Total
Section B

X012/301

| NATIONAL QUALIFICATIONS 2002 | TUESDAY, 4 JUNE 9.00 AM – 11.30 AM | 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—Part 1 Questions 1–30 and Part 2 Questions 31–35

Instructions for completion of **Part 1** and **Part 2** are given on pages two and eight respectively.

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.

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SECTION A

PART 1

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 30 of this part 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 Part 1 of 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 30 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:
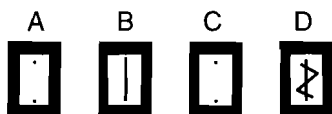
If you want to change back to an answer which has already been scored out, you should **enter a tick (✓)** to the RIGHT of the box of your choice, thus:

1. Which covalent gas dissolves in water to form an alkali?

A HCl

B CH_4

C SO_2

D NH_3

2. When copper is added to a solution containing zinc nitrate and silver nitrate

A deposits of both zinc and silver form

B a deposit of zinc forms

C a deposit of silver forms

D no new deposit forms.

3. Hydrochloric acid reacts with magnesium according to the following equation.

$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$
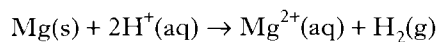
What volume of $4 \ mol \ l^{-1}$ hydrochloric acid reacts with 0·1 mol of magnesium?

A $25 \ cm^3$

B $50 \ cm^3$

C $100 \ cm^3$

D $200 \ cm^3$

4. Two identical samples of zinc were added to an excess of two solutions of sulphuric acid, concentrations $2 \ mol \ l^{-1}$ and $1 \ mol \ l^{-1}$ respectively.

Which of the following would have been the same for the two samples?

A The total mass lost

B The total time for the reaction

C The initial reaction rate

D The average rate of evolution of gas

**5.**

Kinetic energy of molecules
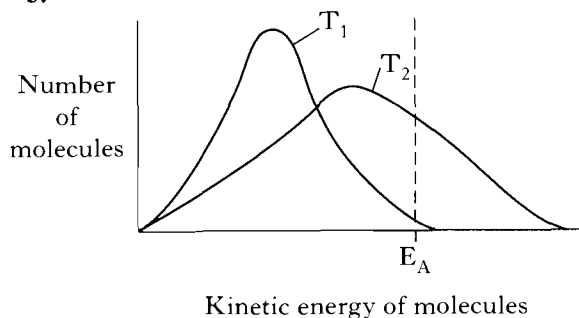
Which of the following is the correct interpretation of the above energy distribution diagram for a reaction as the temperature **decreases** from T_2 to T_1?

	Activation energy (E_A)	Number of successful collisions
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

6. The potential energy diagram for the reaction

$$CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$$
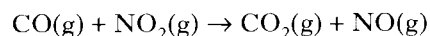
is shown.
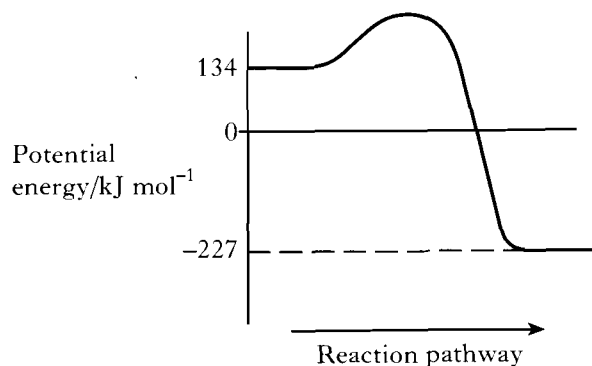
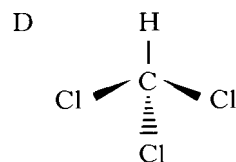
ΔH, in $kJ \ mol^{-1}$, for the forward reaction is
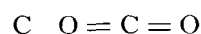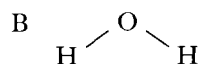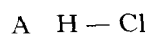
A −361

B −227

C −93

D +361 .

[Turn over

7. Which type of bond is broken when ice is melted?

   A   Ionic

   B   Polar covalent

   C   Hydrogen

   D   Non-polar covalent

8. The shapes of some common molecules are shown below and each contains at least one polar bond.

   Which molecule is non-polar?

   A $H - Cl$

   B
   $$H \diagup \overset{O}{} \diagdown H$$

   C $O = C = O$

   D

   $$\begin{array}{c} H \\ | \\ Cl \blacktriangleleft \overset{}{C} \blacktriangleright Cl \\ | \\ Cl \end{array}$$

9. A metal (melting point 843 °C, density $1·54\,g\,cm^{-3}$) was obtained by electrolysis of its chloride (melting point 772 °C, density $2·15\,g\,cm^{-3}$) at 780 °C.

   During the electrolysis, how would the metal occur?

   A   As a solid on the surface of the electrolyte

   B   As a liquid on the surface of the electrolyte

   C   As a solid at the bottom of the electrolyte

   D   As a liquid at the bottom of the electrolyte

10. Which of the following contains the **largest** number of molecules?

    A $0·10\,g$ of hydrogen gas

    B $0·17\,g$ of ammonia gas

    C $0·32\,g$ of methane gas

    D $0·35\,g$ of chlorine gas

11. The equation for the complete combustion of propane is:

    $$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$$
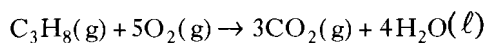
    $50\,cm^3$ of propane is mixed with $500\,cm^3$ of oxygen and the mixture is ignited.

    What is the volume of the resulting gas mixture?

    (All volumes are measured at the same temperature and pressure.)

    A $150\,cm^3$

    B $300\,cm^3$

    C $400\,cm^3$

    D $700\,cm^3$

12. It is now known that protons and neutrons are made up of smaller particles called quarks.

    Each proton and each neutron contains 3 quarks.

    What is the approximate number of quarks in $1\,g$ of carbon-12?

    A 6×10^{23}

    B 9×10^{23}

    C $1·8 \times 10^{24}$

    D $2·16 \times 10^{25}$

13. Which pollutant, produced during internal combustion in a car engine, is **not** the result of incomplete combustion?

    A   Nitrogen dioxide

    B   Hydrocarbons

    C   Carbon

    D   Carbon monoxide

14. Which equation represents an industrial reforming process?

    A $CH_3(CH_2)_6CH_3 \rightarrow$
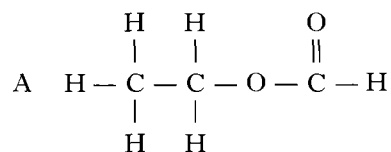 $$CH_3(CH_2)_4CH_3 + CH_2 = CH_2$$

    B $CH_3(CH_2)_6CH_3 \rightarrow$
    $$CH_3C(CH_3)_2CH_2CH(CH_3)_2$$

    C $CH_3(CH_2)_6CH_2OH \rightarrow$
    $$CH_3(CH_2)_5CH = CH_2 + H_2O$$

    D $4CH_2 = CH_2 \rightarrow -(CH_2CH_2)_4-$

15. Which of the following is an isomer of hexanal?

A 2-methylbutanal

B 3-methylpentan-2-one

C 2,2-dimethybutan-1-ol

D 3-ethylpentanal

16. An ester is prepared from methanoic acid and ethanol.

Which of the following is the full structural formula for the ester produced?

A

$$
\begin{array}{ccc}
\text{H} & \text{H} & \text{O} \\
| & | & || \\
\text{H}-\text{C}-\text{C}-\text{O}-\text{C}-\text{H} \\
| & | \\
\text{H} & \text{H}
\end{array}
$$

B

$$
\begin{array}{ccc}
\text{H} & \text{O} & \text{H} \\
| & || & | \\
\text{H}-\text{C}-\text{C}-\text{O}-\text{C}-\text{H} \\
| & & | \\
\text{H} & & \text{H}
\end{array}
$$

C

$$
\begin{array}{ccc}
\text{H} & \text{H} & \text{H} \\
| & | & | \\
\text{H}-\text{C}-\text{C}-\text{O}-\text{C}-\text{H} \\
| & | & | \\
\text{H} & \text{H} & \text{H}
\end{array}
$$

D

$$
\begin{array}{ccc}
\text{H} & \text{H} & \text{O} \\
| & | & || \\
\text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\
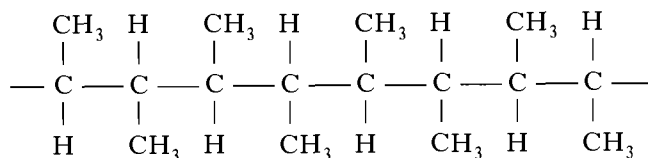| & | \\
\text{H} & \text{H}
\end{array}
$$
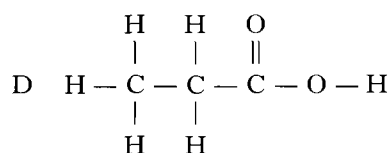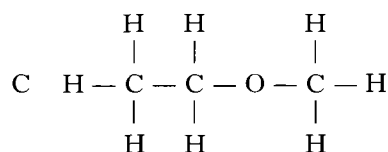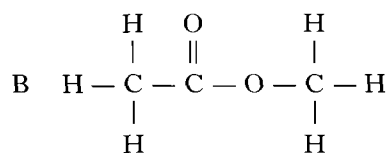
17. Which statement about benzene is correct?

A Benzene is an isomer of cyclohexane.

B Benzene reacts with bromine solution as if it is unsaturated.

C The ratio of carbon to hydrogen atoms in benzene is the same as in ethyne.

D Benzene undergoes addition reactions more readily than hexene.

18. Which reaction can be classified as reduction?

A $CH_3CH_2OH \rightarrow CH_3COOH$

B $CH_3CH(OH)CH_3 \rightarrow CH_3COCH_3$

C $CH_3CH_2COCH_3 \rightarrow CH_3CH_2CH(OH)CH_3$

D $CH_3CH_2CHO \rightarrow CH_3CH_2COOH$

19. Part of a polymer molecule is represented below.

$$
\begin{array}{cccccccc}
\text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \\
| & | & | & | & | & | & | & | \\
-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}- \\
| & | & | & | & | & | & | & | \\
\text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3
\end{array}
$$

The monomer which gives rise to this polymer is

A but-2-ene

B but-1-ene

C methylpropene

D buta-1,3-diene.

20. Which mixture of gases is known as synthesis gas?

A Methane and oxygen

B Carbon monoxide and oxygen

C Carbon dioxide and hydrogen

D Carbon monoxide and hydrogen

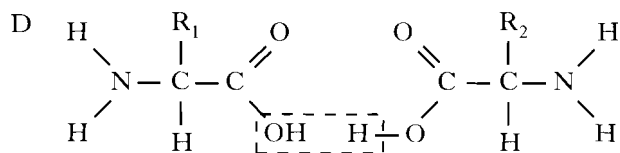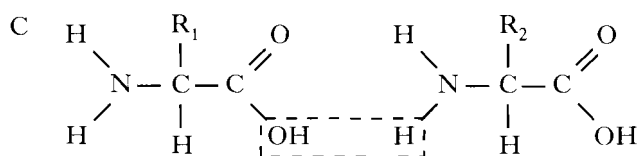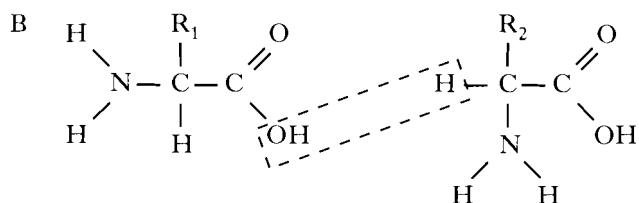**21.** Some recently developed polymers have unusual properties.
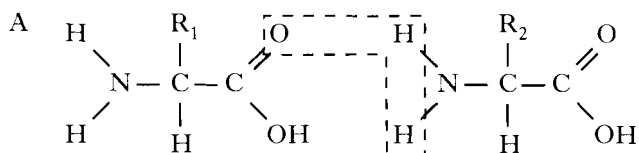
Which polymer is soluble in water?

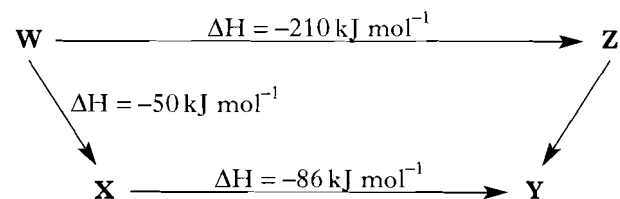A Poly(ethyne)

B Poly(ethenol)

C Biopol

D Kevlar

[Turn over

22. When two amino acids condense together, water is eliminated and a peptide link is formed.

Which of the following represents this process?

A

B

C

D

23. Consider the reaction pathway shown.

According to Hess' Law, the ΔH value, in kJ mol^{-1}, for reaction **Z** to **Y** is

A   +74

B   −74

C   +346

D   −346.

24. Which of the following is likely to apply to the use of a catalyst in a chemical reaction?

	Position of equilibrium	Effect on value of ΔH
A	moved to right	decreased
B	unaffected	increased
C	moved to left	unaffected
D	unaffected	unaffected

25. On the structure shown, four hydrogen atoms have been replaced by letters A, B, C and D.
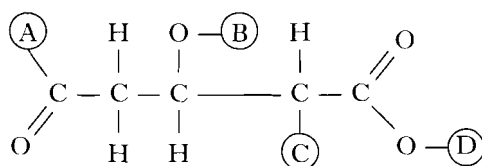
Which letter corresponds to the hydrogen atom which can ionise most easily in aqueous solution?

26. A fully dissociated acid is progressively diluted by the addition of water.

Which of the following would increase with increasing dilution?

A   The pH value

B   The electrical conductivity

C   The rate of its reaction with chalk

D   The volume of alkali which it will neutralise

27. Which of the following is a redox reaction?

A $NaOH + HCl \rightarrow NaCl + H_2O$

B $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

C $NiO + 2HCl \rightarrow NiCl_2 + H_2O$

D $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

28. If $96\,500\,\mathrm{C}$ of electricity are passed through separate solutions of copper(II) chloride and nickel(II) chloride, then

A   equal masses of copper and nickel will be deposited

B   the same number of atoms of each metal will be deposited

C   the metals will be plated on the positive electrode

D   different numbers of moles of each metal will be deposited.

29. Strontium-90 is a radioisotope.

What is the neutron to proton ratio in an atom of this isotope?

A   2·37

B   1·00

C   0·730

D   1·37

30. Which equation represents a fusion process?

A $^{40}_{19}\mathrm{K} \ + \ ^{0}_{-1}\mathrm{e} \ \rightarrow \ ^{40}_{18}\mathrm{Ar}$

B $^{2}_{1}\mathrm{H} \ + \ ^{3}_{1}\mathrm{H} \ \rightarrow \ ^{4}_{2}\mathrm{He} \ + \ ^{1}_{0}\mathrm{n}$

C $^{235}_{92}\mathrm{U} \ + \ ^{1}_{0}\mathrm{n} \ \rightarrow \ ^{90}_{38}\mathrm{Sr} \ + \ ^{144}_{54}\mathrm{Xe} \ + \ 2^{1}_{0}\mathrm{n}$

D $^{14}_{7}\mathrm{N} \ + \ ^{1}_{0}\mathrm{n} \ \rightarrow \ ^{14}_{6}\mathrm{C} \ + \ ^{1}_{1}\mathrm{p}$
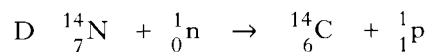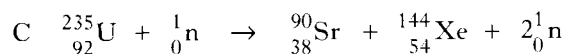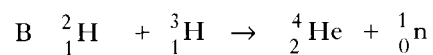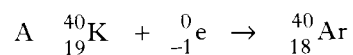
[Turn over

SECTION A

PART 2

In questions 31 to 35 of this part of the paper, an answer is given by circling the appropriate letter (or letters) in the answer grids provided on Part 2 of the answer sheet.

In some questions, two letters are required for full marks.

If more than the correct number of answers is given, marks may be deducted.

In some cases the number of correct responses is NOT identified in the question.

This part of the paper is worth 10 marks.

SAMPLE QUESTION

A CH_4	B H_2	C CO_2
D CO	E C_2H_6	F N_2

(a) Identify the diatomic **compound(s)**.

A	B	C
(D)	E	F

The one correct answer to part (a) is D. This should be circled.

(b) Identify the **two** substances which burn to produce **both** carbon dioxide **and** water.

(A)	B	C
D	(E)	F

As indicated in this question, there are **two** correct answers to part (b). These are A and E. Both answers are circled.

(c) Identify the substance(s) which can **not** be used as a fuel.

A	B	(C)
D	E	(F)

There are **two** correct answers to part (c). These are C and F. Both answers are circled.

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 circle the answer you now consider to be correct. Thus, in part (a), if you want to change an answer **D** to an answer **A**, your answer sheet would look like this:

(A)	B	C
~~D~~	E	F

If you want to change back to an answer which has already been scored out, you should enter a tick (✓) in the box of the answer of your choice, thus:

~~A~~	B	C
✓ ~~D~~	E	F

31. The first twenty elements can be arranged according to bonding and structure.

A	B	C
aluminium	boron	chlorine
D	E	F
hydrogen	phosphorus	silicon

(a) Identify the element which is a discrete molecular solid at room temperature and pressure.

(b) Identify the **two** elements which combine to form the compound with most covalent character. (You may wish to use page 10 of the data booklet.)

32. Compounds can have different structures and properties.

A	B	C
NH_4NO_3	$BaSO_4$	Na_2CO_3
D	E	F
SiO_2	K_2O	P_2O_5

(a) Identify the compound with a covalent network structure.

(b) Identify the salt which dissolves in water to form an alkaline solution.

[Turn over

33. The symbol for the Avogadro Constant is N_A.

Identify the **true** statement(s).

A	64.2 g of sulphur contains approximately N_A atoms.
B	16.0 g of oxygen contains approximately N_A molecules.
C	6.0 g of water contains approximately N_A atoms.
D	1.0 g of hydrogen contains approximately N_A protons.
E	2.0 litres of 0.50 $mol\,l^{-1}$ sulphuric acid contains approximately N_A hydrogen ions.
F	1.0 litre of 1.0 $mol\,l^{-1}$ barium hydroxide solution contains approximately N_A hydroxide ions.

34. Proteins are an important part of a balanced diet.

Identify the **true** statement(s).

A	Proteins are a more concentrated source of energy than carbohydrates.
B	Proteins are made by addition polymerisation.
C	Denaturing of proteins involves changes in the structure of the molecules.
D	Globular proteins are the **major** structural materials of animal tissue.
E	Proteins are compounds of nitrogen, carbon, hydrogen and oxygen.
F	Proteins can be made in animals but **not** in plants.

35. Two flasks contained equal volumes of $0.1\ mol\ l^{-1}$ hydrochloric acid and $0.1\ mol\ l^{-1}$ ethanoic acid. Identify the **true** statement(s) about **both** solutions.

A	They give the same colour with Universal indicator.
B	They have a pH less than 7.
C	They conduct electricity equally well.
D	They have equal concentrations of hydrogen ions.
E	They react at the same rate with magnesium.
F	They neutralise the same number of moles of sodium hydroxide.

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

[Turn over

Marks

SECTION B

1. The three statements below are taken from a note made by a student who is studying trends in the Periodic Table.

> 1 <u>First Ionisation Energy</u>
> The energy required to remove one mole of electrons from one mole of atoms in the gaseous state.
>
> 2 <u>Second Ionisation Energy</u>
> The energy required to remove a second mole of electrons.
>
> 3 _____
> The measure of the attraction an atom has for the shared electrons in a bond.

   (*a*) Complete the note above to give the heading for the third statement.   **1**

   (*b*) What is the trend in the first ionisation energy across a period from left to right?

   1

   (*c*) Why is the second ionisation energy of sodium so much greater than its first ionisation energy?

   1

   (3)

Marks

2. Carbon dating can be used to estimate the age of charcoal found in archaeological sites.

The graph shows how the count rate of a sample of radioactive carbon-14 changes over a period of time.
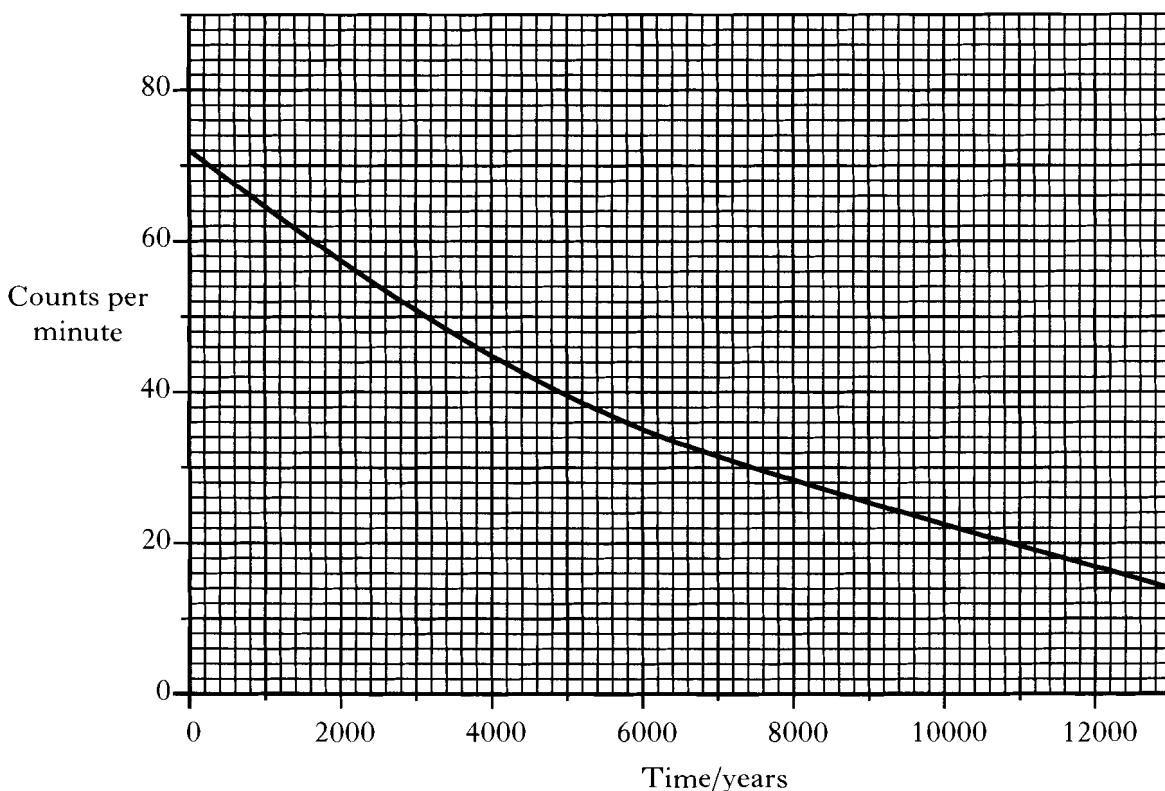
(a) Use the graph to find the half-life of carbon-14.

1

(b) Carbon-14 decays by beta-emission.
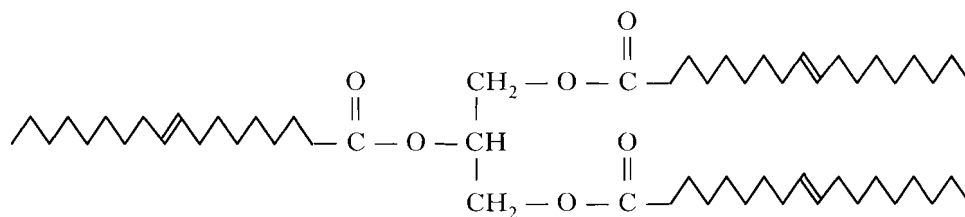
Write the balanced nuclear equation for this decay.

1

(c) Why can carbon dating **not** be used to estimate the age of fossil fuels?

1

(3)

Marks

3. The structure of a molecule found in olive oil can be represented as shown.

(*a*) Olive oil can be hardened using a nickel catalyst to produce a fat.

    (i) What type of catalyst is nickel in this reaction?

1

    (ii) In what way does the structure of a fat molecule differ from that of an oil molecule?

1

(*b*) Olive oil can be hydrolysed using sodium hydroxide solution to produce sodium salts of fatty acids.

    (i) Name the other product of this reaction.

1

    (ii) Give a commercial use for sodium salts of fatty acids.

1

(4)

Marks

4. Hydrogen sulphide, H_2S, is the unpleasant gas produced when eggs rot.

(*a*) (i) The gas can be prepared by the reaction of iron(II) sulphide with dilute hydrochloric acid. Iron(II) chloride is the other product of the reaction. Write a balanced chemical equation for this reaction.

1

(ii) Iron metal is often present as an impurity in iron(II) sulphide. Name the other product which would be formed in the reaction with dilute hydrochloric acid if iron metal is present as an impurity.

1

(*b*) The enthalpy of combustion of hydrogen sulphide is $-563\,kJ\,mol^{-1}$. Use this value and the enthalpy of combustion values in the data booklet to calculate the enthalpy change for the reaction:

$$H_2(g) \quad + \quad \underset{\text{(rhombic)}}{S(s)} \quad \longrightarrow \quad H_2S(g)$$
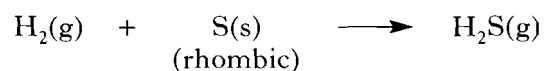
Show your working clearly.

2

(4)

Page fifteen **[Turn over**

5. An ester can be prepared by the following sequence of reactions.

$$
\begin{array}{ccccccc}
 & H & & H & & H & & H \\
 & | & & | & & | & & | \\
H- & C & - & C & - & C & - & C & -H \\
 & | & & | & & | & & | \\
 & H & & H & & Br & & H \\
\end{array}
$$

Step 1 | HBr removed

Compound **A**

$CH_3 - CH = CH - CH_3$
but-2-ene

Step 2

Step 2

$CH_3 - CH_2 - CH_2 - CH_2 - OH$

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

Step 3 | Oxidation

Compound **B**

Step 4 | Condensation

ESTER
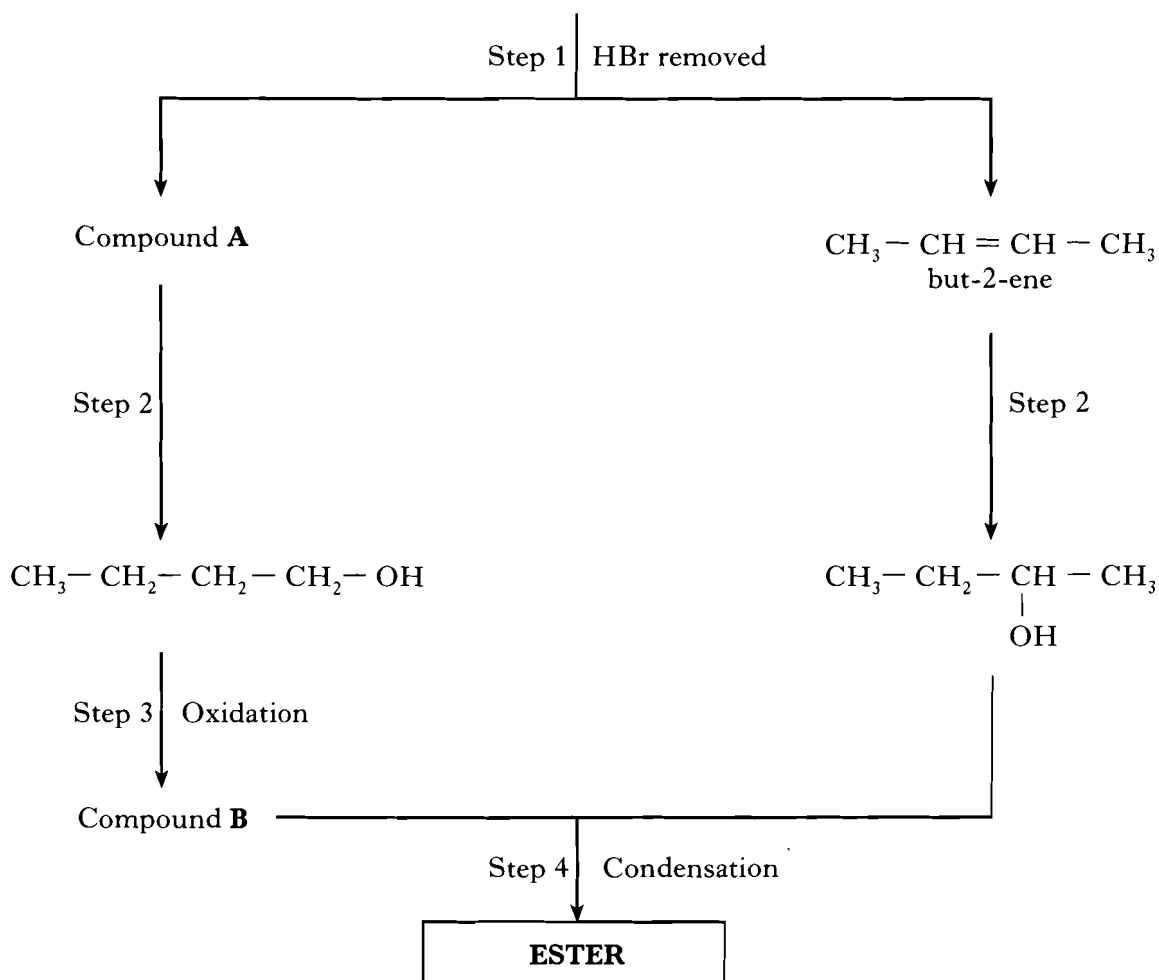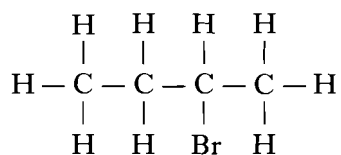
(*a*) (i) Draw a structural formula for compound **A**.

1

5. **(*a*)** **(continued)**

(ii) But-2-ene and compound **A** undergo the same type of reaction in Step 2. Name this type of reaction.

1

(iii) Acidified potassium dichromate solution can be used to carry out Step 3. What colour change would be observed?

1

(iv) Name compound **B**.

1

(*b*) (i) What evidence would show that an ester had been formed in Step 4?

1

(ii) Give **one** use for esters.

1

(6)

[Turn over

6. A calorimeter, like the one shown, can be used to measure the enthalpy of combustion of ethanol.

The ethanol is ignited and burns completely in the oxygen gas. The heat energy released in the reaction is taken in by the water as the hot product gases are drawn through the coiled copper pipe by the pump.

thermometer
to pump
stirrer
coiled copper pipe
glass jar
water
wick
ethanol
ignition coil
oxygen
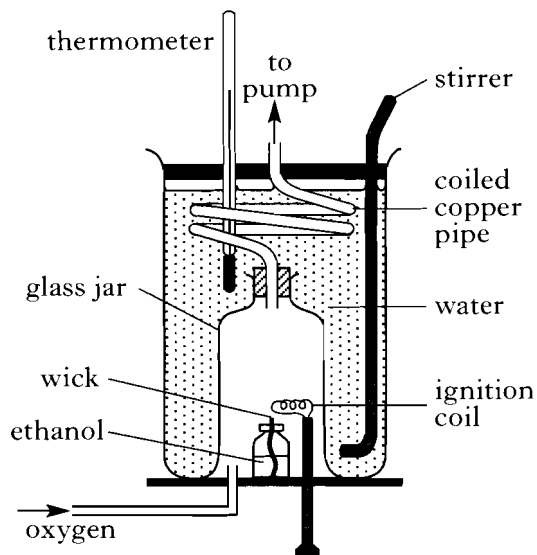
Marks

(*a*) Why is the copper pipe coiled as shown in the diagram?

1

(*b*) The value for the enthalpy of combustion of ethanol obtained by the calorimeter method is higher than the value obtained by the typical school laboratory method.

One reason for this is that more heat is lost to the surroundings in the typical school laboratory method.

Give **one** other reason for the value being higher with the calorimeter method.

1

(*c*) In one experiment the burning of 0·980 g of ethanol resulted in the temperature of 400 cm^3 of water rising from 14·2 °C to 31·6 °C.

Use this information to calculate the enthalpy of combustion of ethanol.

Show your working clearly.

3

Marks

7. A mass spectrometer is an instrument that can be used to gain information about the masses of molecules.

When hydrogen fluoride is analysed in a mass spectrometer, as well as molecules with a relative molecular mass of 20, some "double molecules" (relative molecular mass 40) and "triple molecules" (relative molecular mass 60) are found to exist. No such molecules are found when the elements, hydrogen and fluorine, are separately analysed.

(*a*) Name the weak force of attraction between molecules that is found in both liquid hydrogen and liquid fluorine.
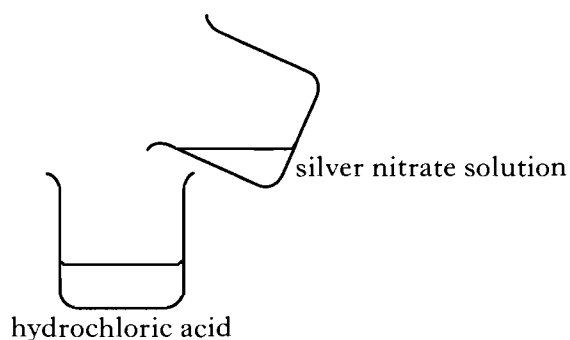
1

(*b*) Why are "double" and "triple" molecules found in hydrogen fluoride but **not** in hydrogen and **not** in fluorine?
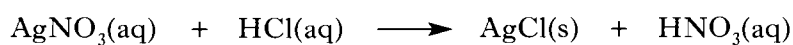
1

(2)

[Turn over

8. A student added $0{\cdot}20\,g$ of silver nitrate, $AgNO_3$, to $25\,cm^3$ of water. This solution was then added to $20\,cm^3$ of $0{\cdot}0010$ $mol\,l^{-1}$ hydrochloric acid as shown in the diagram.

silver nitrate solution

hydrochloric acid

The equation for the reaction which occurs is:

$$AgNO_3(aq) \ + \ HCl(aq) \ \longrightarrow \ AgCl(s) \ + \ HNO_3(aq)$$

(*a*) (i) Name the type of reaction which takes place.

1

(ii) Show by calculation which reactant is in excess.
Show your working clearly.

2

8. (continued)

(*b*) The hydrochloric acid in the experiment can be described as a dilute solution of a strong acid.

(i) What is meant by a strong acid?

1

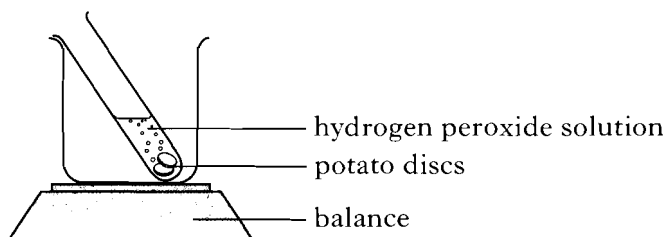(ii) What is the pH of the 0·0010 mol l⁻¹ hydrochloric acid used in the experiment?

1

(5)

[Turn over

9. The decomposition of hydrogen peroxide solution into water and oxygen can be catalysed by an enzyme.

$$2H_2O_2(aq) \xrightarrow{\text{enzyme}} 2H_2O(\ell) \quad + \quad O_2(g)$$

The rate of reaction can be followed by recording the mass loss over a period of time.

hydrogen peroxide solution
potato discs
balance

(a) The following graph was obtained from experiments to find the effect of pH on the efficiency of the enzyme.

Mass of apparatus/g

60·0
59·9
59·8
59·7
59·6
0

pH 1
pH 4
pH 14
pH 7
pH 10
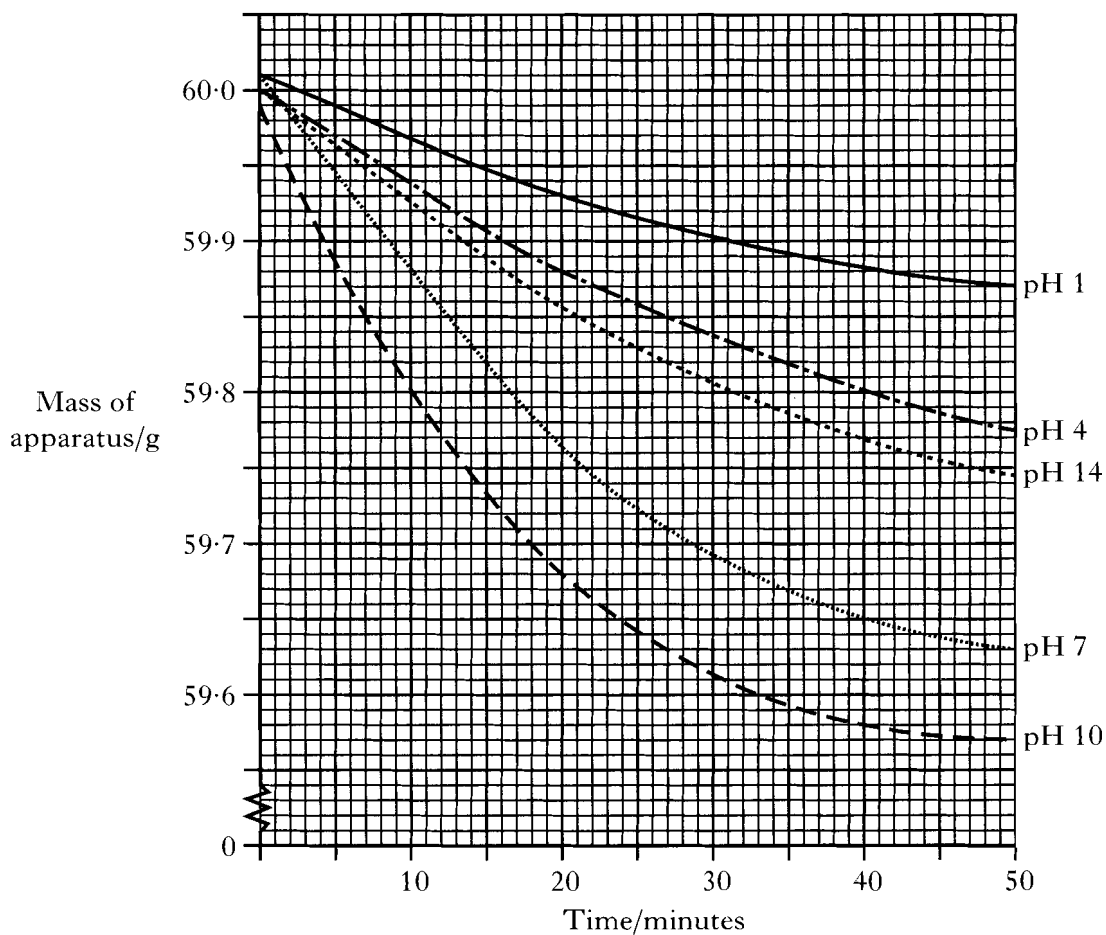
10   20   30   40   50
Time/minutes

9. **(a)** **(continued)**

    (i) Calculate the average rate of reaction over the first 20 minutes, in $g\,min^{-1}$, for the experiment at pH 10.

          2

    (ii) From the results shown on the graph, what can be concluded about the efficiency of the enzyme over the pH range used in the experiment?
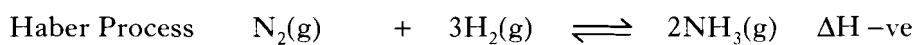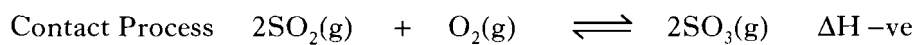
          1

(b) Give **one** other way of following the rate of this reaction.

          1

          (4)

[Turn over

Marks

10. Consider the following industrial processes.

Contact Process $2SO_2(g)$ $+$ $O_2(g)$ $\rightleftharpoons$ $2SO_3(g)$ ΔH $-ve$

Haber Process $N_2(g)$ $+$ $3H_2(g)$ $\rightleftharpoons$ $2NH_3(g)$ ΔH $-ve$

(a) For each process, circle the reactant that can be classified as a raw material.

      1

(b) Explain why increasing the temperature in both processes decreases the equilibrium yield of the products.

      2

(c) Suggest why the Contact Process is carried out at atmospheric pressure but the Haber Process is carried out at 400 atmospheres.

      1

(d) Under certain conditions, 200 kg of hydrogen reacts with excess nitrogen in the Haber Process to produce 650 kg of ammonia.

Calculate the percentage yield of ammonia.

Show your working clearly.

      2

      (6)

Marks

11. Acrylonitrile, CH_2CHCN, is the monomer used in the manufacture of Acrilan.

   (*a*) (i) Draw the full structural formula for acrylonitrile.

1

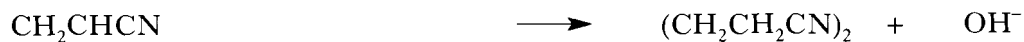   (ii) Name the type of polymerisation which occurs in the manufacture of Acrilan.

1

   (*b*) Acrylonitrile can be reduced in neutral aqueous solution forming $(CH_2CH_2CN)_2$. Hydroxide ions are also produced in the reaction.
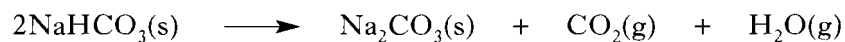   Complete and balance the ion-electron equation for the reduction reaction described above.

   $CH_2CHCN \longrightarrow (CH_2CH_2CN)_2 + OH^-$

1

   (3)

   [Turn over

Marks

12. When sodium hydrogencarbonate is heated to 112 °C it decomposes and the gas, carbon dioxide, is given off:

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

The following apparatus can be used to measure the volume of carbon dioxide produced by the reaction.
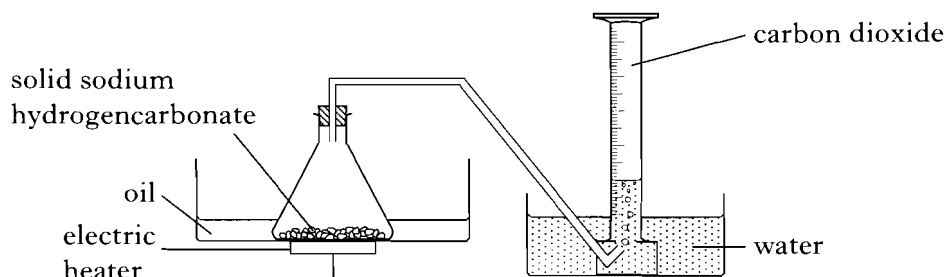
(*a*) Why is an oil bath used and **not** a water bath?

1

(*b*) (i) Calculate the theoretical volume of carbon dioxide produced by the complete decomposition of 1·68 g of sodium hydrogencarbonate.

(Take the molar volume of carbon dioxide to be 23 litre mol^{-1}.)

Show your working clearly.

2

(ii) Assuming that all of the sodium hydrogencarbonate is decomposed, suggest why the volume of carbon dioxide collected in the measuring cylinder would be less than the theoretical value.
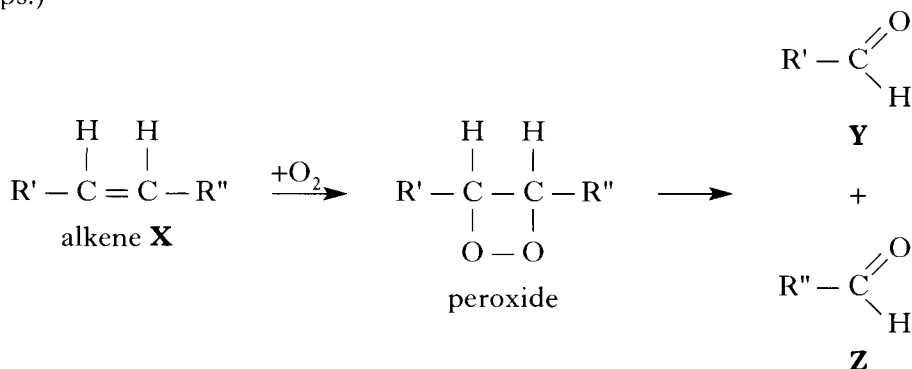
1

(4)

13. Alkenes can react with oxygen to produce unstable compounds called peroxides. These peroxides break down rapidly to form compounds which have the same functional group.

For example, alkene **X** reacts to produce compounds **Y** and **Z**.

(In the following structural formulae R' and R" are used to represent different alkyl groups.)

$$\underset{\text{alkene } \mathbf{X}}{R' - \overset{\overset{\displaystyle H}{|}}{C} = \overset{\overset{\displaystyle H}{|}}{C} - R''} \xrightarrow{+O_2} \underset{\text{peroxide}}{R' - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle O}{|}}{C}} - \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle O}{|}}{C}} - R''} \longrightarrow \begin{array}{c} R' - C \overset{\displaystyle \nearrow O}{\searrow_H} \\ \mathbf{Y} \\ + \\ R'' - C \overset{\displaystyle \nearrow O}{\searrow_H} \\ \mathbf{Z} \end{array}$$

(a) To which homologous series do both compounds **Y** and **Z** belong?

1

(b) In one reaction, alkene **X** reacts to produce the two compounds shown below.

$$CH_3 - C \overset{\displaystyle \nearrow O}{\searrow_H}$$

Y

$$CH_3 - \overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle H}{|}}{C}} - C \overset{\displaystyle \nearrow O}{\searrow_H}$$
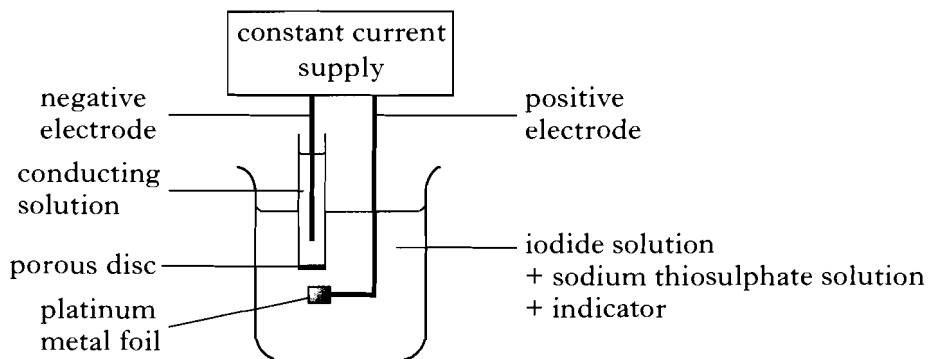
Z

Name alkene **X** in this reaction.

1

(2)

[Turn over

Marks

14. The concentration of a solution of sodium thiosulphate can be found by reaction with iodine.

The iodine is produced by electrolysis of an iodide solution using the apparatus shown.

The current is noted and the time when the indicator detects the end-point of the reaction is recorded.

(a) Iodine is produced from the iodide solution according to the following equation:

$$2I^-(aq) \longrightarrow I_2(aq) + 2e^-$$

Calculate the number of moles of iodine generated during the electrolysis given the following results.
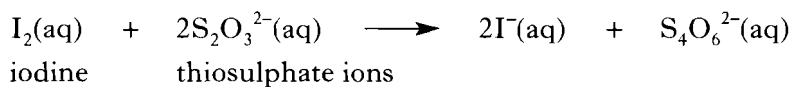
Current $= 0 \cdot 010\,A$
Time $= 1\,\text{min}\,37\,\text{s}$

Show your working clearly.

2

14. (continued)

(*b*) The iodine produced reacts with the thiosulphate ions according to the equation:

$$I_2(aq) \quad + \quad 2S_2O_3^{2-}(aq) \quad \longrightarrow \quad 2I^-(aq) \quad + \quad S_4O_6^{2-}(aq)$$
iodine   thiosulphate ions

At the end-point of the reaction, excess iodine is detected by the indicator.

(i) Name the indicator which could be used to detect the excess iodine present at the end-point.

1

(ii) In a second experiment it was found that $1 \cdot 2 \times 10^{-5}$ mol of iodine reacted with $3 \cdot 0 \, cm^3$ of the sodium thiosulphate solution.

Use this information to calculate the concentration of the sodium thiosulphate solution, in $mol \, l^{-1}$.

Show your working clearly.

2

(iii) The production of iodine takes place at the surface of the platinum foil at the tip of the positive electrode.

Suggest what could be done to the solution during the reaction to increase the accuracy of the results.
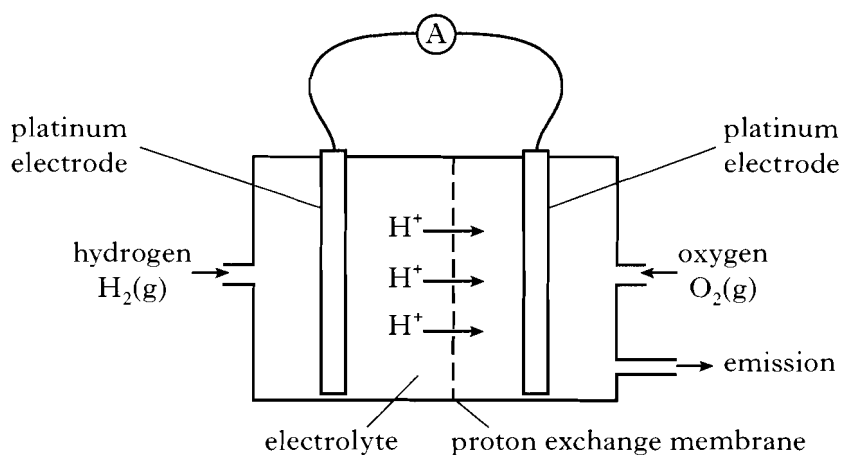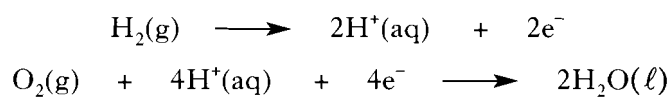
1

(6)

[Turn over

Marks

15. Although they are more expensive, fuel cells have been developed as an alternative to petrol for motor vehicles.

platinum electrode

platinum electrode

hydrogen $H_2(g)$

$H^+ \longrightarrow$
$H^+ \longrightarrow$
$H^+ \longrightarrow$

oxygen $O_2(g)$

emission

electrolyte   proton exchange membrane

(*a*)   (i)   The ion-electron equations for the process occurring at each electrode are:

$$H_2(g) \longrightarrow 2H^+(aq) + 2e^-$$

$$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(\ell)$$

Combine these two equations to give the overall redox equation.

1

(ii)   On the diagram, show by means of an arrow, the path of electron flow.   1

(*b*)   Give **one** advantage that fuel cells have over petrol for providing energy.

1

(3)

[END OF QUESTION PAPER]