Total
Section B

X012/301

NATIONAL QUALIFICATIONS 2004	WEDNESDAY, 2 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—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.

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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:
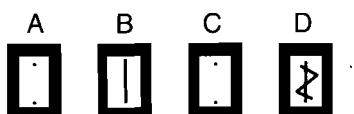
If you want to change back to an answer which has already been scored out, you should **enter a tick (✓)** to the RIGHT of the box of your choice, thus:
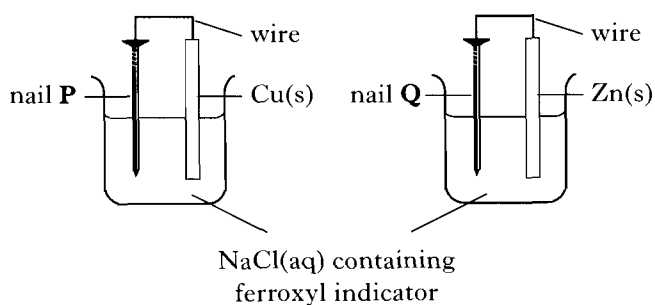
1. Which of the following solids has a low melting point and a high electrical conductivity?

   A   Iodine

   B   Potassium

   C   Silicon oxide

   D   Potassium fluoride

2. Two experiments are set up to study the corrosion of an iron nail.

   Experiment 1   Experiment 2

   NaCl(aq) containing
   ferroxyl indicator

   After a short time, a blue colour will have appeared at

   A   both **P** and **Q**

   B   neither **P** nor **Q**

   C   **P** but not at **Q**

   D   **Q** but not at **P**.

3. In which of the following compounds do **both** ions have the same electron arrangement as argon?

   A   Calcium sulphide

   B   Magnesium oxide

   C   Sodium sulphide

   D   Calcium bromide

4. What volume of sodium hydroxide solution, concentration $0{\cdot}4$ $mol\,l^{-1}$, is needed to neutralise $50\,cm^3$ of sulphuric acid, concentration $0{\cdot}1$ $mol\,l^{-1}$?

   A $25\,cm^3$
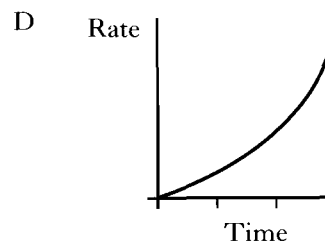
   B $50\,cm^3$

   C $100\,cm^3$

   D $200\,cm^3$

5. Like atoms, molecules can lose electrons to form positive ions.

   1. $[^1H_2{}^{16}O]^+$ 2. $[^1H_2{}^{17}O]^+$ 3. $[^1H_2{}^{18}O]^+$

   4. $[^2H_2{}^{16}O]^+$ 5. $[^2H_2{}^{17}O]^+$ 6. $[^2H_2{}^{18}O]^+$

   Which of the following pairs has ions of the same mass?

   A   1 and 4

   B   2 and 5

   C   3 and 6

   D   3 and 4

6. Which of the following graphs could represent the change in the rate of a reaction between magnesium ribbon and hydrochloric acid?
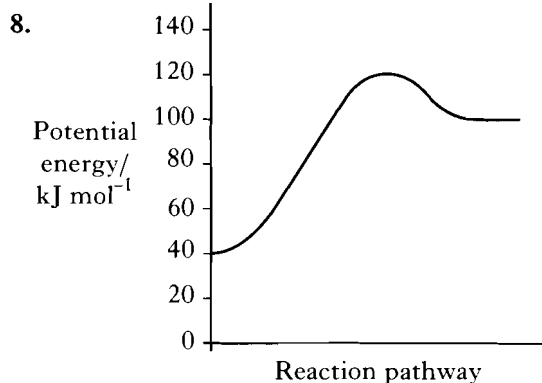
   A

   B

   C

   D
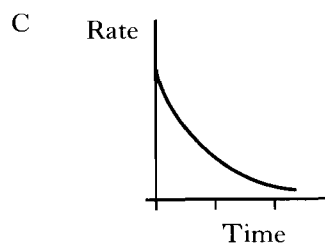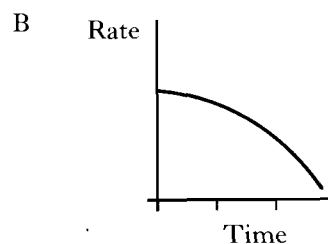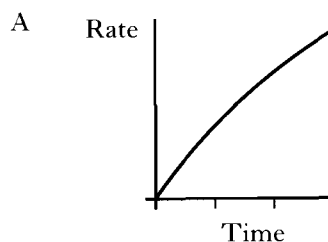
[Turn over

7. 1 mol of hydrogen gas and 1 mol of iodine vapour were mixed and allowed to react. After t seconds, 0·8 mol of hydrogen remained.

The number of moles of hydrogen iodide formed at t seconds was

A 0·2

B 0·4

C 0·8

D 1·6.

8.

Reaction pathway

Which of the following sets of data applies to the reaction represented by the above energy diagram?

	Enthalpy change	Activation energy/ kJ mol^{-1}
A	Exothermic	60
B	Exothermic	80
C	Endothermic	60
D	Endothermic	80

9. Which of the following elements has the greatest electronegativity?

A Caesium

B Oxygen

C Fluorine

D Iodine

10. As the relative atomic mass in the halogens increases

A the boiling point increases

B the density decreases

C the first ionisation energy increases

D the atomic size decreases.

11. Which of the following elements would require the most energy to convert one mole of gaseous atoms into gaseous ions each carrying two positive charges?

(You may wish to use the data booklet.)

A Scandium

B Titanium

C Vanadium

D Chromium

12. Which of the following compounds has polar molecules?

A CH_4

B CO_2

C NH_3

D CCl_4

13. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

How many litres of nitrogen dioxide gas could theoretically be obtained in the reaction of 1 litre of nitrogen monoxide gas with 2 litres of oxygen gas?

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

A 1

B 2

C 3

D 4

14. Which of the following gases has the same volume as 128·2 g of sulphur dioxide gas?

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

A 2·0 g of hydrogen

B 8·0 g of helium

C 32·0 g of oxygen

D 80·8 g of neon

15. 5 g of copper is added to excess silver(I) nitrate solution. After some time, the solid present is filtered off from the copper(II) nitrate solution, washed with water, dried and weighed.
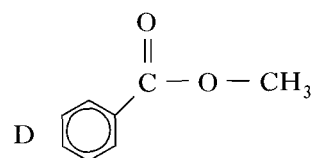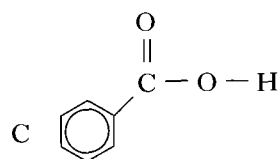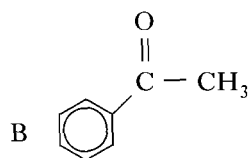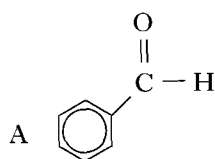
The final mass of the solid will be

A   less than 5 g

B   5 g

C   10 g

D   more than 10 g.

16. Which of the following equations represents a reaction which takes place during reforming?

A $C_6H_{14} \rightarrow C_6H_6 + 4H_2$

B $C_4H_8 + H_2 \rightarrow C_4H_{10}$

C $C_2H_5OH \rightarrow C_2H_4 + H_2O$

D $C_8H_{18} \rightarrow C_4H_{10} + C_4H_8$

17. Which of the following is a ketone?

18. Which of the following is an isomer of 2,2-dimethylpentan-1-ol?

A $CH_3CH_2CH_2CH(CH_3)CH_2OH$

B $(CH_3)_3CCH(CH_3)CH_2OH$

C $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$

D $(CH_3)_2CHC(CH_3)_2CH_2CH_2OH$

19. Ethene is used in the manufacture of addition polymers.

What type of reaction is used to produce ethene from ethane?

A   Addition

B   Cracking

C   Hydrogenation

D   Oxidation

20. The compound $CH_3CH_2COO^-Na^+$ is formed by reaction between sodium hydroxide and

A   propanoic acid

B   propan-1-ol

C   propene

D   propanal.

21. Which of the following is **not** a correct statement about methanol?

A   It is a primary alkanol.

B   It can be oxidised to methanal.

C   It can be made from synthesis gas.

D   It can be dehydrated to an alkene.

22. Ammonia is manufactured from hydrogen and nitrogen by the Haber Process

$$3H_2 \ + \ N_2 \ \rightleftharpoons \ 2NH_3$$
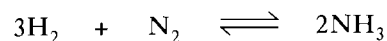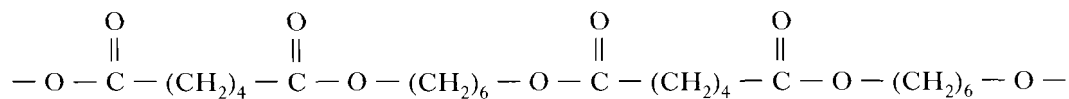
If 80 kg of ammonia is produced from 60 kg of hydrogen, what is the percentage yield?

A $\frac{80}{340} \times 100$

B $\frac{80}{170} \times 100$

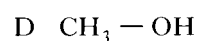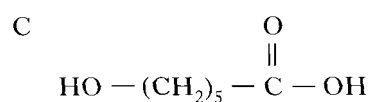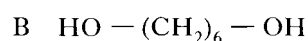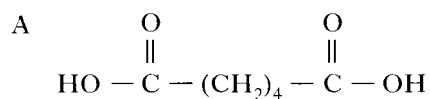C $\frac{30}{80} \times 100$

D $\frac{60}{80} \times 100$

23. What 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

24. Part of a polymer chain is shown below.

$$-O-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-O-(CH_2)_6-O-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-O-(CH_2)_6-O-$$

Which of the following compounds, when added to the reactants during polymerisation, would stop the polymer chain from getting too long?

A
$$HO-\overset{\overset{O}{\|}}{C}-(CH_2)_4-\overset{\overset{O}{\|}}{C}-OH$$

B $HO-(CH_2)_6-OH$

C
$$HO-(CH_2)_5-\overset{\overset{O}{\|}}{C}-OH$$

D CH_3-OH

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25. Which of the following polymers is used in making bullet-proof vests?

A   Kevlar

B   Biopol

C   Poly(ethenol)

D   Poly(ethyne)

26. Which of the following is a structural formula for glycerol?

A CH_2OH
   |
   $CHOH$
   |
   CH_2OH

B CH_2OH
   |
   CH_2
   |
   CH_2OH

C CH_2OH
   |
   CH_2OH

D CH_2OH
   |
   $CHOH$
   |
   CH_2COOH
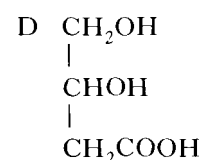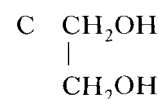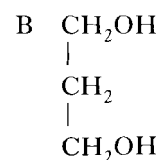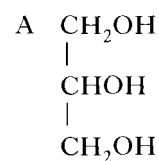
27. Fats have higher melting points than oils because comparing fats and oils

A   fats have more hydrogen bonds

B   fat molecules are more saturated

C   fat molecules are more loosely packed

D   fats have more cross-links between molecules.

28. The monomer units used to construct enzyme molecules are

A   alcohols

B   esters

C   amino acids

D   fatty acids.

29. Which of the following compounds is a raw material in the chemical industry?

A   Ethene

B   Ammonia

C   Sulphuric acid

D   Sodium chloride

30. Consider the reaction pathway shown.

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

A $+110\cdot5\,kJ\,mol^{-1}$

B $-110\cdot5\,kJ\,mol^{-1}$

C $-676\cdot5\,kJ\,mol^{-1}$

D $+676\cdot5\,kJ\,mol^{-1}$

31. Which line in the table applies correctly to the use of a catalyst in a chemical reaction?

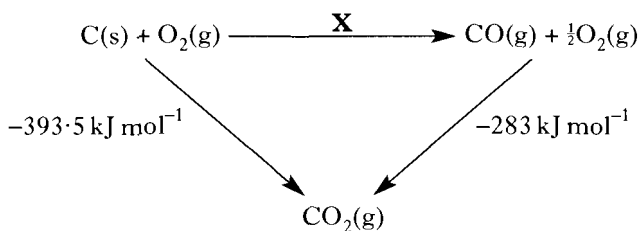|	Position of equilibrium	Effect on value of ΔH
A	Moved to right	Decreased
B	Unaffected	Increased
C	Moved to left	Unaffected
D	Unaffected	Unaffected

32. Some solid ammonium chloride is added to a dilute solution of ammonia.

Which of the following ions will decrease in concentration as a result?

A Ammonium

B Hydrogen

C Hydroxide

D Chloride

33. The pH of a solution of hydrochloric acid was found to be 2·5.

The concentration of the $H^+(aq)$ ions in the acid must be

A greater than $0\cdot1\,mol\,l^{-1}$

B between $0\cdot1$ and $0\cdot01\,mol\,l^{-1}$

C between $0\cdot01$ and $0\cdot001\,mol\,l^{-1}$

D less than $0\cdot001\,mol\,l^{-1}$.

34. Which of the following is the best description of a $0\cdot1\,mol\,l^{-1}$ solution of sulphuric acid?

A Dilute solution of a strong acid

B Dilute solution of a weak acid

C Concentrated solution of a strong acid

D Concentrated solution of a weak acid

35. Excess marble chips (calcium carbonate) were added to $100\,cm^3$ of $1\,mol\,l^{-1}$ hydrochloric acid. The experiment was repeated using the same mass of the marble chips and $100\,cm^3$ of $1\,mol\,l^{-1}$ ethanoic acid.

Which of the following would have been the same for both experiments?

A The time taken for the reaction to be completed

B The rate at which the first $10\,cm^3$ of gas was evolved

C The mass of marble chips left over when the reaction had stopped

D The average rate of the reaction

36. Which line in the table is correct for $0\cdot1\,mol\,l^{-1}$ sodium hydroxide compared with $0\cdot1\,mol\,l^{-1}$ aqueous ammonia?

	pH	Conductivity
A	higher	lower
B	higher	higher
C	lower	higher
D	lower	lower

37. During a redox process in acid solution, iodate ions, $IO_3^-(aq)$, are converted into iodine, $I_2(aq)$.

$$IO_3^-(aq) \rightarrow I_2(aq)$$
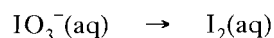
The numbers of $H^+(aq)$ and $H_2O(\ell)$ required to balance the ion-electron equation for the formation of 1 mol of $I_2(aq)$ are, respectively

A 3 and 6

B 6 and 3

C 6 and 12

D 12 and 6.

38. Ammonia reacts with magnesium as shown.

$$3Mg(s) + 2NH_3(g) \rightarrow (Mg^{2+})_3(N^{3-})_2(s) + 3H_2(g)$$
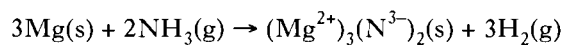
In this reaction, ammonia is acting as

A   an acid

B   a base

C   an oxidising agent

D   a reducing agent.

39. Induced nuclear reactions can be described in a shortened form

$$T\,(x, y)\,P$$
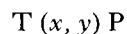
where the participants are the target nucleus (T), the bombarding particle (x), the ejected particle (y) and the product nucleus (P).

Which of the following nuclear reactions would **not** give the product nucleus indicated?

A $^{14}_{7}N$ (α, p) $^{17}_{8}O$

B $^{236}_{93}Np$ (p, α) $^{238}_{92}U$

C $^{10}_{5}B$ (α, n) $^{13}_{7}N$

D $^{242}_{96}Cf$ (n, α) $^{239}_{94}Pu$

40. Which of the following equations represents a nuclear fission process?

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

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

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

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

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

Marks

1. (*a*) Complete the table below by adding the name of an element from **elements 1 to 20** of the Periodic Table for each of the types of bonding and structure described.

Bonding and structure at room temperature and pressure	Name of element
metallic solid	sodium
monatomic gas	
covalent network solid	
discrete covalent molecular gas	
discrete covalent molecular solid	

2

(*b*) Why do metallic solids such as sodium conduct electricity?

1

(3)

Marks

2. Phosphorus-32 is a radioisotope that decays by beta-emission.

   (*a*) Write the nuclear equation for the decay of phosphorus-32.

1

   (*b*) (i) An 8 g sample of phosphorus-32 was freshly prepared.
              Calculate the number of phosphorus atoms contained in the 8 g sample.

1

          (ii) The half-life of phosphorus-32 is 14·3 days.
               Calculate the time it would take for the mass of phosphorus-32 in the 8 g sample to fall to 1 g.
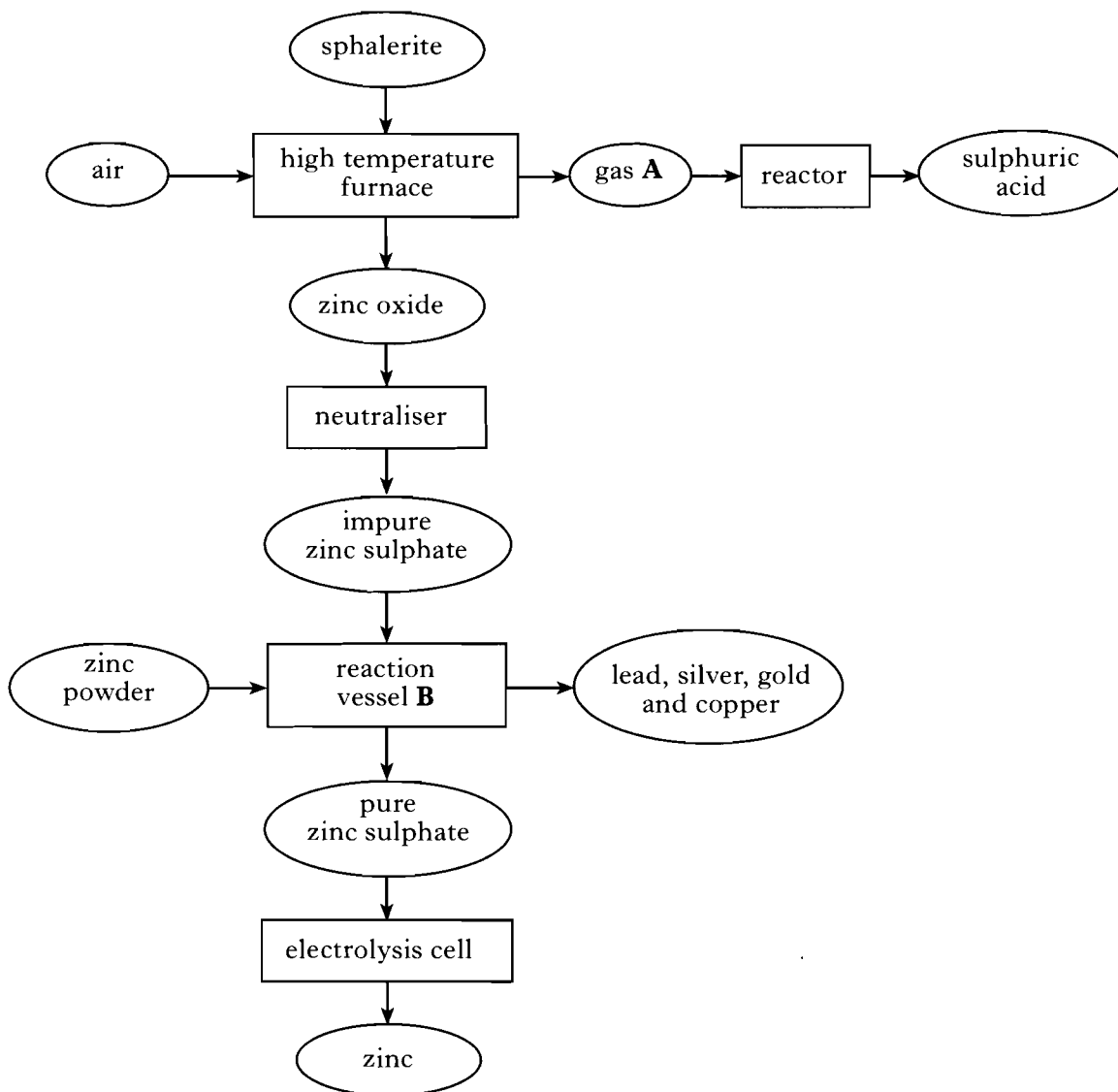
1

(3)

[Turn over

Marks

3. Sphalerite is an impure zinc sulphide ore, containing traces of other metal compounds.

The flow diagram for the extraction of zinc from this ore is shown below.

```
                    ┌──────────────┐
                    │  sphalerite  │
                    └──────┬───────┘
                           │
                           ▼
  ┌─────┐        ┌──────────────────┐      ┌───────┐      ┌──────────┐      ┌───────────┐
  │ air │───────▶│ high temperature │─────▶│ gas A │─────▶│ reactor  │─────▶│ sulphuric │
  └─────┘        │     furnace      │      └───────┘      └──────────┘      │   acid    │
                 └────────┬─────────┘                                       └───────────┘
                          │
                          ▼
                 ┌──────────────┐
                 │  zinc oxide  │
                 └──────┬───────┘
                        │
                        ▼
                 ┌──────────────┐
                 │  neutraliser │
                 └──────┬───────┘
                        │
                        ▼
                 ┌──────────────┐
                 │    impure    │
                 │ zinc sulphate│
                 └──────┬───────┘
                        │
  ┌─────────┐    ┌──────────────┐      ┌───────────────────┐
  │  zinc   │───▶│  reaction    │─────▶│ lead, silver, gold│
  │ powder  │    │  vessel B    │      │    and copper     │
  └─────────┘    └──────┬───────┘      └───────────────────┘
                        │
                        ▼
                 ┌──────────────┐
                 │     pure     │
                 │ zinc sulphate│
                 └──────┬───────┘
                        │
                        ▼
                 ┌──────────────┐
                 │electrolysis  │
                 │    cell      │
                 └──────┬───────┘
                        │
                        ▼
                 ┌──────────────┐
                 │     zinc     │
                 └──────────────┘
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(*a*) Name gas **A**.

1

(*b*) Name the type of reaction taking place in reaction vessel **B**.
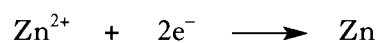
1

Marks

3. (continued)

(*c*) It is economical to make use of the sulphuric acid produced.

Add an arrow to the flow diagram to show how the sulphuric acid could be used in this extraction.

1

(*d*) The ion-electron equation for the production of zinc in the electrolysis cell is

$$Zn^{2+} + 2e^- \longrightarrow Zn$$

If a current of 2000 A is used in the cell, calculate the mass of zinc, in kg, produced in 24 hours.

Show your working clearly.

2

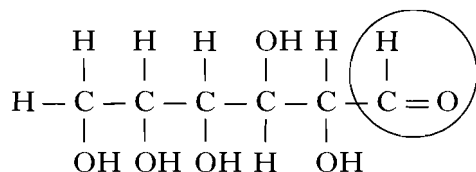**(5)**

[Turn over

Marks

4.   Glucose is produced in plants by photosynthesis.

(*a*)   Plants convert glucose into a condensation polymer for storing energy.
Name this condensation polymer.

1

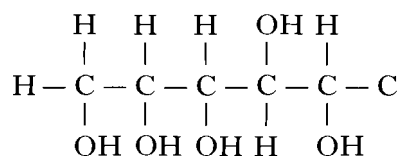(*b*)   One way of representing the structure of glucose in aqueous solution is shown below.

H   H   H   OH H   /H \
| | | | | |
H — C — C — C — C — C —(C = O)
| | | | |
OH OH OH H   OH

In this structure the aldehyde group is circled.

(i)   What would be seen when glucose is oxidised using Tollens' reagent?

1

(ii)   Complete the structure below to show the product formed when glucose is oxidised.

H   H   H   OH H
| | | | |
H — C — C — C — C — C — C
| | | | |
OH OH OH H   OH

1

(*c*)   Under anaerobic conditions, carbohydrates, like glucose, can be used to produce biogas. The main constituent of biogas is methane which is a useful fuel.
State **one** advantage of using biogas as a fuel rather than natural gas.

1

(4)

Marks

5. If the conditions are kept constant, reversible reactions will attain a state of equilibrium.

(*a*) Circle the correct words in the table to show what is true for reactions at equilibrium.

Rate of forward reaction compared to rate of reverse reaction	faster / same / slower
Concentrations of reactants compared to concentrations of products	usually different / always the same

1

(*b*) The following equilibrium involves two compounds of phosphorus.

$$PCl_3(g) + 3NH_3(g) \rightleftharpoons P(NH_2)_3(g) + 3HCl(g)$$
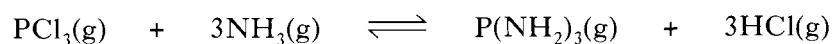
(i) An increase in temperature moves the above equilibrium to the left.
What does this indicate about the enthalpy change for the forward reaction?

1

(ii) What effect, if any, will an increase in pressure have on the above equilibrium?

1

(3)

[Turn over

6. The effect of temperature on reaction rate can be studied using the reaction between oxalic acid and acidified potassium permanganate solutions.

thermometer ——

oxalic acid and acidified potassium permanganate solutions
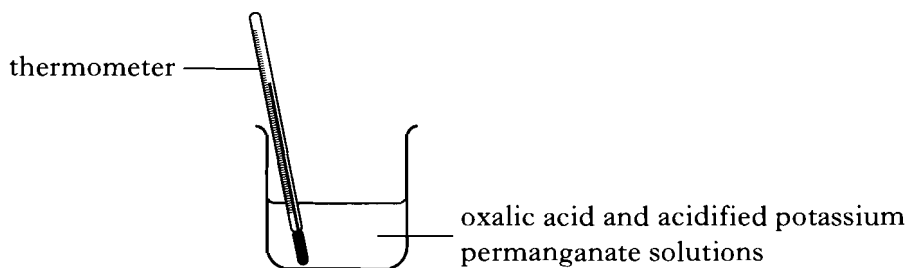
(a) What colour change would indicate that the reaction was complete?

1

(b) A student's results are shown on the graph below.

Rate/s⁻¹

$$Rate/s^{-1}$$
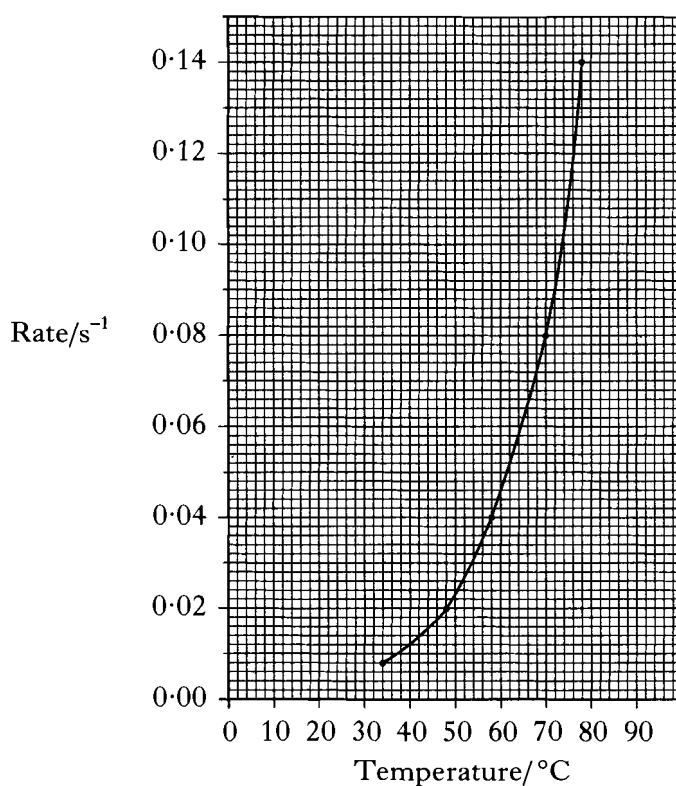
Temperature/°C

(i) Use the graph to calculate the reaction time, in s, at 40 °C.

1

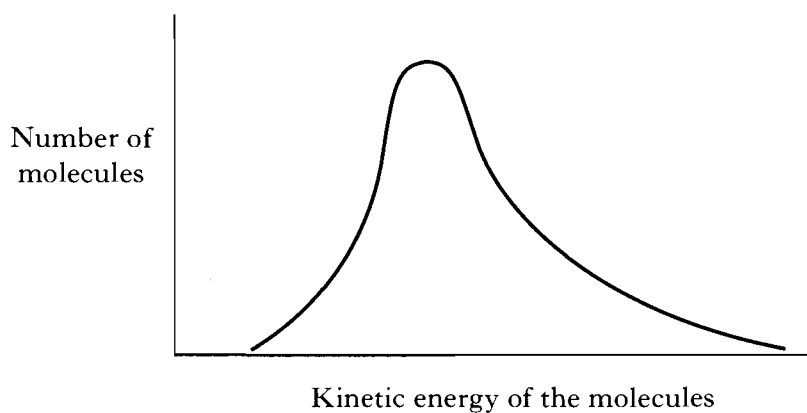## 6. (*b*) (continued)

   (ii) Why is it difficult to obtain an accurate reaction time when the reaction is carried out at room temperature?

1

(*c*) The diagram below shows the energy distribution of molecules in a gas at a particular temperature.

Number of molecules

Kinetic energy of the molecules

Draw a second curve on the diagram to show the energy distribution of the molecules in the gas at a higher temperature.

Label the diagram to indicate why an increase in temperature has such a significant effect on reaction rate.

1

(4)

[Turn over

Marks

7. Enzymes are specific biological catalysts. For example, trypsin, an enzyme produced in the pancreas, will catalyse the hydrolysis of only certain peptide links in a protein.
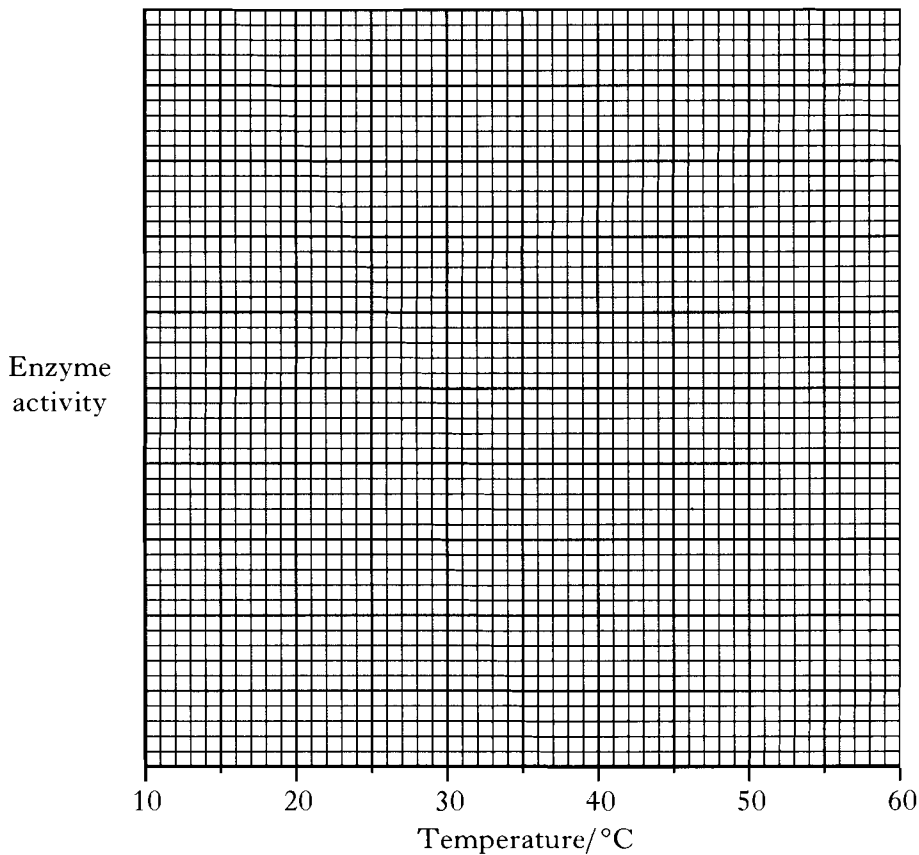
   (*a*) Draw the structure of a peptide link.

   1

   (*b*) Trypsin has an optimum temperature of 37 °C.

   Draw a curve to show how the enzyme activity varies with temperature.

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

Enzyme activity

Temperature/°C

1

   (*c*) Trypsin loses its activity if placed in a solution of very high pH.
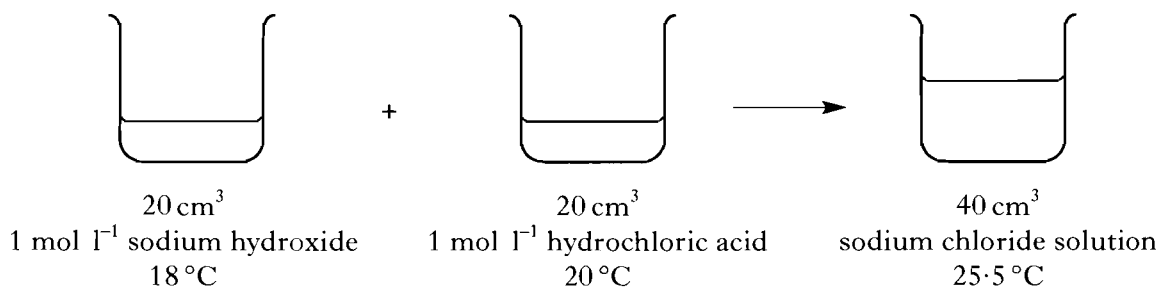
   What happens to the enzyme to cause this loss of activity?

   1

Marks

8. An experiment using dilute hydrochloric acid and sodium hydroxide solution was carried out to determine the enthalpy of neutralisation.

$20\,cm^3$ $20\,cm^3$ $40\,cm^3$
1 mol l^{-1} sodium hydroxide   1 mol l^{-1} hydrochloric acid   sodium chloride solution
18 °C   20 °C   25·5 °C

(*a*) Using the information in the diagram, calculate the enthalpy of neutralisation, in kJ mol^{-1}.

Show your working clearly.

2

(*b*) Calculate the concentration of hydroxide ions in the 1 mol l^{-1} hydrochloric acid used in the experiment.

1

(3)

[Turn over

Marks

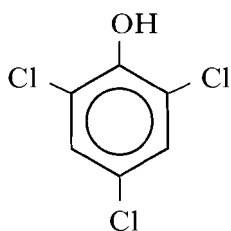**9.** (*a*) Aluminium and phosphorus are close to one another in the Periodic Table but the P^{3-} ion is much larger than the Al^{3+} ion.
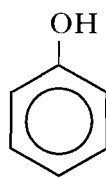
Give the reason for this difference.

1

(*b*) The P^{3-} ion and the Ca^{2+} ion have the same electron arrangement but the Ca^{2+} ion is smaller than the P^{3-} ion.

Give the reason for this difference.

1

(2)

10. The structures of two antiseptics are shown. Both are aromatic.

TCP   phenol

(*a*) (i) What gives the aromatic ring its stability?

1

(ii) Write the molecular formula for TCP.

1

(iii) The systematic name for TCP is 2,4,6-trichlorophenol.
       The systematic name for Dettol, another antiseptic, is
       4-chloro-3,5-dimethylphenol.
       Draw a structural formula for Dettol.

1

(*b*) The feedstocks for the production of antiseptics are made by reforming the
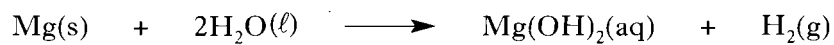   naphtha fraction of crude oil.
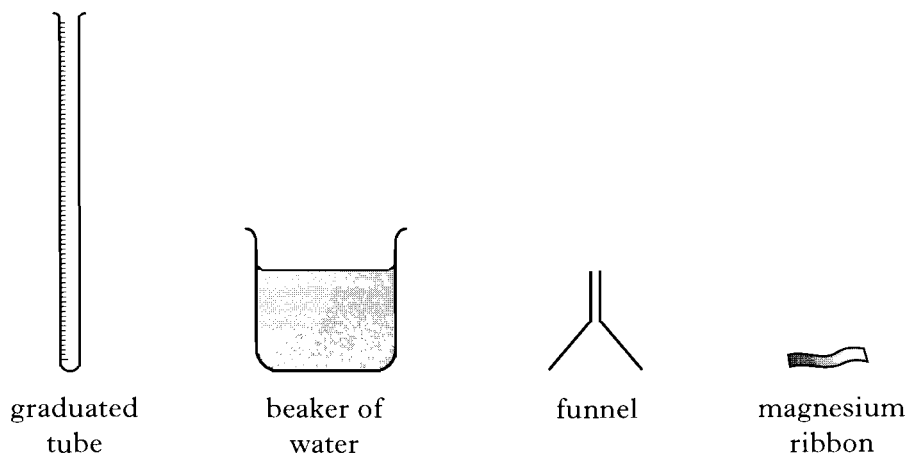   Give another use for reformed naphtha.

1

(4)

11. A student used the slow reaction between magnesium and water to determine the molar volume of hydrogen gas.

$$Mg(s) \quad + \quad 2H_2O(\ell) \quad \longrightarrow \quad Mg(OH)_2(aq) \quad + \quad H_2(g)$$

The following items were used in the experiment.

| graduated tube | beaker of water | funnel | magnesium ribbon |

(a) Draw a diagram to show how the student would have arranged the above items at the start of the experiment.
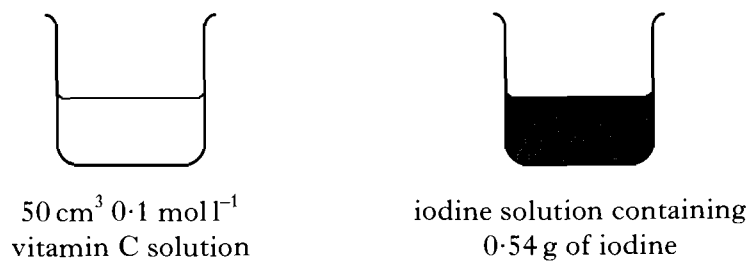
11. (continued)

    (*b*)   What measurements would the student take and how would they be used to calculate the **molar** volume of hydrogen gas?
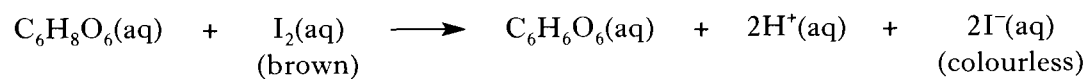
<div align="right">

2

(3)

[Turn over

</div>

12. A student added vitamin C solution to iodine solution.

<div align="center">

$50\,cm^3\ 0{\cdot}1\ mol\,l^{-1}$
vitamin C solution

iodine solution containing
$0{\cdot}54\,g$ of iodine

</div>

The equation for the reaction of vitamin C $(C_6H_8O_6)$ with iodine solution is shown below.

$$C_6H_8O_6(aq)\quad +\quad \underset{\text{(brown)}}{I_2(aq)}\quad \longrightarrow\quad C_6H_6O_6(aq)\quad +\quad 2H^+(aq)\quad +\quad \underset{\text{(colourless)}}{2I^-(aq)}$$

(a) By calculating which reactant was in excess, state whether the iodine solution would have been decolourised.
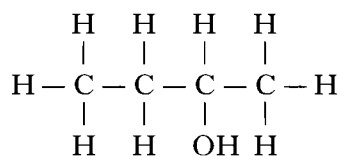
Show your working clearly.

2

(b) Write the ion-electron equation for the oxidation of vitamin C.

1

(3)

Marks

13. Compound **X** is a secondary alcohol.

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

compound **X**

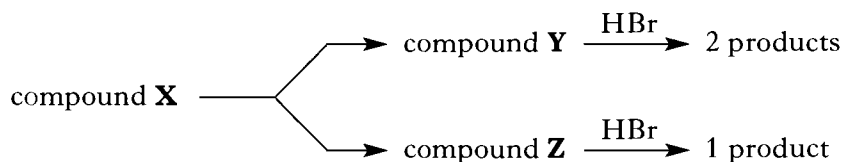(*a*) Name compound **X**.

1

(*b*) Draw a structural formula for the tertiary alcohol that is an isomer of compound **X**.

1

(*c*) When passed over heated aluminium oxide, compound **X** is dehydrated, producing isomeric compounds, **Y** and **Z**.

Both compounds **Y** and **Z** react with hydrogen bromide, HBr. Compound **Y** reacts to produce two products while compound **Z** reacts to produce only one product.

compound **X** $\longrightarrow$
- compound **Y** $\xrightarrow{\text{HBr}}$ 2 products
- compound **Z** $\xrightarrow{\text{HBr}}$ 1 product

Name compound **Z**.

1

(3)

Marks

14. (*a*) Ethanol and propanoic acid can react to form an ester.

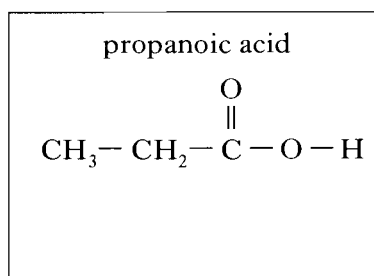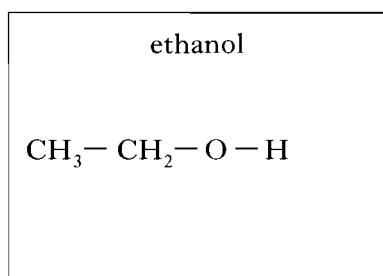(i) Draw a structural formula for this ester.

1

(ii) Draw a labelled diagram of the assembled apparatus that could be used to prepare this ester in the laboratory.

2

(iii) Due to hydrogen bonding, ethanol and propanoic acid are soluble in water whereas the ester produced is insoluble.

In each of the boxes below, draw a molecule of water and use a dotted line to show where a hydrogen bond could exist between the organic molecule and the water molecule.
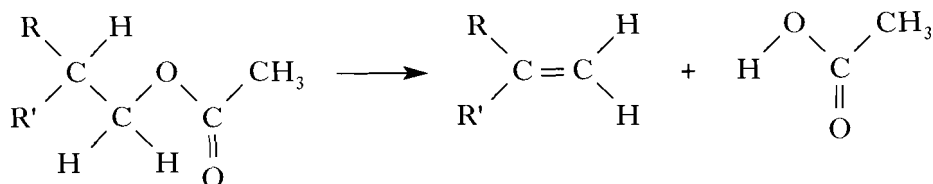
ethanol	propanoic acid
$CH_3 - CH_2 - O - H$	$CH_3 - CH_2 - \overset{\displaystyle O}{\overset{\displaystyle \|}{C}} - O - H$

1

14. (continued)

(b) Pyrolysis (thermal decomposition) of esters can produce two compounds, an alkene and an alkanoic acid, according to the following equation.

(R and R' represent alkyl groups)

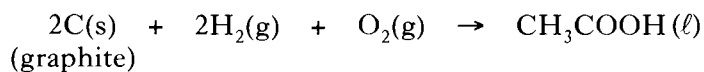Draw a structural formula for the ester that would produce 2-methylbut-1-ene and methanoic acid on pyrolysis.

1

(5)

[Turn over

Marks

15. Vinegar is a dilute solution of ethanoic acid.

    (*a*) Hess's Law can be used to calculate the enthalpy change for the formation of ethanoic acid from its elements.

$$2C(s) + 2H_2(g) + O_2(g) \rightarrow CH_3COOH(\ell)$$
(graphite)

Calculate the enthalpy change for the above reaction, in $kJ\ mol^{-1}$, using information from the data booklet and the following data.

$$CH_3COOH(\ell) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(\ell) \quad \Delta H = -876\ kJ\ mol^{-1}$$
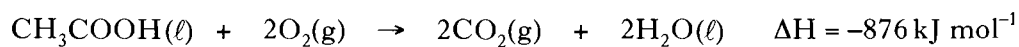
Show your working clearly.

2

    (*b*) Ethanoic acid can be used to prepare the salt, sodium ethanoate, CH_3COONa.
Explain why sodium ethanoate solution has a pH greater than 7.
In your answer you should mention the **two** equilibria involved.

3

(5)

Marks

16. Potassium permanganate is a very useful chemical in the laboratory.

(*a*) Solid potassium permanganate can be heated to release oxygen gas. This reaction can be represented by the equation shown below.

$$KMnO_4(s) \longrightarrow K_2O(s) + MnO_2(s) + O_2(g)$$
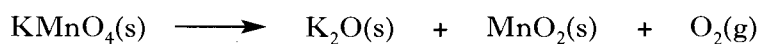
Balance the above equation.   1

(*b*) An acidified potassium permanganate solution can be used to determine the concentration of a solution of iron(II) sulphate by a titration method.

   (i) Apart from taking accurate measurements, suggest **two** points of good practice that a student should follow to ensure that an accurate end-point is achieved in a titration.

1

   (ii) In a titration, a student found that an average of $16 \cdot 7\,cm^3$ of iron(II) sulphate solution was needed to react completely with $25 \cdot 0\,cm^3$ of $0 \cdot 20\,mol\,l^{-1}$ potassium permanganate solution.

The equation for the reaction is:

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$
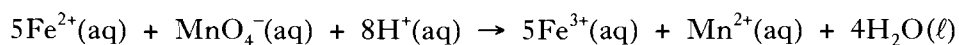
Calculate the concentration of the iron(II) sulphate solution, in $mol\,l^{-1}$.

Show your working clearly.

2

(4)

Marks

17. A proton NMR spectrum can be used to help identify the structure of an organic compound.

The three key principles used in identifying a group containing hydrogen atoms in a molecule are as follows:

- The position of the line(s) on the x-axis of the spectrum is a measure of the "chemical shift" of the hydrogen atoms in the particular group.

Some common "chemical shift" values are given in the table below.

| Group containing hydrogen atoms	Chemical shift
$-CH_3$	1·0
$-C \equiv CH$	2·7
$-CH_2Cl$	3·7
$-CHO$	9·0

- The number of lines for the hydrogen atoms in the group is n + 1 where n is the number of hydrogen atoms on the carbon atom next to the group.

- The maximum height of the line(s) for the hydrogen atoms in the group is relative to the number of hydrogen atoms in the group.

The spectrum for ethanal is shown below.
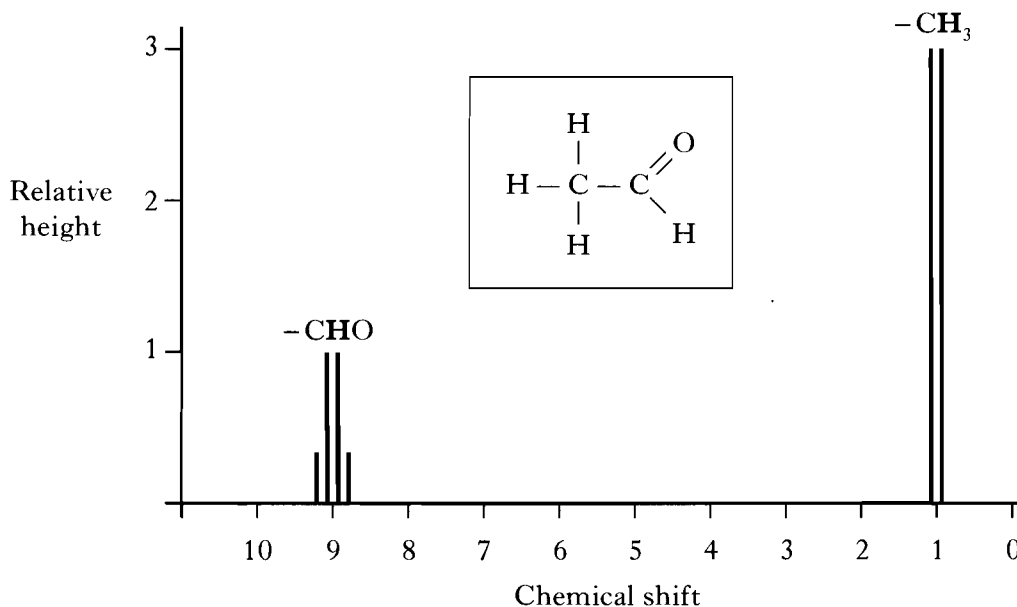
(a) The chemical shift values shown in the table are based on the range of values shown in the data booklet for proton NMR spectra.
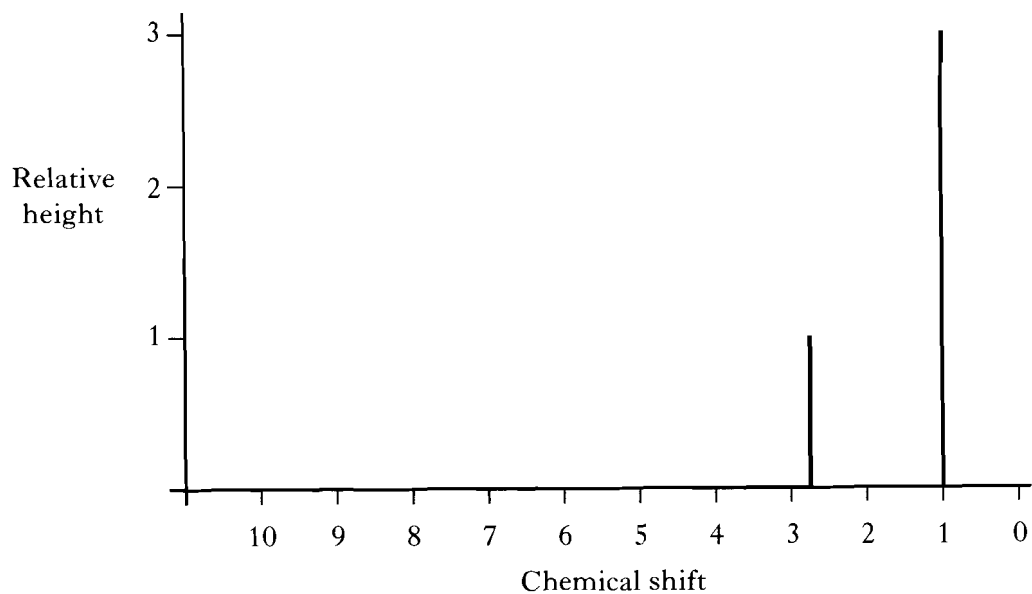
Use the data booklet to find the range in the chemical shift values for hydrogen atoms in the following environment:

1
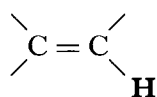
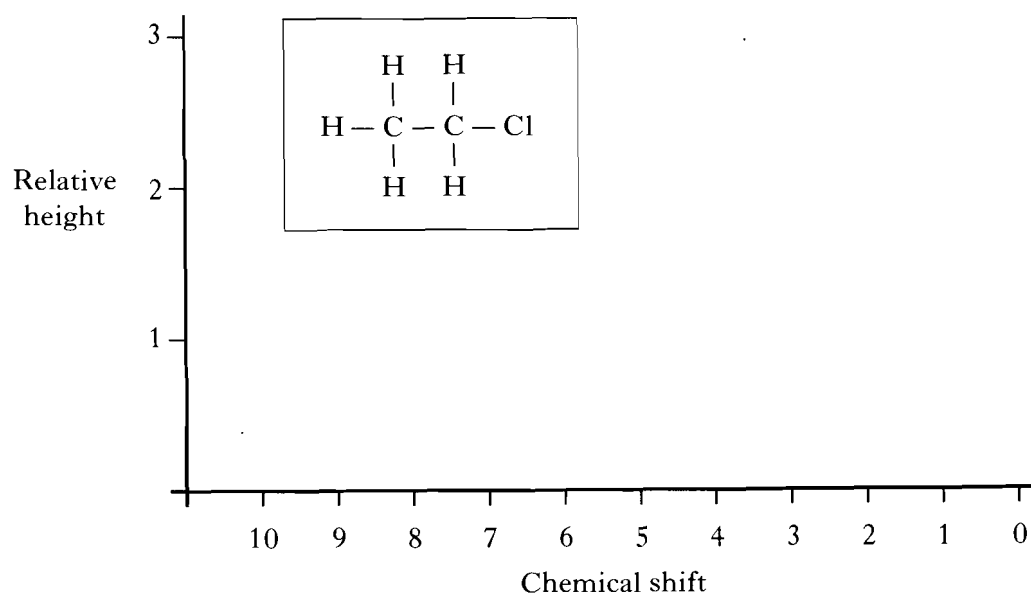**17.** **(continued)**

(*b*)   A carbon compound has the following spectrum.

Name this compound.

1

(*c*)   Draw the spectrum that would be obtained for chloroethane.

1

(3)

[END OF QUESTION PAPER]