## Rate +Chemical Changes part 3

## Q1.

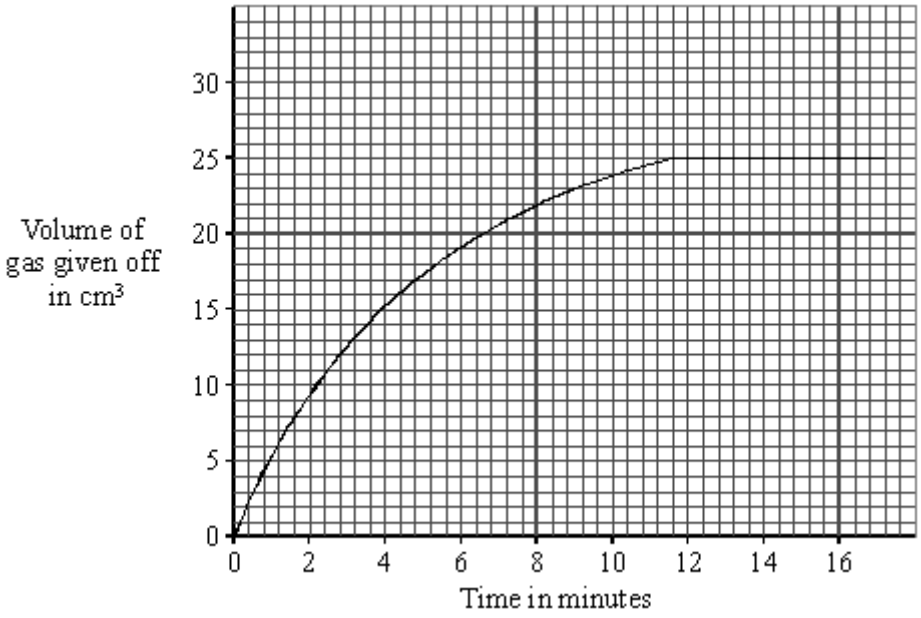
Zinc powder normally reacts slowly with hydrochloric acid.

(a) Balance the symbol equation for the reaction.

$Zn + HCl \rightarrow ZnC1_2 + H_2$

**(1)**

The graph shows the results from a reaction of 1.0 g of zinc powder with 20 $cm^3$ of dilute hydrochloric acid. It gives off a gas and forms zinc chloride, $ZnCl_2$. Some unreacted zinc is left at the end.




(b) Copper powder is a good catalyst for the reaction of zinc with hydrochloric acid.

(i) A mixture of 10 $cm^3$ of the same dilute hydrochloric acid and 1.0 g of copper powder was added to 1.0 g of zinc powder. What is the maximum volume of gas which could be given off?

_____ $cm^3$

**(1)**

(ii) Draw a graph, on the axes above, for an experiment where 20 $cm^3$ of the same dilute hydrochloric acid was added to 1.0 g of copper powder mixed with 1.0 g of zinc powder.

**(2)**

(iii) Give **two** other ways the reaction described in part (i) could be made to go faster.

1. _____

2. _____

**(2)**

(c) Copper powder can be formed by adding copper sulphate solution to the mixture of

zinc powder and acid.

(i) Why does zinc react with copper sulphate solution to produce copper?

_____

_____

**(1)**

(ii) Write the word equation for the reaction.

_____

**(1)**

**(Total 8 marks)**

## Q2.

(a) In industry ammonia is produced from nitrogen and hydrogen. The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) What does the symbol (g) represent?

_____

**(1)**

(ii) What does the symbol $\rightleftharpoons$ represent?

_____

**(1)**

(iii) Nitrogen is used for the industrial production of ammonia. From what raw material does this nitrogen come?

_____

**(1)**

(iv) Hydrogen is used for the industrial production of ammonia. It is obtained from the reaction between methane and steam. The equation for this reaction is:

$CH_4 + H_2O \rightarrow 3H_2 + CO$

Explain how you can tell that this equation is balanced.

_____

_____

_____

_____

**(2)**

(b) Ammonia is used to make ammonium salts which can be used as fertilisers.

(i) Complete the names in the following sentence.

One example is ammonium _____ which is made by reacting

ammonia with _____ acid.

**(2)**

(ii) All ammonium salts are soluble in water. Why is this a useful property of a fertiliser?

_____

_____

**(1)**

(c) Ammonia is a covalent, chemical compound.

(i) Complete the following sentence to describe a chemical compound.

In a chemical compound, two or more _____

_____

_____

**(1)**

(ii) What is a covalent bond?

_____

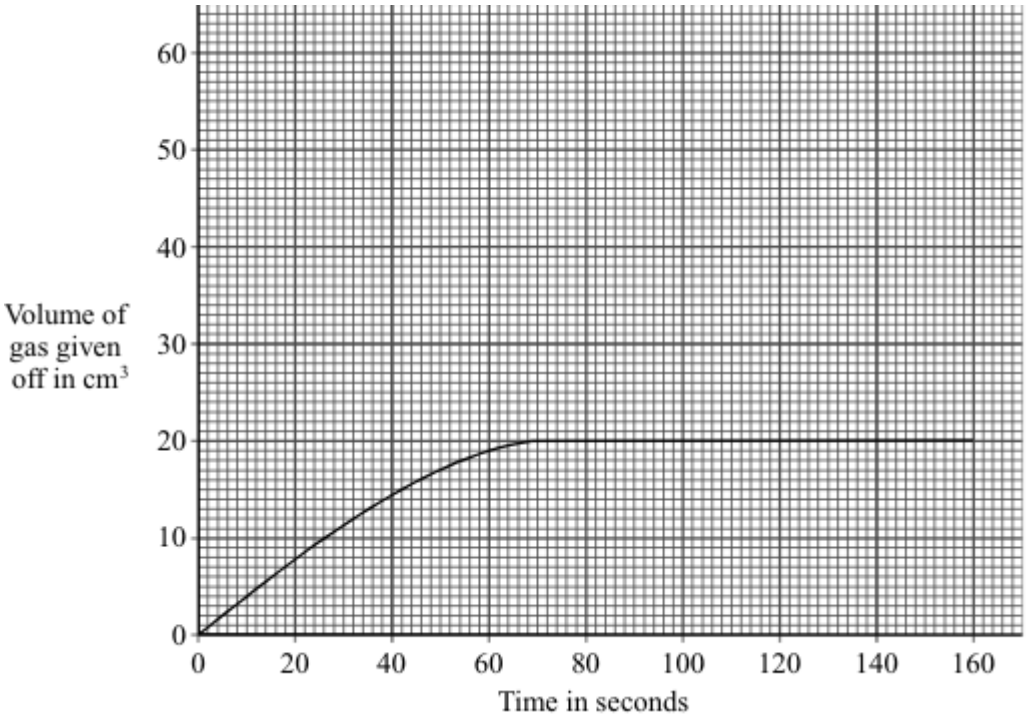
_____

**(1)**

**(Total 10 marks)**

## Q3.

The graph shows the volume of gas given off during an experiment using hydrogen peroxide solution and manganese oxide.



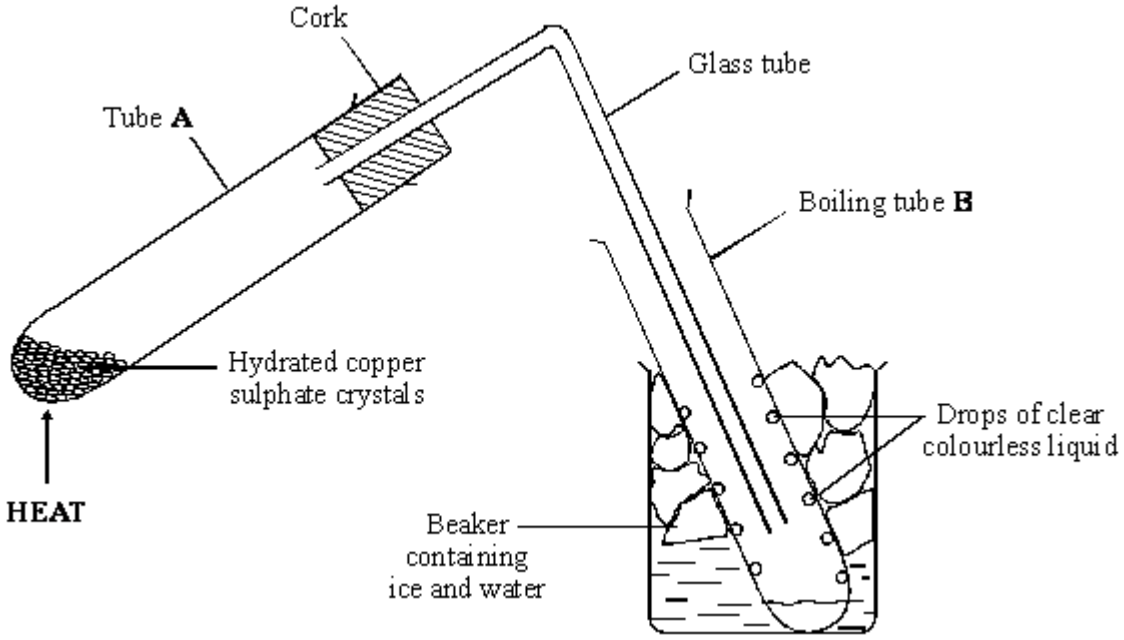

Draw, on the axes above, a graph to show the result you would expect if the volume of hydrogen peroxide solution had been the same, but it was **twice** as

concentrated.

**(Total 3 marks)**

## Q4.

The diagram shows the apparatus for an experiment. Hydrated copper sulphate crystals were heated. They became anhydrous copper sulphate.




(a) Name a suitable piece of equipment to heat tube **A**.

_____

**(1)**

(b) Use words from the box to complete the **two** spaces in the table. You may use each word once or not at all.

| black | blue | orange | red | purple | white |
|---|---|---|---|---|---|

| **Name** | **Colour** |
|---|---|
| Hydrated copper sulphate crystals | _____ |
| Anhydrous copper sulphate | _____ |

**(2)**

(c) What is the purpose of the ice and water in the beaker?

_____

_____

**(1)**

(d) Drops of a clear, colourless liquid formed on the inside of tube **B**.

(i) Name the liquid.

_____

**(1)**

(ii) Explain how the liquid came to be inside tube **B**.

_____

_____

_____

**(2)**

(e) Anhydrous copper sulphate can be turned into hydrated copper sulphate. What would you need to add? Apart from the change in colour, what could you observe?

_____

_____

_____

**(2)**

(f) Copper sulphate can be made from black copper oxide by reacting it with an acid. Name the acid.

_____

**(1)**

**(Total 10 marks)**

## Q5.

(a) Ammonia is manufactured from nitrogen and hydrogen. The equation for the reaction between them is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) What is the source of the nitrogen?

_____

**(1)**

(ii) Why does increasing the pressure increase the chance of molecules of hydrogen reacting with molecules of nitrogen?

_____

_____

**(1)**

(iii) The percentage yield of ammonia is the percentage, by mass, of the nitrogen and hydrogen which has been converted to ammonia. Calculate the mass, in tonnes, of ammonia which can be produced from 90 tonnes of hydrogen when the percentage yield is 50%. The relative atomic masses are: H 1; N 14.

Show clearly how you get to your answer.

_____

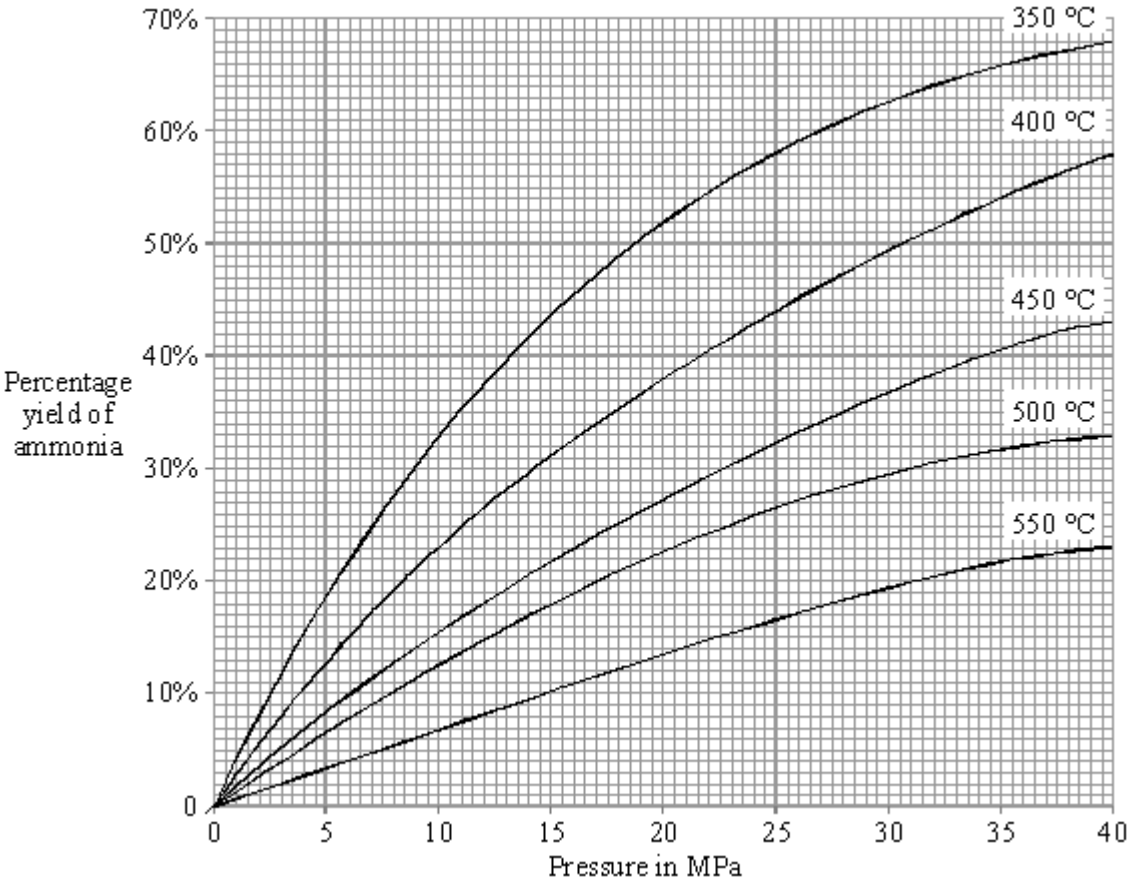
_____

_____

Mass = _____ tonnes

**(2)**

(b) The percentage yield of ammonia depends on the temperature and pressure inside the reaction vessel. The set of graphs show this.




(i) MPa is the symbol for which unit?

_____

**(1)**

(ii) What is the percentage yield of ammonia produced at a temperature of 450 °C and a pressure of 20 MPa?

_____

**(1)**

(iii) Suggest what changes the chemical engineers should make to both the temperature and the pressure to **increase** the percentage yield of ammonia.

Temperature _____

Pressure _____

**(1)**

(iv) How can the rate of ammonia production be increased without changing the temperature or pressure or the mass of hydrogen and nitrogen?

_____

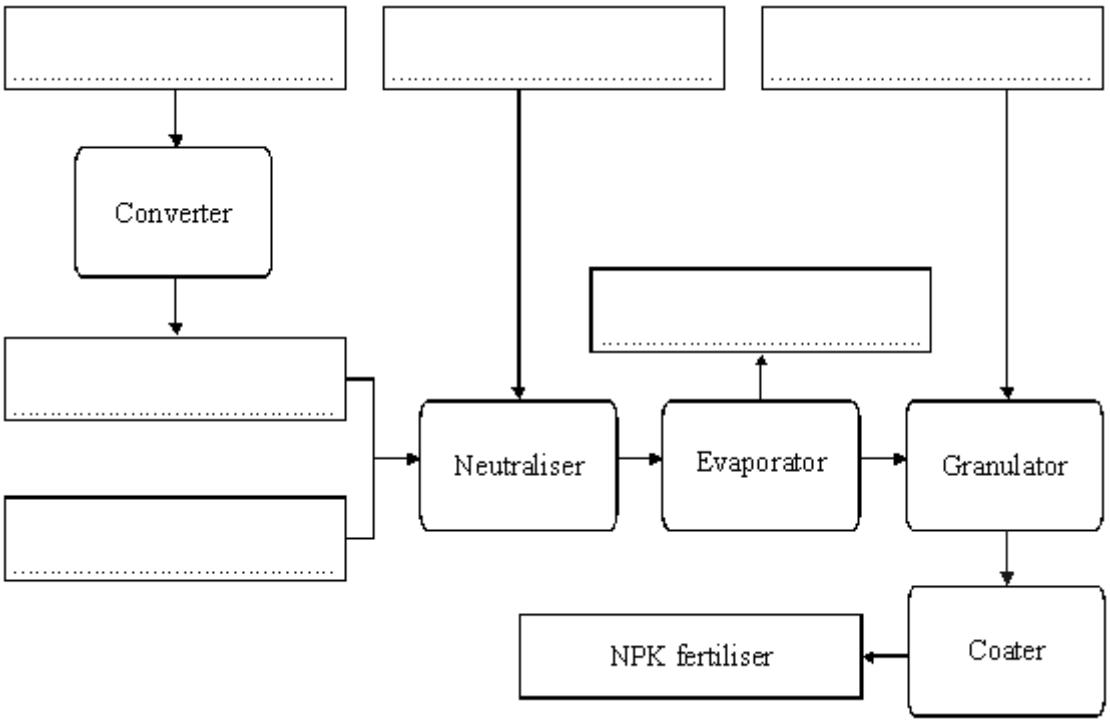
_____

**(1)**

(c) About four-fifths of ammonia production is used to produce fertilisers. One of them is known as NPK. It is made in the following way.

- Some ammonia is converted to nitric acid which is then mixed with phosphoric acid.
- The mixture is neutralised with more ammonia and the solution is partly evaporated.
- Potassium chloride is added to form granules.
- The granules are coated to make the fertiliser free-flowing.

Complete the flow-chart for the production of NPK by writing in the names of the correct chemicals in the **six** boxes.

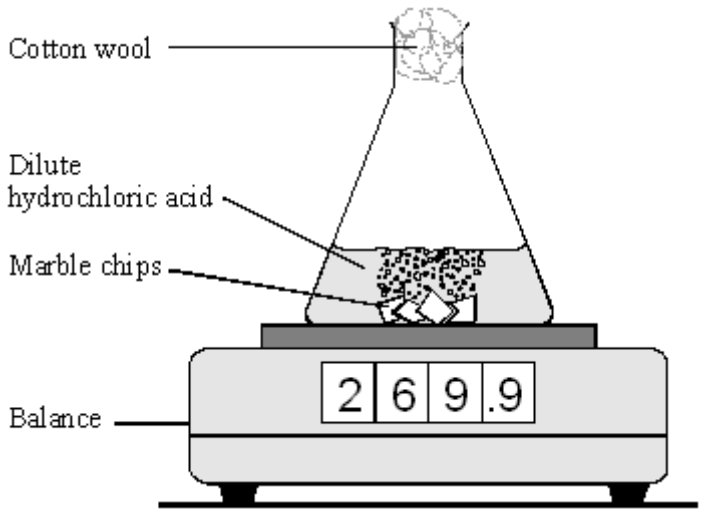



**(2)**

**(Total 10 marks)**

## Q6.

The apparatus shown in the diagram was used to investigate the rate of reaction of excess marble chips with dilute hydrochloric acid, HCl. Marble is calcium carbonate, formula $CaCO_3$. The salt formed is calcium chloride, $CaCl_2$.




(a) Write a balanced equation for the reaction.

_____

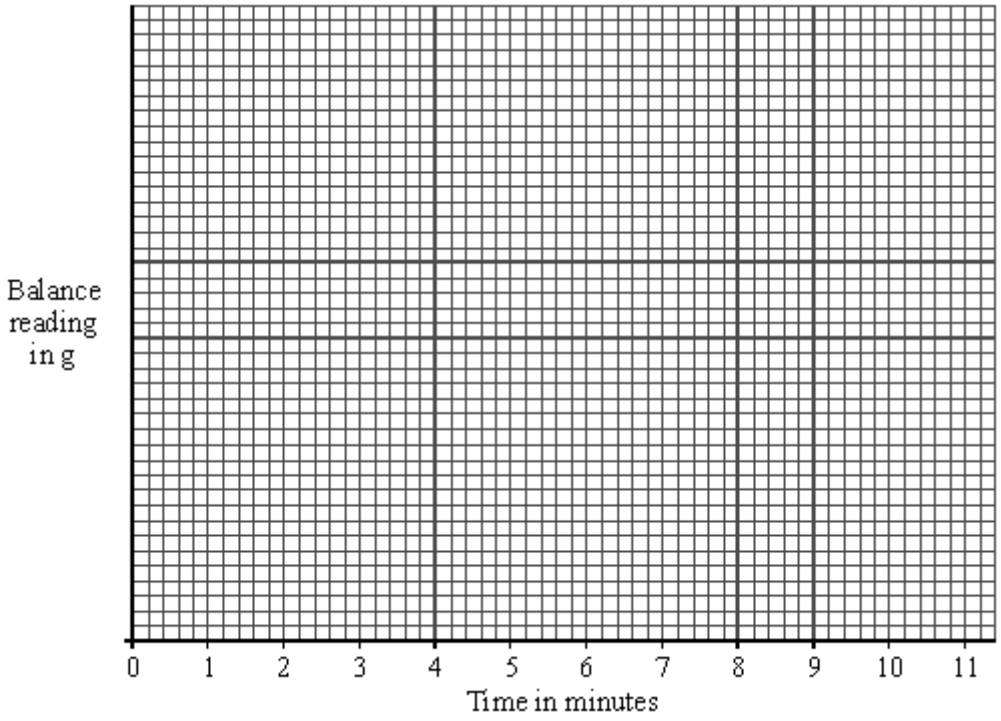
_____

**(2)**

The following results were obtained from the experiment.

| **Time in minutes** | **Reading on balance in g** |
|---|---|
| 0.5 | 269.6 |
| 1.0 | 269.3 |
| 2.0 | 269.0 |
| 3.0 | 268.8 |
| 5.0 | 268.7 |
| 9.0 | 268.6 |

(b) (i) Plot the results and draw a graph on the axes below.




**(3)**

(ii) Continue the graph you have drawn to show the expected reading after11 minutes.

**(1)**

(iii) On the axes above, sketch a graph of the result which would be obtained if in a similar experiment the same mass of powdered marble was used instead of marble chips.

**(2)**

**(Total 8 marks)**

## Q7.

Potassium reacts violently with cold water.

It forms an alkaline solution of potassium hydroxide and hydrogen.

**potassium** + **water** → **potassium hydroxide** + **hydrogen**

(a) In what physical state is hydrogen given off?

Choose your answer from the words in the box.

| gas | liquid | solid | solution |
|---|---|---|---|

_____

**(1)**

(b) (i) What type of substance will neutralise potassium hydroxide solution?

_____

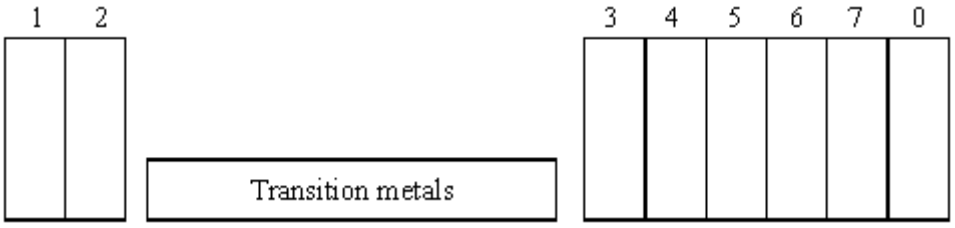
**(1)**

(ii) What is the pH of the neutral solution?

_____

**(1)**

(c) In the Periodic Table there are eight main groups.




What is the number of the group that has potassium in it?

_____

**(1)**

(d) Sodium is in the same group as potassium.

(i) How does sodium react with cold water and what is formed?

_____

_____

**(2)**

(ii) How can you prove that an alkaline solution is formed when sodium reacts with water?

_____

_____

**(2)**

(e) Lithium reacts more slowly with cold water than sodium.

State **two** ways the reaction can be made to go faster.

_____

_____

**(2)**

**(Total 10 marks)**

## Q8.

(a) Ammonium sulphate is made by the reaction:

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

(i) Complete the **three** answers in the table.

| Question | Answer |
|---|---|
| How many hydrogens are there in the formula of ammonium | |

| | |
|---|---|
| sulphate? | _____ |
| What is the name of the substance with the formula $NH_3$? | _____ |
| What is the name of the substance with the formula $H_2SO_4$? | _____ |

**(3)**

(ii) What is the main use for ammonium sulphate?

_____

**(1)**

(iii) A similar reaction is used to make ammonium nitrate. What is the name of the acid which must be used?

_____

**(1)**

(b) $NH_3$ is made by the reversible reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(i) Explain what the term *reversible reaction* means.

_____

_____

_____

**(2)**

(ii) What is the name of the raw material which is the source of nitrogen ($N_2$)?

_____

**(1)**

(iii) Nitrogen is an element. Explain what the term *element* means.

_____

_____

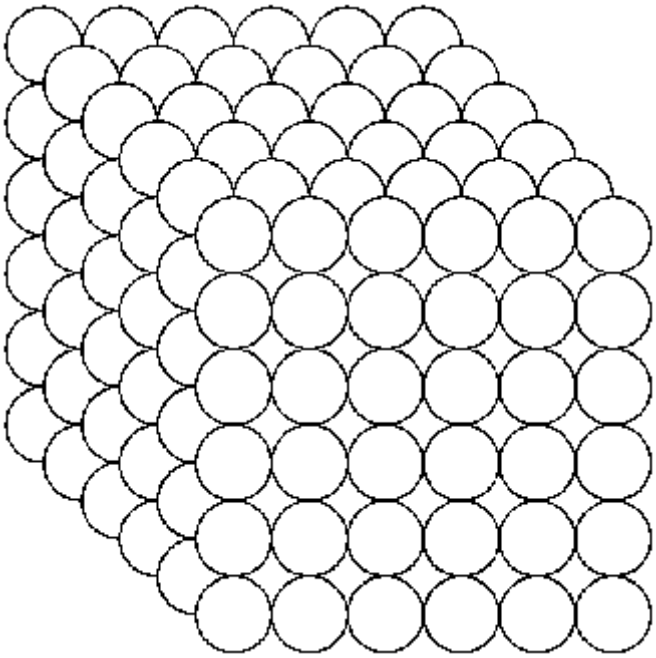
_____

**(2)**

**(Total 10 marks)**

## Q9.

The diagram represents the particles in a piece of reactive metal.



The piece of reactive metal is added to dilute hydrochloric acid.

(a) (i) Which particle will probably react first?

Choose from:

- a particle inside the piece;
- a particle at the centre of a face;
- a particle on one of the corners.

_____

**(1)**

(ii) Explain the reason for your choice.

_____

_____

**(1)**

(b) The reaction can be speeded up by making changes to the hydrochloric acid or the solid.

(i) State **two** ways to speed up the reaction by changing the hydrochloric acid. In each case explain in terms of particles why the reaction is faster.

1. _____

_____

_____

**(2)**

2. _____

_____

_____

**(2)**

(ii) What change can you make to the piece of solid to speed up the reaction? Explain in terms of the particles why the reaction is able to speed up.

_____

_____

**(2)**

**(Total 8 marks)**

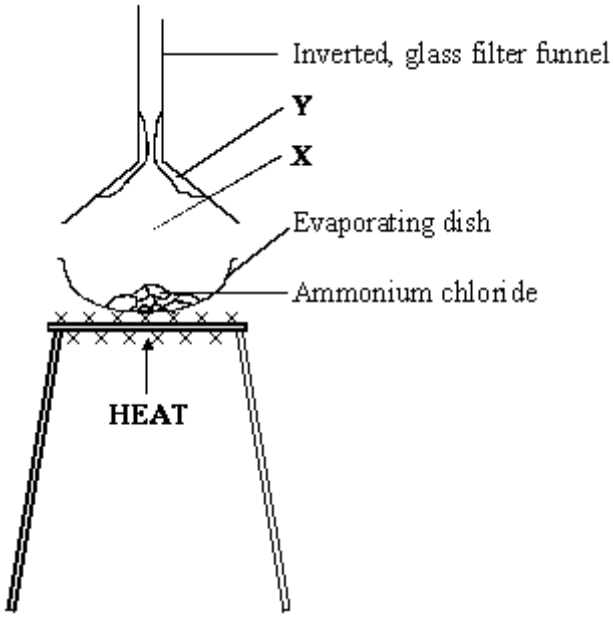
## Q10.

(a) The equation for the reaction that takes place when ammonium chloride is heated is:

$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$

ammonium chloride — ammonia — hydrogen chloride

The diagram shows how a teacher demonstrated this reaction. The demonstration was carried out in a fume cupboard.




(i) Apart from the gases normally in the atmosphere, which two gases would be at **X**?

_____ and _____

**(1)**

(ii) Name the white solid that has formed at **Y**.

_____

**(1)**

(iii) Why was the demonstration carried out in a fume cupboard?

_____

_____

**(1)**

(iv) Complete the **four** spaces in the passage.

The chemical formula of ammonia is $NH_3$. This shows that there is one atom of _____ and three atoms of _____ in each _____ of ammonia. These atoms are joined by bonds that are formed by sharing pairs of electrons. This type of bond is called a _____ bond.

**(4)**

(b) Electrons, neutrons and protons are sub-atomic particles.

(i) Complete the **three** spaces in the table.

| Name of sub-atomic particle | Relative mass | Relative charge |
|---|---|---|
| _____ | 1 | +1 |
| _____ | 1 | 0 |
| _____ | $\frac{1}{1840}$ | –1 |

**(2)**

(ii) Which **two** sub-atomic particles are in the nucleus of an atom?

_____ and _____

**(1)**

**(Total 10 marks)**

## Q11.

(a) Iron powder is used in the manufacture of ammonia. Why is it used?

_____

_____

**(1)**

(b) Ammonia is manufactured from nitrogen and hydrogen. The equation for the reaction between them is:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(i) Which **two** raw materials are used to make the hydrogen?

_____ and _____

**(1)**

(ii) Why does increasing the pressure increase the chance of molecules of nitrogen reacting with molecules of hydrogen?

_____

_____

**(1)**

(iii) Calculate the mass, in tonnes, of ammonia which could be produced from 560 tonnes of nitrogen.

The relative atomic masses are: H 1; N 14.

Show clearly how you get to your answer.

_____

_____

_____

Mass of ammonia = _____ tonnes

**(3)**

**(Total 6 marks)**

## Q12.

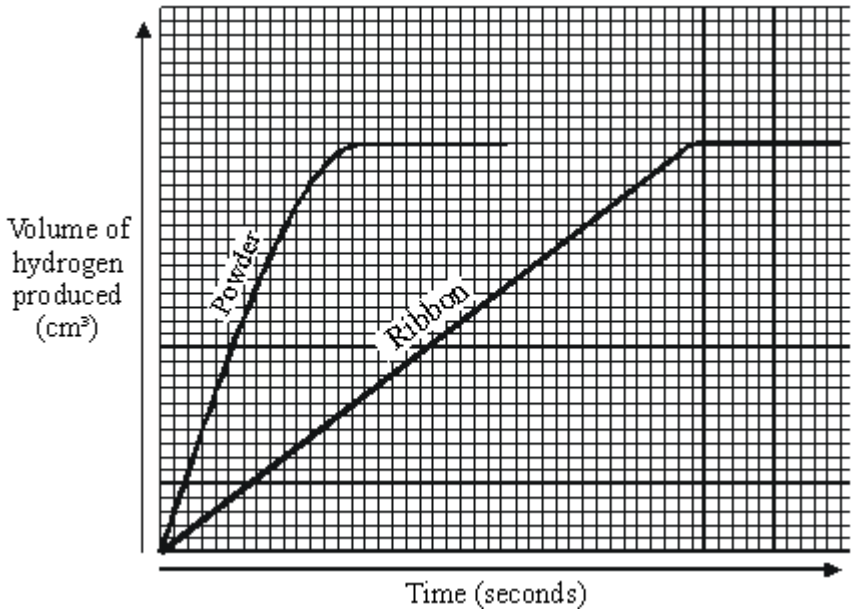
Some students were investigating how fast hydrogen gas is released in the reaction between magnesium and dilute hydrochloric acid.

To begin with they used 0.1 g of magnesium ribbon.

Next, they repeated the experiment using 0.1 g of magnesium powder.

In each case, they used enough acid to react with all the metal.

(a) Their results are shown on the graph below.




Hydrogen is produced in both the reactions.

Use the information on the graph to describe **two other** ways in which the two reactions are similar.

1. _____

2. _____

_____

**(2)**

(b) Describe **one** way in which the reactions are different.

_____

_____

**(1)**

**(Total 3 marks)**

## Q13.

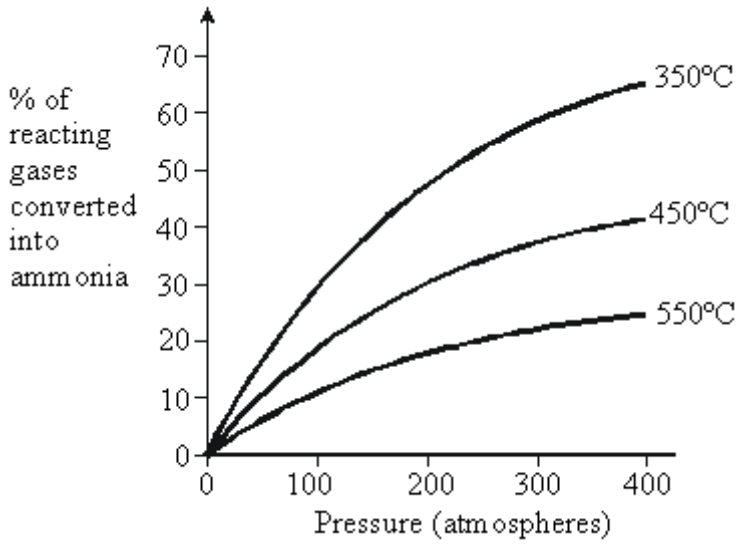
Ammonia is manufactured in the Haber Process, from nitrogen and hydrogen.

(a) Balance this symbol equation for the process.

$$N_2 + \quad H_2 \rightleftharpoons \quad NH_3$$

**(2)**

(b) The graph below shows the percentage of reacting gases converted into ammonia, at different temperatures and pressures.




(i) What does the graph suggest about the temperature and pressure needed to convert the maximum percentage of reacting gases into ammonia?

_____

_____

_____

**(2)**

(ii) Suggest reasons why the manufacture of ammonia in the Haber Process is usually carried out at about 400°C and 200 atmospheres pressure.

_____

_____

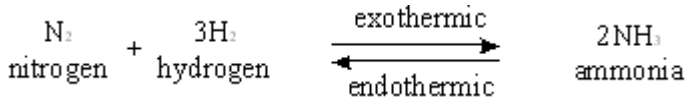
_____

**(2)**

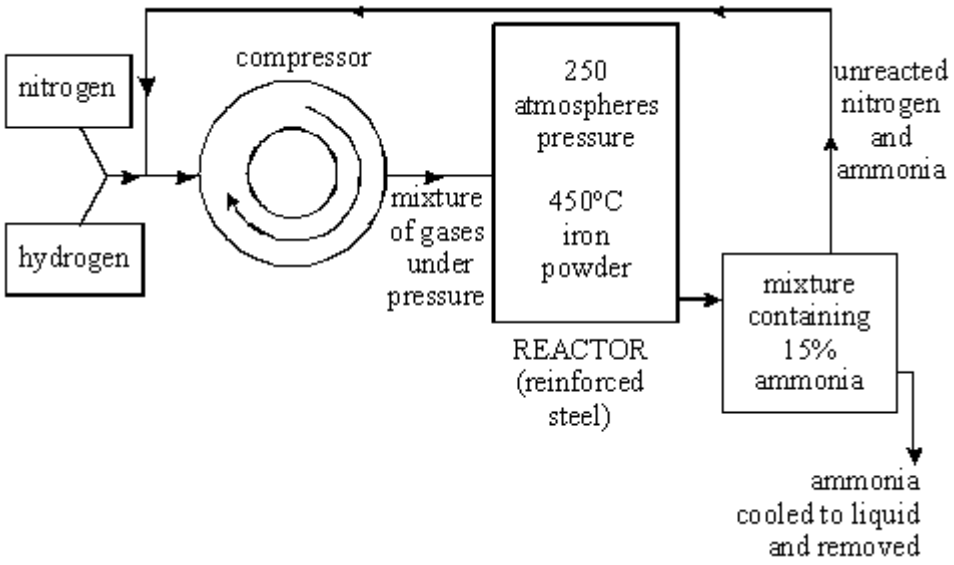
**(Total 6 marks)**

## Q14.

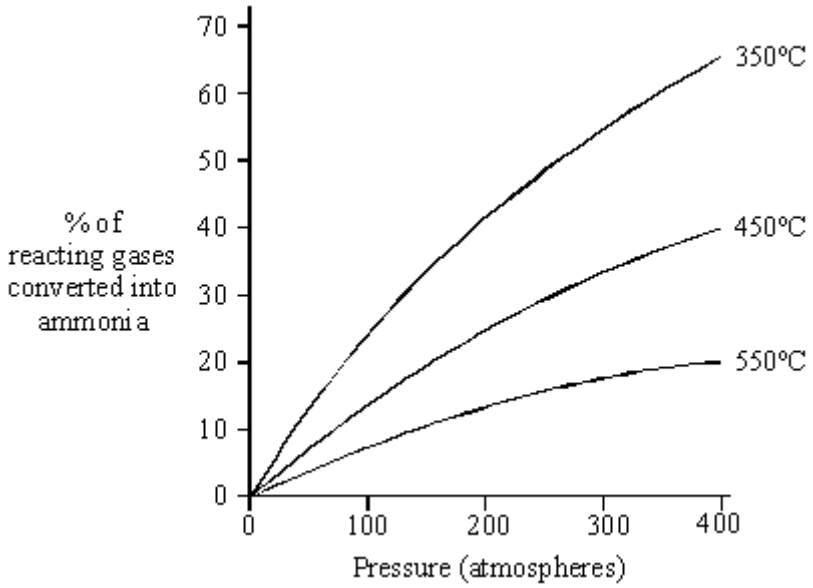
Ammonia is manufactured from nitrogen and hydrogen. The reaction is shown in the equation below.




The diagram shows some details of the manufacturing process.




The graph shows the percentage of reacting gases converted into ammonia at different temperatures and pressures.




At room temperature and pressure, the reaction is very slow and only a small percentage of the reacting gases is converted to ammonia.

Use the information on the diagram and graph to:

(a) describe the conditions used in the manufacture of ammonia **to increase the rate of reaction**.

**(4)**

(b) describe and explain the conditions used in the manufacture of ammonia **to increase the yield.**

**(7)**

**(Total 11 marks)**

## Q15.

Ammonia is manufactured by the Haber Process, where nitrogen and hydrogen react together as follows:

$N_2 + 3H_2 \Leftrightarrow 2NH_3$

The reaction is reversible. A balance is eventually reached when ammonia is being formed at the same rate at which it is decomposing.

This point is called ‘equilibrium’.

| | PERCENTAGE OF AMMONIA AT EQUILIBRIUM | | |
|---|---|---|---|
| PRESSURE (ATM) | 100° C | 300° C | 500° C |
| 25 | 91.7 | 27.4 | 2.9 |
| 100 | 96.7 | 52.5 | 10.6 |
| 400 | 99.4 | 79,7 | 31.9 |

(a) (i) What is meant by a ‘reversible reaction’?

_____

_____

**(1)**

(ii) Which substances are present in the mixture at equilibrium?

_____

**(1)**

(b) (i) Under what conditions shown in the table is the maximum yield of ammonia obtained?

_____

_____

**(2)**

(ii) The Haber Process is usually carried out at a higher temperature than that which would produce the maximum yield. Suggest why.

_____

_____

_____

_____

**(2)**

(c) Ammonia can be converted into nitric acid in three stages:

Stage 1 Ammonia reacts with oxygen from the air to form nitrogen monoxide and water

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

Stage 2 On cooling, nitrogen monoxide reacts with oxygen from the air to form nitrogen dioxide.

Stage 3 Nitrogen dioxide reacts with water to form nitric acid and nitrogen monoxide.

(i) Describe the conditions under which the reaction in Stage 1 takes place.

_____

_____

_____

_____

**(3)**

(ii) Balance the equation for the reaction at Stage 2.

$NO \quad + \quad O_2 \longrightarrow NO_2$

**(1)**

(iii) Balance the equation for the reaction at Stage 3.

$NO_2 \quad + \quad H_2O \longrightarrow HNO_3 \quad + \quad NO$

**(1)**

(d) The chemical plant for manufacturing ammonia is often on the same site as plants manufacturing nitric acid and fertilisers.

(i) What advantages will this have for the manufacturing company?

_____

_____

_____

_____

**(2)**

(ii) Briefly describe **two** important ways in which it is possible to reduce the environmental impact of such plants on the surrounding area.

1. _____

_____

2. _____

_____

**(2)**

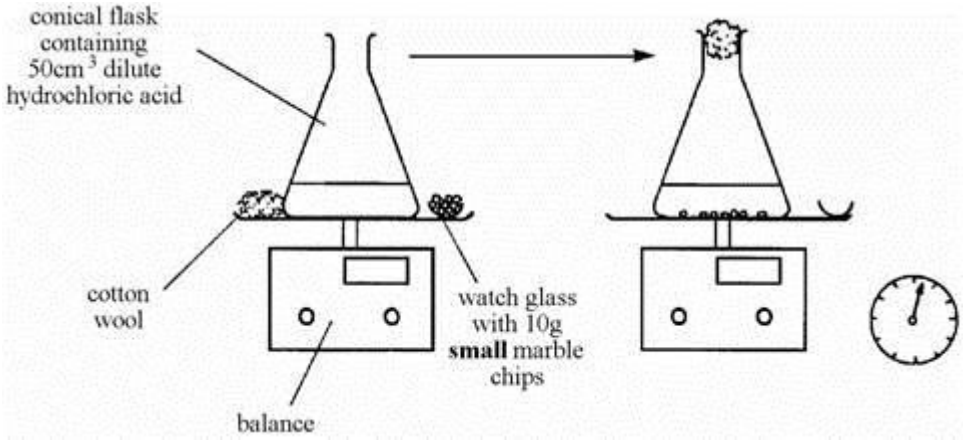
**(Total 15 marks)**

## Q16.

Marble chips (calcium carbonate) react with dilute hydrochloric acid.

calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide + water

A student wanted to find out if the size of the marble chips made a difference to how fast the reaction took place.




(a) What readings should she take?

_____

_____

_____

**(2)**

(b) She repeated the experiment but this time used the same mass (10g) of **large** marble chips. In both experiments there was some marble left in the flask when the reaction stopped.

These are the results of the two experiments.

| TIME (minutes) | 0 | 2 | 4 | 6 | 8 | 10 | 12 |
|---|---|---|---|---|---|---|---|
| Loss in mass (g), using small chips | 0.00 | 0.40 | 0.72 | 0.91 | 1.04 | 1.04 | 1.04 |
| Loss in mass (g), using large chips | 0.00 | 0.28 | 0.52 | 0.70 | 0.84 | 0.94 | 1.04 |

(i) Explain the loss in mass in the two experiments.

_____

_____

_____

_____

**(1)**

(ii) What difference does the size of the chips make?

_____

_____

**(1)**

(c) A chemical reaction occurs when reacting particles collide with sufficient energy. The reaction between marble and hydrochloric acid is faster if the acid is at a higher temperature. Explain why.

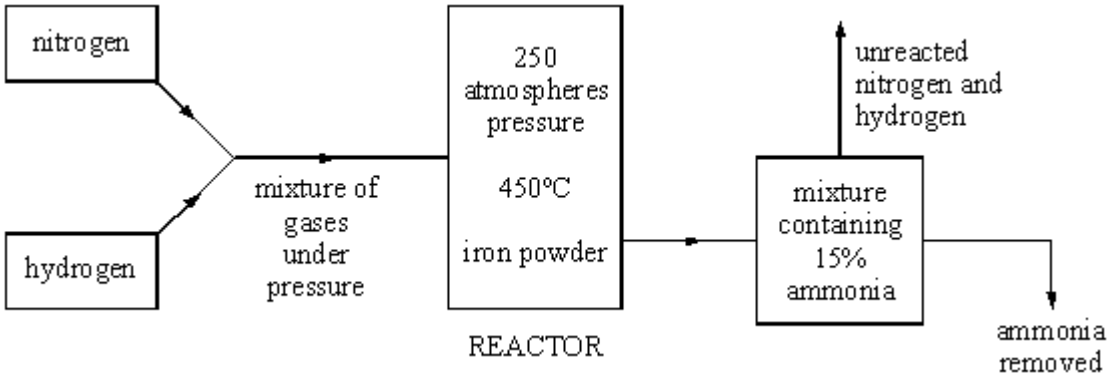
_____

**(3)**

**(Total 7 marks)**

## Q17.

Ammonia is manufactured from nitrogen and hydrogen in the Haber Process. The diagram shows some details of the manufacturing process.




(a) Nitrogen is obtained from the air.
From where is the hydrogen obtained?

**(1)**

(b) What happens to the unreacted nitrogen and hydrogen?

**(1)**

(c) Ammonium nitrate is made from ammonia.

Farmers spread nitrates on to soil to make crops grow better.

The nitrates may get into people's bodies even if they do not eat the crops.

Explain how this can happen.

**(2)**

(d) The equation for the Haber Process is this:

$$N_2 + 3H_2 \rightleftharpoons^{\text{exothermic}} 2NH_3$$

At equilibrium, nitrogen, hydrogen and ammonia are present in the reactor.

(i) What is meant by 'equilibrium'?

_____

_____

_____

**(1)**

(ii) Explain, as fully as you can, why:

- the yield of ammonia decreases with increase in temperature,
- despite this fact, a comparatively high temperature of 4500C is used for the industrial process,
- iron powder is added to the reactor.

_____

_____

_____

_____

_____

_____

_____

**(4)**

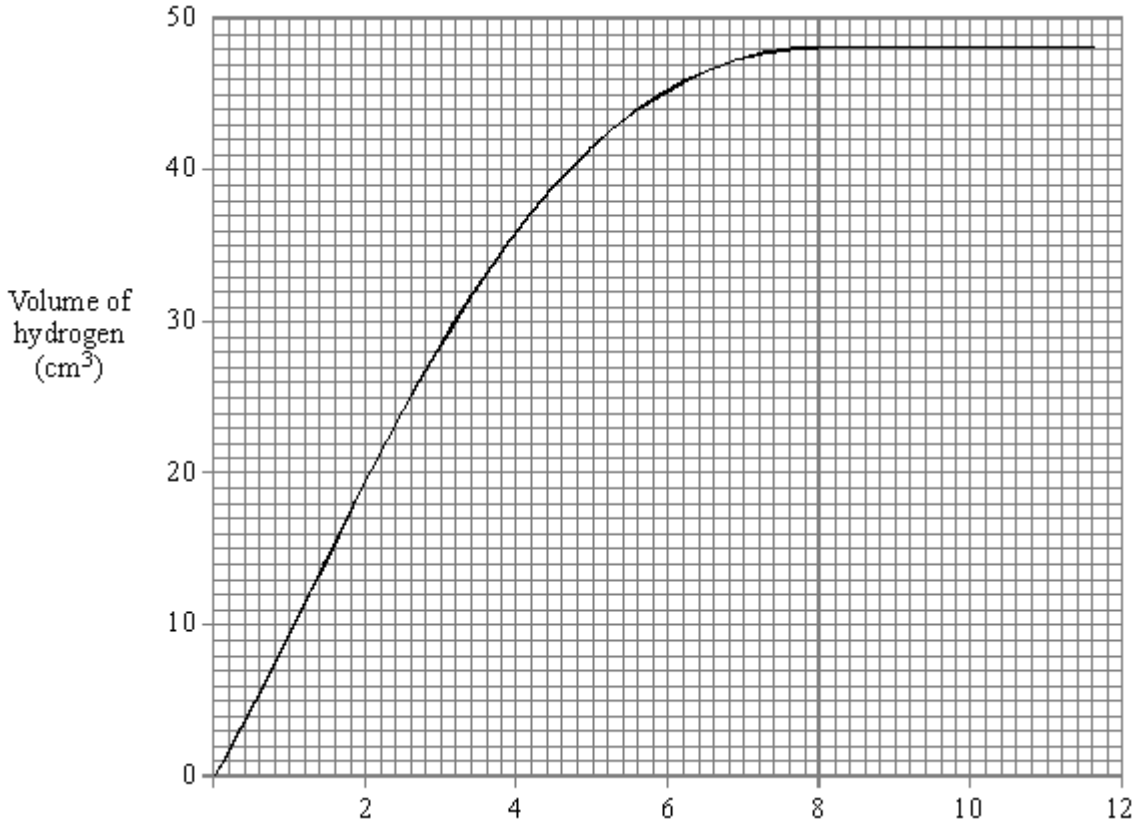
**(Total 9 marks)**

## Q18.

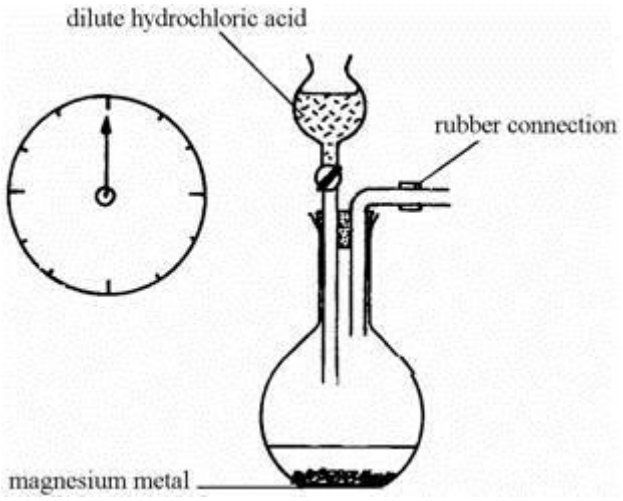
A student does an experiment to examine the rate of reaction between magnesium and dilute hydrochloric acid.
She adds 25 $cm^3$ of the acid to a weighed amount of the metal.
The reaction produces hydrogen gas.

Magnesium + hydrochloric acid ⟶ magnesium + hydrogen chloride

She collects the gas and measures the volume collected at one minute intervals.
All the metal reacted but there was some acid left unreacted.
Her results are shown on the graph.




(a) The diagram shows part of the apparatus she used for the experiment.
Complete the diagram to show how the student could collect the hydrogen produced and measure the volume after each minute.




**(2)**

(b) (i) When is the rate of reaction at its fastest?

_____

**(1)**

(ii) State **one** way in which she could increase the rate of reaction.

_____

**(1)**

(c) (i) What is the total volume of hydrogen collected in the experiment?

_____ $cm^3$

**(1)**

(ii) State **one** way in which she could increase the final volume of hydrogen collected.

_____

**(1)**

**(Total 6 marks)**