

# Mastering Chemistry

- Book 2A
- Topic 4 Acids and Bases



# Content

- ➡ 16.1 Neutralising an acid
- ➡ 16.2 Energy change during neutralisation
- ➡ 16.3 Salts
- ➡ 16.4 Naming of salts
- ➡ 16.5 Soluble salts and insoluble salts
- ➡ 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts)
- ➡ 16.7 Preparing sodium, potassium and ammonium salts

Continued on next page ➡



## Content

- ➡ **16.8 Preparing insoluble salts**
- ➡ **16.9 Calculations involving salt formation**
- ➡ **16.10 Uses of neutralisation**
- ➡ **Key terms**
- ➡ **Summary**
- ➡ **Unit Exercise**



## 16.1 Neutralising an acid (p.71)

- ◆ A base is a substance that neutralises an acid to form a salt and water only. It is a chemical opposite of an acid.





## 16.1 Neutralising an acid (p.71)

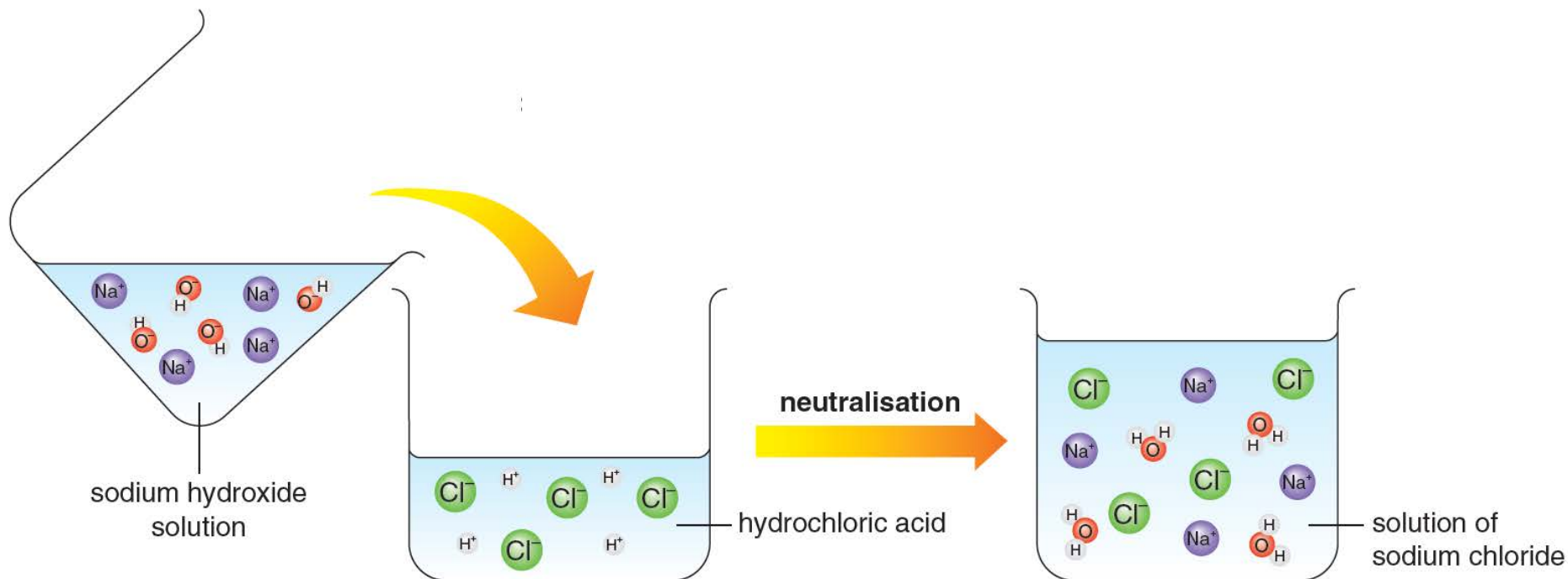
### Neutralising an acid with an alkali

- ◆ The pH changes when neutralisation happens. The pH increases when sodium hydroxide solution is added to the acid.
- ◆ If equal volumes of the same concentration of hydrochloric acid and sodium hydroxide solution are mixed, the resulting solution has a pH of 7. The acid has been neutralised and a neutral solution has been formed.



## 16.1 Neutralising an acid (p.71)

- Hydrochloric acid reacts with sodium hydroxide solution to form sodium chloride and water.

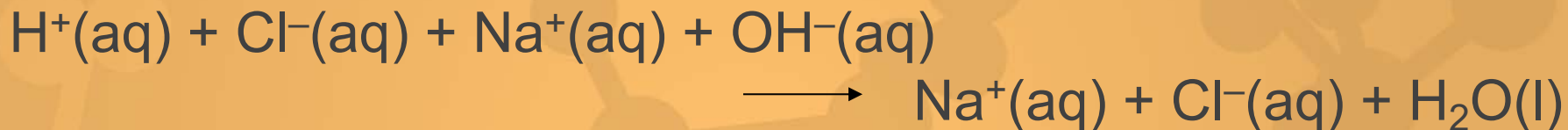




## 16.1 Neutralising an acid (p.71)

- ◆ The best way to show what is happening in the neutralisation reaction is to write an ionic equation for it.

- ◆ First, rewrite the equation to show the ions in the solution.



- ◆ Leaving out the chloride ions and sodium ions that do not take part in the reaction, the ionic equation for the reaction is obtained.



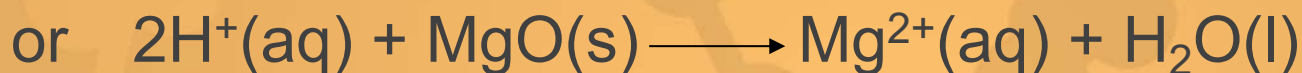
- ◆ The ionic equation shows that ions which cause acidity ( $\text{H}^+(\text{aq})$ ) react with ions which cause alkalinity ( $\text{OH}^-(\text{aq})$ ) to produce neutral water molecules ( $\text{H}_2\text{O}(\text{l})$ ).



## 16.1 Neutralising an acid (p.71)

### Neutralising an acid with an insoluble metal oxide / hydroxide

- ◆ Dilute sulphuric acid reacts with magnesium oxide to form magnesium sulphate and water.



- ◆ Dilute nitric acid reacts with copper(II) hydroxide to form copper(II) nitrate and water.



**Neutralisation is the combination of hydrogen ions and hydroxide ions (or oxide ions) to form water molecules.**



## 16.1 Neutralising an acid (p.71)

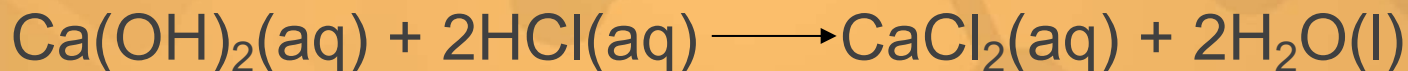
### Practice 16.1

1 Some farmers use calcium hydroxide to control soil acidity.

a) Why is it important to control soil acidity?

Plants cannot grow well if the soil is too acidic. / Crop yields are lower if the soil is too acidic.

b) Calcium hydroxide solution reacts with hydrochloric acid according to the equation below.



i) Name this type of chemical reaction.

Neutralisation

ii) Write the ionic equation for the reaction.





## 16.1 Neutralising an acid (p.71)

### Practice 16.1 (continued)

2 Phosphoric acid can be used to remove rust,  $\text{Fe}_2\text{O}_3$ .



a) Complete the above chemical equation for the reaction involved.

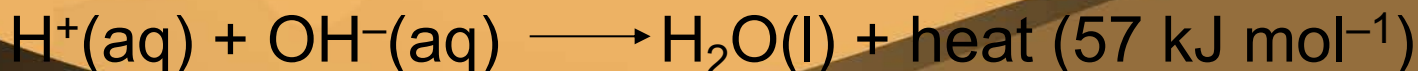
b) Name the salt produced.

Iron(III) phosphate



## 16.2 Energy change during neutralisation (p.73)

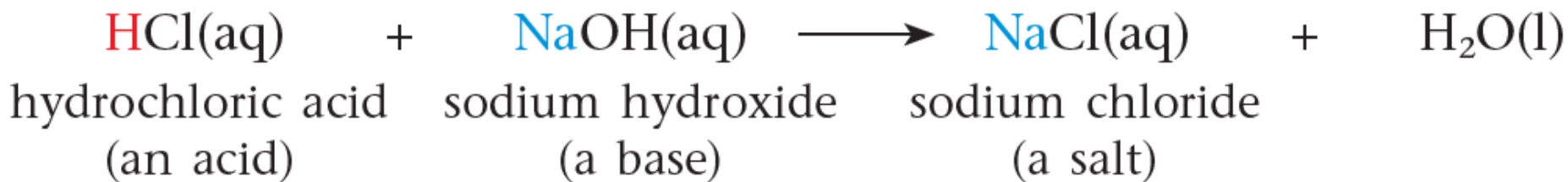
- ◆ When a chemical reaction occurs, it is usually accompanied by an energy change. Energy may be taken in from or given out to the surroundings, usually in the form of heat.
- ◆ Reactions that give out heat to the surroundings are **exothermic (放熱)**. Neutralisation is an example of exothermic reactions.
- ◆ For neutralisation between all strong acids and strong alkalis, 57 kilojoules (kJ) of heat are given out per mole of water produced. This is because strong acids and strong alkalis undergo complete dissociation in water. The reaction between a strong acid and a strong alkali is the combination of hydrogen ions and hydroxide ions to form water molecules.





## 16.3 Salts (p.74)

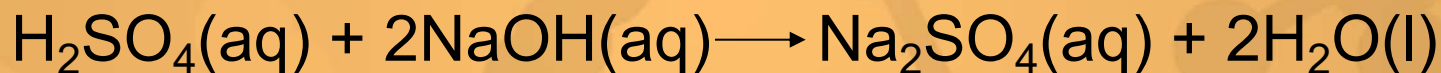
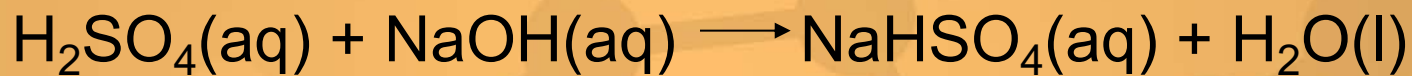
- ◆ In the neutralisation of an acid, the hydrogen ions react with a base to form a salt and water.
- ◆ Salt is the general name for a compound formed when the hydrogen ions in an acid are wholly or partially replaced by metal ions or ammonium ions from a base.
- ◆ For example, when hydrochloric acid is neutralised by sodium hydroxide solution, the salt sodium chloride is formed.





## 16.3 Salts (p.74)

- ◆ Sulphuric acid is a dibasic acid. One molecule of sulphuric acid can produce two hydrogen ions in water.
- ◆ It can form two different salts, sodium hydrogensulphate and sodium sulphate, when reacted with sodium hydroxide solution:



- ◆ A salt formed by replacing only part of the hydrogen ions from an acid is called **acid salt (酸式鹽)**. A salt formed by replacing all of the hydrogen ions from an acid is called **normal salt (正鹽)**.
- ◆ Sodium hydrogensulphate is an acid salt while sodium sulphate is a normal salt.



## 16.3 Salts (p.74)

- ◆ Hydrochloric acid, nitric acid and ethanoic acid all produce one hydrogen ion per molecule. Thus, they form normal salts only.



## 16.4 Naming of salts (p.75)

- The names of salts and the acids they are formed from.

Acid	Chemical formula of acid	Normal salt		Acid salt	
		Name	Chemical formula	Name	Chemical formula
Hydrochloric acid	HCl	calcium chloride	CaCl <sub>2</sub>		
Nitric acid	HNO <sub>3</sub>	iron(II) nitrate	Fe(NO <sub>3</sub> ) <sub>2</sub>		
Ethanoic acid	CH <sub>3</sub> COOH	ammonium ethanoate	CH <sub>3</sub> COONH <sub>4</sub>		
Carbonic acid	H <sub>2</sub> CO <sub>3</sub>	potassium carbonate	K <sub>2</sub> CO <sub>3</sub>	potassium hydrogencarbonate	KHCO <sub>3</sub>
Sulphuric acid	H <sub>2</sub> SO <sub>4</sub>	sodium sulphate	Na <sub>2</sub> SO <sub>4</sub>	sodium hydrogensulphate	NaHSO <sub>4</sub>
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	sodium phosphate	Na <sub>3</sub> PO <sub>4</sub>	sodium dihydrogenphosphate	NaH <sub>2</sub> PO <sub>4</sub>
				disodium hydrogenphosphate	Na <sub>2</sub> HPO <sub>4</sub>



## 16.4 Naming of salts (p.75)

- ◆ To form the salt, the hydrogen ion in the acid is replaced by metal or ammonium ion from a base.
- ◆ Notice the link between the name of the acid and that of the salt (shown in blue):
  - hydrochloric acid forms chlorides;
  - nitric acid forms **nitrates** (硝酸鹽);
  - sulphuric acid forms **sulphates** (硫酸鹽).



## 16.4 Naming of salts (p.75)

### Practice 16.2

1 Nitric acid is present in acid rain. It is neutralised by calcium oxide spread on fields.

a) Name the salt formed in the reaction.

**Calcium nitrate**

b) Suggest whether the salt is an acid salt or a normal salt.

**Normal salt**

c) Write the chemical equation for the reaction.





## 16.4 Naming of salts (p.75)

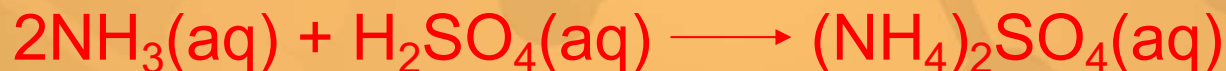
### Practice 16.2 (continued)

2 Ammonium sulphate can be prepared by reacting aqueous ammonia with sulphuric acid.

a) Why can ammonium sulphate be described as a salt?

Hydrogen ions formed from sulphuric acid have been replaced by ammonium ions.

b) Write the chemical equation for the reaction.



c) Name another salt that is produced by reacting aqueous ammonia with sulphuric acid. Give the chemical formula of the salt.

Ammonium hydrogensulphate  $\text{NH}_4\text{HSO}_4$



## 16.5 Soluble salts and insoluble salts (p.77)

- ◆ Salts are ionic compounds.
- ◆ Sodium chloride, common salt, is the salt used to flavour and preserve food. Copper(II) sulphate is another salt. Its solution is used as a fungicide spray for grapevines.



## 16.5 Soluble salts and insoluble salts (p.77)

- Whether a salt is water-soluble or not is one important consideration when working out a preparation method.

Salts	Soluble	Insoluble
Sodium salts	all are soluble	none
Potassium salts	all are soluble	none
Ammonium salts	all are soluble	none
Nitrates	all are soluble	none
Ethanoates	all are soluble	none
Chlorides	most are soluble	silver chloride, lead(II) chloride
Sulphates	most are soluble	barium sulphate, lead(II) sulphate, calcium sulphate
Carbonates	sodium carbonate, potassium carbonate, ammonium carbonate	most are insoluble



## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)

- ♦ The reaction of an acid with a metal, an insoluble base, or an insoluble carbonate, is a common way to make soluble salts like copper(II) sulphate.

**metal + acid  $\longrightarrow$  salt + hydrogen**

**insoluble base + acid  $\longrightarrow$  salt + water**

**insoluble carbonate + acid  $\longrightarrow$  salt + water + carbon dioxide**



## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)

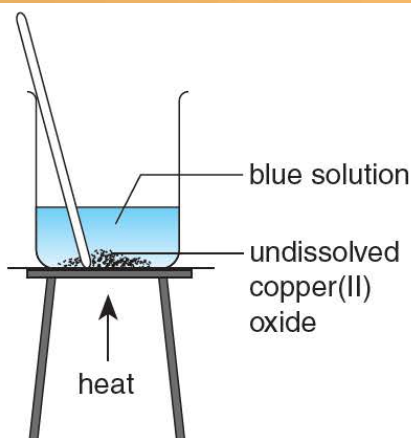
- ♦ The method can be divided into five steps.
  - Step 1* Add an excess of the solid to the acid. Allow to react.
  - Step 2* Filter off the remaining solid. Collect the filtrate.
  - Step 3* Heat the filtrate gently to evaporate the water and concentrate the salt solution. This can be done on a hot water bath.
  - Step 4* Cool the concentrated solution to room temperature to let the crystals form.
  - Step 5* Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper.



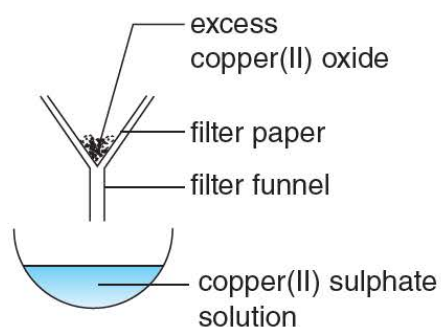
## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)

### Steps in preparing copper(II) sulphate

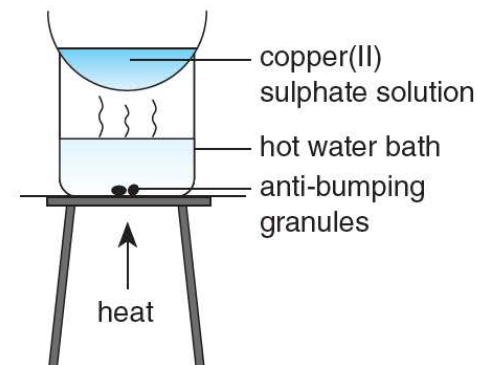
- Copper does not react with dilute sulphuric acid. So to make copper(II) sulphate, you can start with copper(II) oxide, which is insoluble. The reaction that takes place is:



- 1 Add some copper(II) oxide to dilute sulphuric acid. It dissolves on warming, and the solution turns blue. Add more oxide until no more dissolves.



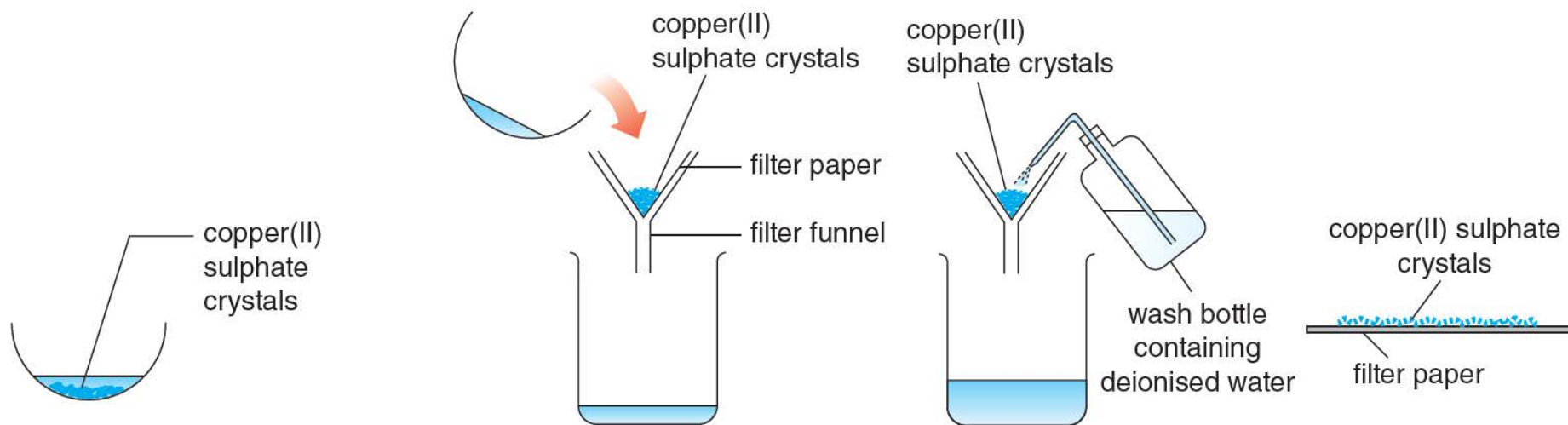
- 2 Filter off the remaining copper(II) oxide. Collect the filtrate.



- 3 Heat to evaporate the water and concentrate the copper(II) sulphate solution.



## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)



- 4 Cool the concentrated copper(II) sulphate solution to room temperature to let the crystals form.

- 5 Filter off the copper(II) sulphate crystals. Wash and dry.

**Preparing copper(II) sulphate crystals by the reaction between dilute sulphuric acid and copper(II) oxide**



## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)

- ◆ Copper(II) sulphate can also be prepared using copper(II) carbonate in this preparation. The reaction that takes place is:



**Copper(II) sulphate crystals**



**Preparing magnesium sulphate crystals from the reaction between an acid and an insoluble carbonate *Ref.***



## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)

### Practice 16.3

An experiment on the preparation of hydrated iron(II) nitrate involves the following five steps:

*Step 1* Warm 30 cm<sup>3</sup> of a dilute acid in a beaker. Add iron(II) carbonate to the acid until in excess.

*Step 2* Filter the reaction mixture and collect the filtrate.

*Step 3* Heat the filtrate until it becomes saturated. Allow it to cool slowly to crystallise out hydrated iron(II) nitrate.

*Step 4* Filter off the crystals formed, and then wash them with a small amount of cold deionised water.

*Step 5* Dry the crystals.

a) Refer to *Step 1*,

- name the acid used; **Dilute nitric acid**
- suggest how one can know that iron(II) carbonate is in excess.

**Any one of the following:**

- Add iron(II) carbonate until unreacted solid can be seen.
- Add iron(II) carbonate until no more gas bubbles off.



## 16.6 Preparing soluble salts (except sodium, potassium and ammonium salts) (p.78)

### Practice 16.3 (continued)

b) Refer to *Step 3*,

i) suggest ONE way to show that a saturated solution has been obtained;

Remove a drop of the solution with a glass rod and place it on a microscopic slide. Observe whether any solids form quickly on the cool glass.

ii) explain why the hot filtrate is allowed to cool slowly.

To give time for the formation of bigger crystals.

c) Refer to *Step 5*,

i) explain why the crystals should NOT be dried by using a Bunsen flame;

Anhydrous salt would be obtained.

ii) suggest a method for drying the crystals.

Absorbs the water by using filter papers. / Place in a desiccator.

d) In case iron(II) carbonate is not available, name another chemical which can react with the acid to make iron(II) nitrate.

Iron(II) oxide / iron(II) hydroxide / iron



## 16.7 Preparing sodium, potassium and ammonium salts (p.81)

- ◆ All sodium, potassium and ammonium compounds are water-soluble.
- ◆ Take sodium sulphate as an example. You can prepare it by the reaction between sodium hydroxide solution and sulphuric acid.



- ◆ Both reactants are soluble, and no gas bubbles are given off. So how can you tell when the reactants have completely reacted? The answer is by carrying out a **titration** (滴定).
- ◆ In a titration, one reactant is slowly added to the other in the presence of an indicator. The indicator changes colour when the reaction is complete.



Preparing sodium sulphate  
from an acid-alkali titration  
Ref.



## 16.7 Preparing sodium, potassium and ammonium salts (p.81)

### Steps in preparing potassium chloride

- ♦ Potassium chloride can be prepared by reacting dilute potassium hydroxide solution with dilute hydrochloric acid.



Potassium chloride crystals



## 16.7 Preparing sodium, potassium and ammonium salts (p.81)

**1** Place dilute hydrochloric acid in a burette.  
Using a pipette and a pipette filler to place 25.00 cm<sup>3</sup> of dilute potassium hydroxide solution in a conical flask. Add a few drops of phenolphthalein.

**2** Run the acid into the flask until the phenolphthalein turns colourless.  
Note the exact volume of acid added.

**3** Place 25.00 cm<sup>3</sup> of the alkali in a conical flask. Run the same volume of acid as noted in **2** into the flask, producing a potassium chloride solution.

**4** Heat gently to evaporate the water and concentrate the potassium chloride solution.

**5** Allow the concentrated potassium chloride solution to cool to room temperature to let the crystals form.

Labels in diagrams: dilute hydrochloric acid, burette, phenolphthalein, indicator turns pink, dilute potassium hydroxide solution, white tile, potassium chloride solution, hot water bath, anti-bumping granules, heat, concentrated potassium chloride solution, potassium chloride crystals, potassium chloride crystals, filter paper, filter funnel, wash bottle containing deionised water, potassium chloride crystals, filter paper.

**Preparing potassium chloride crystals by the reaction between dilute hydrochloric acid and dilute potassium hydroxide solution**



## 16.7 Preparing sodium, potassium and ammonium salts (p.81)

### Practice 16.4

A student prepared some crystals of ammonium sulphate. The following extract was taken from her notes.

Preparing ammonium sulphate  
25 cm<sup>3</sup> of aqueous ammonia and 5 drops of indicator were placed in a conical flask. An acid was added to the flask until the indicator changed colour. The volume of acid used was noted.

- a) Name the acid that the student should use. **Dilute sulphuric acid**  
b) Write the chemical equation for the reaction between aqueous ammonia and the acid stated in (a).



- c) How could the student obtain ammonium sulphate crystals using this method?

Run the same volume of acid as noted before into 25 cm<sup>3</sup> of aqueous ammonia, producing an ammonium sulphate solution.

Heat gently to evaporate the water and concentrate the ammonium sulphate solution.

Allow the concentrated ammonium sulphate solution to cool to room temperature to let the crystals form.

Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper.



## 16.8 Preparing insoluble salts (p.83)

- ◆ Insoluble salts can be prepared by mixing solutions of two soluble salts.
- ◆ Lead(II) nitrate and sodium iodide are soluble salts. They both dissolve in water to form clear, colourless solutions. However, a yellow solid appears when the salts are mixed together. The yellow solid is a precipitate of insoluble lead(II) iodide. It is formed in a **precipitation reaction** (沉淀作用).



- ◆ Any insoluble salts can be prepared using precipitation reactions, provided that appropriate soluble salts are available.



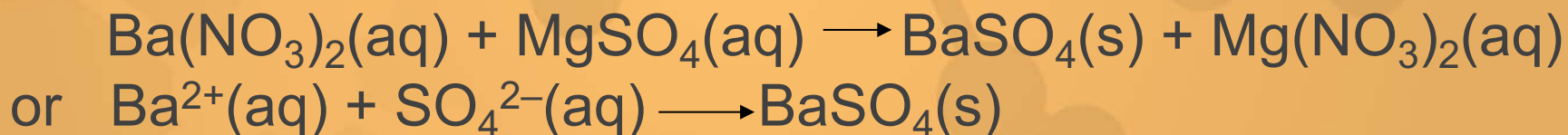
A yellow precipitate of lead(II) iodide forms when lead(II) nitrate solution is mixed with sodium iodide solution



## 16.8 Preparing insoluble salts (p.83)

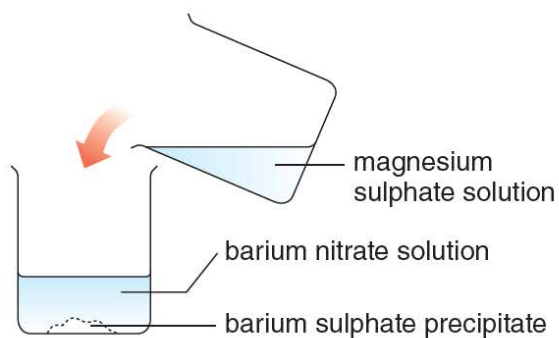
### Steps in preparing barium sulphate

- ♦ Barium sulphate is insoluble in water. Two soluble salts are needed to prepare it. One must contain barium ions and the other contains sulphate ions.
- ♦ Barium nitrate and magnesium sulphate are both soluble in water. The following equations show what happens when their solutions are mixed.

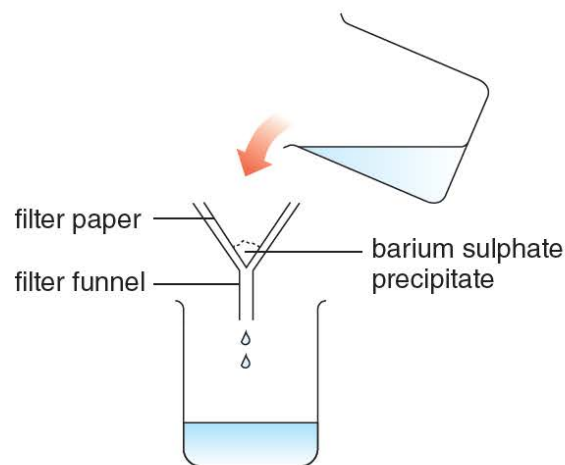




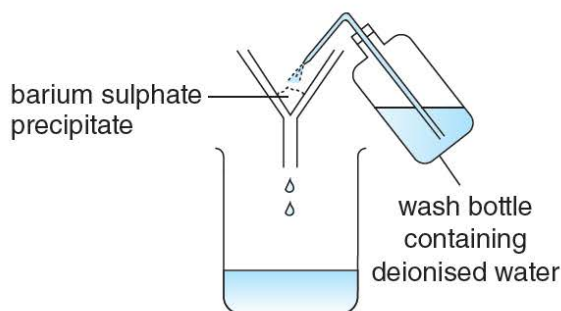
## 16.8 Preparing insoluble salts (p.83)



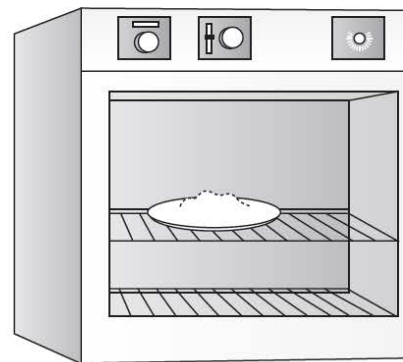
1 Mix solutions of barium nitrate and magnesium sulphate.



2 Filter off the barium sulphate precipitate.



3 Wash the precipitate with cold deionised water.

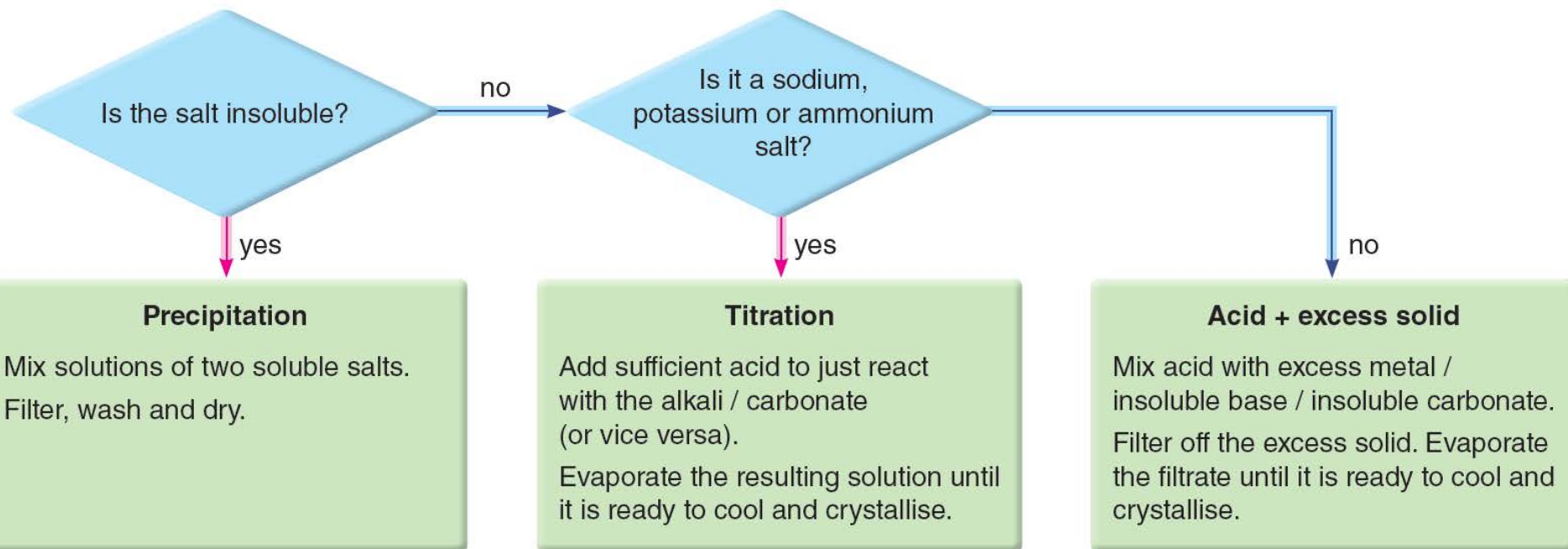


4 Place the precipitate in a warm oven to dry.

**Preparing barium sulphate by the reaction between barium nitrate solution and magnesium sulphate solution**



## 16.8 Preparing insoluble salts (p.83)



**A flow diagram summarising how an appropriate preparation method can be chosen for a particular salt**



**Preparing barium sulphate  
by precipitation Ref.**



## 16.8 Preparing insoluble salts (p.83)

### Practice 16.5

- 1 Outline the steps in preparing silver bromide from solid silver nitrate. State the additional chemical reagents that are required.

Dissolve solid silver nitrate in water.

Mix with excess sodium / potassium bromide solution.

Filter the mixture to obtain the precipitate (silver bromide).

Wash the precipitate with cold deionised water and then dry in an oven.



## 16.8 Preparing insoluble salts (p.83)

### Practice 16.5 [\(continued\)](#)

2 Three ways of preparing salts are

*Method 1* reaction of acid with excess insoluble base or carbonate;

*Method 2* titration using alkali or soluble carbonate;

*Method 3* precipitation.

Complete the table of salt preparations.

Salt	Preparation method	Reagent 1	Reagent 2
Sodium nitrate	Method 2	Nitric acid	Sodium hydroxide / carbonate / hydrogencarbonate
Zinc nitrate	Method 1	Nitric acid	Zinc oxide / hydroxide / carbonate
Lead(II) sulphate	Method 3	Lead(II) nitrate solution	Sodium / potassium / ammonium sulphate solution / dilute sulphuric acid
Magnesium sulphate	Method 1	magnesium carbonate	dilute sulphuric acid



## 16.9 Calculations involving salt formation (p.86)

- ◆ When you mix two solutions to form a salt, you can calculate the concentration of the resulting salt solution or the mass of the salt obtained from the known concentrations and volumes of the two solutions involved.



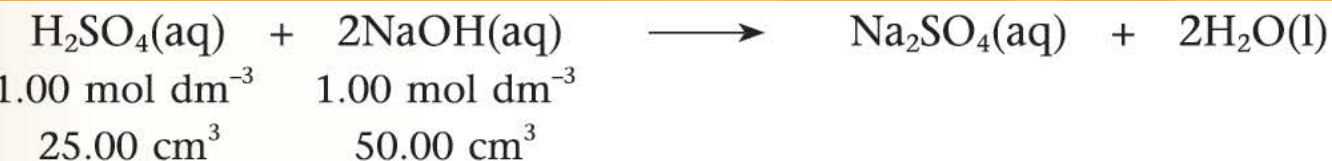
## 16.9 Calculations involving salt formation (p.86)

### Q (Example 16.1)

25.00 cm<sup>3</sup> of 1.00 mol dm<sup>-3</sup> sulphuric acid are completely neutralised by 50.00 cm<sup>3</sup> of 1.00 mol dm<sup>-3</sup> sodium hydroxide.

What is the concentration of the sodium sulphate solution produced by the reaction?

A



Number of moles of acid / alkali used = molarity of solution x volume of solution

$$\begin{aligned} \text{Number of moles of H}_2\text{SO}_4 \text{ used} &= 1.00 \text{ mol dm}^{-3} \times \frac{25.00}{1\,000} \text{ dm}^3 \\ &= 0.0250 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{Number of moles of NaOH used} &= 1.00 \text{ mol dm}^{-3} \times \frac{50.00}{1\,000} \text{ dm}^3 \\ &= 0.0500 \text{ mol} \end{aligned}$$



## 16.9 Calculations involving salt formation (p.86)

### Q (Example 16.1) [\(continued\)](#)

A

According to the equation, 1 mole of  $\text{H}_2\text{SO}_4$  reacts with 2 moles of  $\text{NaOH}$  to produce 1 mole of  $\text{Na}_2\text{SO}_4$ .

In this reaction, 0.0250 mole of  $\text{H}_2\text{SO}_4$  reacts with 0.0500 mole of  $\text{NaOH}$  to produce 0.0250 mole of  $\text{Na}_2\text{SO}_4$ .

$$\begin{aligned}\text{Total volume of the solution} &= (25.00 + 50.00) \text{ cm}^3 \\ &= 75.00 \text{ cm}^3\end{aligned}$$

$$\begin{aligned}\text{Concentration of the sodium sulphate solution produced} &= \frac{\text{number of moles of Na}_2\text{SO}_4}{\text{volume of solution}} \\ &= \frac{0.0250 \text{ mol}}{\left(\frac{75.00}{1\,000}\right) \text{ dm}^3} \\ &= 0.333 \text{ mol dm}^{-3}\end{aligned}$$

$\therefore$  the concentration of the sodium sulphate solution produced is  $0.333 \text{ mol dm}^{-3}$ .



## 16.9 Calculations involving salt formation (p.86)

### Q (Example 16.2)

300.0 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> calcium nitrate solution are mixed with 100.0 cm<sup>3</sup> of 0.300 mol dm<sup>-3</sup> potassium phosphate solution. They react to give calcium phosphate precipitate according to the equation below.



What is the theoretical mass of the calcium phosphate obtained?

(Molar mass of  $\text{Ca}_3(\text{PO}_4)_2 = 310.3 \text{ g mol}^{-1}$ )

### A



Number of moles of  $\text{Ca}(\text{NO}_3)_2$  used = molarity of solution  $\times$  volume of solution

$$\begin{aligned} &= 0.100 \text{ mol dm}^{-3} \times \frac{300.0}{1\,000} \text{ dm}^3 \\ &= 0.0300 \text{ mol} \end{aligned}$$



## 16.9 Calculations involving salt formation (p.86)

### Q (Example 16.2) (continued)

A

Number of moles of  $\text{K}_3\text{PO}_4$  used = molarity of solution  $\times$  volume of solution

$$= 0.300 \text{ mol dm}^{-3} \times \frac{100.0}{1\,000} \text{ dm}^3$$

$$= 0.0300 \text{ mol}$$

According to the equation, 3 moles of  $\text{Ca}(\text{NO}_3)_2$  react with 2 moles of  $\text{K}_3\text{PO}_4$  to give 1 mole of  $\text{Ca}_3(\text{PO}_4)_2$ .

In this reaction, 0.0300 mole of  $\text{Ca}(\text{NO}_3)_2$  reacts with 0.0200 mole of  $\text{K}_3\text{PO}_4$ . Thus,  $\text{K}_3\text{PO}_4$  is in excess.

$$\begin{aligned}\text{Theoretical number of moles of } \text{Ca}_3(\text{PO}_4)_2 \text{ obtained} &= \frac{0.0300}{3} \text{ mol} \\ &= 0.0100 \text{ mol}\end{aligned}$$

$$\begin{aligned}\text{Theoretical mass of } \text{Ca}_3(\text{PO}_4)_2 \text{ obtained} &= \text{number of moles} \times \text{molar mass} \\ &= 0.0100 \text{ mol} \times 310.3 \text{ g mol}^{-1} \\ &= 3.10 \text{ g}\end{aligned}$$

$\therefore$  the theoretical mass of the calcium phosphate obtained is 3.10 g.



## 16.9 Calculations involving salt formation (p.86)

### Practice 16.6

In an experiment to prepare lead(II) chloride, excess dilute hydrochloric acid was added to 10.0 cm<sup>3</sup> of 2.00 mol dm<sup>-3</sup> lead(II) nitrate solution. What was the theoretical mass of the lead(II) chloride obtained? (Molar mass of PbCl<sub>2</sub> = 278.2 g mol<sup>-1</sup>)



Number of moles of Pb(NO<sub>3</sub>)<sub>2</sub>  
= molarity of solution x volume of solution  
= 2.00 mol dm<sup>-3</sup> x  $\frac{10.0}{1\,000}$  dm<sup>3</sup>  
= 0.0200 mol

According to the equation, 1 mole of Pb(NO<sub>3</sub>)<sub>2</sub> reacts with HCl to form 1 mole of PbCl<sub>2</sub>.

i.e. number of moles of PbCl<sub>2</sub> = 0.0200 mol

Mass of PbCl<sub>2</sub>  
= number of moles of PbCl<sub>2</sub>  
x molar mass of PbCl<sub>2</sub>  
= 0.0200 mol x 278.2 g mol<sup>-1</sup>  
= 5.56 g

∴ theoretical mass of lead(II) chloride obtained is 5.56 g.



## 16.10 Uses of neutralisation (p.88)

### Soil treatment

- ◆ Soils with high peat content or with rotting vegetation tend to be acidic. Soils in limestone areas are alkaline.
- ◆ Most crops grow best when the pH of the soil is close to 7.
- ◆ To reduce its acidity, the soil may be treated with calcium oxide. On the other hand, ammonium sulphate may be used to reduce the alkalinity of the soil.



A farmer is liming a field with powdered calcium oxide



## 16.10 Uses of neutralisation (p.88)

### Effluent and waste water treatment

- ◆ Liquid waste from factories is often acidic. If such waste gets into a river, the acid will kill the fish and other aquatic lives.
- ◆ Slaked lime (calcium hydroxide) is often added to the waste to neutralise the acid.
- ◆ Slaked lime is also used to treat the water of streams, rivers and lakes affected by acid rain.



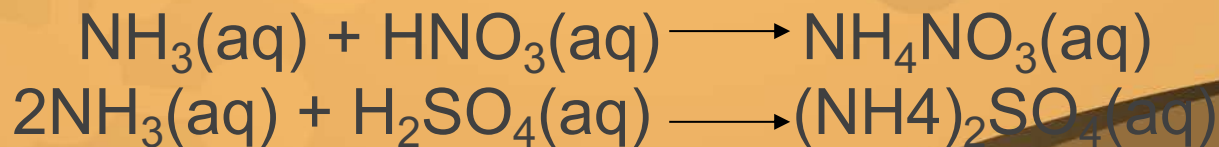
**Addition of slaked lime to stream water to reduce the acidity**



## 16.10 Uses of neutralisation (p.88)

### Production of ammonium salts as fertilisers

- ◆ As plants grow, they absorb minerals and water through their roots from the soil. Over time, the soil may become deficient in minerals.
- ◆ Fertilisers are substances added to the soil to replace the minerals used up by plants.
- ◆ Ammonium salts, such as ammonium nitrate and ammonium sulphate, are the main ingredients in many artificial fertilisers. These two chemicals are prepared from neutralisation reactions involving aqueous ammonia.

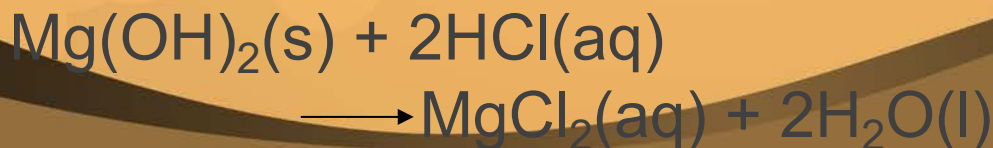




## 16.10 Uses of neutralisation (p.88)

### Acid indigestion treatment

- ◆ The human stomach contains hydrochloric acid which is needed to digest food.
- ◆ Sometimes there is too much of the acid in the stomach that makes people develop symptoms of indigestion.
- ◆ Taking an **antacid** (制酸劑) neutralises some of the hydrochloric acid and relieves the symptoms.
- ◆ Antacid contains two bases: aluminium hydroxide and magnesium hydroxide. These bases neutralise the excess hydrochloric acid in the stomach.



An antacid containing aluminium hydroxide and magnesium hydroxide



## 16.10 Uses of neutralisation (p.88)

### Practice 16.7

- 1 Ant stings contain methanoic acid. What household substance could be used to ease the effect of the sting?

**Baking soda**

- 2 Fish live in water which is neutral. Acid rain decreases the pH of water in lakes and rivers. Both calcium oxide and calcium carbonate can react with the acid and increase the pH.

Explain why calcium carbonate is a better choice.

**Calcium oxide is soluble in water. It reacts with water to form calcium hydroxide. The water becomes alkaline. / Calcium carbonate is insoluble in water. It does not make water alkaline.**



## Key terms (p.92)

exothermic	放熱	sulphate	硫酸鹽
acid salt	酸式鹽	titration	滴定
normal salt	正鹽	precipitation reaction	沉澱作用
nitrate	硝酸鹽		



## Summary (p.93)

- 1 Neutralisation is the combination of hydrogen ions and hydroxide ions (or oxide ions) to form water molecules.
- 2 In neutralisation reactions, salt and water are the only products.  
acid + alkali  $\longrightarrow$  salt + water  
e.g.  $\text{HCl(aq)} + \text{NaOH(aq)} \longrightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$   
acid + insoluble metal oxide / hydroxide  $\longrightarrow$  salt + water  
e.g.  $\text{H}_2\text{SO}_4\text{(aq)} + \text{MgO(s)} \longrightarrow \text{MgSO}_4\text{(aq)} + \text{H}_2\text{O(l)}$   
 $2\text{HNO}_3\text{(aq)} + \text{Cu(OH)}_2\text{(s)} \longrightarrow \text{Cu(NO}_3)_2\text{(aq)} + 2\text{H}_2\text{O(l)}$
- 3 Neutralisation reactions are exothermic reactions. Heat is released in these reactions.



## Summary (p.93)

4 Hydrochloric acid forms chlorides.

Nitric acid forms nitrates.

Sulphuric acid forms sulphates.

5 The following table summarises methods for the preparation of salts.

Salt	Method of preparation	Example(s)
Soluble salts (except sodium, potassium and ammonium salts)	acid + $\begin{cases} \text{metal; or} \\ \text{insoluble base; or} \\ \text{insoluble carbonate} \end{cases}$	Preparing magnesium sulphate: $\text{Mg(s)} + \text{H}_2\text{SO}_4\text{(aq)} \longrightarrow \text{MgSO}_4\text{(aq)} + \text{H}_2\text{(g)}$ $\text{MgO(s)} + \text{H}_2\text{SO}_4\text{(aq)} \longrightarrow \text{MgSO}_4\text{(aq)} + \text{H}_2\text{O(l)}$ $\text{MgCO}_3\text{(s)} + \text{H}_2\text{SO}_4\text{(aq)} \longrightarrow \text{MgSO}_4\text{(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$
Sodium, potassium and ammonium salts	acid + $\begin{cases} \text{alkali; or} \\ \text{carbonate (titration)} \end{cases}$	Preparing potassium chloride: $\text{KOH(aq)} + \text{HCl(aq)} \longrightarrow \text{KCl(aq)} + \text{H}_2\text{O(l)}$ $\text{K}_2\text{CO}_3\text{(aq)} + 2\text{HCl(aq)} \longrightarrow 2\text{KCl(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$
Insoluble salts	precipitation	Preparing barium sulphate: $\text{Ba}^{2+}\text{(aq)} + \text{SO}_4^{2-}\text{(aq)} \longrightarrow \text{BaSO}_4\text{(s)}$ <div style="display: flex; justify-content: space-around; width: 100%;"> <span>from</span> <span>from</span> </div> $\text{Ba(NO}_3)_2\text{(aq)} \quad \text{MgSO}_4\text{(aq)}$



## Summary (p.93)

6 Some uses of neutralisation:

- a) The acidity of soil can be reduced by adding calcium oxide to it.
- b) The acidity of liquid waste from factories can be reduced by adding slaked lime (calcium hydroxide) to it.
- c) Fertilisers such as ammonium nitrate and ammonium sulphate are prepared by neutralization reactions.
- d) Antacids contain bases, such as aluminium hydroxide and magnesium hydroxide, that neutralize excess hydrochloric acid in the stomach.



## Unit Exercise (p.95)

**Note: Questions are rated according to ascending level of difficulty (from 1 to 5):**



**question targeted at level 3 and above;**



**question targeted at level 4 and above;**



**question targeted at level 5.**

**' \* ' indicates 1 mark is given for effective communication.**

# Unit Exercise (p.95)

## PART I KNOWLEDGE AND UNDERSTANDING

1 Complete the following concept map.

(a) acid / base

(b) acid / base

(c) water

(d) insoluble

(e) precipitation reaction

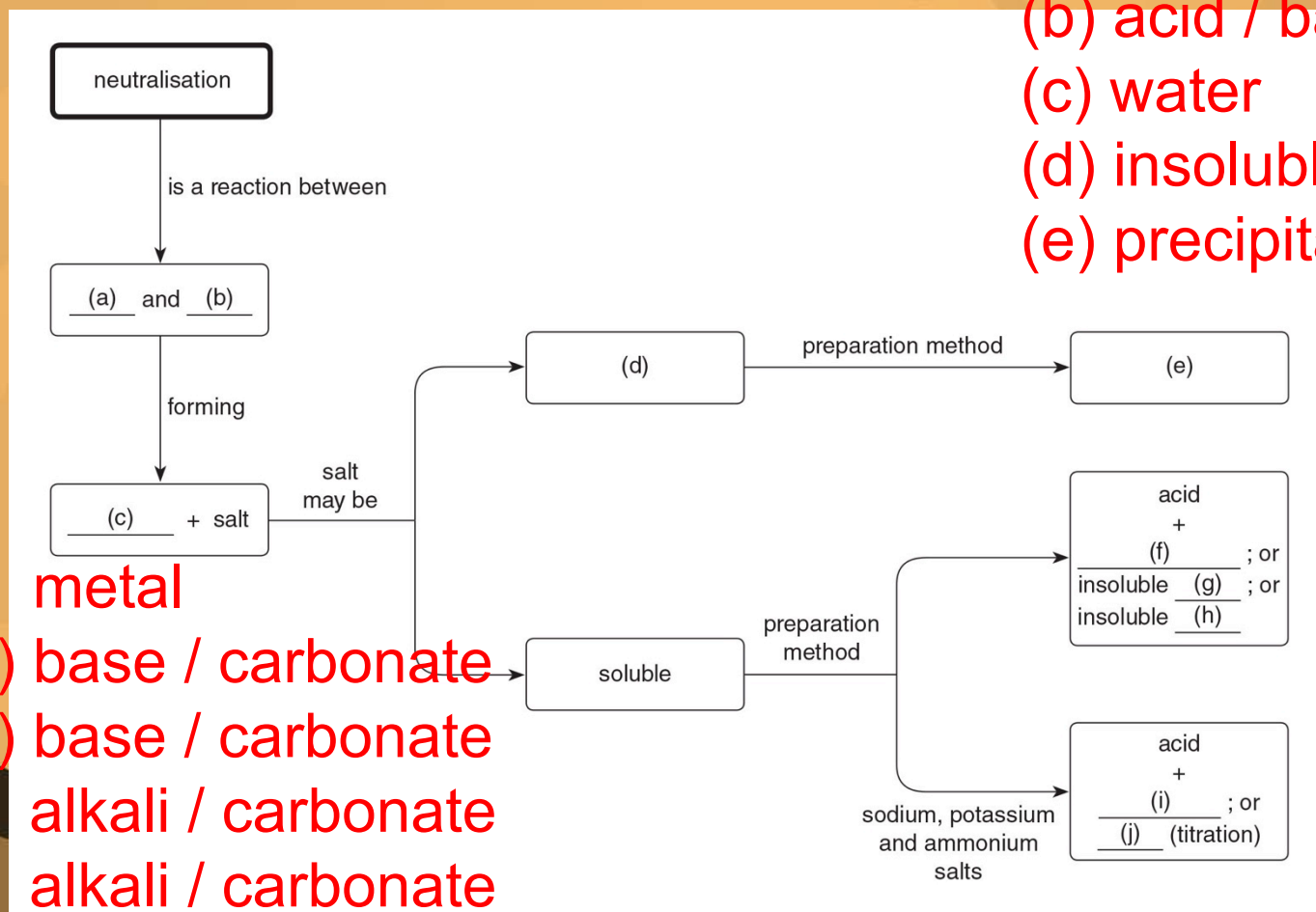
(f) metal

(g) base / carbonate

(h) base / carbonate

(i) alkali / carbonate

(j) alkali / carbonate





## Unit Exercise (p.95)

### PART II MULTIPLE CHOICE QUESTIONS



2 When  $25 \text{ cm}^3$  of  $1 \text{ mol dm}^{-3} \text{ NaOH(aq)}$  are mixed with  $25 \text{ cm}^3$  of  $1 \text{ mol dm}^{-3} \text{ HCl(aq)}$ , the temperature of the mixture rises by  $6^\circ \text{C}$ . Which of the following reactants, when mixed under the same conditions, would give a similar temperature rise?

- A  $25 \text{ cm}^3$  of  $2 \text{ mol dm}^{-3} \text{ NaOH(aq)}$  and  $25 \text{ cm}^3$  of  $2 \text{ mol dm}^{-3} \text{ HCl(aq)}$
- B  $25 \text{ cm}^3$  of  $1 \text{ mol dm}^{-3} \text{ NaOH(aq)}$  and  $25 \text{ cm}^3$  of  $1 \text{ mol dm}^{-3} \text{ HNO}_3(\text{aq})$
- C  $25 \text{ cm}^3$  of  $1 \text{ mol dm}^{-3} \text{ NH}_3(\text{aq})$  and  $25 \text{ cm}^3$  of  $1 \text{ mol dm}^{-3} \text{ H}_3\text{COOH(aq)}$
- D  $25 \text{ cm}^3$  of  $2 \text{ mol dm}^{-3} \text{ NH}_3(\text{aq})$  and  $25 \text{ cm}^3$  of  $2 \text{ mol dm}^{-3} \text{ H}_3\text{COOH(aq)}$

Answer: B



# Unit Exercise (p.95)

## PART II MULTIPLE CHOICE QUESTIONS

### 2 (continued)



### Explanation:

		Number of moles of water formed	Temperature rise	Explanation
	25 cm <sup>3</sup> of 1 mol dm <sup>-3</sup> NaOH(aq) + 25 cm <sup>3</sup> of 1 mol dm <sup>-3</sup> HCl(aq)	0.025 mole	6 °C	—
Option A	25 cm <sup>3</sup> of 2 mol dm <sup>-3</sup> NaOH(aq) + 25 cm <sup>3</sup> of 2 mol dm <sup>-3</sup> HNO <sub>3</sub> (aq)	0.050 mole	> 6 °C	—
Option B	25 cm <sup>3</sup> of 1 mol dm <sup>-3</sup> NaOH(aq) + 25 cm <sup>3</sup> of 1 mol dm <sup>-3</sup> HNO <sub>3</sub> (aq)	0.025 mole	6 °C	—
Option C	25 cm <sup>3</sup> of 1 mol dm <sup>-3</sup> NH <sub>3</sub> (aq) + 25 cm <sup>3</sup> of 1 mol dm <sup>-3</sup> CH <sub>3</sub> COOH(aq)	0.025 mole	< 6 °C	NH <sub>3</sub> (aq) is a weak alkali while CH <sub>3</sub> COOH(aq) is a weak acid. The heat given out is less than 57 kJ per mole of water produced.
Option D	25 cm <sup>3</sup> of 2 mol dm <sup>-3</sup> NH <sub>3</sub> (aq) + 25 cm <sup>3</sup> of 2 mol dm <sup>-3</sup> CH <sub>3</sub> COOH(aq)	0.050 mole	> 6 °C	



## Unit Exercise (p.95)

3 Which of the following pairs of substances, when mixed together, can be used to prepare copper(II) sulphate crystals?

- A  $\text{CuO(s)}$  and  $\text{H}_2\text{SO}_4\text{(aq)}$
- B  $\text{CuO(s)}$  and  $\text{MgSO}_4\text{(aq)}$
- C  $\text{Cu(s)}$  and  $\text{H}_2\text{SO}_4\text{(aq)}$
- D  $\text{Cu(s)}$  and  $\text{MgSO}_4\text{(aq)}$

Answer: A

*(HKDSE, Paper 1A, 2016, 8)*



## Unit Exercise (p.95)

- 4 Which of the following is NOT the appropriate substance for preparing magnesium sulphate by directly mixing it with dilute sulphuric acid?
- A Magnesium metal
  - B Magnesium oxide
  - C Magnesium nitrate
  - D Magnesium carbonate

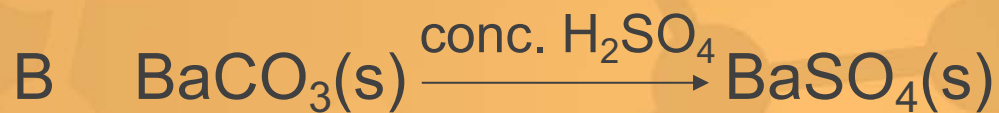
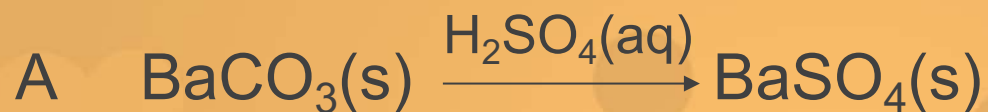
Answer: C

(HKDSE, Paper 1A, 2017, 6)



## Unit Exercise (p.95)

5 Which of the following reaction routes can best be used to prepare barium sulphate from barium carbonate?



(HKDSE, Paper 1A, 2013, 8)

Answer: C



## Unit Exercise (p.95)

- 6 Nickel(II) sulphate is prepared by adding excess nickel(II) carbonate to 50.0 cm<sup>3</sup> of 2.00 mol dm<sup>-3</sup> sulphuric acid.



How many moles of nickel(II) sulphate crystals can be obtained?

- A 0.100
- B 0.150
- C 0.200
- D 0.250

Explanation:

Number of moles of H<sub>2</sub>SO<sub>4</sub>  
= molarity of solution x volume of solution

$$= 2.00 \text{ mol dm}^{-3} \times \frac{50.0}{1000} \text{ dm}^3$$

$$= 0.100 \text{ mol}$$

According to the equation, 1 mole of NiCO<sub>3</sub> reacts with H<sub>2</sub>SO<sub>4</sub> to give 1 mole of NiSO<sub>4</sub>.  
i.e. number of moles of NiSO<sub>4</sub> = 0.100 mol

Answer: A



## Unit Exercise (p.95)

7 Which of the following pairs of ions would react together to form a precipitate?

- A  $\text{Cu}^{2+}(\text{aq})$  and  $\text{Cl}^{-}(\text{aq})$
- B  $\text{Mg}^{2+}(\text{aq})$  and  $\text{CO}_3^{2-}(\text{aq})$
- C  $\text{Na}^{+}(\text{aq})$  and  $\text{SO}_4^{2-}(\text{aq})$
- D  $\text{Pb}^{2+}(\text{aq})$  and  $\text{NO}_3^{-}(\text{aq})$

**Explanation:**

$\text{Mg}^{2+}(\text{aq})$  and  $\text{CO}_3^{2-}(\text{aq})$  react to give a white precipitate ( $\text{MgCO}_3$ ).

**Answer: B**



## Unit Exercise (p.95)

- 8 In an experiment to prepare calcium sulphate, excess dilute sulphuric acid is added to  $10.0 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$  calcium nitrate solution. Which of the following is the theoretical mass of the calcium sulphate obtained?

(Relative atomic masses: O = 16.0, S = 32.1, Ca = 40.1)

- A 0.68 g
- B 1.36 g
- C 2.72 g
- D 4.08 g

(HKDSE, Paper 1A, 2015, 9)

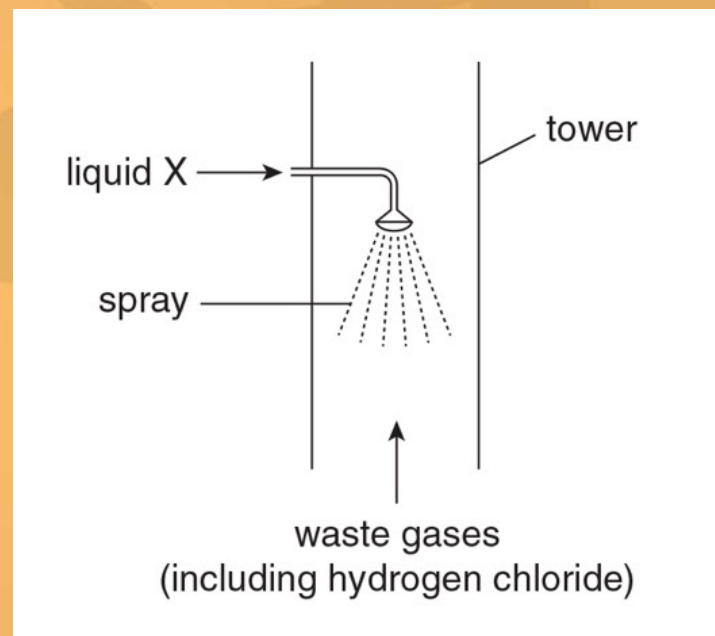
Answer: B

 Unit Exercise (p.95)

9 When a plastic PVC burns in an incinerator, hydrogen chloride gas is formed. The gas is removed by absorbing it in a liquid sprayed down a tower.

What is liquid X?

- A Calcium hydroxide solution
- B Sodium chloride solution
- C Dilute sulphuric acid
- D Potassium chloride solution



Answer: A

Explanation:

Calcium hydroxide solution can neutralise hydrogen chloride gas.



## Unit Exercise (p.95)

10 Which of the following pairs of aqueous solutions, when mixed, would give a precipitate / precipitates?


- (1) Aluminium nitrate and ammonia
- (2) Copper(II) sulphate and sodium nitrate
- (3) Calcium chloride and potassium nitrate

- A (1) only
- B (2) only
- C (1) and (3) only
- D (2) and (3) only

Answer: A



## Unit Exercise (p.95)

11 Which of the following statements about  $\text{HCl(aq)}$  is / are correct?  


- (1) The reaction between  $\text{HCl(aq)}$  and  $\text{NaOH(aq)}$  is exothermic.
- (2) Sodium chloride is prepared by the reaction between  $\text{Na(s)}$  and  $\text{HCl(aq)}$  in the laboratory.
- (3) The pH of  $\text{HCl(aq)}$  of any concentration is greater than zero.

- A (1) only
- B (2) only
- C (1) and (3) only
- D (2) and (3) only

Answer: A

Explanation:

(2) An explosive reaction occurs between  $\text{Na(s)}$  and  $\text{HCl(aq)}$ . Thus, the reaction is NOT used for preparing sodium chloride.

(3) The pH of  $\text{HCl(aq)}$  of concentration greater than  $1 \text{ mol dm}^{-3}$  is negative.

 Unit Exercise (p.95)**PART III STRUCTURED QUESTIONS**

12 A salt is formed when the hydrogen ion(s) in an acid is / are, replaced by metal ion or ammonium ion. The table below lists the chemical formulae of two acids:

Acid	carbonic acid	phosphoric acid
Chemical formula	$\text{H}_2\text{CO}_3$	$\text{H}_3\text{PO}_4$

Deduce the chemical formulae of all possible salts that could be formed when

a) potassium hydroxide solution reacts with carbonic acid;



b) potassium hydroxide solution reacts with phosphoric acid;

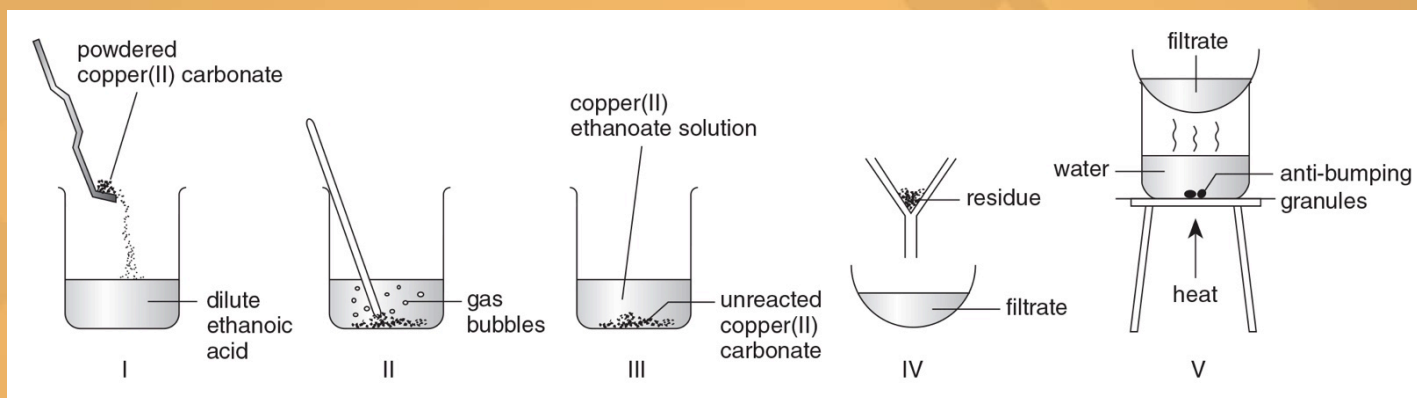


c) magnesium oxide reacts with phosphoric acid

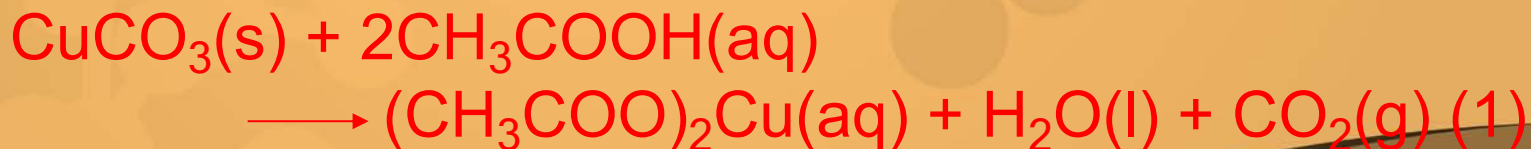


 Unit Exercise (p.95)

13 The drawings show the first five steps in the preparation of copper(II) ethanoate, a salt of ethanoic acid.



- a) What gas is given off in *Step II*? Carbon dioxide
- b) i) Write the chemical equation for the reaction in *Step II*.



ii) How can you tell when it is over?

Unreacted solid can be seen. / No more gas bubbles off. (1)



## Unit Exercise (p.95)

### 13 (continued)

- c) Describe how copper(II) ethanoate is obtained after *Step V*.

Allow the concentrated filtrate to cool to room temperature to let the crystals form. (1)

Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper. (1)

- d) Suggest another copper compound to use instead of copper(II) carbonate, to make the salt.

Copper(II) oxide / copper(II) hydroxide (1)



## Unit Exercise (p.95)

14 A student prepared nickel(II) chloride crystals ( $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ ) from nickel(II) oxide using the steps below.



*Step 1* Nickel(II) oxide was added to hot dilute hydrochloric acid in a beaker until it was in excess.

*Step 2* The mixture was filtered.

*Step 3* The filtrate was partially evaporated by heating. It was allowed to cool for nickel(II) chloride crystals to form.

a) Write the chemical equation for the reaction involved.



b) Why was it necessary to use excess nickel(II) oxide?

To react with all the acid. (1)



## Unit Exercise (p.95)

### 14 (continued)



c) Suggest how the student could know that nickel(II) oxide was in excess.

Any one of the following:

- No more nickel(II) oxide solid dissolved. (1)
- Unreacted nickel(II) oxide remained in the beaker. (1)
- The green colour of nickel(II) ion solution did not get more intense. (1)

d) Why was the filtrate partially evaporated by heating, rather than evaporated to dryness?

Any one of the following:

- At high temperature,  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  becomes anhydrous  $\text{NiCl}_2$ . (1)
- To retain the water of crystallisation. (1)



## Unit Exercise (p.95)

### 14 (continued)

e) What additional steps should be carried out to obtain dry crystals?

Allow the concentrated filtrate to cool to room temperature to let the crystals form. (1)

Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper. (1)



## Unit Exercise (p.95)

### 14 (continued)

- f) In this experiment, excess nickel(II) oxide was added to 40.0 cm<sup>3</sup> of 2.00 mol dm<sup>-3</sup> hydrochloric acid. Calculate the theoretical mass of nickel(II) chloride crystals (NiCl<sub>2</sub>•6H<sub>2</sub>O) obtained.  
(Molar mass of NiCl<sub>2</sub>•6H<sub>2</sub>O = 237.7 g mol<sup>-1</sup>)

$$\begin{aligned}\text{Number of moles of HCl} &= \text{molarity of solution} \times \text{volume of solution} \\ &= 2.00 \text{ mol dm}^{-3} \times \frac{40.0}{1\,000} \text{ dm}^3 \\ &= 0.0800 \text{ mol} \quad (1)\end{aligned}$$

According to the equation, 2 moles of HCl react with NiO to give 1 mole of NiCl<sub>2</sub>.

$$\text{i.e. number of moles of NiCl}_2 = \frac{0.0800}{2} \text{ mol} = 0.0400 \text{ mol} \quad (1)$$

Theoretical mass of nickel(II) chloride crystals

$$\begin{aligned}&= \text{number of moles of NiCl}_2 \cdot 6\text{H}_2\text{O} \times \text{molar mass of NiCl}_2 \cdot 6\text{H}_2\text{O} \quad (1) \\ &= 0.0400 \text{ mol} \times 237.7 \text{ g mol}^{-1} \\ &= 9.51 \text{ g}\end{aligned}$$



## Unit Exercise (p.95)



15 Copper(II) sulphate solution,  $\text{CuSO}_4(\text{aq})$ , can be made by adding an excess of solid copper(II) oxide,  $\text{CuO}(\text{s})$ , to boiling dilute sulphuric acid. This is an exothermic reaction.

The balanced equation for this reaction is



a) i) Complete the ionic equation for this reaction, including state symbols.





## Unit Exercise (p.95)

### 15 (continued)

a) ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mole of sulphuric acid is completely reacted.

(Relative atomic masses: Cu = 63.5, O = 16.0)

According to the equation, 1 mole of CuO reacts with 1 mole of  $\text{H}_2\text{SO}_4$ .

i.e. number of moles of CuO reacted with 0.020 mole of  $\text{H}_2\text{SO}_4$  = 0.020 mol (1)

Molar mass of CuO =  $(63.5 + 16.0) \text{ g mol}^{-1} = 79.5 \text{ g mol}^{-1}$

Mass of CuO reacted with 0.020 mole of  $\text{H}_2\text{SO}_4$

= number of moles of CuO x molar mass of CuO

=  $0.020 \text{ mol} \times 79.5 \text{ g mol}^{-1}$

= 1.59 g (1)

Mass of CuO needed =  $1.59 \text{ g} \times 1.10 = 1.75 \text{ g}$  (1)

 Unit Exercise (p.95)15 (continued)

b) i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulphuric acid.

Any one of the following:

- Add in small portions. (1)
- Use a spatula. (1)
- Add slowly. (1)

Reason

To prevent the mixture boiling over / spilling / splashing. (1)

 Unit Exercise (p.95)15 (continued)

b) ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulphate-5-water,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

Remove a drop of the solution with a glass rod and place it on a microscopic slide. Observe whether any solids form quickly on the cool glass. (1)



## Unit Exercise (p.95)

15 (continued)

b) iii) After cooling the solution, crystals form. State the colour of the crystals.

**Blue (1)**

iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

**The ions are arranged in a regular way. (1)**

*(Edexcel Advanced Subsidiary GCE, Unit 1, Jun. 2013, 20(a)–(b))*



## Unit Exercise (p.95)



- \*16 Potassium sulphate is made when potassium hydroxide solution reacts with dilute sulphuric acid.



Describe a laboratory method for making pure potassium sulphate crystals from potassium hydroxide solution and dilute sulphuric acid.



## Unit Exercise (p.95)

### \*16 (continued)



Place dilute sulphuric acid in a burette.

Using a pipette and a pipette filler to place  $25.00 \text{ cm}^3$  of dilute potassium hydroxide solution in a conical flask. (1)

Add a few drops of phenolphthalein.

Run the acid into the flask until the phenolphthalein turns colourless. (1)

Note the exact volume of acid added.

Place  $25.00 \text{ cm}^3$  of the alkali in a conical flask. Run the same volume of acid as noted into the flask, producing a potassium sulphate solution. (1)

Heat gently to evaporate the water and concentrate the potassium sulphate solution. (1)

Allow the concentrated potassium sulphate solution to cool to room temperature to let the crystals form. (1)

Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper. (1)

Communication mark (1)



## Unit Exercise (p.95)

17 A student prepared hydrated calcium chloride ( $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ ) by carrying out the following experiment.



*Step 1* An excess of a solid calcium compound, X, was added to dilute hydrochloric acid. The mixture fizzed as the solid reacted.

*Step 2* The mixture was filtered to give a calcium chloride solution.

*Step 3* .....

*Step 4* .....

a) Describe a chemical test that the student could carry out to show that the filtrate contained chloride ions.

Add silver nitrate solution. (1)

A white precipitate forms (1)



## Unit Exercise (p.95)

### 17 (continued)



b) A friend of the student suggested that solid X was calcium oxide.

i) State ONE reason why the student's friend was INCORRECT.

The mixture fizzed / produced a gas. (1)

ii) Suggest what solid X was.

Calcium carbonate (1)

c) Complete Steps 3 and 4 for obtaining dry crystals of hydrated calcium chloride ( $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ ).

Heat the solution gently to evaporate the water and concentrate the calcium chloride solution. (1)

Allow the concentrated solution to cool to room temperature to let the crystals form. (1)

Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper. (1)



## Unit Exercise (p.95)

18 Many naturally occurring carbon compounds are acidic. Most contain the  $\text{-COOH}$  group in which the H can be replaced to form a salt.



a) Ethanoic acid can react with  $\text{NaOH(aq)}$  to form the salt sodium ethanoate,  $\text{CH}_3\text{COONa}$ .

What is the chemical formula of magnesium ethanoate?

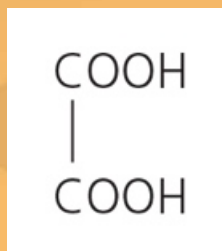
$(\text{CH}_3\text{COO})_2\text{Mg}$  (1)



## Unit Exercise (p.95)

18 (continued)

b) The structure of ethanedioic acid, a dibasic acid, is shown below:



Ethanedioic acid can also form salts. What are the chemical formulae of

- i) potassium ethanedioate?  $\text{K}_2\text{C}_2\text{O}_4$  (1)
- ii) magnesium ethanedioate?  $\text{MgC}_2\text{O}_4$  (1)



## Unit Exercise (p.95)

19 The following solutions are available:

sodium carbonate      copper(II) sulphate      Lead(II) nitrate

Any two of the solutions can be mixed together at a time.

- Predict which combinations of these solutions will produce precipitates. Name the precipitate in each case.
- Write the ionic equation for each reaction.

Solutions that will produce a precipitate	Name of precipitate	Ionic equation	
sodium carbonate solution + copper(II) sulphate solution	copper(II) carbonate (1)	$\text{Cu}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \longrightarrow \text{CuCO}_3(\text{s})$	(1)
sodium carbonate solution + lead(II) nitrate solution	lead(II) carbonate (1)	$\text{Pb}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \longrightarrow \text{PbCO}_3(\text{s})$	(1)
copper(II) sulphate solution + lead(II) nitrate solution	lead(II) sulphate (1)	$\text{Pb}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \longrightarrow \text{PbSO}_4(\text{s})$	(1)




## Unit Exercise (p.95)

20 Salt X is known to be one of the following substances:

lead(II) nitrate      potassium sulphate  
lead(II) chloride    potassium nitrate

X gives a lilac flame in flame test. When a solution of X is mixed with calcium chloride solution, a white precipitate forms. Deduce what X is.

A lilac flame suggest that salt X contains potassium ions. (1)  
The white precipitate formed is calcium sulphate. This suggests that salt X contains sulphate ions. (1)  
Salt X is potassium sulphate. (1)

 Unit Exercise (p.95) 21 A student prepared crystals of magnesium nitrate,  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , from magnesium oxide. The following extract was taken from his practical notes.Preparing crystals of magnesium nitrate

- Step 1* 50 cm<sup>3</sup> of acid were poured into a beaker. Magnesium oxide was added a little at a time and the mixture was stirred.
- Step 2* When no more magnesium oxide reacted, the excess magnesium oxide was separated from the mixture and the solution was collected in an evaporating dish.
- Step 3* The solution was boiled strongly for ten minutes.

a) Name the acid used in this preparation.

**Nitric acid (1)**

b) Name the apparatus used in *Step 1* to  
i) add the magnesium oxide to the acid;

**Spatula (1)**

 Unit Exercise (p.95)21 [\(continued\)](#)

b) ii) stir the mixture.

**Stirring rod / glass rod (1)**c) Name the separation method used in *Step 2*.**Filtration (1)**d) The teacher said that *Step 3* was INCORRECT. How should the student change *Step 3* so as to obtain dry crystals of magnesium nitrate?

Heat the filtrate gently to evaporate the water and concentrate the magnesium nitrate solution. (1)

Allow the concentrated magnesium nitrate solution to cool to room temperature to let the crystals form. (1)

Filter off the crystals. Wash with a small amount of cold deionised water. Dry the crystals between two pieces of filter paper. (1)



## Unit Exercise (p.95)



\*22 Outline the steps in preparing solid silver chloride from solid silver nitrate. You have to state the additional chemical reagents that are required, but need NOT mention the apparatus involved.

Dissolve solid silver nitrate in water. (1)

Mix with excess sodium / potassium chloride solution. (1)

Filter the mixture to obtain the precipitate (silver chloride).

Wash the precipitate with cold deionised water and then dry in an oven. (1)

Communication mark (1)



## Unit Exercise (p.95)

23 A patient suffered from a stomach ache due to excess hydrochloric acid secretion. The active ingredient in one brand of antacid tablet is aluminium hydroxide.

a) Write the chemical equation for the reaction between hydrochloric acid and aluminium hydroxide.



b) How does the pH of the gastric juice change after the patient takes the tablet?

The pH increases. (1)

 Unit Exercise (p.95)23 (continued)

c) The gastric juice of the patient was found to contain  $0.0500 \text{ mol dm}^{-3}$  hydrochloric acid. He produces  $2.00 \text{ dm}^3$  of gastric juice each day. This volume of gastric juice is to be treated with the antacid tablets containing 520 mg of aluminium hydroxide per tablet.

i) Calculate the mass of aluminium hydroxide required to neutralize the  $2.00 \text{ dm}^3$  of gastric juice.

(Relative atomic masses: H = 1.0, O = 16.0, Al = 27.0)

$$\begin{aligned}\text{Number of moles of HCl} &= \text{molarity of solution} \times \text{volume of solution} \\ &= 0.0500 \text{ mol dm}^{-3} \times 2.00 \text{ dm}^3 \\ &= 0.100 \text{ mol (1)}\end{aligned}$$

According to the equation, 3 moles of HCl is neutralised by 1 mole of  $\text{Al(OH)}_3$ .

$$\begin{aligned}\text{i.e. number of moles of Al(OH)}_3 &= \frac{0.100}{3} \text{ mol} \\ &= 0.0333 \text{ mol (1)}\end{aligned}$$

$$\begin{aligned}\text{Molar mass of Al(OH)}_3 &= (27.0 + 3 \times 16.0 + 3 \times 1.0) \text{ g mol}^{-1} \\ &= 78.0 \text{ g mol}^{-1}\end{aligned}$$

$$\begin{aligned}\text{Mass of Al(OH)}_3 &= \text{number of moles of Al(OH)}_3 \times \text{molar mass of Al(OH)}_3 \\ &= 0.0333 \text{ mol} \times 78.0 \text{ g mol}^{-1} \\ &= 2.60 \text{ g (1)}\end{aligned}$$

 Unit Exercise (p.95)23 (continued)

c) i) Deduce the number of tablets that has to be taken each day.

$$\begin{aligned}\text{Number of tablets} &= \frac{2.60 \text{ g}}{0.520 \text{ g}} \\ &= 5 \text{ (1)}\end{aligned}$$



## Unit Exercise (p.95)

24 Ewan and Gwyneth are given four unlabelled bottles.



They know that these contain the following four solutions:

potassium carbonate

sodium hydroxide

barium chloride

magnesium nitrate

a) Ewan predicted what will happen when each of the four solutions is added to the others, and presented this information in the grid below.

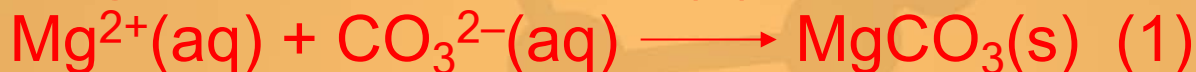
i) Complete the three empty boxes with the observations expected in each of these cases.

	Magnesium nitrate	Barium chloride	Sodium hydroxide
Potassium carbonate	white precipitate	white precipitate	no visible change
Sodium hydroxide	white precipitate (1)	white precipitate (1)	(Ba(OH) <sub>2</sub> is precipitated only from concentrated barium chloride solution)
Barium chloride	no visible change (1)		

 Unit Exercise (p.95)24 (continued)

ii) Name the white precipitate formed when magnesium nitrate solution is mixed with potassium carbonate solution, and write an ionic equation for its formation.

Magnesium carbonate (1)



 Unit Exercise (p.95)24 [\(continued\)](#)

b) Gwyneth uses different tests to identify the four solutions. Each test allows her to distinguish between some of the solutions. For each test, state the solution(s) that would give a visible change and the observation(s) that would be made.

i) Addition of litmus solution

Sodium hydroxide solution turns blue / purple. (1)

ii) Flame test

Potassium carbonate gives a lilac flame. (1)

Sodium hydroxide gives a golden yellow flame. (1)

Barium chloride gives an apple green flame. (1)

 Unit Exercise (p.95)24 [\(continued\)](#)

b) iii) Addition of sodium sulphate solution

Barium chloride solution gives a white precipitate. (1)

*(WJEC GCE Advanced Subsidiary / Advanced Level, CH2, Jun.  
2014, 7)*



## Unit Exercise (p.95)



\*25 You are required to prepare dry pure zinc carbonate. The chemical supplied are

- zinc oxide powder;
- dilute nitric acid;
- sodium carbonate solution.

Describe how you could prepare the salt. Include the chemical equations involved.

Add zinc oxide powder to warm dilute nitric acid until no more oxide dissolves. (1)

Filter off the remaining zinc oxide powder. Collect the filtrate (zinc nitrate solution). (1)

Mix the filtrate with excess sodium carbonate solution. (1)

Filter the mixture to obtain the precipitate (zinc carbonate). Wash the precipitate with cold deionised water and then dry in an oven. (1)



Communication mark (1)



## Unit Exercise (p.95)

25 (continued)



Add zinc oxide powder to warm dilute nitric acid until no more oxide dissolves. (1)

Filter off the remaining zinc oxide powder. Collect the filtrate (zinc nitrate solution). (1)

Mix the filtrate with excess sodium carbonate solution. (1)

Filter the mixture to obtain the precipitate (zinc carbonate).

Wash the precipitate with cold deionised water and then dry in an oven. (1)



Communication mark (1)