acid → salt + water**

- A **metal carbonate** e.g. $CuCO_3$, $ZnCO_3$

Reaction: **metal + acid → salt + water + CO_2**

How will we know when the reaction is complete?

How can remove unreacted reactants?

How can remove any products we don't want?

MATERIALS AND METHODS

1. Add solid reactant to acid until no more will react and some solid is left. Warming may be needed if the reaction is slow (e.g. with metal oxides).
2. Filter to remove unreacted solid reactant.
3. Boil the salt solution in an evaporating dish to remove water until the solution becomes saturated; heat until crystals start to form e.g. on the end of a glass rod after dipping in the solution.
4. Allow the salt solution to cool so that crystals form.
5. Filter to obtain the crystals and discard the remaining solution.
6. Dry the crystals (warm oven), or leave in warm place for the remaining water to evaporate.

Use this method to prepare the salt copper sulphate from a metal oxide. A full write-up of this practical is required.

Making a salt with acid + metal

General equation:

METAL + ACID → SALT + HYDROGEN

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

Works for:

Reactive metals, but **DANGEROUS** if the metal is too reactive (e.g**. Na or K**) because reaction is exothermic.

Observations:

The solid metal will disappear as it reacts

There will be **bubbling/fizzing** as a gas is produced Heat will be produced

Making a salt with acid + metal oxide

General equation:

METAL OXIDE + ACID → SALT + WATER

e.g. $CuO_{(s)}$ + $H_2SO_{4(aq)}$ → $CuSO_{4(aq)}$ + $H_2O_{(l)}$

Works for:

All metal oxides. Useful for making salts of unreactive metals e.g. copper or lead.

Observations:

The solid metal oxide will disappear as it reacts

Note:

The acid may require warming to speed up the reaction

Making a salt with acid + metal carbonate

General equation:

METAL CARBONATE + ACID → SALT + WATER + CARBON DIOXIDE

e.g. $ZnCO_{3(s)}$ + $H_2SO_{4(aq)}$ → $ZnSO_{4(aq)}$ + $H_2O_{(l)}$ + $CO_{2(g)}$

Works for:

All metal carbonates. Useful for making salts of unreactive metals e.g. copper

Observations:

Solid metal carbonates will disappear as they react There will be bubbling/fizzing as a gas is produced

Making a salt with acid + alkali

We know that an alkali neutralizes an acid to make a salt and water, and we can crystallize the salt solution.

- Where are the difficulties?
- How will we know when the reaction is complete?
- How can remove unreacted reactants?
- How can remove any products we don't want?

When we react an acid and an alkali, we need to add exactly the right amount of each so there is no acid or alkali left over:

- we could use a **pH** probe to stop when **pH=7**
- we could test drops of the reaction mixture with universal indicator paper to get **pH=7**
- we could do a **titration** to determine what volumes of acid and alkali to add

METAL HYDROXIDE + ACID → SALT + WATER

e.g. $NaOH_{(aq)}$ + $HCl_{(aq)}$ → $NaCl_{(aq)}$ + $H_2O_{(l)}$

Works for:

All alkalis. Useful for salts of reactive metals such as sodium or potassium and to make ammonium salts.

Ammonia solution contains ammonium hydroxide:

$$NH_3(g) + H_2O(L) \rightarrow NH_4OH(aq)$$

Observations:

None! You are adding two colorless solutions together to form a colorless solution and water.

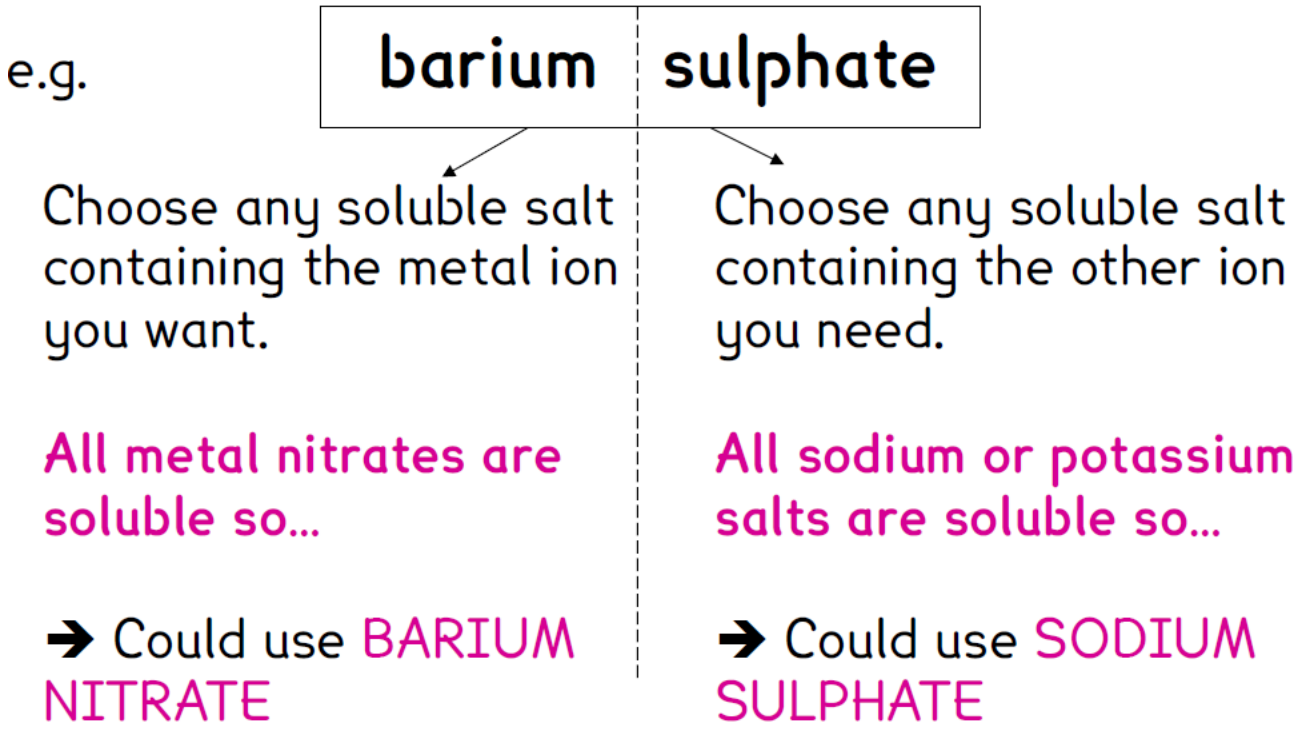
Use this method to prepare the salt ammonium chloride. A full write-up of this practical is required.

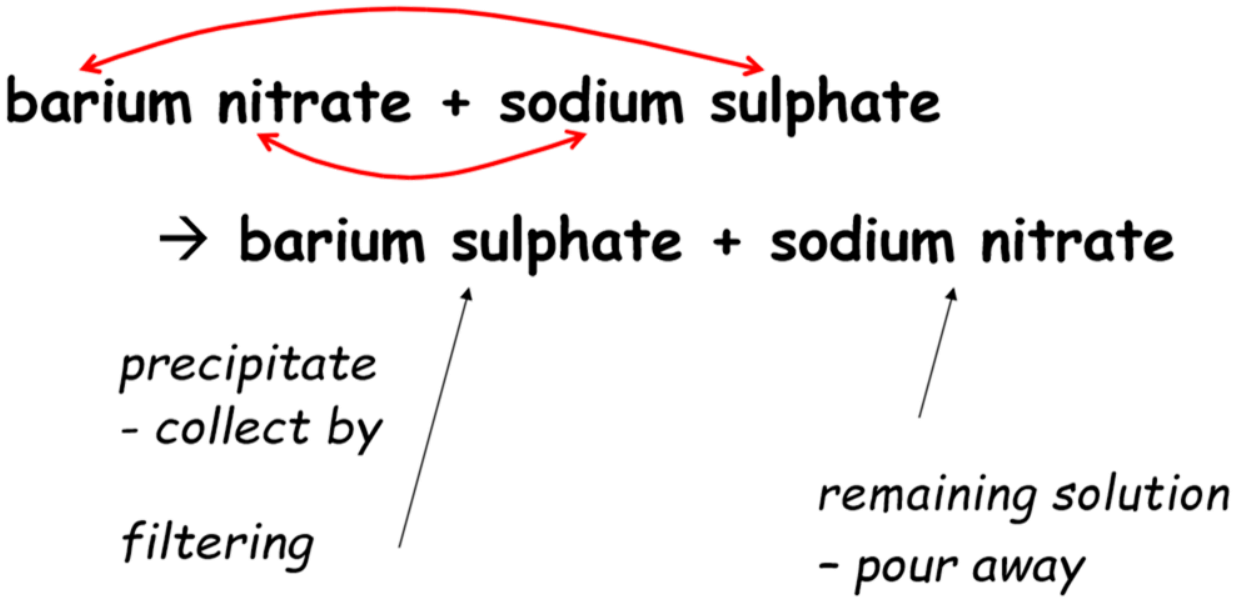
Method for making <u>insoluble</u> salts

- Why not just use the same method we have learnt for making soluble salts? Which step in that method will make it fail when the product is an insoluble salt?
- When we need to make an insoluble salt, we can't filter to remove unreacted solid reactants, so we choose for both of our reactants to be solutions (liquids).
- Making an insoluble solid by reacting solutions of two soluble substances together is called a **precipitation** reaction. The **precipitate** of our insoluble salt can be separated from the remaining solutions after the reaction by filtration.

Choosing which soluble substances to react

Write the name of the substance you want to make





Q/ Explain how you would make insoluble silver bromide by this method?

MATERIALS AND METHODS

1. Mix two solutions in a to form a precipitate of the insoluble salt.
2. Remove the precipitate from the remaining solution by filtering.
3. Wash the solid precipite with distilled water to remove traces of the soluble reactants and products.
4. Dry the precipitate (warm oven) to remove the remaining water.

Use this method to prepare the salt lead sulphate. A full write-up of this practical is required.