FOR OFFICIAL USE

Total Section B

X012/301

NATIONAL
QUALIFICATIONS
2003

FRIDAY, 23 MAY
1.00 PM – 3.30 PM

CHEMISTRY
HIGHER

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth

Day Month Year   Scottish candidate number   Number of seat

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet (1999 edition).

SECTION A—Questions 1–40

Instructions for completion of **Section A** are given on page two.

SECTION B

1   All questions should be attempted.

2   The questions may be answered in any order but all answers are to be written in the spaces provided in this answer book, and must be written clearly and legibly in ink.

3   Rough work, if any should be necessary, should be written in this book and then scored through when the fair copy has been written.

4   Additional space for answers and rough work will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the invigilator and should be inserted inside the **front** cover of this book.

5   The size of the space provided for an answer should not be taken as an indication of how much to write. It is not necessary to use all the space.

6   Before leaving the examination room you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.

SCOTTISH
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SECTION A

1. Check that the answer sheet provided is for Chemistry Higher (Section A).

2. Fill in the details required on the answer sheet.

3. **In questions 1 to 40 of the paper, an answer is given by indicating the choice A, B, C or D by a stroke made in INK in the appropriate place in the answer sheet—see the sample question below.**

4. **For each question there is only ONE correct answer.**

5. Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—**not** on the answer sheet.

6. At the end of the examination the answer sheet for Section A **must** be placed **inside** the front cover of this answer book.


This part of the paper is worth 40 marks.

SAMPLE QUESTION

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

        A fractional distillation

        B chromatography

        C fractional crystallisation

        D filtration.

The correct answer is B—chromatography. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed **B** as shown **in the example on the answer sheet**.

If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer **D** to an answer **B**, your answer sheet would look like this:
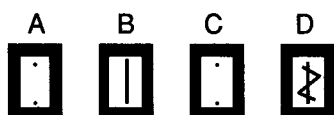
If you want to change back to an answer which has already been scored out, you should **enter a tick (✓)** to the RIGHT of the box of your choice, thus:

1. Which of the following substances is a non-conductor when solid, but becomes a good conductor on melting?

   A Argon

   B Potassium

   C Potassium fluoride

   D Tetrachloromethane

2. Which of the following covalent gases does **not** react with water forming ions?

   A HCl

   B SO_2

   C NH_3

   D CH_4

3. An iron nail is covered with water.

   Which of the following procedures would **not** increase the rate at which the iron nail corrodes?

   A Adding some sodium sulphate to the water

   B Adding some glucose to the water

   C Attaching a copper wire to the nail

   D Passing carbon dioxide through the water

4. Naturally occurring nitrogen consists of two isotopes ^{14}N and ^{15}N.

   How many different types of nitrogen molecules will occur in the air?

   A 1

   B 2

   C 3

   D 4

5. A mixture of sodium chloride and sodium sulphate is known to contain 0·6 mol of chloride ions and 0·2 mol of sulphate ions.

   How many moles of sodium ions are present?

   A 0·4

   B 0·5

   C 0·8

   D 1·0

6. When copper carbonate reacts with excess acid, carbon dioxide is produced. The curves shown were obtained under different conditions.
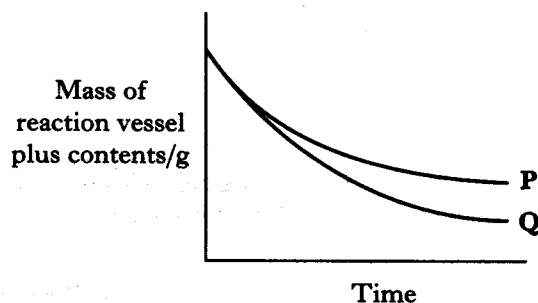
   The change from **P** to **Q** could be brought about by

   A increasing the concentration of the acid

   B increasing the mass of copper carbonate

   C decreasing the particle size of the copper carbonate

   D adding a catalyst.

7. When 3·6 g of butanal (relative formula mass = 72) was burned, 134 kJ of energy was released.

   From this result, what is the enthalpy of combustion, in kJ mol^{-1}?

   A −6·7

   B +6·7

   C −2680

   D +2680

8. Which of the following chlorides is likely to have the **most** ionic character?

   A LiCl

   B CsCl

   C $BeCl_2$

   D $CaCl_2$

9. Which equation represents the first ionisation energy of a diatomic element, X_2?

   A $\frac{1}{2}X_2(s) \rightarrow X^+(g)$

   B $\frac{1}{2}X_2(g) \rightarrow X^-(g)$

   C $X(g) \rightarrow X^+(g)$
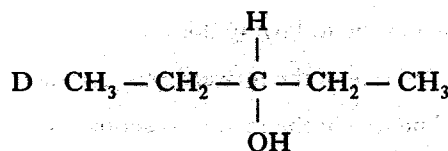
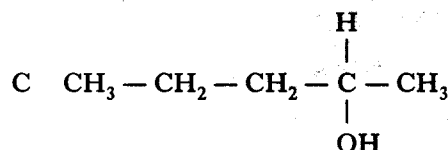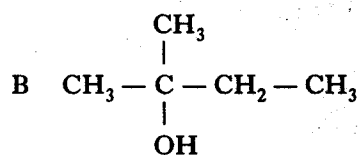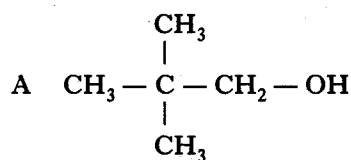   D $X(s) \rightarrow X^-(g)$

[Turn over

10. Which of the following elements exists as discrete molecules?

   A Boron

   B Carbon (diamond)

   C Silicon

   D Sulphur

11. Which of the following chlorides is most likely to be soluble in tetrachloromethane, CCl_4?

   A Barium chloride

   B Caesium chloride

   C Calcium chloride

   D Phosphorus chloride

12. In which of the following liquids does hydrogen bonding occur?

   A Ethanoic acid

   B Ethyl ethanoate

   C Hexane

   D Hex-1-ene

13. A compound boils at $-33\,^\circ C$. It also dissolves in water to give an alkaline solution.

   Which type of bonding is present within the compound?

   A Metallic

   B Covalent (polar)

   C Ionic

   D Covalent (non-polar)

14. The number of moles of ions in 1 mol of copper(II) phosphate is

   A 1

   B 2

   C 4

   D 5.

15. The Avogadro Constant is the same as the number of

   A atoms in 24 g of carbon

   B molecules in 16 g of oxygen

   C molecules in 2 g of hydrogen

   D ions in 1 litre of sodium chloride solution, concentration $1\,mol\,l^{-1}$.

16. What volume of oxygen, in litres, is required for the complete combustion of 1 litre of butane gas?

   (All volumes are measured under the same conditions of temperature and pressure.)

   A 1

   B 4

   C 6·5

   D 13

17. Which of the following processes can be used industrially to produce aromatic hydrocarbons?

   A Reforming of naphtha

   B Catalytic cracking of propane

   C Reforming of coal

   D Catalytic cracking of heavy oil fractions

18. Which line in the table refers to a hydrocarbon that is **not** a member of the same homologous series as the others?

	Relative formula mass
A	44
B	72
C	84
D	100

19. Which of the following compounds does **not** have isomeric structures?

   A C_2HCl_3

   B $C_2H_4Cl_2$

   C Propene

   D Propan-1-ol

20. Which of the following structural formulae represents a tertiary alcohol?

A
$$CH_3 - \underset{\underset{\displaystyle CH_3}{|}}{\overset{\overset{\displaystyle CH_3}{|}}{C}} - CH_2 - OH$$

B
$$CH_3 - \underset{\underset{\displaystyle OH}{|}}{\overset{\overset{\displaystyle CH_3}{|}}{C}} - CH_2 - CH_3$$

C
$$CH_3 - CH_2 - CH_2 - \underset{\underset{\displaystyle OH}{|}}{\overset{\overset{\displaystyle H}{|}}{C}} - CH_3$$

D
$$CH_3 - CH_2 - \underset{\underset{\displaystyle OH}{|}}{\overset{\overset{\displaystyle H}{|}}{C}} - CH_2 - CH_3$$

21. Oxidation of 4-methylpentan-2-ol to the corresponding ketone results in the alcohol

A losing 2 g per mole

B gaining 2 g per mole

C gaining 16 g per mole

D not changing in mass.

22. What type of reaction takes place when propene is formed from propanol?

A Condensation

B Hydrolysis

C Dehydration

D Hydration

23. The extensive use of which type of compound is thought to contribute significantly to the depletion of the ozone layer?

A Oxides of carbon

B Hydrocarbons

C Oxides of sulphur

D Chlorofluorocarbons

24. Polyesters can exist as fibres and cured resins.

Which line in the table describes correctly the structure of their molecules?

	Polyester fibre	Cured polyester resin
A	cross-linked	cross-linked
B	linear	linear
C	cross-linked	linear
D	linear	cross-linked

25. Ammonia solution may be used to distinguish $Fe^{2+}(aq)$ from $Fe^{3+}(aq)$ as follows:

$Fe^{2+}(aq)$ gives a green precipitate of $Fe(OH)_2$;

$Fe^{3+}(aq)$ gives a brown precipitate of $Fe(OH)_3$.

Which of the following is most likely to give similar results if used instead of ammonia?

A An amine

B An alcohol

C An aldehyde

D A carboxylic acid

26. In the formation of "hardened" fats from vegetable oils, the hydrogen

A causes cross-linking between chains

B causes hydrolysis to occur

C increases the carbon chain length

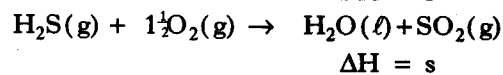D reduces the number of carbon-carbon double bonds.
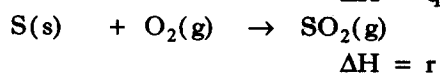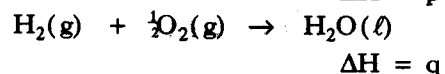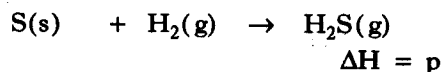
[Turn over

27. Olestra is a calorie free fat made by reacting fatty acids with sucrose. The structure of a sucrose molecule can be represented as shown.
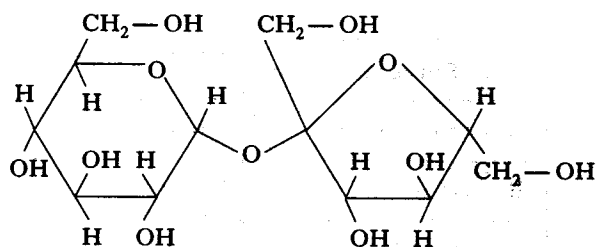
How many fatty acid molecules can react with one molecule of sucrose?

A 3

B 5

C 8

D 11

28. Proteins can be denatured under acid conditions.

During this denaturing, the protein molecule

A changes shape

B is dehydrated

C is neutralised

D is polymerised.

29. Which of the following substances is a raw material for the chemical industry?

A Benzene

B Methane

C Aluminium

D Iron

30. What is the relationship between enthalpies p, q, r and s?

$$S(s) \ + \ H_2(g) \ \rightarrow \ H_2S(g)$$
$$\Delta H = p$$
$$H_2(g) \ + \ \tfrac{1}{2}O_2(g) \ \rightarrow \ H_2O(\ell)$$
$$\Delta H = q$$
$$S(s) \ + \ O_2(g) \ \rightarrow \ SO_2(g)$$
$$\Delta H = r$$
$$H_2S(g) + 1\tfrac{1}{2}O_2(g) \rightarrow \ H_2O(\ell) + SO_2(g)$$
$$\Delta H = s$$

A $p = q + r - s$

B $p = s - q - r$

C $p = q - r - s$

D $p = s + r - q$

31. A catalyst is added to a reaction at equilibrium.

Which of the following does **not** apply?

A The rate of the forward reaction increases.

B The rate of the reverse reaction increases.

C The position of equilibrium remains unchanged.

D The position of equilibrium shifts to the right.

32. $ICl(\ell) \ + \ Cl_2(g) \ \rightleftharpoons \ ICl_3(s) \quad \Delta H = -106 \, kJ \, mol^{-1}$

Which line in the table identifies correctly the changes that will cause the greatest increase in the proportion of solid in the above equilibrium?

	Temperature	Pressure
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

33. Which of the following is the best description of a $0.1 \, mol \, l^{-1}$ solution of ethanoic acid?

A Dilute solution of a weak acid

B Dilute solution of a strong acid

C Concentrated solution of a weak acid

D Concentrated solution of a strong acid

34. The concentration of $OH^-(aq)$ ions in a solution is 1×10^{-2} mol l^{-1}.

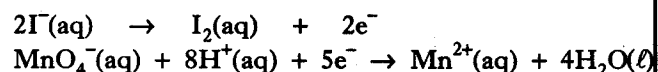What is the concentration of $H^+(aq)$ ions, in mol l^{-1}?

A 1×10^{-2}

B 1×10^{-5}

C 1×10^{-9}

D 1×10^{-12}

35. When a certain aqueous solution is diluted, its conductivity decreases but its pH remains constant.

The solution could be

A ethanoic acid

B sodium chloride

C sodium hydroxide

D nitric acid.

36. The ion-electron equations for a redox reaction are:

$2I^-(aq) \rightarrow I_2(aq) + 2e^-$
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$

How many moles of iodide ions are oxidised by one mole of permanganate ions?

A 0·2

B 0·4

C 2

D 5

37. In which of the following reactions is hydrogen gas acting as an oxidising agent?

A $H_2 + C_2H_4 \rightarrow C_2H_6$

B $H_2 + Cl_2 \rightarrow 2HCl$

C $H_2 + 2Na \rightarrow 2NaH$

D $H_2 + CuO \rightarrow H_2O + Cu$

38. When 10 g of lead pellets containing radioactive lead are placed in a solution containing 10 g of lead nitrate, radioactivity soon appears in the solution.

Compared to the pellets the solution will show

A different intensity of radiation and different half-life

B the same intensity of radiation but different half-life

C different intensity of radiation but the same half-life

D the same intensity of radiation and the same half-life.

39. Which line in the table describes correctly the result of an atom losing a beta-particle?

	Atomic number	Mass number
A	increased	no change
B	decreased	no change
C	no change	increased
D	no change	decreased

40. $^2_1H + ^3_1H \rightarrow ^4_2He + ^1_0n$

The above process represents

A nuclear fission

B nuclear fusion

C proton capture

D neutron capture.

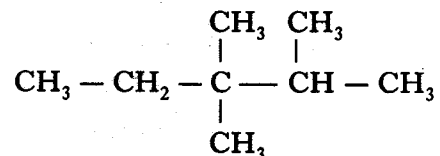**Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of this answer book.**

[Turn over

SECTION B

Marks

1. Unleaded petrol uses hydrocarbons with a high degree of molecular branching in order to improve the efficiency of burning.

   The structure of one such hydrocarbon is shown.

$$CH_3 - CH_2 - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - \underset{\underset{}{}}{\overset{\overset{CH_3}{|}}{CH}} - CH_3$$

   (a) Give the systematic name for this hydrocarbon.

   1

   (b) Name **one** other **type** of hydrocarbon that is used in petrol for the same reason.
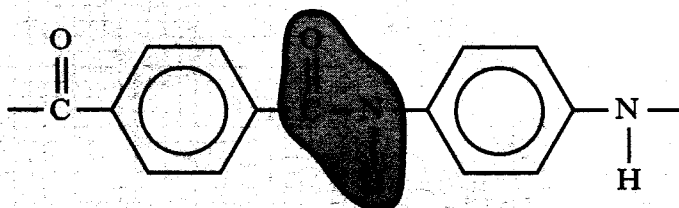
   1

   (2)

Marks

2. Concorde aircraft were grounded after an incident in which the fuel tank in one of the aeroplanes was punctured by a piece of metal. As a result the fuel tanks are now coated with the polymer, Kevlar.

   (*a*) What property of Kevlar makes it suitable for this use?

   1

   (*b*) The repeating unit in Kevlar is shown.

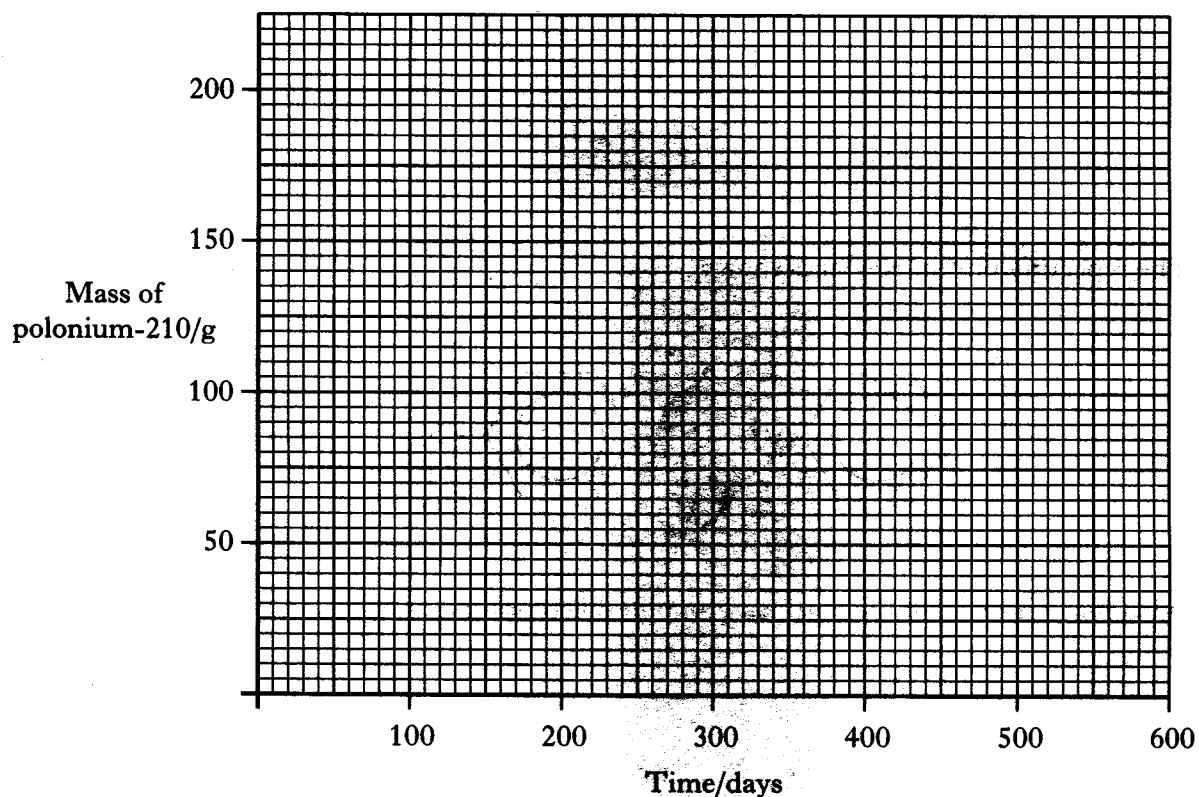   What name is given to the outlined group in this repeating unit?

   1

   (2)

   [Turn over

Marks

3. Polonium-210 is a radioisotope that decays by alpha-emission.

   The half-life of polonium-210 is 140 days.

   (*a*) Draw a graph to show how the mass of 200 g of the radioisotope would change with time.

   (Additional graph paper, if required, can be found on page 32.)

1

   (*b*) Write a balanced nuclear equation for the alpha-decay of polonium-210.

1

   (*c*) Calculate the number of atoms in 105 g of polonium-210.
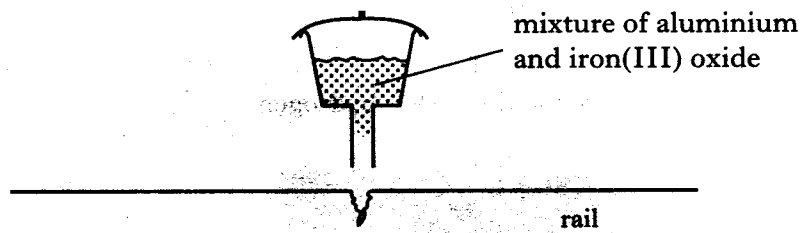
1

(3)

Marks

4. The Thermite Process involves the reaction between aluminium and iron(III) oxide to produce iron and aluminium oxide.

   This highly exothermic reaction, which generates so much heat that the temperature of the mixture rises to around 3000 °C, is used for repairing cracked railway lines as shown in the diagram below.


mixture of aluminium
and iron(III) oxide

rail

   (a) Suggest why this process is suitable for repairing cracked railway lines.

   1

   (b) The enthalpy changes for the formation of one mole of aluminium oxide and one mole of iron(III) oxide are shown below.

$$2Al(s) \quad + \quad 1\tfrac{1}{2}O_2(g) \quad \longrightarrow \quad Al_2O_3(s) \quad \Delta H = -1676\,kJ\,mol^{-1}$$
$$2Fe(s) \quad + \quad 1\tfrac{1}{2}O_2(g) \quad \longrightarrow \quad Fe_2O_3(s) \quad \Delta H = -825\,kJ\,mol^{-1}$$

   Use the above information to calculate the enthalpy change for the reaction:

$$2Al(s) \quad + \quad Fe_2O_3(s) \quad \longrightarrow \quad Al_2O_3(s) \quad + \quad 2Fe(s)$$
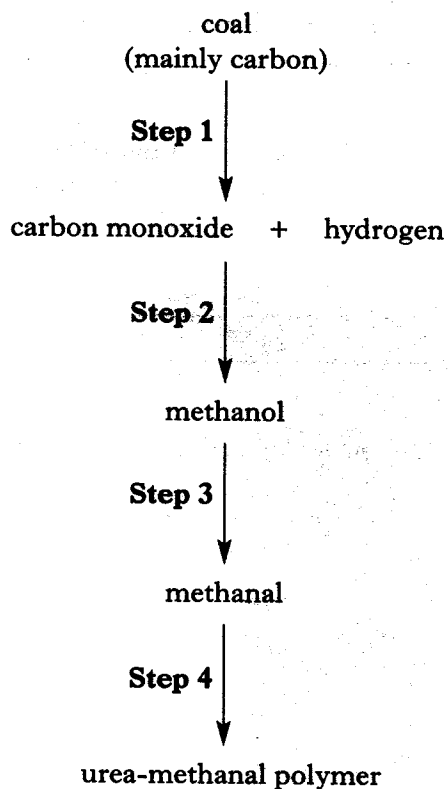
   1

   (2)
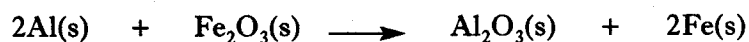
[Turn over

Marks

5. Urea-methanal is a polymer which can be made using coal as a feedstock.
   The flow diagram shows the steps involved in the production of the polymer.

coal
(mainly carbon)

Step 1

↓

carbon monoxide   +   hydrogen

Step 2

↓

methanol

Step 3

↓

methanal

Step 4

↓

urea-methanal polymer

(a) Name the mixture of gases produced in **Step 1**.

1

(b) Name the type of reaction taking place in **Step 3**.

1

Marks

5. (continued)

(c) (i) In **Step 4** methanal reacts with urea, H_2NCONH_2.
Draw the full structural formula for urea.

1

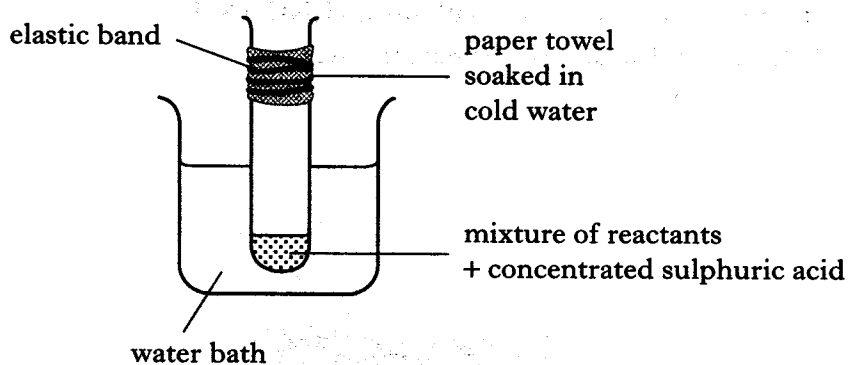(ii) The urea-methanal polymer does **not** soften on heating.
What name is given to this type of plastic?

1

(4)

[Turn over

Marks

6. Ethyl pentanoate is an ester. It can be prepared in the lab as shown below.

elastic band

paper towel
soaked in
cold water

mixture of reactants
+ concentrated sulphuric acid

water bath

(*a*) (i) Why is a water bath used for heating?

1

(ii) What is the purpose of the wet paper towel?

1

(*b*) Draw a structural formula for ethyl pentanoate.

1

Marks

6. **(continued)**

(c) Starting with a mass of 3·6 g of ethanol, and a slight excess of pentanoic acid, a student achieved a 70% yield of ethyl pentanoate (mass of one mole = 130 g).

Calculate the mass of ester obtained.
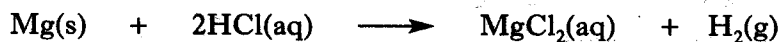
Show your working clearly.

2

(5)

[Turn over

Marks

7. A student added 50 cm^3 of 4·0 mol l^{-1} hydrochloric acid to 4·0 g of magnesium ribbon.

(a) The balanced equation for the reaction is:

$$Mg(s) \quad + \quad 2HCl(aq) \quad \longrightarrow \quad MgCl_2(aq) \quad + \quad H_2(g)$$

Show by calculation which reactant was in excess.

Show your working clearly.

2

(b) The hydrogen produced in the reaction can be contaminated with small quantities of hydrogen chloride vapour.

This vapour is very soluble in water.

Complete the diagram to show how the hydrogen chloride can be removed before the hydrogen is collected.

hydrochloric acid

hydrochloric acid + magnesium

gas syringe to collect hydrogen
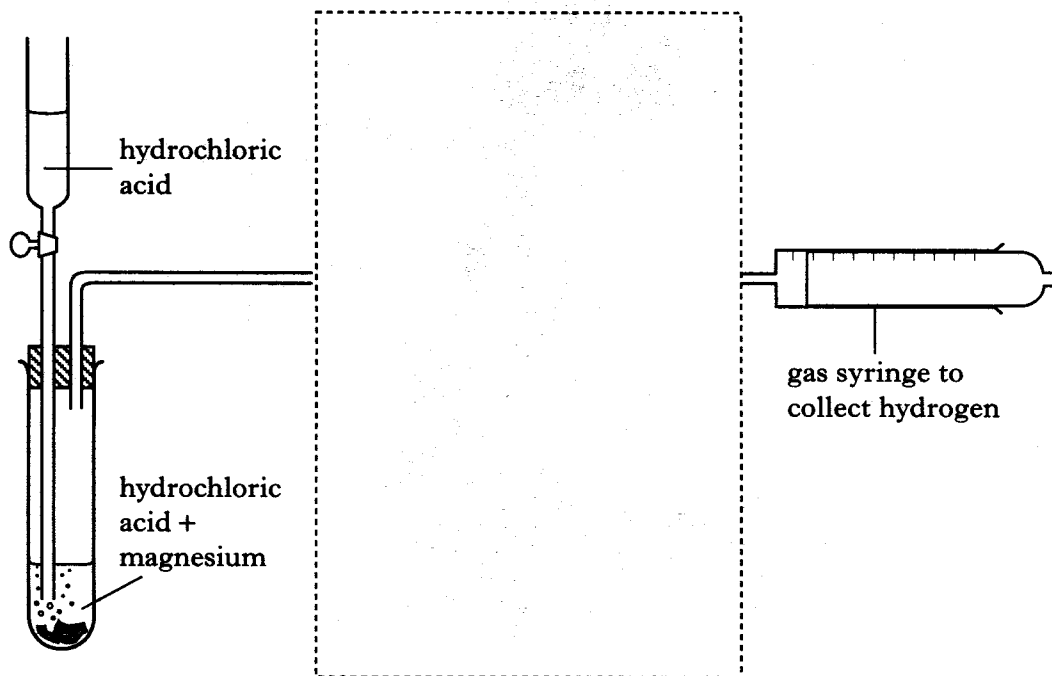
1

Marks

7. (continued)

(c) The experiment was repeated under the same conditions using ethanoic acid instead of hydrochloric acid.

Circle the correct words in the table to show the results for ethanoic acid.

	Ethanoic acid
Rate of reaction	faster/same/slower
Volume of gas produced	more/same/less

1

(4)

[Turn over

Marks

8. Although aldehydes and ketones have different structures, they both contain the carbonyl functional group.

   (*a*) (i) In what way is the structure of an aldehyde different from that of a ketone?

   1

   (ii) As a result of the difference in structure, aldehydes react with Fehling's (or Benedict's) solution and Tollens' reagent but ketones do not.

   What colour change would be observed when propanal is heated with Fehling's (or Benedict's) solution?

   1

   (iii) In the reaction of propanal with Tollens' reagent, silver ions are reduced to form silver metal.

   Complete the following ion-electron equation for the oxidation.

   $$C_3H_6O \longrightarrow C_2H_5COOH$$ 1

   (iv) Name the compound with the formula C_2H_5COOH.
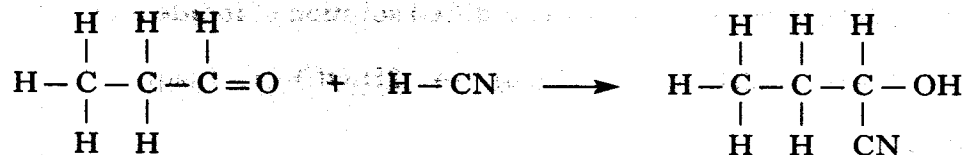
   1

Marks

8. (continued)

(b) As a result of both containing the carbonyl group, aldehydes and ketones react in a similar way with hydrogen cyanide.

The equation for the reaction of propanal and hydrogen cyanide is shown.

$$\begin{array}{c} H \quad H \quad H \\ | \quad\; | \quad\; | \\ H-C-C-C=O \;+\; H-CN \longrightarrow \\ | \quad\; | \\ H \quad H \end{array} \quad \begin{array}{c} H \quad H \quad H \\ | \quad\; | \quad\; | \\ H-C-C-C-OH \\ | \quad\; | \quad\; | \\ H \quad H \quad CN \end{array}$$

(i) Suggest a name for this type of reaction.

1

(ii) Draw a structure for the product of the reaction between propanone and hydrogen cyanide.

1

(6)

[Turn over

Marks

9. A student was asked to write a plan of the procedure for an investigation. The entry made in her laboratory note book is shown.

Aim

To find the effect of concentration on the rate of the reaction between hydrogen peroxide and an acidified solution of iodide ions.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(\ell) + I_2(aq)$$
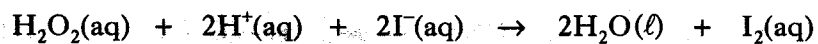
Procedure

1. Using a 100 cm³ measuring cylinder, measure out 10 cm³ of sulphuric acid, 10 cm³ of sodium thiosulphate solution, 1 cm³ of starch solution and 25 cm³ of potassium iodide solution into a dry 100 cm³ glass beaker and place the beaker on the bench.

2. Measure out 5 cm³ of hydrogen peroxide solution and start the timer.

3. Add the hydrogen peroxide solution to the beaker. When the blue/black colour just appears, stop the timer and record the time (in seconds).

4. Repeat this procedure four times but using different concentrations of potassium iodide solution. This is achieved by adding 5 cm³, 10 cm³, 15 cm³ and 20 cm³ of water to the 25 cm³ of potassium iodide solution before adding it to the glass beaker.

(a) Why is instruction 4 **not** the best way of altering the concentration of the potassium iodide solution?

1

(b) State **two** other ways of improving the student's plan of this investigation procedure.

1

(2)

Marks

10. If both potassium iodide solution, KI(aq), and liquid chloroform, $CHCl_3(\ell)$, are added to a test-tube with some iodine, the iodine dissolves in both. Two layers are formed as shown in the diagram.

I_2 in KI(aq) —

I_2 in chloroform
$CHCl_3(\ell)$

— interface
between
layers
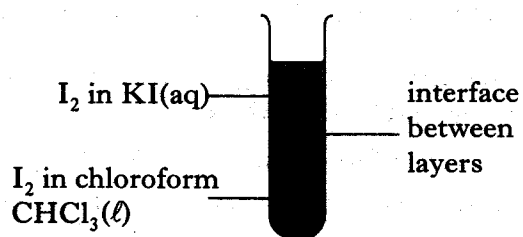
An equilibrium is set up:

$$I_2 \text{ in KI(aq)} \rightleftharpoons I_2 \text{ in } CHCl_3(\ell)$$

The iodine is always distributed between the two layers in the same ratio:

$$\frac{\text{concentration of } I_2 \text{ in } CHCl_3(\ell)}{\text{concentration of } I_2 \text{ in KI(aq)}} = \frac{3}{1}$$

(a) What is meant by the term **equilibrium**?

1

(b) When more potassium iodide solution is added to the top layer the equilibrium is disturbed.

What happens to restore the equilibrium?

1

(c) 0·4 g of I_2 is dissolved in $10\,cm^3$ of KI(aq) and $10\,cm^3$ of $CHCl_3(\ell)$.

Calculate the concentration of iodine, **in g l⁻¹**, contained in $CHCl_3(\ell)$.

1

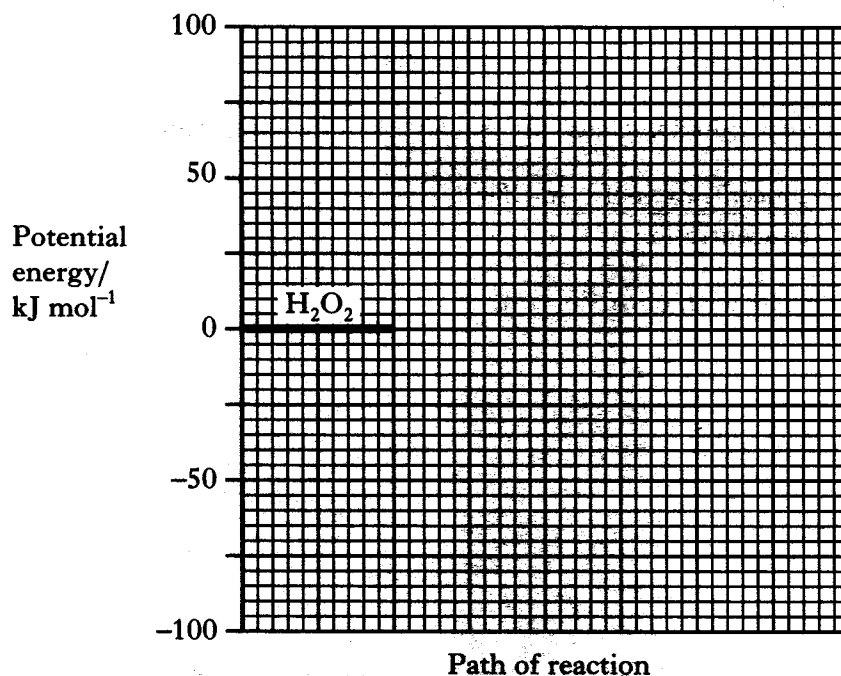**(3)**

Marks

11. Hydrogen peroxide, H_2O_2, decomposes very slowly to produce water and oxygen.

(a) The activation energy (E_A) for the reaction is **75 kJ mol^{-1}** and the enthalpy change (ΔH) is **−26 kJ mol^{-1}**.

Use this information to complete the potential energy diagram for the reaction.

(Additional graph paper, if required, can be found on page 32.)

Potential energy/ kJ mol^{-1}

Path of reaction

1

(b) Powdered manganese dioxide catalyses the decomposition of hydrogen peroxide solution.
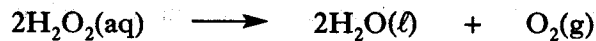
(i) What name is given to this type of catalyst?

1

(ii) Add a dotted line to the above diagram to show the path of the reaction when the catalyst is used.
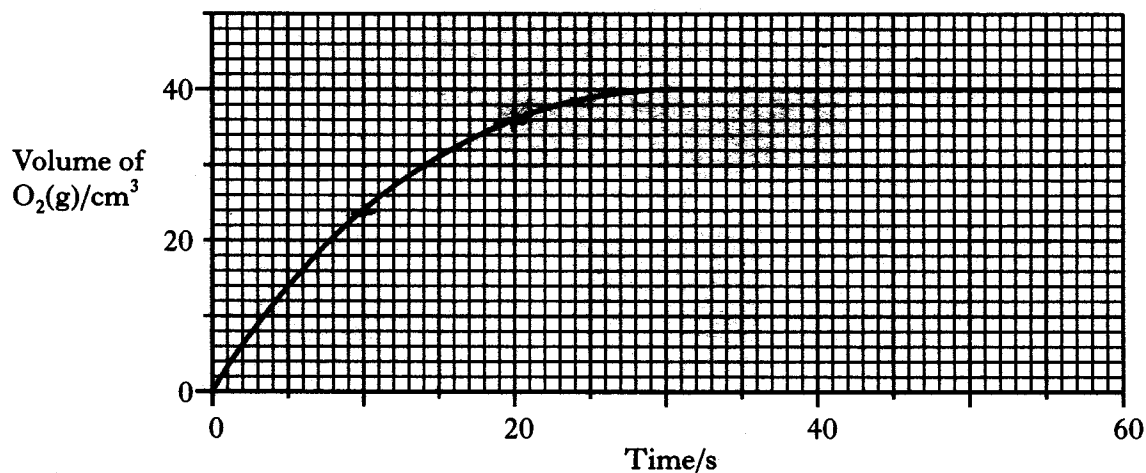
1

Marks

11. (continued)

(c) The balanced equation for the reaction is:

$$2H_2O_2(aq) \longrightarrow 2H_2O(\ell) + O_2(g)$$

(i) The following graph is obtained for the volume of oxygen released over time.

Calculate the average rate of reaction between 10 and 20 s.

1

(ii) Using information from the above graph, calculate the mass of hydrogen peroxide used in the reaction, assuming all the hydrogen peroxide decomposed.

(Take the molar volume of oxygen to be 24 litres mol^{-1}.)

Show your working clearly.

2

(6)

Marks

12. Although propane and ethanol have similar molecular masses, the alkane is a gas at room temperature while the alcohol is a liquid. This difference in boiling points is due to the different strengths of the intermolecular forces in the two compounds.

Explain why propane is a gas at room temperature while ethanol is a liquid.

In your answer you should name the intermolecular forces involved in each compound and explain how they arise.

(4)

Marks

13. Potassium cyanide, KCN, can be made by the reaction of an acid with an alkali. A solution of the salt has a pH of 8.

(a) What is the concentration of $H^+(aq)$, in $mol\,l^{-1}$, in the solution?

1

(b) What can be concluded about the strengths of the acid and the alkali used in the reaction?

1

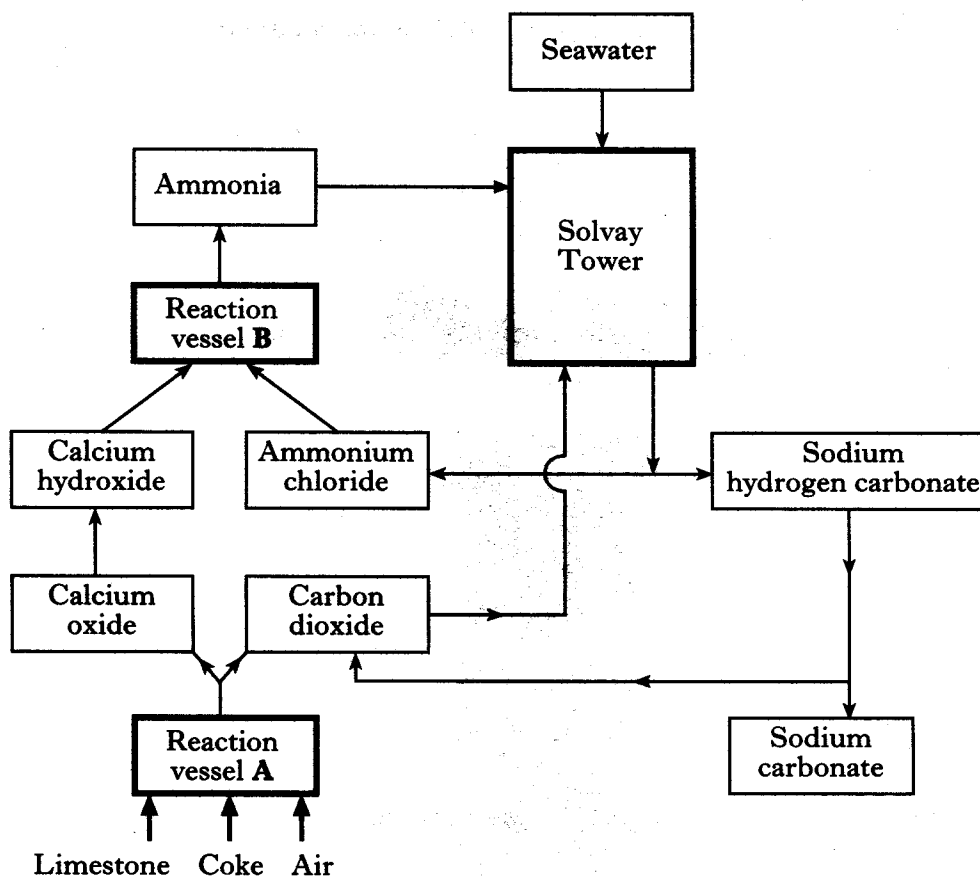(c) Write the formula for the acid used in the reaction.
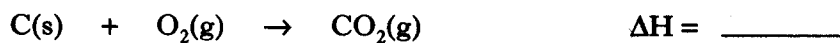
1

(3)

[**Turn over**

Marks

14. The following flow diagram outlines the manufacture of sodium carbonate by the Solvay Process.

(a) Name the reactants in the reaction taking place in the Solvay Tower.

1

(b) In reaction vessel **A**, carbon dioxide is produced by the following two reactions.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g) \qquad \Delta H = \underline{\qquad}$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = \underline{\qquad}$$

For each reaction, add a sign after the ΔH to show whether the reaction is endothermic or exothermic.

1

Marks

14. (continued)

(c) As well as ammonia, a salt and water are produced in reaction vessel **B**.

Write a balanced equation for the production of ammonia in this reaction vessel.

1

(d) The seawater used in the Solvay Process can contain contaminant magnesium ions. These can be removed by the addition of sodium carbonate solution.

Why is sodium carbonate solution suitable for removing contaminant magnesium ions?

1

(e) Using the information in the flow diagram, give **two different** features of the Solvay Process that make it economical.

2

(6)

[Turn over

Marks

15. Electrophoresis, widely used in medicine and forensic testing, involves the movement of ions in an electric field. The technique can be used to separate and identify amino acids produced by the breakdown of proteins.

(a) Name the type of reaction that takes place during the breakdown of proteins.

1

(b)　(i)　The amino acid, glycine, has the following structural formula:

$$
\begin{array}{c}
NH_2 \\
| \\
H-C-H \\
| \\
COOH
\end{array}
$$
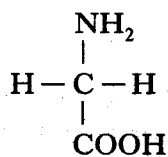
Like all amino acids, glycine exists as ions in solution and the charge on the ions depends on the pH of the solution. In solutions with **low** pH, glycine exists as a **positively** charged ion:

$$
\begin{array}{c}
NH_3^+ \\
| \\
H-C-H \\
| \\
COOH
\end{array}
$$
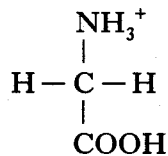
In solutions with a **high** pH, glycine exists as a **negatively** charged ion. Draw the structure of this negatively charged ion.

1

Marks

15. (b) (continued)

(ii) The table below shows the structures and molecular masses of three amino acids, **A**, **B** and **C**.

Amino acid	Structure	Molecular mass
A	NH_2 $\mid$ $H-C-CH_2-\bigcirc$ $\mid$ $COOH$	165·0
B	NH_2 $\mid$ $H-C-CH_2CH_2CH_2CH_2-NH_2$ $\mid$ $COOH$	146·0
C	NH_2 $\mid$ $H-C-CH_2CH_2-COOH$ $\mid$ $COOH$	147·0

A mixture of amino acids, **A**, **B** and **C**, was applied to the centre of a strip of filter paper which had been soaked in a solution of pH 2. All three amino acids exist as ions in this acidic solution. A high voltage was then applied across the filter paper.

filter paper soaked in
a solution of pH 2

positive
electrode $\boxed{+}$ ———————————— $\boxed{-}$ negative
electrode

mixture of amino
acids **A**, **B** and **C**
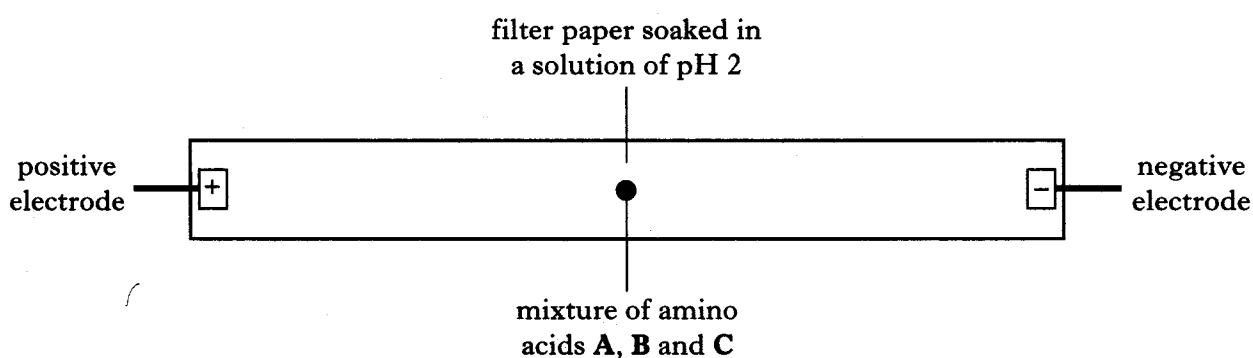
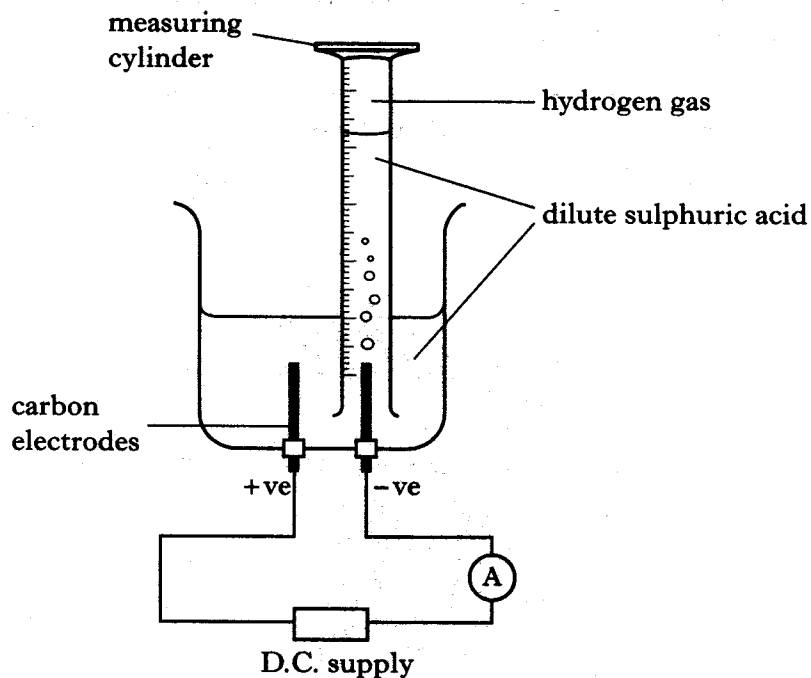The amino acid ions separate according to their **charge** and **molecular mass**.

On the diagram above, indicate the approximate positions of **A**, **B** and **C** once electrophoresis has separated the ions.

2

(4)

[Turn over

Marks

16. A student electrolysed dilute sulphuric acid using the apparatus shown in order to estimate the volume of one mole of hydrogen gas.

(a) The measurements recorded by the student were:

Current = 0·5 A
Time = 14 minutes
Volume of hydrogen collected = 52 cm^3

Calculate the molar volume of hydrogen gas.
Show your working clearly.

3

(b) What change could be made to the apparatus to reduce a possible significant source of error?

1

[END OF QUESTION PAPER]

(4)