Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

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General Certificate of Secondary Education
June 2006

CHEMISTRY (SPECIFICATION B) **3421/H**
Higher Tier

H

Wednesday 14 June 2006 9.00 am to 11.15 am

For this paper you must have:
- a ruler
- the Data Sheet (enclosed)

You may use a calculator.

Time allowed: 2 hours 15 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 135.
- The marks for questions are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers.

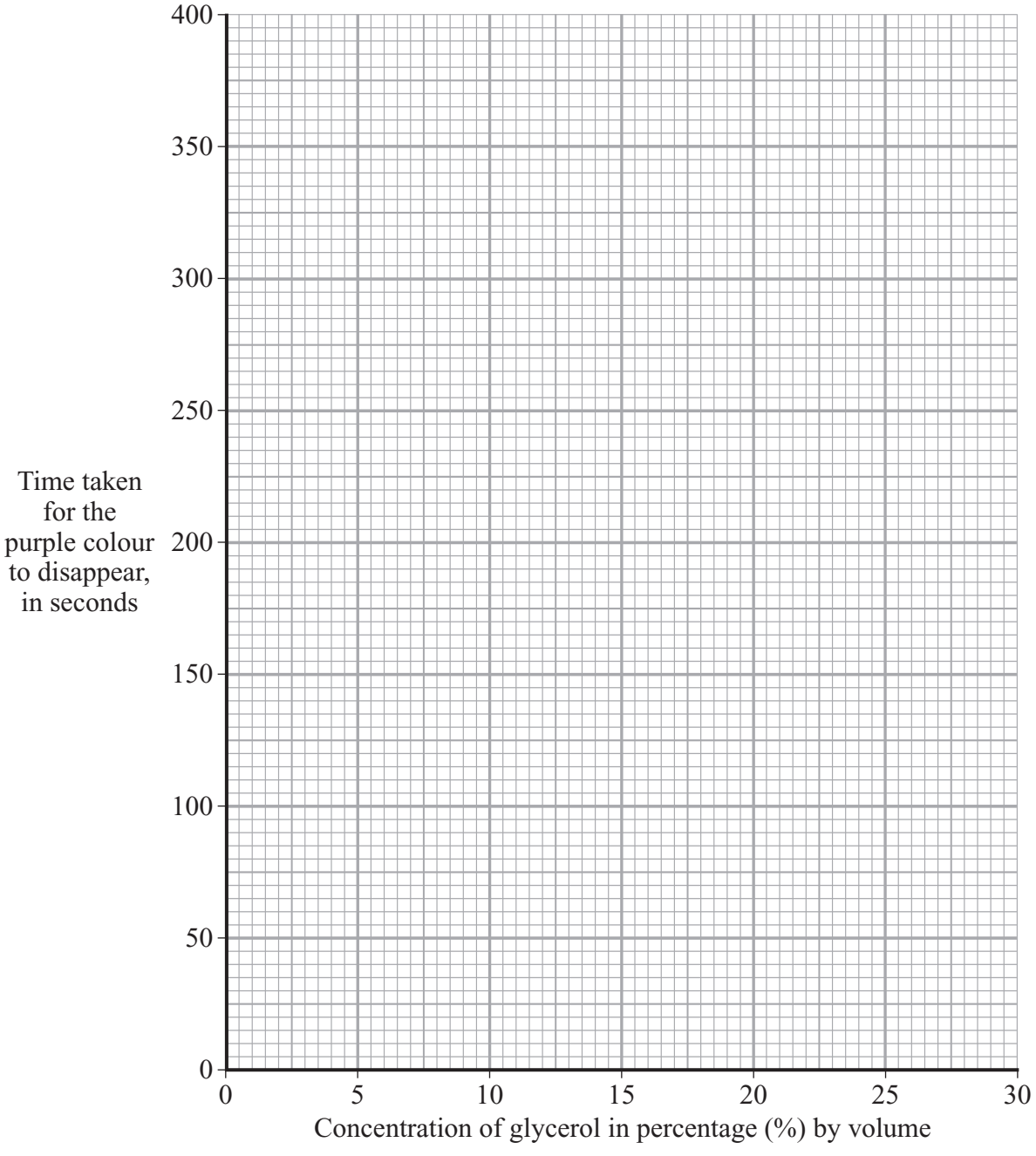
For Examiner's Use			
Number	Mark	Number	Mark
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	
		21	
		22	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

1 Glycerol reacts with a purple solution to form colourless products. The time taken for the purple colour to disappear can be used to measure the rate of this reaction.

A student did some experiments to find out how the concentration of glycerol affects the rate of this reaction. The results are shown in the table.

Concentration of glycerol in percentage (%) by volume	4	10	16	24	30
Time taken for the purple colour to disappear, in seconds	375	150	94	63	50

(a) Plot these points on the graph and draw a smooth curve through the points.



(3 marks)

(b) The time taken for the purple colour to disappear when the concentration of the glycerol is 10 % is 150 seconds.

(i) Use your graph to estimate the time it would take for the purple colour to disappear when the concentration of glycerol is 20 %.

Time = ... seconds

(1 mark)

(ii) If the concentration of glycerol is doubled, what happens to the **rate** of reaction?

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(1 mark)

(iii) Explain, in terms of particles, why increasing the concentration of glycerol increases the rate of this reaction.

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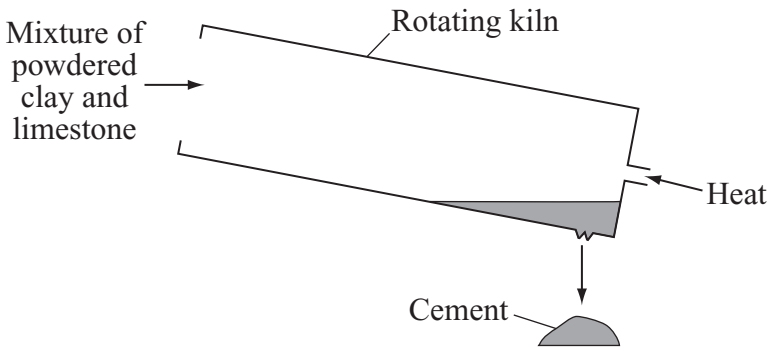
(2 marks)

7

Turn over for the next question

2 (a) Limestone is an important raw material in the manufacture of cement.



In this process:

- powdered limestone and clay are mixed in a rotating kiln;
- *thermal decomposition* of the limestone takes place to produce calcium oxide;
- the calcium oxide then reacts with the clay to make cement.

(i) Explain what is meant by the term *thermal decomposition*.

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(2 marks)

(ii) Thermal decomposition of calcium carbonate also produces a gas which turns limewater milky.

Name this gas. .....

(1 mark)

(iii) Suggest why a rotating kiln is used.

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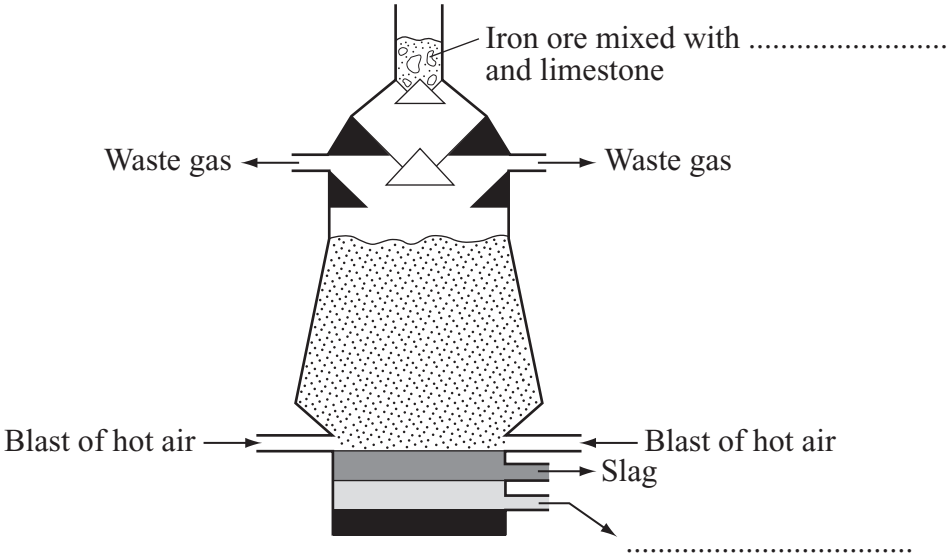
(1 mark)

(b) Limestone is also used in the extraction of iron in the blast furnace.

The diagram shows a blast furnace.

(i) Complete the diagram by adding the **two** missing labels.



(2 marks)

(ii) The iron ore (iron oxide) is *reduced* in the furnace.

Explain what is meant by the term *reduced*.

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(1 mark)

(iii) The slag obtained from the blast furnace can be ground up and used to make a type of cement.
This is different from the method described in part (a) of this question.

Suggest and explain **one** advantage of using blast furnace slag to make cement.

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(2 marks)

9

3 Read the information about plastic-tar and then answer the questions.

Plastic-Tar Roads!

A town in India has made a road from plastic-tar. The town mayor is quoted as saying, 'using plastic-tar will reduce the problem of plastic waste'.

Roads are usually made from a mixture of bitumen and gravel. Plastic-tar is made by mixing the bitumen and gravel with plastic. This plastic is obtained from household waste material.

Plastic-tar is harder and more waterproof than ordinary tar. This helps it to last longer.

(a) Use your knowledge of plastics to explain why the disposal of plastic waste is difficult, making it a problem for the environment.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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(4 marks)

(b) Suggest **two** advantages of using waste plastic to make plastic-tar.

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(2 marks)

6

4 Iron(II) sulphate tablets are used to treat people with iron deficiency.

This label was on a bottle of tablets.

Iron(II) sulphate tablets

$FeSO_4$

100 iron(II) sulphate tablets.
Each tablet contains 0.2 g of $FeSO_4$

(a) Calculate the relative formula mass (M_r) of iron(II) sulphate, $FeSO_4$.

Relative atomic masses: O = 16; S = 32; Fe = 56.

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Relative formula mass = ...
(2 marks)

(b) Calculate the percentage by mass of iron in iron(II) sulphate.

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Percentage by mass of iron = ... %
(2 marks)

(c) The 100 iron tablets in the bottle contain a total mass of 20 g of iron(II) sulphate.

Calculate the mass of iron in 20 g of iron(II) sulphate.

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Mass of iron = ... g
(2 marks)

6

5 The periodic table on the Data Sheet may help you to answer this question.

The diagram shows a Group in a periodic table designed by John Newlands in 1864. The Group contains elements found in Group 7 (the halogens) of the modern periodic table (fluorine, chlorine, bromine and iodine) and other elements.

H
F
Cl
Co/Ni
Br
Pd
I
Pt/Ir

(a) Cobalt, nickel, palladium, platinum and iridium are now classed as transition elements. State **three** ways in which the properties of transition elements are different from halogens.

1 .....

2 .....

3 .....

(3 marks)

(b) Hydrogen is difficult to place in the modern periodic table.

(i) Use the table of ions on the Data Sheet to help you to give **one** way in which hydrogen is similar to the elements in Group 1.

.....

.....

(1 mark)

(ii) Give **one** property of hydrogen which makes it similar to the elements at the top of Group 7.

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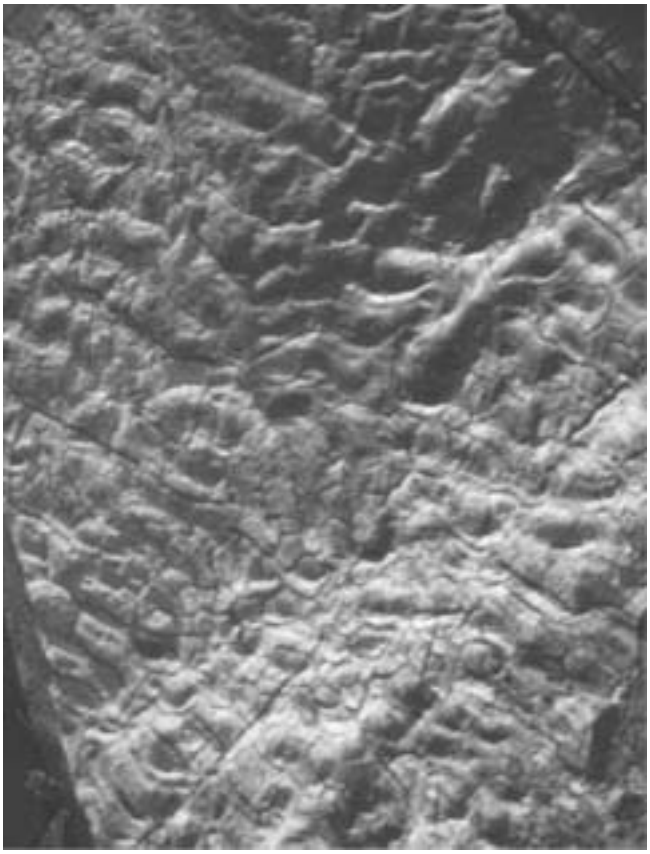
(1 mark)

5

6 The picture shows ripple marks on rock found in Dorset.



These ripple marks were formed when the sediments were first laid down.

Explain how these ripple marks could have been formed.

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(2 marks)

2

7 (a) A solution of magnesium chloride can be made by reacting magnesium oxide with **warm** hydrochloric acid.

(i) Balance the equation for this reaction.

$MgO\ (s) \quad + \quad .....HCl\ (aq) \quad \rightarrow \quad MgCl_2\ (aq) \quad + \quad H_2O\ (l)$

(1 mark)

(ii) Describe how you would make a solution of magnesium chloride starting with magnesium oxide powder and hydrochloric acid.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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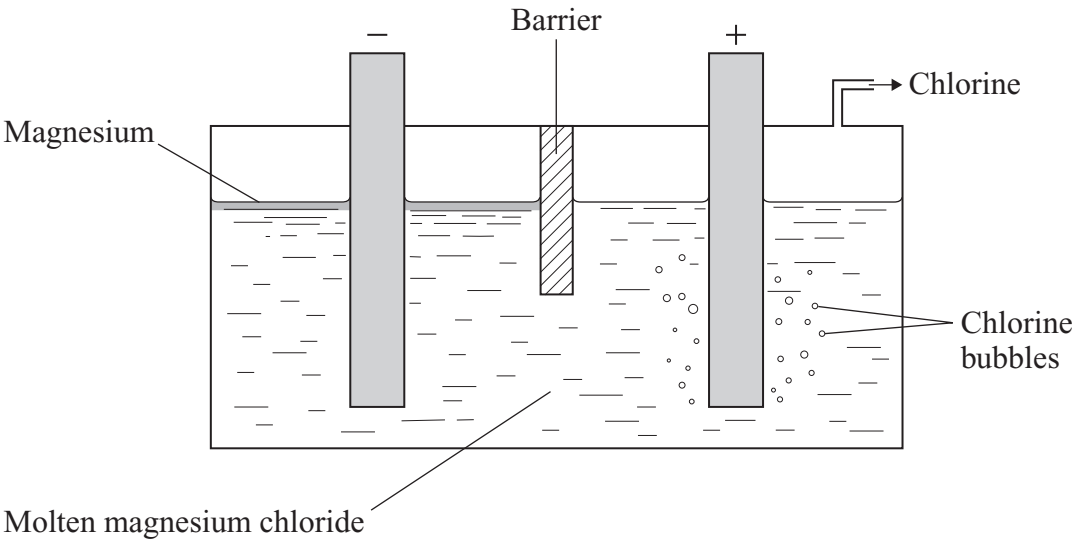
(5 marks)

(b) Magnesium and chlorine can be made by the electrolysis of molten magnesium chloride.



(i) Magnesium is formed at the negative electrode.

Explain why.

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(2 marks)

(ii) Chlorine is often added to drinking water.

Explain why.

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(1 mark)

9

8 (a) (i) Describe how to make a dilute solution of ethanol from sugar by fermentation.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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(5 marks)

(ii) Name the gas which is produced by fermentation.

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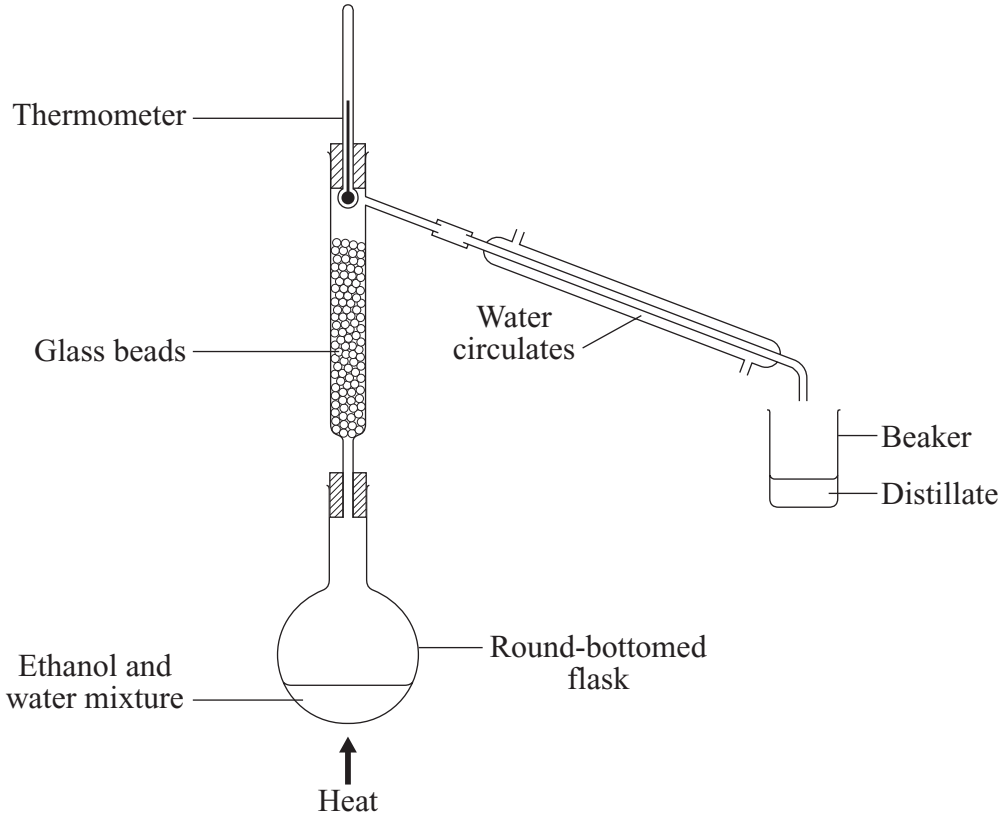
(1 mark)

(b) The diagram shows how ethanol (boiling point 78 ºC) can be separated from water (boiling point 100 ºC).



(i) Name this type of distillation.

.....

(1 mark)

(ii) Which liquid, ethanol or water, will be the first to distil over into the beaker?

.....

Give a reason for your answer.

.....

(1 mark)

8

9 These labels are from two bottles of spring water.

Still

Alice's Spring

Australian Spring Water

Ions present	Concentration (mg per litre)
chloride	20.0
sodium	14.0
magnesium	5.0
calcium	3.0
hydrogencarbonate	2.0
potassium	1.0

SOURCE

Still Natural Mineral Water

Ions present	Concentration (mg per litre)
chloride	5.0
calcium	4.5
sulphate	4.0
sodium	3.0
nitrate	1.9
magnesium	1.3
potassium	0.5

(a) (i) Suggest why the amounts of sodium ions in these spring waters are different.

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(2 marks)

(ii) 'Alice's Spring' water is harder than 'Source' water.

Use the information on the label to explain why.

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(1 mark)

(iii) Describe and give the result of a test to show that these spring waters are hard.

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(2 marks)

(b) Explain how sodium carbonate softens hard water.

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(2 marks)

(c) State **one** advantage of hard water.

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(1 mark)

8

Turn over for the next question

10 Arrhenius in 1884, and Brønsted and Lowry in 1923, put forward ideas that explained acid-base behaviour.

(a) Hydrochloric acid, HCl, behaves as an acid when it reacts with sodium hydroxide, NaOH.

Explain why, using the ideas of Arrhenius.

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(2 marks)

(b) The work of Arrhenius took much longer to be accepted than the work of Brønsted and Lowry.

Suggest a reason why.

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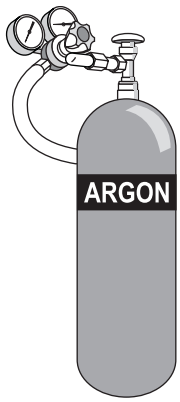
(1 mark)

3

11 Argon gas is extracted from the air and stored in cylinders.
This cylinder contains 180 litres (dm^3) of argon gas.



(a) Air contains 0.9 % of argon by volume.

Calculate the volume of air that would contain 180 litres of argon.

.....

.....

..... litres
(2 marks)

(b) Welding involves heating metals to high temperatures.
Argon is used to provide an unreactive atmosphere around metals during welding.

(i) Explain, in terms of electrons, why argon is unreactive.

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(2 marks)

(ii) Suggest why hot metals need to be protected from the air.

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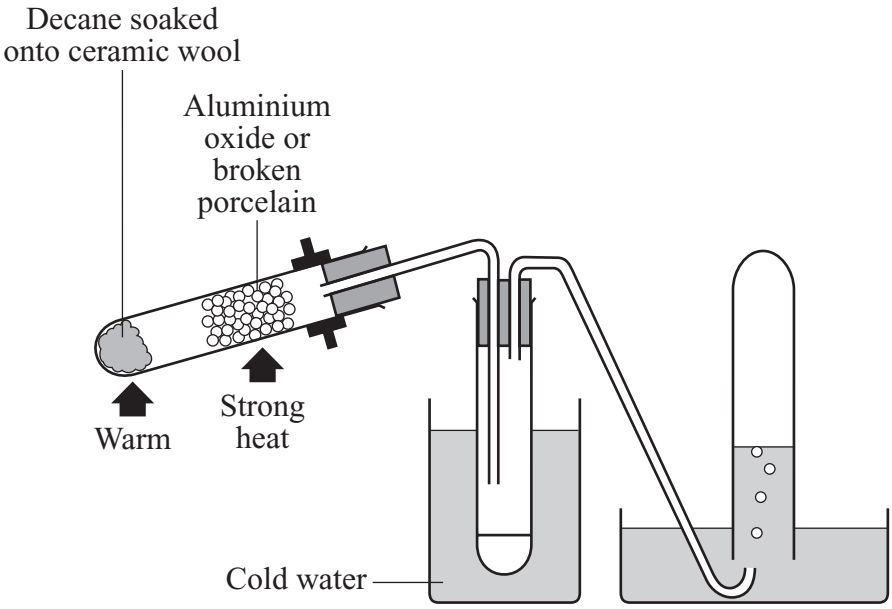
(1 mark)

5

12 Cracking is an important type of reaction used in the oil industry.

The diagram shows an apparatus that can be used in a school laboratory to show cracking.



(a) (i) What is the purpose of the broken porcelain or aluminium oxide?

.....

(1 mark)

(ii) Explain why cracking is used in the oil industry.

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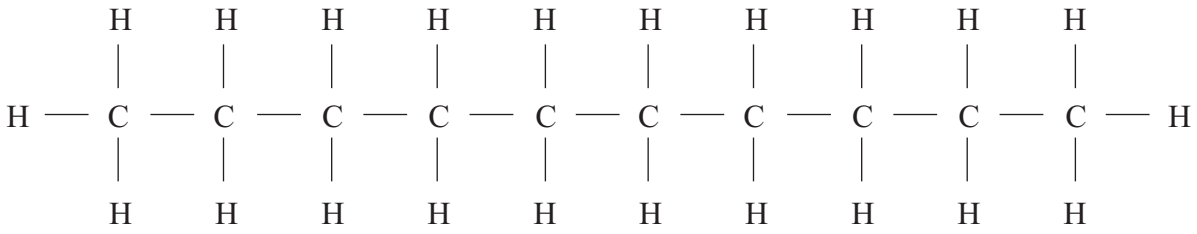
(2 marks)

(b) The equation represents a reaction that takes place when decane, $C_{10}H_{22}$, is cracked.

$$C_{10}H_{22} \rightarrow C_2H_4 + C_8H_{18}$$

Draw an **X** on the diagram to show where ethene, C_2H_4, molecules collect. *(1 mark)*

(c) The diagram below represents a decane molecule.



Draw similar diagrams for:

(i) C_8H_{18}

(1 mark)

(ii) C_2H_4

(1 mark)

6

Turn over for the next question

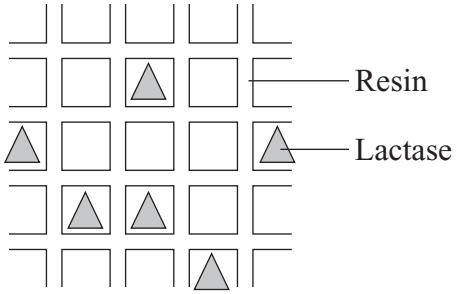
13 Read the information about the use of lactase and then answer the questions.

Lactose is a sugar found in milk. It makes many Thai, Chinese and Afro-Caribbean people ill. One way to help to solve this problem is to use lactase to convert the lactose into the sugars glucose and galactose.

$$\text{lactose} \xrightarrow{\text{lactase}} \text{glucose} + \text{galactose}$$

Lactase is expensive so it is *immobilised* when it is used in industry.

Alginate gel can be used to immobilise lactase. Lactase is mixed with alginate gel solution. Drops of the mixture are then allowed to solidify and form alginate beads.



Magnified cross-section of an alginate bead

A column is filled with the alginate beads. The milk is then poured through the column in a continuous process.

(a) What type of substance is lactase? .....

(1 mark)

(b) Explain the meaning of the term *immobilised*, using the information above.

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.....

(2 marks)

(c) Suggest **one** reason, other than cost, for immobilising the lactase rather than simply adding it to the milk.

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(1 mark)

(d) Suggest **one** advantage of using a continuous process instead of a batch process.

.....

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(1 mark)

5

Turn over for the next question

LEAVE MARGIN BLANK

14 The periodic table on the Data Sheet may help you to answer this question about the alkali metals.

(a) The electronic structure of a sodium atom can be represented as:

2, 8, 1

Give the electronic structure of a potassium atom.

.....

(1 mark)

(b) Explain, in terms of electrons, why sodium and potassium have similar properties.

.....

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(1 mark)

(c) Both sodium and potassium react with water.

Explain, in terms of electrons, why potassium reacts more violently than sodium.

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(3 marks)

(d) Alkali metal compounds have many uses.

Sodium hydroxide reacts with phosphoric acid to make a salt that is used to inhibit the growth of mould on fruit.

Complete the word equation for this reaction.

phosphoric acid + sodium hydroxide → ..... phosphate + ...

(2 marks)

7

15 (a) Read the passage about the manufacture of steel.

> Molten iron from the blast furnace is mixed with recycled scrap iron and pure **X** is passed into the mixture.
>
> The non-metal impurities are converted into oxides. Substance **Y** is then added to remove these oxides.
>
> Calculated quantities of carbon and/or other elements are then added to make steels with particular properties.

Identify substances **X** and **Y** and explain, as fully as you can, the details of the processes in terms of:

- redox reactions;
- acid-base reactions.

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(5 marks)

(b) Stainless steel is used to make cutlery. One type is commonly known as 18/8 stainless steel. It contains 18 % chromium and 8 % nickel by mass.

An 18/8 stainless steel fork has a mass of 45 g.

Calculate the number of moles of chromium in this fork.

Relative atomic mass: Cr = 52.

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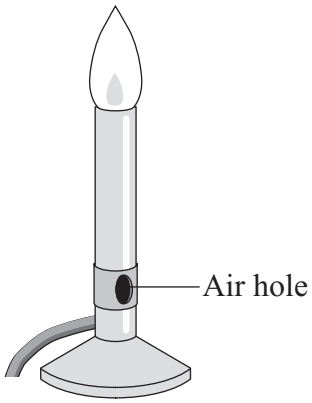
Moles of chromium = ...

(2 marks)

7

16 The diagram shows a Bunsen burner.



(a) The fuel used is methane, CH_4.

The equation for the complete combustion of methane is shown below.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

The relative formula mass (M_r) of methane is 16.

Calculate the mass of oxygen that reacts with 16 g of methane.

Relative atomic masses: H = 1; C = 12; O = 16.

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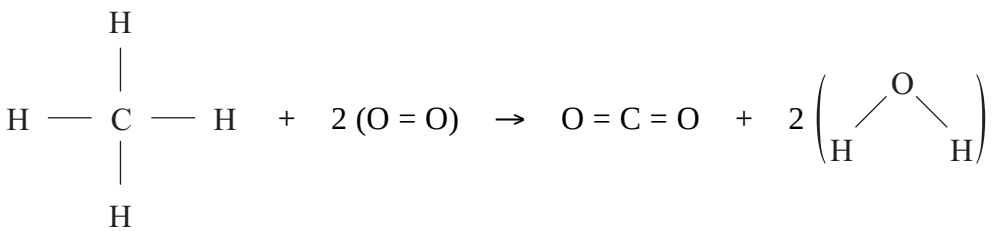
Mass of oxygen = ... g

(2 marks)

(b) The equation for the combustion of methane can also be represented by this equation.



(i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy (kJ)
C — H	435
O = O	498
C = O	805
O — H	464

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Energy change = ... kJ

(3 marks)

(ii) Explain, in terms of bond energies, why the combustion of methane is exothermic.

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(1 mark)

(c) The amount of energy you have calculated, in (b)(i), is the maximum amount of energy released on the complete combustion of 16 g of methane, when the air hole is open.

Suggest why the amount of energy released is less when the air hole is closed.

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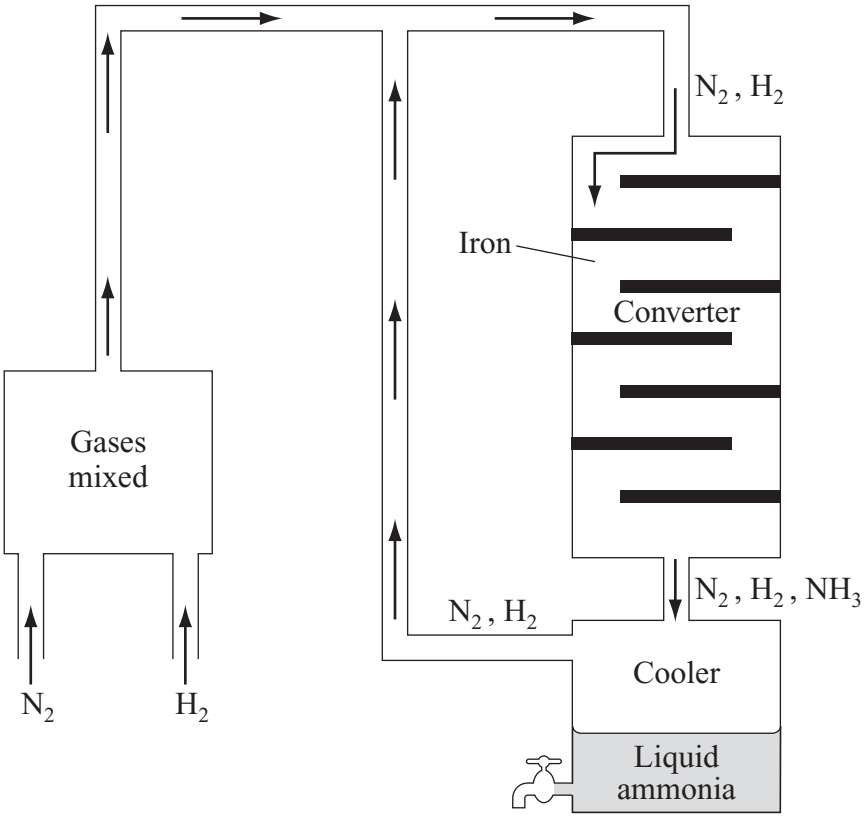
(1 mark)

7

17 The diagram shows the Haber process to make ammonia.



In the converter nitrogen and hydrogen react to form ammonia.

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

(a) Not all of the nitrogen and hydrogen is changed into ammonia. Explain how ammonia is separated from unreacted nitrogen and hydrogen.

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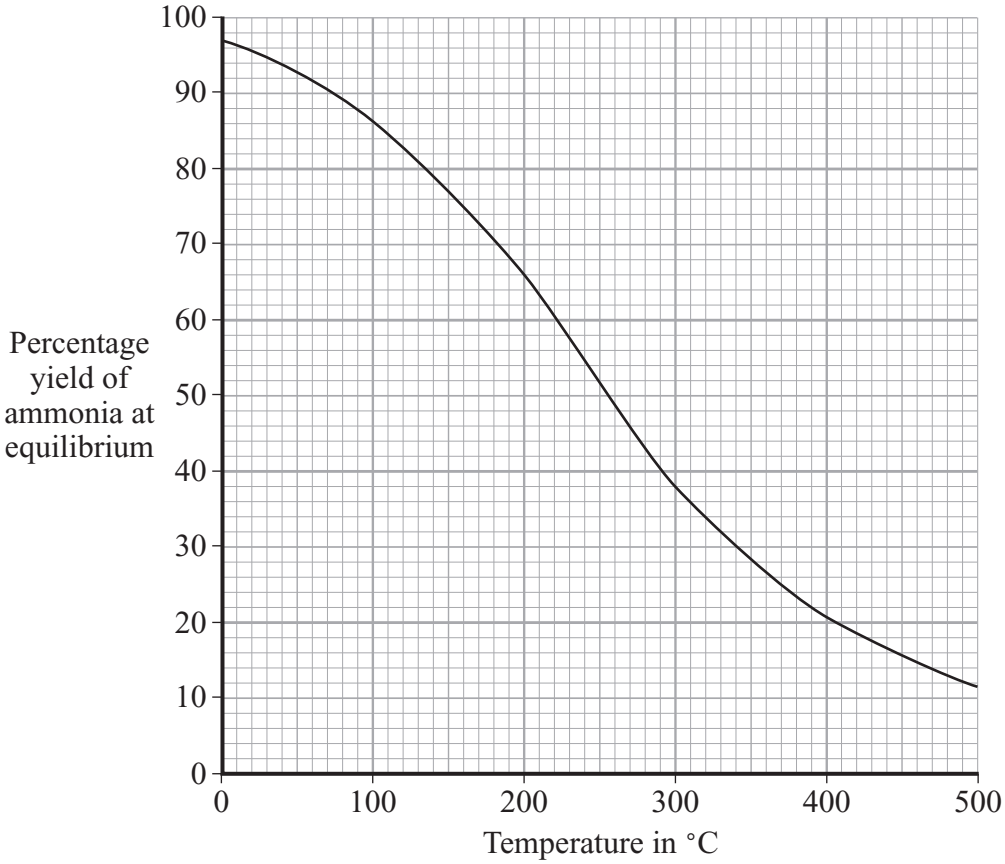
(2 marks)

(b) What is the purpose of the iron in the converter?

.....

(1 mark)

(c) The graph shows how the percentage yield of ammonia at equilibrium changes as the temperature is increased. The pressure is constant.



(i) Explain why the highest percentage of ammonia at equilibrium is obtained at low temperature.

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.....

(1 mark)

(ii) Explain why the actual temperature used in this process is about 450 ºC.

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(1 mark)

5

18 Phosphorus compounds have many uses.

(a) (i) About 250 000 tonnes of phosphorus trichloride, $\mathbf{PCl_3}$, are produced each year.

$\mathbf{PCl_3}$ is made by the reaction of phosphorus, $\mathbf{P_4}$, with chlorine, $\mathbf{Cl_2}$.

The word equation for this reaction is shown below.

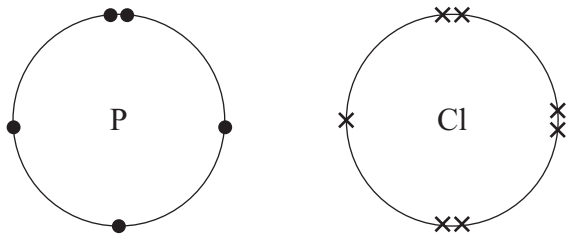
phosphorus + chlorine → phosphorus trichloride

Write a balanced symbol equation for this reaction. State symbols are **not** needed.

.....

(2 marks)

(ii) The diagrams show how the electrons are arranged in the outer shell (highest occupied energy level) of a phosphorus atom and a chlorine atom.



Draw a diagram to show the bonding in a molecule of phosphorus trichloride. Use dots and crosses to represent the electrons. Show only the outer shell electrons.

(2 marks)

(iii) Phosphorus trichloride has a melting point of – 92 ºC and a boiling point of 76 ºC.

Is it a solid, a liquid or a gas at room temperature (20 ºC)?

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(1 mark)

(iv) Explain why phosphorus trichloride has a low melting point and boiling point.

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(2 marks)

(b) Phosphorus reacts with zinc to form a compound that is used as a rat poison.

A sample of this compound was found to contain 1.95 g of zinc and 0.62 g of phosphorus.

Calculate the formula of this compound.

You must show all your working to gain full marks.

Relative atomic masses: P = 31; Zn = 65.

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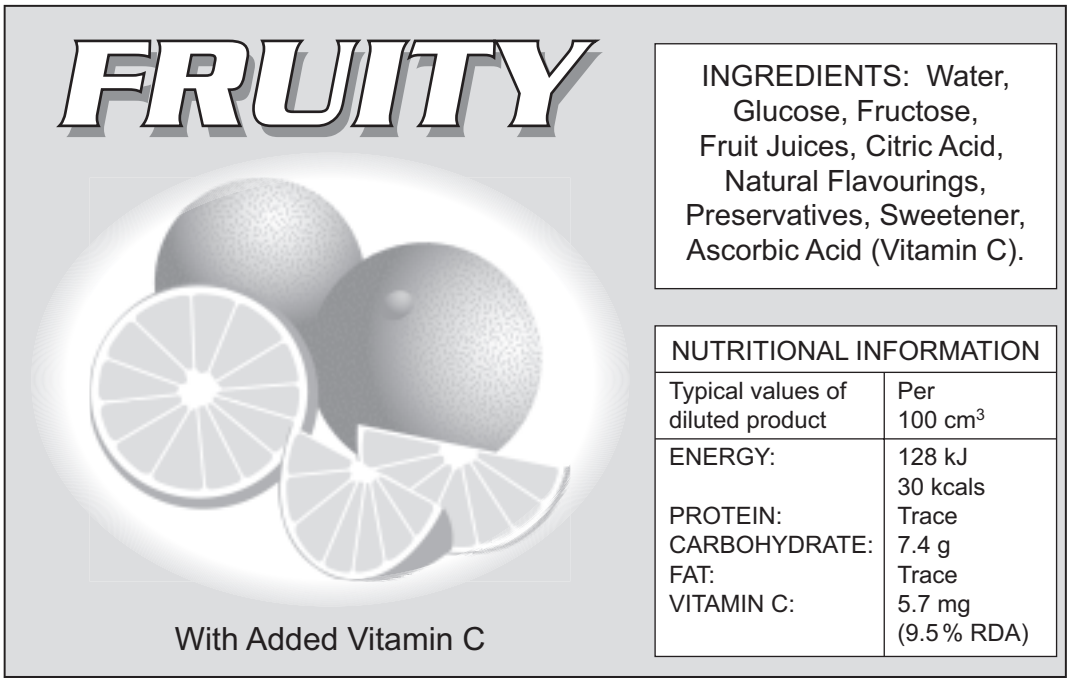
(4 marks)

11

19 Many soft drinks, such as 'Fruity', contain vitamin C.



The chemical name for vitamin C is ascorbic acid.

(a) 25.0 cm^3 of 'Fruity' were placed in a conical flask. Describe how the volume of dilute sodium hydroxide required to neutralise the acid in 25.0 cm^3 of 'Fruity' can be found accurately by titration. Name any other apparatus and materials used.

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(4 marks)

(b) The volume of sodium hydroxide used in the titration was far more than was needed to neutralise the ascorbic acid in the 'Fruity'. Suggest why.

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(1 mark)

(c) 100 cm^3 of diluted 'Fruity' contains 0.0057 g of ascorbic acid.

Calculate the concentration of ascorbic acid in moles per cubic decimetre.

Relative formula mass of ascorbic acid = 176.

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.....

Concentration = ... moles per cubic decimetre
(2 marks)

7

Turn over for the next question

20 This label is from a packet of 'Keep Off '.

Animal Deterrent

KEEP OFF

Contains 88% ww aluminium ammonium sulphate

Keep Off is a really effective and safe method of saving your garden from your neighbour's cats and dogs.

DIRECTIONS FOR USE: Dissolve contents of sachet in 4 pints of water. Apply as necessary.

The active chemical is aluminium ammonium sulphate, $Al(NH_4)(SO_4)_2$.

Describe how adding dilute sodium hydroxide to a solution of 'Keep Off ' shows that it contains both aluminium ions and ammonium ions.

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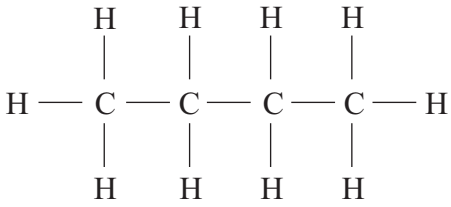
(3 marks)

3

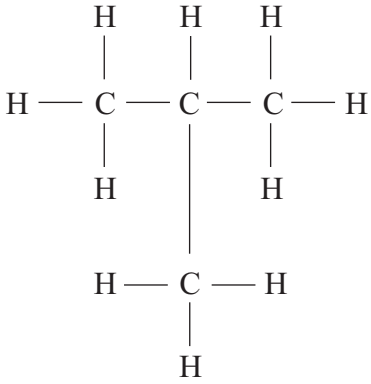
21 Butane and propane are useful hydrocarbon fuels.

(a) Butane, C_4H_{10}, has two isomers. They can be represented as shown below.

Butane



2-methylpropane



(i) What is isomerism?

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(2 marks)

(ii) Explain why butane has a higher boiling point than 2-methylpropane.

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(2 marks)

(b) There are no isomers of propane, C_3H_8. Explain why.

.....

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(1 mark)

5

22 (a) 'Instrumental methods of analysis are more useful compared with chemical tests.'

Explain this statement in terms of:

(i) the technologies that have helped the development of instrumental methods;

.....

.....

(1 mark)

(ii) **one** advantage of instrumental methods.

.....

.....

(1 mark)

(b) Read the information about mass spectrometry.

> Mass spectrometry is an instrumental method of analysis. It can be used to find the formula mass of organic compounds.
>
> In this method energy is used to change molecules into positive ions. If enough energy is supplied, some bonds break and smaller ions are produced.
>
> The machine then separates the ions and records their relative formula masses as a bar chart. The pattern of bars is called a *mass spectrum* and each bar corresponds to a particular mass.
>
> The bar produced by the heaviest ion (the one with the highest m/z) gives the relative formula mass of the compound.

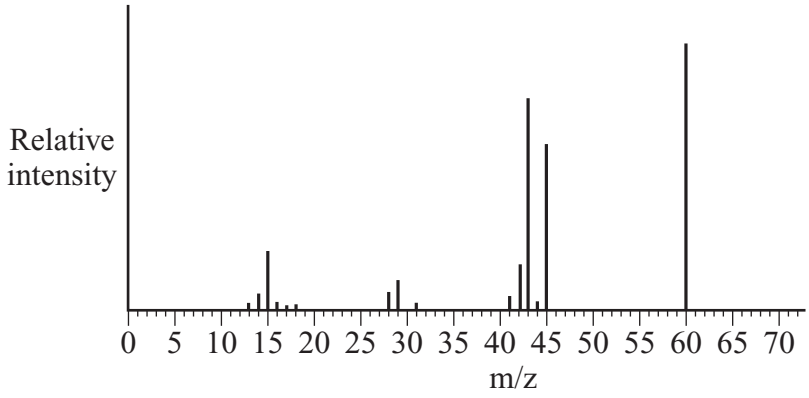
(i) Suggest the name of the atomic particle that must be lost from a molecule to change it into a positive ion.

.....

(1 mark)

(ii) Methanoic acid (HCOOH), ethanoic acid (CH_3COOH) and propanoic acid (C_2H_5COOH) are carboxylic acids.

A mass spectrum of one of **these** acids is shown below.



Use the information given and the relative atomic masses, H = 1, C = 12, O = 16, to identify this carboxylic acid.

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.....

The carboxylic acid is .....

(1 mark)

4

END OF QUESTIONS

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