Total
Section B

X012/301

NATIONAL
QUALIFICATIONS
2006

TUESDAY, 30 MAY
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—Questions 1–40 (40 marks)

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

For this section of the examination you must use an **HB pencil**.

SECTION B (60 marks)

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. If further space is required, a supplementary sheet for rough work may be obtained from the invigilator.

4   Additional space for answers 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

Read carefully

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

2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.

3 Check that the answer sheet you have been given has **your name**, **date of birth**, **SCN** (Scottish Candidate Number) and **Centre Name** printed on it.

   Do not change any of these details.

4 If any of this information is wrong, tell the Invigilator immediately.

5 If this information is correct, **print** your name and seat number in the boxes provided.

6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).

7 There is **only one correct** answer to each question.

8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.

9 At the end of the exam, put the **answer sheet for Section A inside the front cover of your answer book**.

Sample Question

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

A chromatography

B fractional distillation

C fractional crystallisation

D filtration.

The correct answer is **A**—chromatography. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).
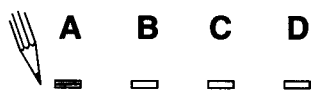

Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.
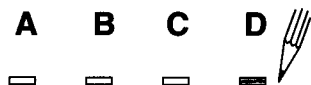
1. A negatively charged particle with electronic arrangement 2, 8 could be

   A   a fluoride ion

   B   a sodium atom

   C   an aluminium ion

   D   a neon atom.

2. Which of the following exists as diatomic molecules?

   A   Helium

   B   Methane

   C   Carbon monoxide

   D   Sodium chloride

3. When an atom **X** of an element in Group 1 reacts to become **X**$^+$

   A   the mass number of **X** increases

   B   the charge of the nucleus increases

   C   the atomic number of **X** decreases

   D   the number of filled energy levels decreases.

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

   What is the number of moles of magnesium ions present?

   A   0·4

   B   0·5

   C   0·8

   D   1·0

5. When a gas was bubbled through dilute hydrochloric acid, the pH increased.

   The gas could have been

   A   ammonia

   B   hydrogen

   C   methane

   D   sulphur dioxide.

6. The graph below shows the change in the concentration of a reactant with time for a given chemical reaction.
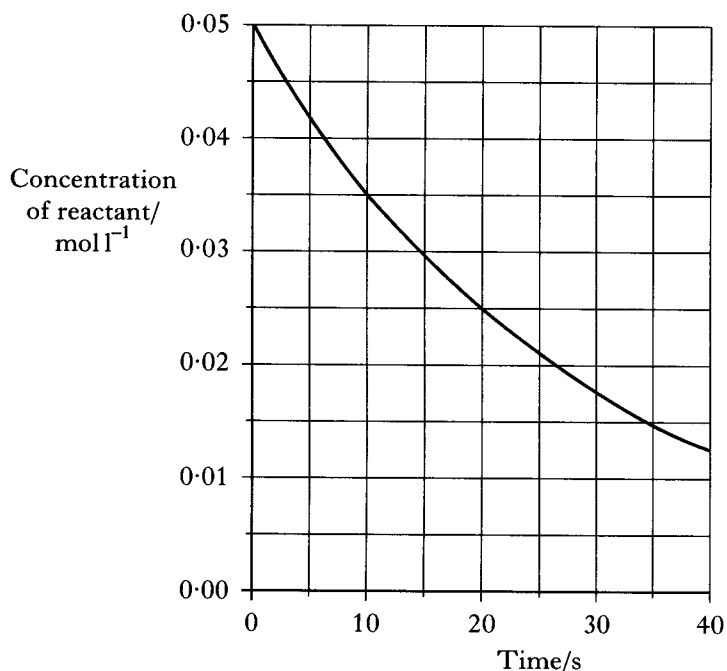

   What is the average rate of this reaction, in $mol\,l^{-1}\,s^{-1}$, between 10 and 20 s?

   A $1·0 \times 10^{-2}$

   B $1·0 \times 10^{-3}$

   C $1·5 \times 10^{-2}$

   D $1·5 \times 10^{-3}$

7. A small increase in temperature results in a large increase in rate of reaction.

   The **main** reason for this is that

   A   more collisions are taking place

   B   the enthalpy change is lowered

   C   the activation energy is lowered

   D   many more particles have energy greater than the activation energy.

[Turn over

8. When copper carbonate reacts with excess acid, carbon dioxide is produced. The curves shown were obtained under two different conditions.
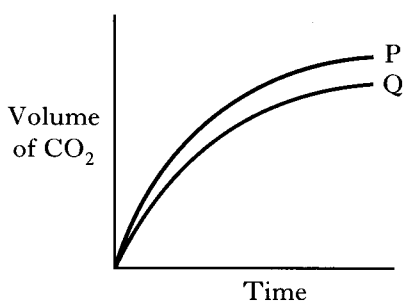

The change from **P** to **Q** could be brought about by

A   increasing the concentration of the acid

B   decreasing the mass of copper carbonate

C   decreasing the particle size of the copper carbonate

D   adding a catalyst.

9. $63 \cdot 5$ g of copper is added to 1 litre of 1 $mol\,l^{-1}$ silver(I) nitrate solution.

Which of the following statements is always true for this reaction?

A   The resulting solution is colourless.

B   All the copper dissolves.

C $63 \cdot 5$ g of silver is formed.

D   One mole of silver is formed.

10. A potential energy diagram is shown.
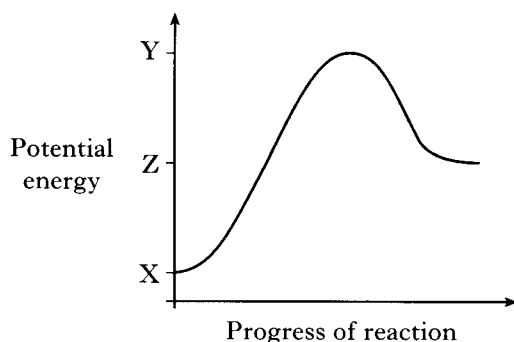
What is the activation energy (E_A) for the forward reaction?

A   Y

B   Z – X

C   Y – X

D   Y – Z

11. A group of students added 6 g of ammonium chloride crystals to $200\,cm^3$ of water at a temperature of $25\,°C$.

The enthalpy of solution of ammonium chloride is $+13 \cdot 6$ kJ mol^{-1}.

After dissolving the crystals, the temperature of the solution would most likely be

A $23\,°C$

B $25\,°C$

C $27\,°C$

D $30\,°C$.

12. The spike graph shows the variation in successive ionisation energies of an element, **Z**.
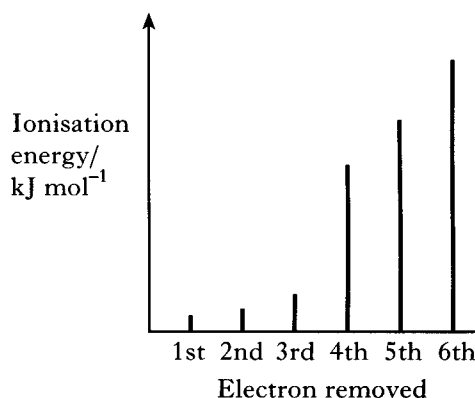

In which group of the Periodic Table is element **Z**?

A   1

B   3

C   4

D   6

13. Which equation represents the second ionisation energy of magnesium?

A $Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{-}$

B $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{-}$

C $Mg(s) \rightarrow Mg^{2+}(g) + 2e^{-}$

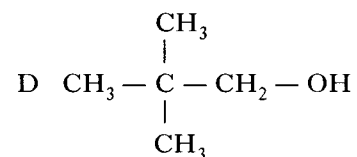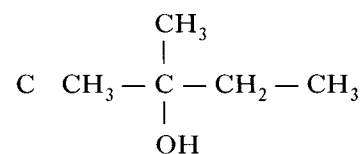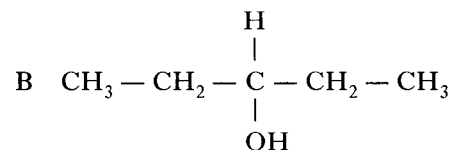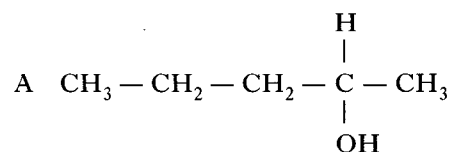D $Mg^{+}(s) \rightarrow Mg^{2+}(s) + e^{-}$

14. Carbon dioxide is a gas at room temperature while silicon dioxide is a solid because

A van der Waals' forces are much weaker than covalent bonds

B carbon dioxide contains double covalent bonds and silicon dioxide contains single covalent bonds

C carbon-oxygen bonds are less polar than silicon-oxygen bonds

D the relative formula mass of carbon dioxide is less than that of silicon dioxide.

15. Which of the following contains the same number of atoms as 16 g of helium?

A 16 g of methane

B 16 g of oxygen

C 17 g of ammonia

D 20 g of argon

16. A one carat diamond used in a ring contained 1×10^{22} carbon atoms.

What is the approximate mass of the diamond?

A 0·1 g

B 0·2 g

C 1·0 g

D 1·2 g

17. $C_2H_6(g) + 3\frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

When $20\,cm^3$ of ethane was sparked with $100\,cm^3$ of oxygen, what was the final volume of gases?

All volumes were measured at atmospheric pressure and room temperature.

A $40\,cm^3$

B $70\,cm^3$

C $100\,cm^3$

D $130\,cm^3$

18. During the manufacture of petrol, the process of reforming is used to produce a petrol with a higher percentage of molecules which are

A aromatic

B larger

C unbranched

D unsaturated.

19. An ester has the following structural formula:
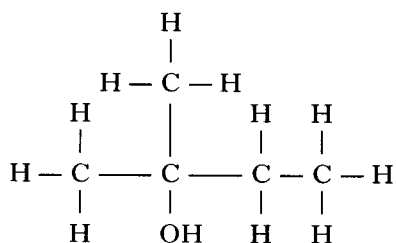
$CH_3CH_2CH_2COOCH_2CH_3$
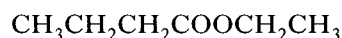
The name of this ester is

A propyl propanoate

B ethyl butanoate

C butyl ethanoate

D ethyl propanoate.

20. Which of the following compounds has isomeric forms?

A C_2H_3Cl

B C_2H_5Cl

C C_2HCl_3

D $C_2H_4Cl_2$

21. Which of the following structural formulae represents a primary alcohol?

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

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

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

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

[Turn over

22. What product(s) would be expected on dehydrating the following alcohol?

$$
\begin{array}{c}
\text{H} \\
| \\
\text{H} - \text{C} - \text{H} \\
\quad\quad | \\
\text{H} \quad\quad | \quad\quad \text{H} \quad \text{H} \\
| \quad\quad | \quad\quad | \quad | \\
\text{H} - \text{C} \underline{\quad\quad} \text{C} \underline{\quad\quad} \text{C} - \text{C} - \text{H} \\
| \quad\quad | \quad\quad | \quad | \\
\text{H} \quad\quad \text{OH} \quad \text{H} \quad \text{H}
\end{array}
$$

A 2-methylbut-2-ene only

B 2-methylbut-2-ene and 2-methylbut-1-ene

C 2-methylbut-1-ene only

D 3-methylbut-1-ene and 2-methylbut-1-ene

23. Which of the following statements 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 then hexene.

24. Which of the following consumer products is **least** likely to contain esters?

A Flavourings

B Perfumes

C Solvents

D Toothpastes

25. Which of the following types of bond is broken during hydrolysis of a polyamide?

A $C - N$

B $C = O$

C $N - H$

D $C - C$

26. Synthesis gas can be made by

A reacting ethene gas with steam

B burning carbon in excess air

C burning methane gas in excess air

D reacting methane gas with steam.

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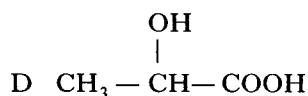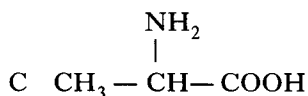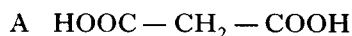
Which polymer is soluble in water?

A Poly(ethyne)

B Poly(ethenol)

C Biopol

D Kevlar

28. The flow diagram shows two steps in the preparation of a feedstock for use in making a plastic.
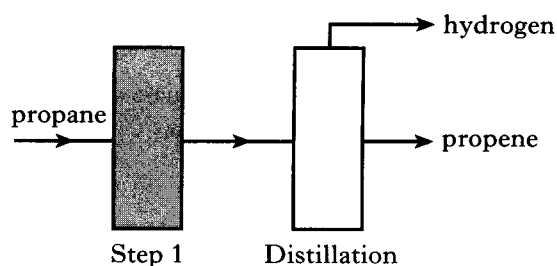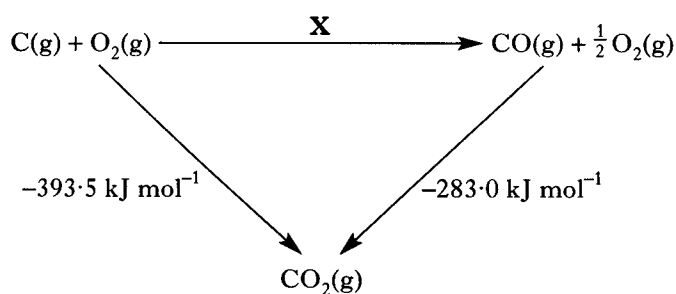

The reaction taking place during step 1 is an example of

A cracking

B oxidation

C dehydration

D hydrogenation.

29. What type of reaction is involved in the conversion of vegetable oils into "hardened" fats?

A Condensation

B Hydration
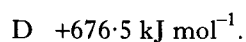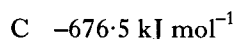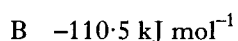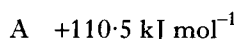
C Hydrogenation

D Polymerisation

30. Which of the following could be a monomer for the formation of a protein?

A $HOOC — CH_2 — COOH$

B $HOCH_2 — CHOH — CH_2OH$

C
$$CH_3 — \overset{\overset{\displaystyle NH_2}{|}}{CH} — COOH$$

D
$$CH_3 — \overset{\overset{\displaystyle OH}{|}}{CH} — COOH$$

31. Consider the reaction pathways shown below.

$$C(g) + O_2(g) \xrightarrow{\;\;\;\;\textbf{X}\;\;\;\;} CO(g) + \tfrac{1}{2}O_2(g)$$

$-393 \cdot 5 \text{ kJ mol}^{-1}$ $-283 \cdot 0 \text{ kJ mol}^{-1}$

$$CO_2(g)$$

According to Hess's Law, the enthalpy change for reaction **X** is

A $+110 \cdot 5 \text{ kJ mol}^{-1}$

B $-110 \cdot 5 \text{ kJ mol}^{-1}$

C $-676 \cdot 5 \text{ kJ mol}^{-1}$

D $+676 \cdot 5 \text{ kJ mol}^{-1}$.

32. In a reversible reaction, equilibrium is reached when

A   molecules of reactants cease to change into molecules of products

B   the concentrations of reactants and products are equal

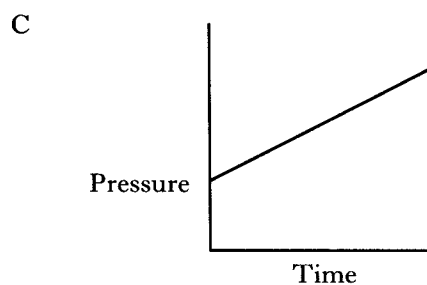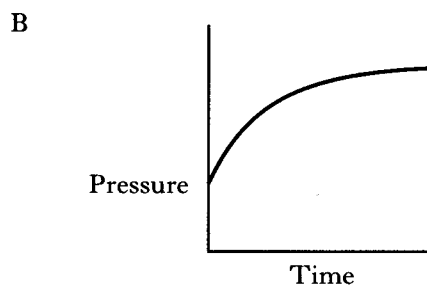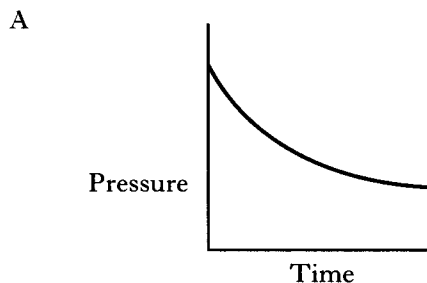C   the concentrations of reactants and products are constant

D   the activation energy of the forward reaction is equal to that of the reverse reaction.

33. Gaseous iodine and hydrogen were reacted together in a sealed container.

$$I_2(g) + H_2(g) \rightleftharpoons 2HI(g)$$
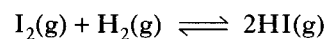
Which of the following graphs shows the pressure inside the vessel as the reaction proceeds at constant temperature?

A

B

C

D
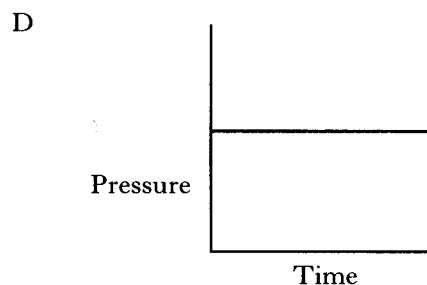
34. Which of the following is the same for equal volumes of $0.1 \ mol \ l^{-1}$ solutions of sodium hydroxide and ammonia?

A   The pH of solution

B   The mass of solute present

C   The conductivity of solution

D   The number of moles of hydrochloric acid needed for neutralisation

35. Which of the following would cause the pH of an acid solution to be changed from 2 to 4?

A   Diluting $100 \ cm^3$ of solution to $200 \ cm^3$ with water

B   Evaporating $100 \ cm^3$ of solution until $50 \ cm^3$ remain

C   Diluting $1 \ cm^3$ of solution to $100 \ cm^3$ with water

D   Evaporating $100 \ cm^3$ of solution until $1 \ cm^3$ remains

36. Which of the following compounds dissolves in water to give an alkaline solution?

A   Sodium nitrate

B   Potassium ethanoate

C   Ammonium chloride

D   Lithium sulphate

37. $HgCl_2(aq) + SnCl_2(aq) \rightarrow Hg(\ell) + SnCl_4(aq)$

What ion is oxidised in the above redox reaction?

A $Sn^{2+}(aq)$

B $Sn^{4+}(aq)$

C $Hg^{2+}(aq)$

D $Cl^{-}(aq)$

38. The unlabelled line on the graph below was obtained by plotting the mass of copper metal deposited against charge passed during the electrolysis of a melt of copper(I) chloride.
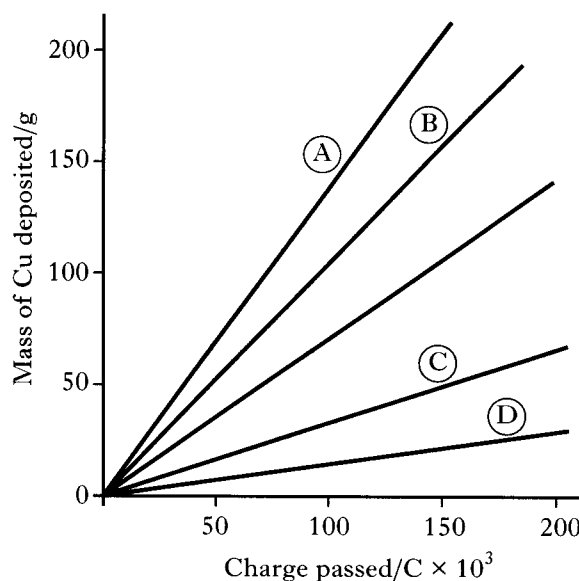
If a melt of copper(II) chloride was electrolysed, which line would correspond to the mass of copper metal deposited against charge passed?

39. ^{14}C has a half life of 5600 years. An analysis of charcoal from a wood fire shows that its ^{14}C content is 25% that of living wood.

How many years have passed since the wood for the fire was cut?

A   1400

B   4200

C   11 200

D   16 800

40. A radioisotope of thorium forms protactinium-231 by beta-emission.

What is the mass number of the radioisotope of thorium?

A   230

B   231

C   232

D   235

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

SECTION B

All answers must be written clearly and legibly in ink.

1. The melting and boiling points and electrical conductivities of four substances are given in the table.

Substance	Melting point/°C	Boiling point/°C	Solid conducts electricity?	Melt conducts electricity?
A	92	190	no	no
B	1050	2500	yes	yes
C	773	1407	no	yes
D	1883	2503	no	no

Complete the table below by adding the appropriate letter for each type of bonding and structure.

Substance	Bonding and structure at room temperature
	covalent molecular
	covalent network
	ionic
	metallic

(2)

[Turn over

Marks

2. The elements in the second row of the Periodic Table are shown below.

Li	Be	B	C	N	O	F	Ne

(a) Why does the atomic size decrease crossing the period from lithium to neon?

1

(b) Diamond and graphite are forms of carbon that exist as network solids.
Name a form of carbon that exists as discrete molecules.

1

(c) Use the electronegativity values to explain why nitrogen chloride contains pure covalent bonds.

1

(3)

Marks

3. Catalytic converters in car exhaust systems convert poisonous gases into less harmful gases.

(*a*) Two less harmful gases are formed when nitrogen monoxide reacts with carbon monoxide.

Name the **two** gases produced.

1

(*b*) The catalyst is made up of the metals platinum, palladium and rhodium.

Explain what happens to molecules in the exhaust gas during their catalytic conversion to less harmful gases.

You may wish to draw labelled diagrams.

2

(3)

[Turn over

4. The enthalpy of combustion of methanol (CH_3OH) can be determined from measurements using the apparatus shown.

thermometer

copper can

$100\,cm^3$ water
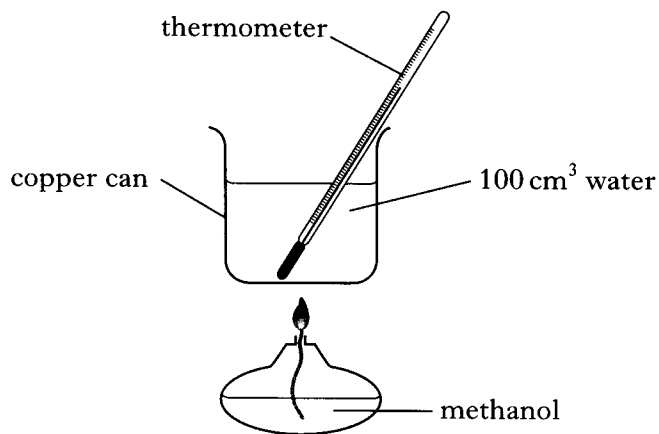
methanol

(*a*) In an experiment, the following results were obtained.

> mass of methanol burned = 0·45 g
>
> temperature rise of water = 10·0 °C

Use these results to calculate the enthalpy of combustion, in $kJ\,mol^{-1}$, of methanol.

Show your working clearly.

3

Marks

4. (continued)

(*b*) Suggest **two** reasons why the experimental value for the enthalpy of combustion of methanol is different from the value given on page 9 of the data booklet.
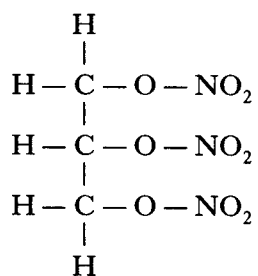
2

(5)

[Turn over

5. Glycerol trinitrate is an explosive with the structure shown.

$$
\begin{array}{c}
H \\
| \\
H-C-O-NO_2 \\
| \\
H-C-O-NO_2 \\
| \\
H-C-O-NO_2 \\
| \\
H
\end{array}
$$

(a) Glycerol trinitrate is produced from glycerol.
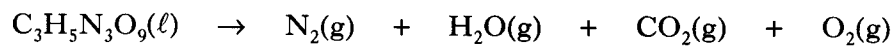
(i) Draw a structural formula for glycerol.

1

(ii) Name a group of naturally occurring esters that can be hydrolysed to obtain glycerol.

1

(b) When exploded, glycerol trinitrate decomposes to give nitrogen, water, carbon dioxide and oxygen.

Balance the equation for this reaction.

$$C_3H_5N_3O_9(\ell) \rightarrow N_2(g) + H_2O(g) + CO_2(g) + O_2(g)$$

1

(3)

Marks

6. An enzyme found in potatoes can catalyse the decomposition of hydrogen peroxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$
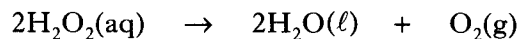
The rate of the decomposition of hydrogen peroxide can be studied using the apparatus shown.

hydrogen peroxide
solution

water

potato disk
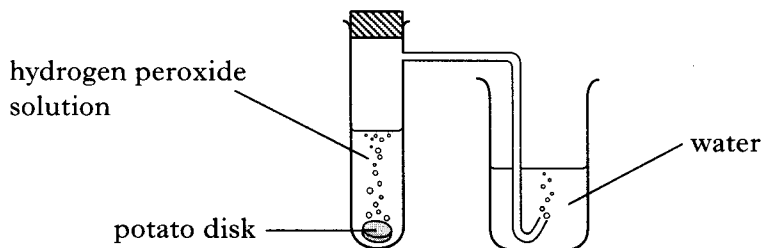
(*a*) Describe how this apparatus can be used to investigate the effect of temperature on the rate of decomposition of hydrogen peroxide.

2

(*b*) The graph shows how the rate of the enzyme catalysed reaction changes with temperature.

Reaction
rate

0   40   80
Temperature/°C
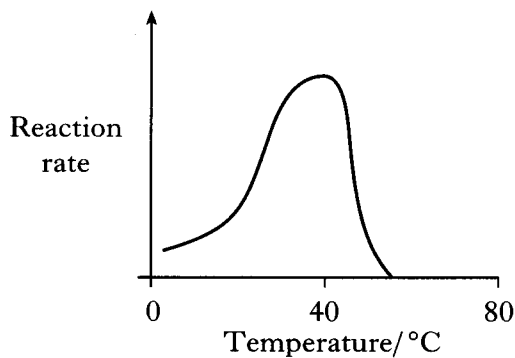
Why does the reaction rate decrease above the optimum temperature of 40 °C?

1

(3)

7. An industrial method for the production of ethanol is outlined in the flow diagram.

```
  ( ethene )                    ( water )
       |                           |
       └──────→ [ reaction vessel ] ←─┘
                      |
                      ↓
                 [ cooler ]
                      |
                      ↓
         ( ethanol, ethene and water )
                      |
                      ↓
  ( ethene ) ←── [ separator A ]
                      |
                      ↓
              [ dilute ethanol ]
                      |
                      ↓
              [ separator B ] ──→ ( water )
                      |
                      ↓
         ( concentrated ethanol )
```
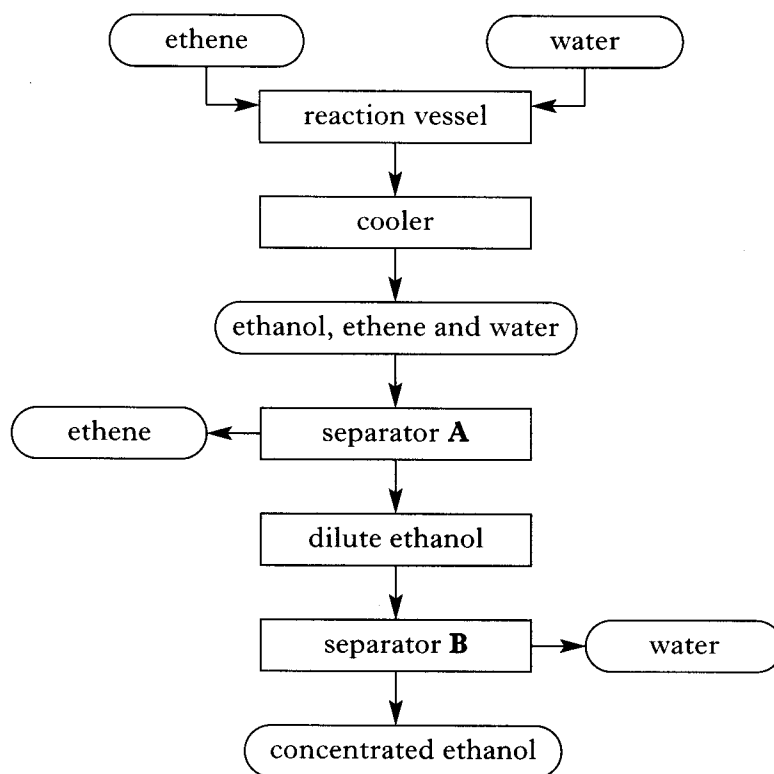
(a) The starting materials are ethene and water. Water is a raw material but ethene is not. Why is ethene **not** a raw material?

1

(b) (i) Unreacted ethene is removed in separator **A**.

Suggest how the separated ethene could be used to increase the efficiency of the overall process.

1

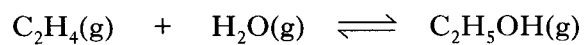(ii) Name the process that takes place in separator **B**.

1

7. (continued)

(c) In the reaction vessel, ethanol is produced in an exothermic reaction.

$$C_2H_4(g) \quad + \quad H_2O(g) \quad \rightleftharpoons \quad C_2H_5OH(g)$$

(i) Name the type of chemical reaction that takes place in the reaction vessel.

1

(ii) What would happen to the equilibrium position if the temperature inside the reaction vessel was increased?

1

(iii) If 1·64 kg of ethanol (relative formula mass = 46) is produced from 10·0 kg of ethene (relative formula mass = 28), calculate the percentage yield of ethanol.

2

(7)

Marks

8. "Self-test" kits can be used to check the quantity of alcohol present in a person's breath.

The person blows through a glass tube until a plastic bag at the end is completely filled.

breath →

acidified potassium
dichromate crystals

plastic bag
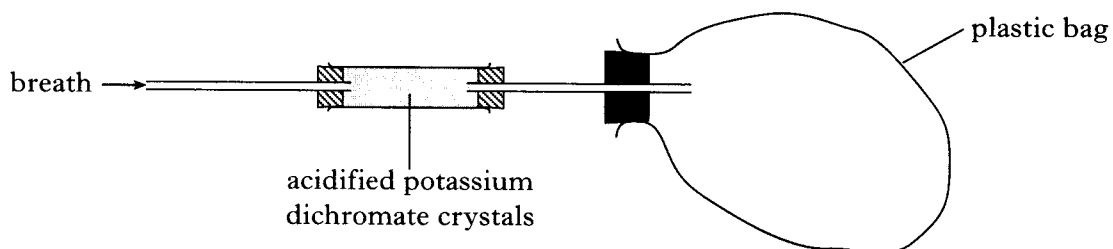
The tube contains orange acidified potassium dichromate crystals that turn green when they react with ethanol. The chemical reaction causing the colour change is:

$$Cr_2O_7^{2-} \ + \ 14H^+ \ + \ 6e^- \longrightarrow \ 2Cr^{3+} \ + \ 7H_2O$$
orange $\qquad\qquad\qquad\qquad\qquad$ green
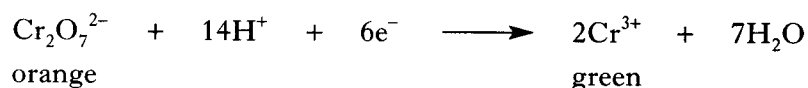
The more ethanol present in the person's breath, the further along the tube the green colour travels.

(*a*) What is the purpose of the plastic bag?

1

(*b*) Why are the potassium dichromate crystals acidified?

1

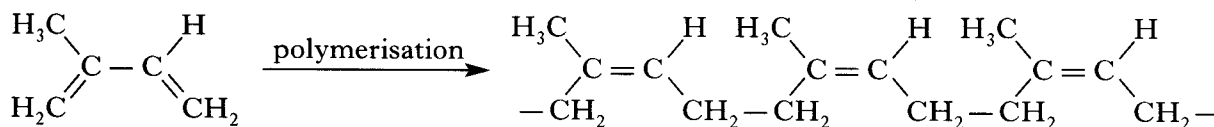(*c*) Name a carbon compound formed by the reaction of ethanol with acidified potassium dichromate crystals.

1

(3)

Marks

9. Car tyres can be made from natural or synthetic rubber.

Natural rubber is a thermoplastic polymer. The monomer used for the polymerisation is called 2-methylbuta-1,3-diene.
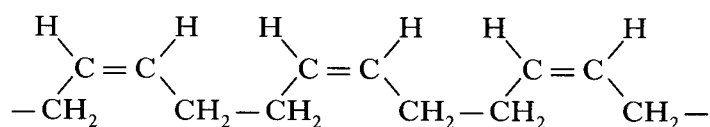
$$H_3C \diagdown C = C \diagup H \qquad \xrightarrow{\text{polymerisation}} \qquad H_3C \diagdown C = C \diagup H \quad H_3C \diagdown C = C \diagup H \quad H_3C \diagdown C = C \diagup H$$

2-methylbuta-1,3-diene   poly(2-methylbuta-1,3-diene)

(*a*) Synthetic rubber is a similar polymer.

Part of the structure of synthetic rubber showing three monomer units linked together is shown.

$$H \diagdown C = C \diagup H \quad H \diagdown C = C \diagup H \quad H \diagdown C = C \diagup H$$

(i) Draw the monomer used to form synthetic rubber.

1

(ii) Name the type of polymerisation involved in the manufacture of synthetic rubber.

1

(*b*) In making tyre rubber, the polymer chains are cross-linked to give a three-dimensional structure by heating with sulphur and sulphur compounds.

In what way will the **properties** of the rubber be improved by cross-linking?

1

(3)

10. When copper is added to an acid, what happens depends on the acid and the conditions.
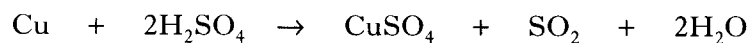
(*a*) When copper reacts with dilute nitric acid, nitrate ions are reduced.
Complete the ion-electron equation for the reduction of the nitrate ions.

$$NO_3^-(aq) \qquad\qquad \rightarrow \quad NO(g)$$

1

(*b*) Copper reacts with hot, concentrated sulphuric acid to produce sulphur dioxide.

$$Cu \ + \ 2H_2SO_4 \ \rightarrow \ CuSO_4 \ + \ SO_2 \ + \ 2H_2O$$

Calculate the volume, in litres, of sulphur dioxide gas that would be produced when 10 g of copper reacts with excess concentrated sulphuric acid.

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

Show your working clearly.

2

(3)

11. (*a*) State the pH of 0·01 mol l⁻¹ hydrochloric acid.

(*b*) The pH values of 0·01 mol l⁻¹ ethanoic acid and 0·01 mol l⁻¹ sulphuric acid were measured.

The results were compared to the pH of 0·01 mol l⁻¹ hydrochloric acid.

Circle the words in the table that show the correct comparisons.

Solution	pH compared to hydrochloric acid
ethanoic acid	higher / lower / the same
sulphuric acid	higher / lower / the same

(*c*) In pure ethanoic acid, the molecules are held together in pairs.
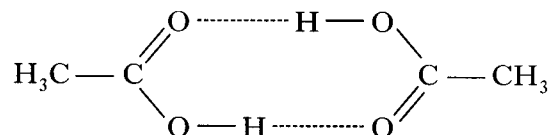
Explain why this happens.

In your answer you should name the type of intermolecular forces involved in pure ethanoic acid and explain how they arise.
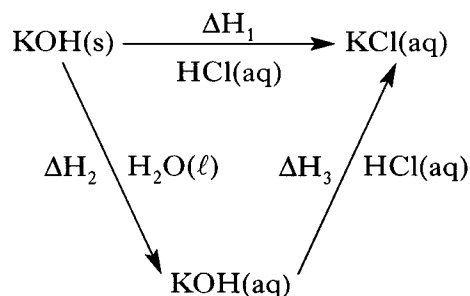
[Turn over

12. The Swiss-born Russian chemist Germain Henri Hess first put forward his law in 1840.

(*a*)   (i)   Hess's Law can be verified using the reactions summarised below.

$$KOH(s) \xrightarrow[\text{HCl(aq)}]{\Delta H_1} KCl(aq)$$

$$\Delta H_2 \searrow H_2O(\ell) \qquad \Delta H_3 \nearrow HCl(aq)$$

$$KOH(aq)$$

Complete the list of measurements that would have to be made in order to determine ΔH_3.

1   volume of potassium hydroxide solution

2

3

4
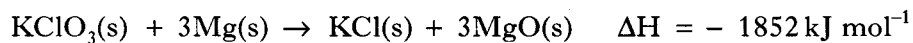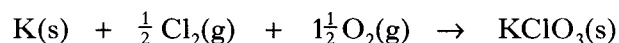
5   **2**

(ii)   Hess's Law can be used to obtain enthalpy changes for reactions that cannot be measured directly.

Use the following enthalpy changes

$$KClO_3(s) + 3Mg(s) \rightarrow KCl(s) + 3MgO(s) \qquad \Delta H = -\ 1852\ kJ\ mol^{-1}$$
$$K(s) + \tfrac{1}{2}Cl_2(g) \rightarrow KCl(s) \qquad \Delta H = -\ 437\ kJ\ mol^{-1}$$
$$Mg(s) + \tfrac{1}{2}O_2(g) \rightarrow MgO(s) \qquad \Delta H = -\ 602\ kJ\ mol^{-1}$$

to calculate the enthalpy change in $kJ\ mol^{-1}$, for the reaction:

$$K(s) + \tfrac{1}{2}Cl_2(g) + 1\tfrac{1}{2}O_2(g) \rightarrow KClO_3(s)$$

2

12. (continued)

(b) The enthalpy change for the reaction

$$K(s) \ + \ \tfrac{1}{2}Cl_2(g) \ + \ 1\tfrac{1}{2}O_2(g) \ \rightarrow \ KClO_3(s)$$
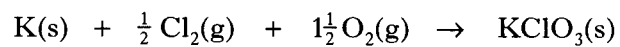
is an example of an enthalpy of formation.

The enthalpy of formation of a compound can be defined as the enthalpy change for the formation of one mole of a compound from its elements as they exist at room temperature.
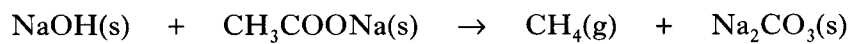
Write the equation, including state symbols, corresponding to the enthalpy of formation of sodium oxide (Na_2O).

1

(5)

[Turn over

Marks

13. When a mixture of solid sodium hydroxide and solid sodium ethanoate is heated, methane gas and solid sodium carbonate are produced.

$$NaOH(s) \quad + \quad CH_3COONa(s) \quad \rightarrow \quad CH_4(g) \quad + \quad Na_2CO_3(s)$$

(*a*) Draw a diagram of an apparatus which could be used for this reaction showing how the methane gas can be collected and its volume measured.

2

(*b*) Name the gas produced when sodium propanoate is heated with solid sodium hydroxide.

1

(3)

14. Americium-241 is an alpha-emitting radioisotope that is used in a popular type of smoke detector.

(*a*) (i) Write a balanced nuclear equation for the alpha decay of americium-241 (atomic number 95).

1

(ii) Suggest a reason why this type of smoke detector is not regarded as a health hazard, even though it contains a radioactive source.

1

(*b*) The americium-241 is present in the smoke detector as the metal oxide.

If the smoke detector contains 0·00025 g of americium-241 oxide, AmO_2, calculate the mass present, in grams, of americium-241.
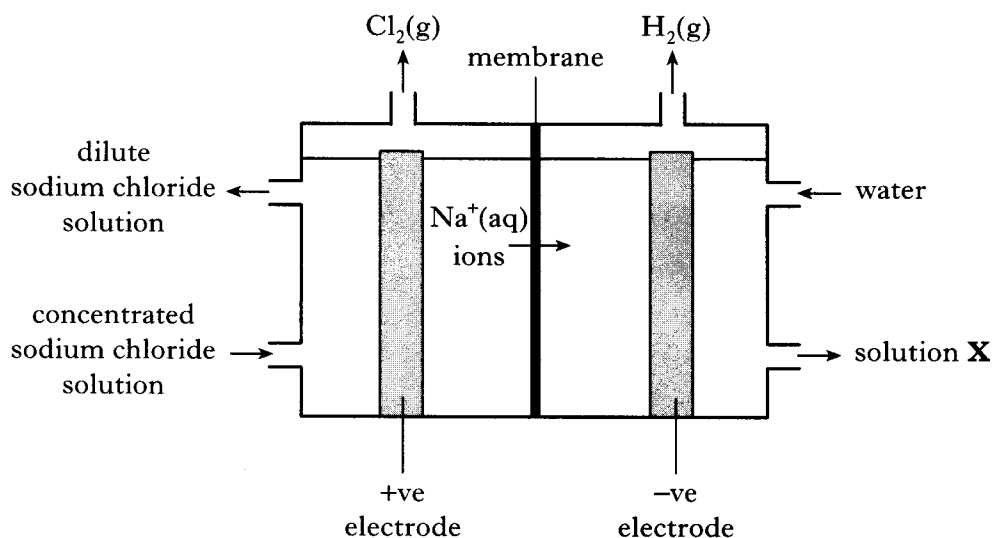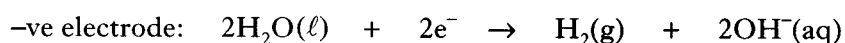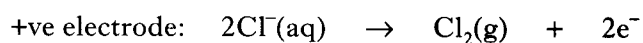
1

(3)

[Turn over

Marks

15. Chlorine can be produced commercially from concentrated sodium chloride solution in a membrane cell.

Only sodium ions can pass through the membrane. These ions move in the direction shown in the diagram.

The reactions at each electrode are:

+ve electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

−ve electrode: $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

(*a*) Write the overall redox equation for the reaction in the membrane cell.

1

(*b*) (i) Name solution **X**.

1

(ii) Hydrogen gas is produced at the negative electrode in the membrane cell. Suggest why this gas could be a valuable resource in the future.

1

15. (continued)

(*c*) Calculate the mass of chlorine, in kilograms, produced in a membrane cell using a current of 80 000 A for 10 hours.

Show your working clearly.

3

(6)

[Turn over

16. Infrared spectroscopy can be used to help identify the bonds which are present in an organic molecule.

Different bonds absorb infrared radiation of different wave numbers.

The table below shows the range of wave numbers of infrared radiation absorbed by the bonds indicated with thicker lines.

Bond	Wave number range/cm^{-1}
O — H	3650 – 3590
C ≡ C — H	3300
C – C — H	2962 – 2853
C ≡ C	2260 – 2100
C — O	1150 – 1070

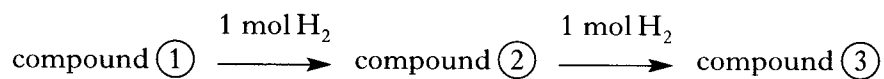The infrared spectrum and full structural formula for compound ① are shown.
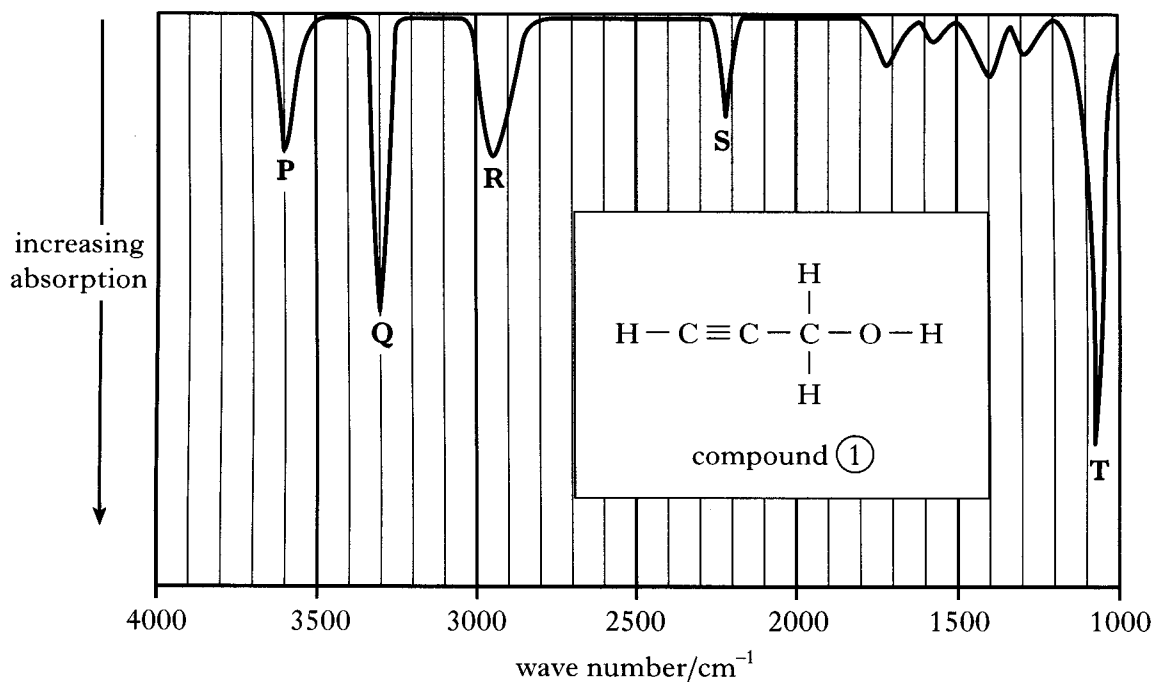
(a) In the above full structural formula for compound ①, use an arrow to indicate the bond that could be responsible for the absorption at **T** in its infrared spectrum.

1

16. (continued)

(b) A series of reactions is carried out starting with compound ①.

$$\text{compound } ① \xrightarrow{\text{1 mol H}_2} \text{compound } ② \xrightarrow{\text{1 mol H}_2} \text{compound } ③$$

(i) Give the letters for the **two** absorptions which would **not** appear in the infrared spectrum for compound ②.

<div align="right">1</div>

(ii) Name compound ③.

<div align="right">1</div>
<div align="right">(3)</div>

[END OF QUESTION PAPER]