0500/201

CHEMISTRY
HIGHER GRADE
Paper I

Check that the answer sheet provided is for Chemistry Higher I.

Fill in the details required on the answer sheet.

Reference may be made to the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 edition).

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

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

In questions 1 to 40 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.

For each question there is only ONE correct answer.

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:
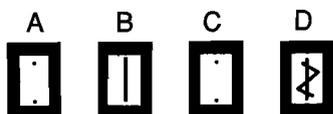
    A   B   C   D

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:

    A   B   C   D   A   B   C   D   **OR**

1. Solutions of barium chloride and silver nitrate are mixed together.

   The reaction that takes place is an example of

   A neutralisation

   B precipitation

   C dehydration

   D oxidation.

2. The following oxides are added to water.

   A Carbon dioxide

   B Copper(II) oxide

   C Sulphur dioxide

   D Sodium oxide

   Which forms a solution with pH greater than 7?

3. What is the relative formula mass for calcium nitrate?

   A 82

   B 102

   C 142

   D 164

4. A hydrocarbon contains 88·9% carbon and 11·1% hydrogen.

   Which structural formula could represent the hydrocarbon?

   A
   $$\begin{array}{c} H \quad\quad H \\ \backslash \quad\quad / \\ C = C \\ | \quad | \\ C = C \\ / \quad\quad \backslash \\ H \quad\quad H \end{array}$$

   B
   $$\begin{array}{c} H \quad H \\ | \quad | \\ H - C - C - H \\ | \quad | \\ H - C - C - H \\ | \quad | \\ H \quad H \end{array}$$

   C
   $$\begin{array}{c} H \quad H \\ | \quad | \\ H - C = C - C - C - H \\ | \quad | \quad | \quad | \\ H \quad H \quad H \quad H \end{array}$$

   D
   $$\begin{array}{c} H \quad\quad H \\ \backslash \quad\quad / \\ C = C \\ | \quad | \\ H - C - C - H \\ | \quad | \\ H \quad H \end{array}$$
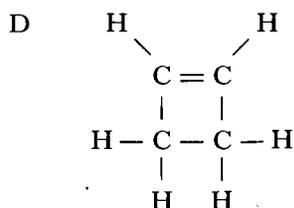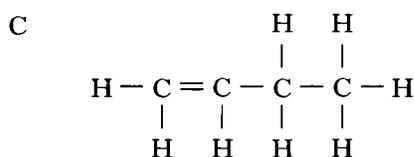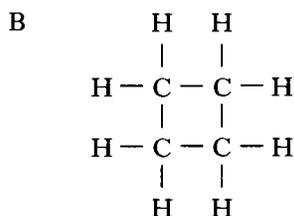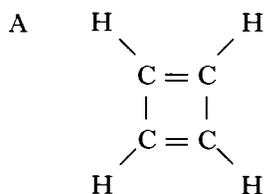
5. The same reaction was carried out at four different temperatures. The table shows the times taken for the reaction to occur.

Temperature/°C	20	30	40	50
Time/s	60	30	14	5

   The results show that

   A a small rise in temperature results in a large increase in reaction rate

   B the activation energy increases with increasing temperature

   C the rate of the reaction is directly proportional to the temperature

   D the reaction is endothermic.

6. The potential energy diagram below refers to the reversible reaction involving reactants **R** and products **P**.

Reaction pathway
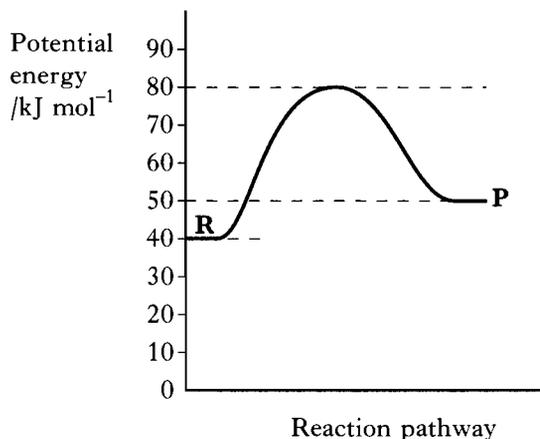
What is the enthalpy change, in $kJ\ mol^{-1}$, for the reverse reaction $P \rightarrow R$?

A $+30$

B $+10$

C -10

D -40

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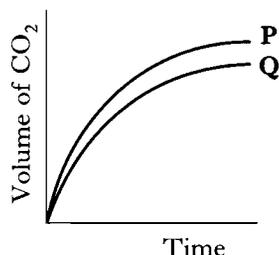
The change from **P** to **Q** could be brought about by

A increasing the concentration of the acid

B decreasing the mass of copper carbonate

C decreasing the particle size of the copper carbonate

D adding a catalyst.

8. Synthesis gas consists mainly of

A CH_4 alone

B CH_4 and CO

C CO and H_2

D CH_4, CO and H_2.

9. Which hydrocarbon is most likely to be found in petrol?

A CH_4

B C_3H_8

C C_8H_{18}

D $C_{14}H_{30}$

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

A 2-methylbutanal

B 3-methylpentan-2-one

C 2, 2-dimethylbutan-1-ol

D 3-ethylpentanal

11. Which equation represents an addition reaction?

A $CH_3OH + O_2 \rightarrow HCOOH + H_2O$

B $CH_3CH_2OH \rightarrow CH_2CH_2 + H_2O$

C $CH_2CH_2 + H_2O \rightarrow CH_3CH_2OH$

D $CH_3CH_3 \rightarrow CH_2CH_2 + H_2$

12. Which process is used industrially to produce aromatic hydrocarbons?

A Reforming of naphtha

B Catalytic cracking of propane

C Steam reforming of coal

D Hydrocracking of heavy oil fractions

13. 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 $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

14. How many moles of oxygen atoms are in 0·5 mol of carbon dioxide?

A 0·25

B 0·5

C 1

D 2

15. Iodide ions can be oxidised using acidified potassium permanganate solution.

The equations are:

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

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$$
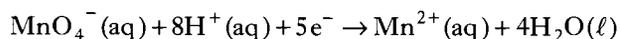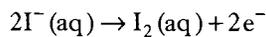
How many moles of iodide ions are oxidised by one mole of permanganate ions?

A 1·0

B 2·0

C 2·5

D 5·0

16. A new form of carbon has been discovered. It consists of a football-shaped molecule consisting of 60 carbon atoms.

Approximately how many such molecules are present in 12 g of this type of carbon?

A $1·0 \times 10^{22}$

B $1·2 \times 10^{23}$

C $6·0 \times 10^{23}$

D $3·6 \times 10^{25}$

17. In which reaction would the products have a lower volume than the reactants?

A $2C(s) + O_2(g) \rightarrow 2CO(g)$

B $C(s) + O_2(g) \rightarrow CO_2(g)$

C $CaCO_3(s) + 2HCl(aq)$
$\rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$

D $Ca(OH)_2(aq) + 2CO_2(g)$
$\rightarrow Ca(HCO_3)_2(aq)$

18. Which of the following is an ester?

A

B

C

D
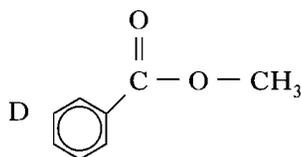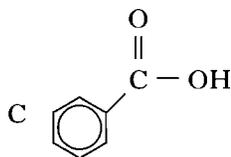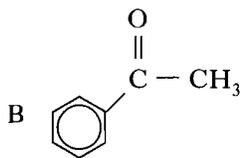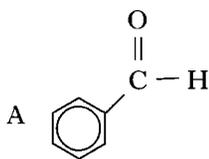
19. What is the structural formula for glycerol?

A CH₂OH
   |
   CH₂
   |
   CH₂OH

B CH₂OH
   |
   CH₂OH

C CH₂OH
   |
   CHOH
   |
   CH₂COOH

D CH₂OH
   |
   CHOH
   |
   CH₂OH
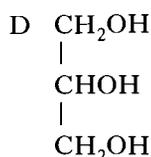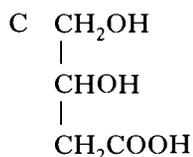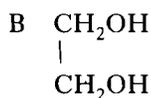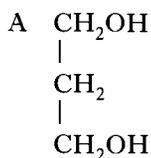
[Turn over

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

A Condensation

B Hydration

C Hydrogenation

D Polymerisation

21. Some amino acids are called α-amino acids because the amino group is on the carbon atom next to the acid group.

Which of the following is an α-amino acid?

A $CH_3 - CH - COOH$
        $|$
        $CH_2 - NH_2$

B $CH_2 - CH - COOH$
    $|$ $|$
    SH NH_2

C
NH_2

$COOH$

D
NH_2

$COOH$
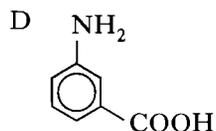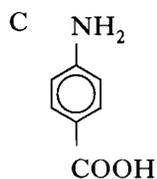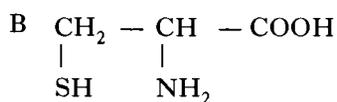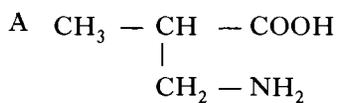
22. The rate of hydrolysis of a protein, using an enzyme, was studied at different temperatures.

Which graph could be obtained?

A

Reaction rate

0   40   80
Temperature/°C

B

Reaction rate

0   40   80
Temperature/°C

C

Reaction rate

0   40   80
Temperature/°C

D

Reaction rate

0   40   80
Temperature/°C
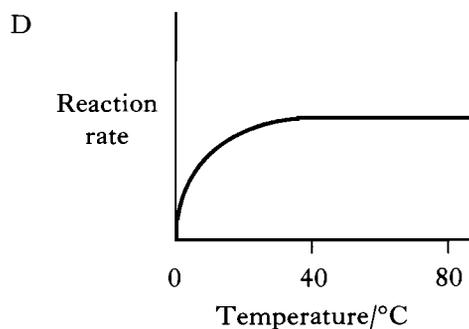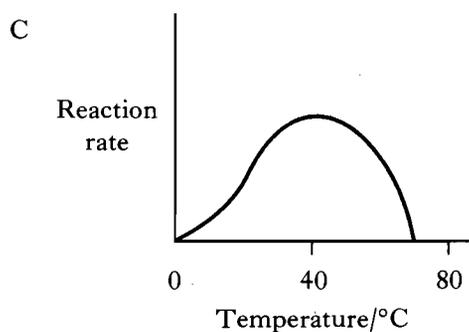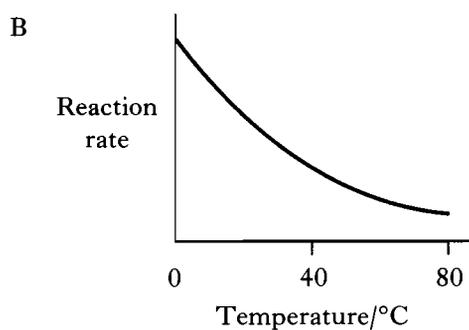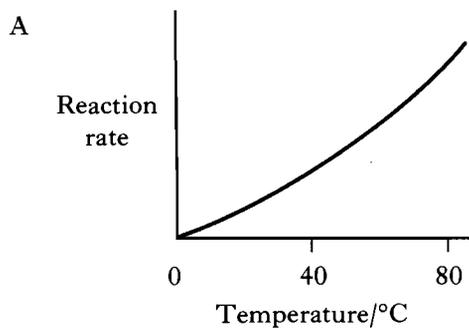
23. Which of the following occurs when crude oil is distilled?

A Covalent bonds break and form again.

B Covalent bonds break and van der Waals' bonds form.

C Van der Waals' bonds break and covalent bonds form.

D Van der Waals' bonds break and form again.

24. Which equation represents the first ionisation energy of chlorine?

A $Cl(g) + e^- \rightarrow Cl^-(g)$

B $Cl(g) \rightarrow Cl^+(g) + e^-$

C $Cl^-(g) \rightarrow Cl(g) + e^-$

D $Cl^+(g) + e^- \rightarrow Cl(g)$

25. Which compound contains hydride ions?

A NH_3

B HCl

C H_2S

D CaH_2

26. Which reaction **cannot** be described as an enthalpy of formation?

A $Si(s) + 4Cl(g) \rightarrow SiCl_4(\ell)$

B $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s)$

C $C(s) + 2H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(\ell)$

D $2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$

27. Silicon carbide can be used as

A a lubricant

B a tip for cutting/grinding tools

C a substitute for pencil "lead"

D an electrical conductor.

28. Which chloride is most likely to be soluble in tetrachloromethane, CCl_4?

A Barium chloride

B Caesium chloride

C Calcium chloride

D Phosphorus chloride

29. Which of the following shows the types of bonding in **decreasing** order of strength?

A Covalent : hydrogen : van der Waals'

B Covalent : van der Waals' : hydrogen

C Hydrogen : covalent : van der Waals'

D Van der Waals' : hydrogen : covalent

30. Which equation represents an exothermic process?

A $Cl_2(g) \rightarrow 2Cl(g)$

B $Na(s) \rightarrow Na(g)$

C $Na(s) \rightarrow Na^+(g) + e^-$

D $Na^+(g) + Cl^-(g) \rightarrow Na^+Cl^-(s)$

31. When $3 \cdot 6\,g$ of butanal (relative formula mass = 72) was burned, $134\,kJ$ of energy was released.

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

A $-6 \cdot 7$

B $+6 \cdot 7$

C -2680

D $+2680$

32. The enthalpies of formation of cyclohexene and cyclohexane are -3 and $-123\,kJ\,mol^{-1}$, respectively.

What is the enthalpy of hydrogenation of cyclohexene to cyclohexane, in $kJ\,mol^{-1}$?

A $+126$

B $+120$

C -120

D -126

33. The mean bond enthalpy of the $N-H$ bond is equal to one third of the value of ΔH for which change?

A $N(g) + 3H(g) \rightarrow NH_3(g)$

B $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

C $\frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g) \rightarrow NH_3(g)$

D $2NH_3(g) + 1\frac{1}{2}O_2(g) \rightarrow N_2(g) + 3H_2O(g)$

[Turn over

34. 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

35. 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 $0·1$ mol l^{-1}

B between $0·1$ and $0·01$ mol l^{-1}

C between $0·01$ and $0·001$ mol l^{-1}

D less than $0·001$ mol l^{-1}.

36. Ethanoic acid is referred to as a weak acid because in water

A there is partial ionisation of the $O - H$ bonds

B it has a pH of about 4

C it is not very soluble

D it produces only one $H^+(aq)$ ion per molecule.

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

It could be

A ethanoic acid

B sodium chloride

C sodium hydroxide

D nitric acid.

38. Which of the following has an electrical charge?

A α-particles

B X-rays

C Neutrons

D γ-rays

39. Which of the following needs to be known to calculate the relative atomic mass of an element?

A The number of protons and the number of neutrons in each isotope

B The identities of the isotopes present and their relative abundance

C The number of neutrons in each isotope

D The number of protons, neutrons and electrons in each isotope

40. $_1^2H + _1^3H \rightarrow _2^4He + _0^1n$

The above process represents

A nuclear fission

B nuclear fusion

C proton capture

D beta emission.

PART 2

In questions 41 to 48 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 20 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
Ⓓ	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.

Ⓐ	B	C
D	Ⓔ	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	Ⓒ
D	E	Ⓕ

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:

Ⓐ	B	C
D̸	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:

A̸	B	C
✓D̸	E	F

41. There are many different families of organic compounds.

A	B	C
$CH_3 - CH_2 - CH_2 - C{\overset{\displaystyle O}{\underset{\displaystyle H}{\Big\langle}}}$	$CH_3 - CH_2 - \overset{\displaystyle O}{\overset{\displaystyle \|}{C}} - CH_3$	$CH_3 - CH_2 - O - \overset{\displaystyle O}{\overset{\displaystyle \|}{C}} - CH_3$

D	E	F
$CH_3 - CH_2 - CH_2 - CH_2 - OH$	$CH_3 - CH_2 - CH_2 - C{\overset{\displaystyle O}{\underset{\displaystyle OH}{\Big\langle}}}$	$CH_3 - CH_2 - O - CH_2 - CH_3$

(a) Identify the aldehyde.

(b) Identify the compound which could be formed by the hydration of but-1-ene.

(c) Identify the compound which could be reduced to give the compound shown in box **A**.

42. The grid shows statements which can be applied to different substances in the solid state.

A	It conducts electricity.
B	It is soluble in water.
C	It has covalent bonding.
D	It has a network structure.
E	It has hydrogen bonding.
F	Van der Waals' forces exist.

(a) Identify the statement which can be applied to argon.

(b) Identify the statement which can be applied to silicon dioxide **but** not carbon dioxide.

(c) Identify the statement which can be applied to hydrogen fluoride but **not** hydrogen chloride.

43. Many different compounds are associated with foods.

A		B		C	
glucose, a carbohydrate		glycerol, an alcohol		starch, a carbohydrate	
D		E		F	
glycine, an amino acid		oleic acid, a fatty acid		glyceryl tristearate, a fat	

(*a*) Identify the polymer.

(*b*) Identify the compound which could be formed by the hydrolysis of a protein.

(*c*) Identify the **two** compounds which could be formed by the hydrolysis of an oil.

44. The relative volumes of hydrogen produced in a given time for three reactions are plotted on the graph.
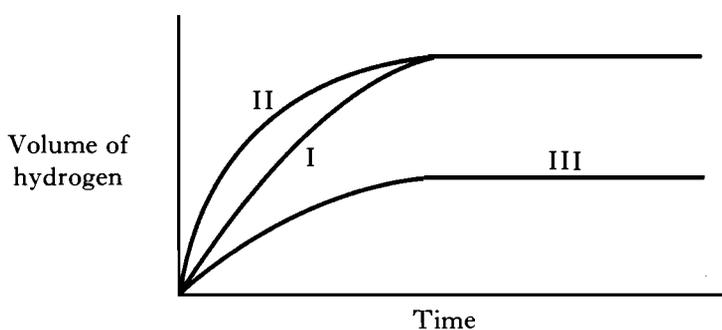
Curve I is for the reaction of excess zinc powder with $100\,cm^3$ of $0 \cdot 1$ $mol\,l^{-1}$ hydrochloric acid.

A		B		C	
excess magnesium powder		$50\,cm^3$ of $0 \cdot 1$ $mol\,l^{-1}$ hydrochloric acid		$50\,cm^3$ of $0 \cdot 2$ $mol\,l^{-1}$ sulphuric acid	
D		E		F	
excess iron powder		$200\,cm^3$ of $0 \cdot 1$ $mol\,l^{-1}$ hydrochloric acid		$100\,cm^3$ of $0 \cdot 05$ $mol\,l^{-1}$ sulphuric acid	

(*a*) Identify the **two** chemicals which would react to give the results plotted in curve II.

(*b*) Identify the **two** chemicals which would react to give the results plotted in curve III.

[Turn over

45. There are many different types of reactions.

A	addition	B	condensation	C	dehydration
D	hydrogenation	E	hydrolysis	F	polymerisation

Poly(ethenol) is a recently developed plastic which is soluble in water.

It is made by the reactions shown.

poly(ethenol)

(a) Identify the type of reaction taking place at Step 2.

(b) Identify the term(s) which can be applied to the reaction taking place at Step 1.

46. Identify the enthalpy change(s) which can be measured **directly** by a classroom experiment.

A	enthalpy of combustion of methanol
B	bond enthalpy of the $C - H$ bond in $CH_4(g)$
C	enthalpy of solution of potassium hydroxide
D	enthalpy of formation of propane
E	lattice enthalpy of sodium chloride
F	electron gain enthalpy of bromine

47. The following radioactive decay series occurs in nuclear reactors.

$$^{241}_{94}Pu \xrightarrow{\beta} Q \longrightarrow R \xrightarrow{\alpha} {}^{233}_{91}Pa$$

Identify the true statement(s).

A	**Q** has a lower atomic number than $^{233}_{91}Pa$.
B	**Q** has a lower mass number than $^{233}_{91}Pa$.
C	$^{241}_{94}Pu$ and **Q** are isotopes of the same element.
D	**Q** is an alpha emitter.
E	When **R** decays to give $^{233}_{91}Pa$, a positive particle is absorbed.
F	When $^{241}_{94}Pu$ decays to give **Q**, a negative particle is emitted.

48. The value of the Avogadro Constant, symbol L, is $6 \cdot 02 \times 10^{23}$ mol^{-1}.

Identify the true statement(s).

A	2 g of helium contains L electrons.
B	18 g of ammonia contains L molecules.
C	2 g of hydrogen contains L atoms.
D	10 g of neon contains L protons.
E	24 g of magnesium contains L neutrons.
F	50 g of calcium carbonate contains L ions.

[END OF QUESTION PAPER]

Presenting Centre No.	Subject No. 0500	Grade H	Paper No. 2	Group No.	Marker's No.

Total

0500/202

SCOTTISH
CERTIFICATE OF
EDUCATION
1999

MONDAY, 17 MAY
9.00 AM – 11.30 AM

CHEMISTRY
HIGHER GRADE
Paper II

Fill in these boxes and read what is printed below.

Full name of school or college

Town

First name and initials

Surname

Date of birth

Day Month Year   Candidate number   Number of seat

All questions should be attempted.

Necessary data will be found in the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 Edition) which is provided.

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

Rough work, if any should be necessary, as well as the fair copy, is to be written in this book.

Rough work should be scored through when the fair copy has been written.

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 booklet.

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.

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

SCOTTISH
QUALIFICATIONS
AUTHORITY

1. Many granite rocks contain radioactive elements which decay to release radon gas. The gas is an alpha-emitter with a half-life of 55 s and contributes to background radiation.

    (*a*) Give another source of background radiation.

    1

    (*b*) Write a balanced nuclear equation for the alpha-decay of radon-220.

    1

    (*c*) A sample of radon had a count rate of 80 counts min^{-1}.
    How long would it take for the count rate to fall to 5 counts min^{-1}?

    1

    (*d*) What effect would a temperature rise of 20 °C have on the half-life of radon-220?

    1

    (4)

2. Esters are a widely used class of organic compounds.

(*a*) Draw a labelled diagram to show how to prepare an ester from an alkanol and an alkanoic acid.

1

(*b*) State any safety precaution that would be taken (apart from wearing eye protection) and give a reason for it.

1

(*c*) Give a use for an ester.

1

(*d*) Draw a structural formula for the ester produced in the reaction between methanol and ethanoic acid.

1

(4)

[Turn over

3. (*a*) Two reactions involving a carbon compound, **A**, are shown.

A

$$CH_3 - CH - CH_2 - CH_3$$
$$|$$
$$OH$$

$H^+(aq)/Cr_2O_7^{2-}(aq)$

Reaction 1

Reaction 2

B

C_4H_8O

$$CH_2 = CH - CH_2 - CH_3$$
but-1-ene

$$CH_3 - CH = CH - CH_3$$
but-2-ene
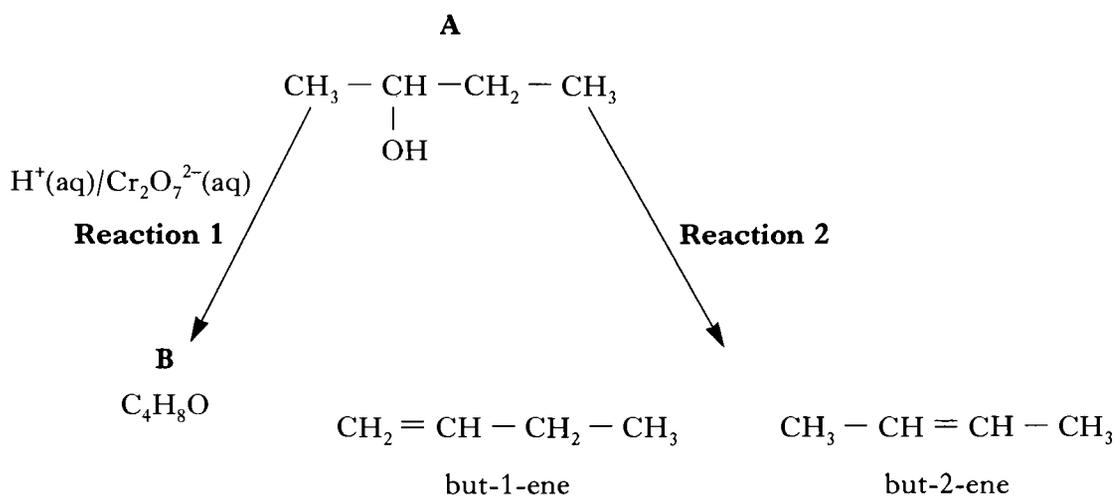
(i) Name compound **A**.

1

(ii) Draw a structural formula for compound **B**.

1

(iii) Name a substance used to convert compound **A** into but-1-ene and but-2-ene.

1

(*b*) Both but-1-ene and but-2-ene form addition polymers.
Draw a structural formula for an isomer of but-1-ene and but-2-ene which can also form an addition polymer.

1

(4)

4. When hydrochloric acid is added to a solution of sodium thiosulphate the following reaction takes place.

$$2HCl(aq) \; + \; Na_2S_2O_3(aq) \longrightarrow 2NaCl(aq) \; + \; SO_2(g) \; + \; S(s) \; + \; H_2O(\ell)$$

Solid sulphur forms in the solution.

In one set of experiments the effect of varying the concentration of sodium thiosulphate was studied. Some of the volumes of solutions used are shown.

Volume of $0.05 \, mol \, l^{-1}$ $Na_2S_2O_3(aq)/cm^3$	Volume of water/cm^3	Volume of $0.1 \, mol \, l^{-1}$ $HCl(aq)/cm^3$	Reaction time/s
200	0	5	20
160			25
120			33
80			50
40			100

(a) Complete the table to show the volumes of water and acid that would have been used.

1

(b) Describe how the reaction time could have been measured.

1

(c) Describe how the relative rate of reaction would be obtained from each of the results.

1

(3)

5. (a) Graph 1 shows the distribution of kinetic energies of molecules in a gas at 30 °C.

Graph 1

Number of
molecules
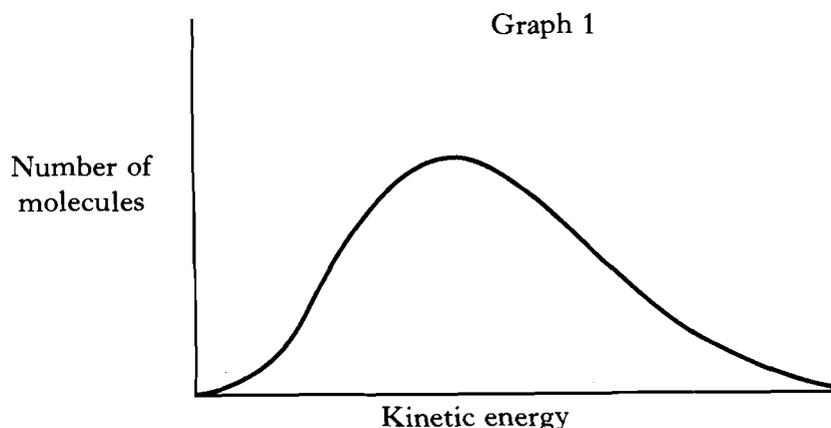
Kinetic energy

Add a dotted line to Graph 1 to show the distribution of kinetic energies at 20 °C.

1

(b) In Graph 2, the shaded area represents the number of molecules with the required energy of activation, E_A, for reaction to occur.

Graph 2

Number of
molecules

Kinetic energy E_A
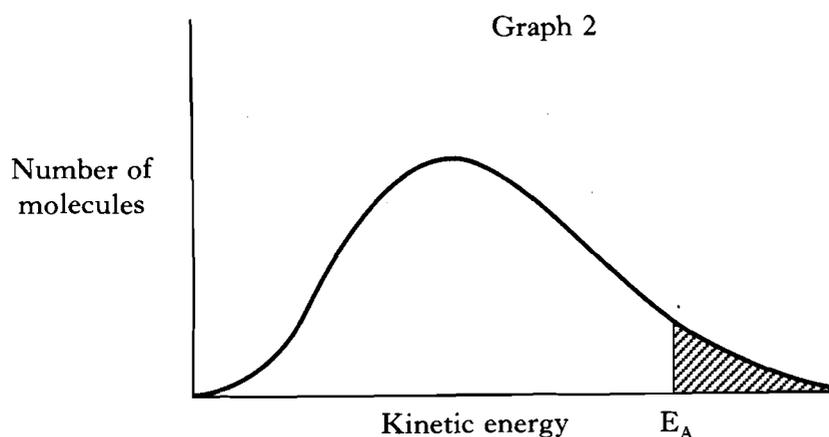
Draw a line to show how a catalyst affects the energy of activation.

1

(c) A collision involving molecules with the required energy of activation may **not** result in reaction.

State a reason for this.

1

(3)

6. There are many different enzymes in the human body.

(*a*) Which **four** elements do all enzymes contain?

1

(*b*) Salivary amylase is an enzyme which can convert starch into maltose. The pH of saliva is about 7, which is close to the optimum pH for that enzyme. Amylase stops functioning when it enters the stomach where the pH is about 2.

What happens to the enzyme, on entering the stomach, that would cause it to stop functioning?

1

(*c*) Many enzymes are specific and can catalyse only one reaction. For example, salivary amylase can catalyse the hydrolysis of starch to maltose, but cannot catalyse the hydrolysis of proteins to amino acids.

Give a reason for this.

1

(3)

[Turn over

7. Air bags in cars are intended to prevent injuries in a car crash. They contain sodium azide, NaN_3, which produces nitrogen if an impact is detected.

The reaction which generates nitrogen is:

$$2NaN_3(s) \longrightarrow 3N_2(g) + 2Na(s)$$
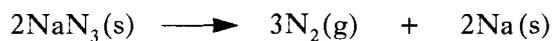
(a) Other chemicals are present in air bags. These chemicals take part in further reactions.

Suggest why these reactions are necessary.

1

(b) Calculate the mass of sodium azide required to produce 75 litres of nitrogen.
(Take the molar volume to be 24 litre mol^{-1}.)
(Show your working clearly.)

2

7. (continued)

(c) In order to provide protection, the gas must be generated very rapidly. The graph shows how the volume of nitrogen produced changes over a period of time.
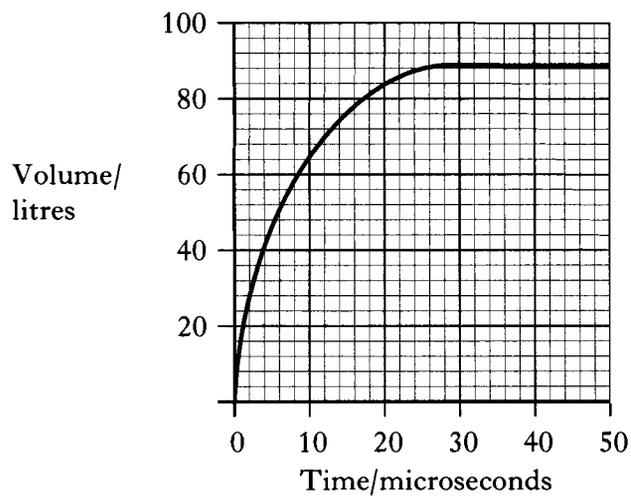
Calculate the average rate of nitrogen production, in litres per microsecond, over the first 20 microseconds.

8. Experiments were carried out with 0·1 mol l⁻¹ hydrochloric acid and with 0·1 mol l⁻¹ ethanoic acid. Some of the results are shown in the following table.

Experiment	$0·1 \text{ mol l}^{-1}$ hydrochloric acid	$0·1 \text{ mol l}^{-1}$ ethanoic acid
Rate of reaction with magnesium		
pH	very low	low
Conductivity		
Volume of $0·1 \text{ mol l}^{-1}$ sodium hydroxide to neutralise 20 cm^3 acid	20 cm^3	20 cm^3

(a) Complete the table to show a comparison of all the test results.   1

(b) The concentration of hydrogen ions in 0·1 mol l⁻¹ ethanoic acid is much less than in 0·1 mol l⁻¹ hydrochloric acid.

Explain why the same volume of 0·1 mol l⁻¹ sodium hydroxide is required for neutralisation in each case.

2

(3)

9. Cyanogen gas, $C_2N_2(g)$, is a compound of carbon and nitrogen.

(a) Draw a possible full structural formula for the cyanogen molecule.

1

(b) Cyanogen burns in excess oxygen to form carbon dioxide and nitrogen.

$$C_2N_2(g) \quad + \quad 2O_2(g) \longrightarrow 2CO_2(g) \quad + \quad N_2(g)$$
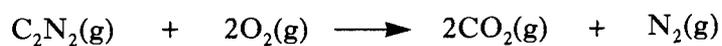
(i) Calculate the volume and composition of the resulting gas mixture when $20\,cm^3$ of cyanogen is burned completely in $80\,cm^3$ of oxygen.

1

(ii) The resulting gas mixture is shaken with sodium hydroxide solution. What volume of gas remains?

1

(3)

[Turn over

Marks

10. Kevlar is a strong, low density, linear polymer.

Part of the molecular structure is shown.
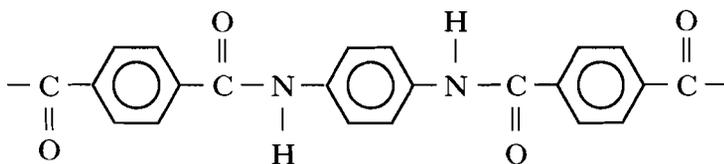
(a) What kind of polymerisation takes place in the formation of Kevlar?

1

(b) (i) One of the monomers used to make Kevlar is shown.
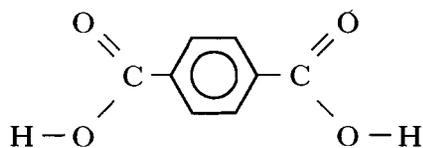
Write the molecular formula for this monomer.

1

(ii) Draw a structural formula for the other monomer.

1

10. (continued)

(c) Kevlar is strong because of the intermolecular bonding between neighbouring polymer chains.
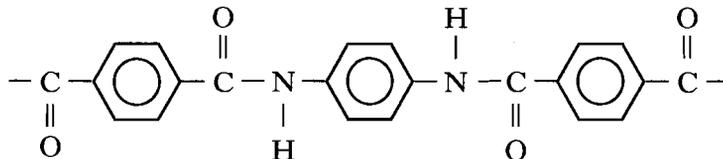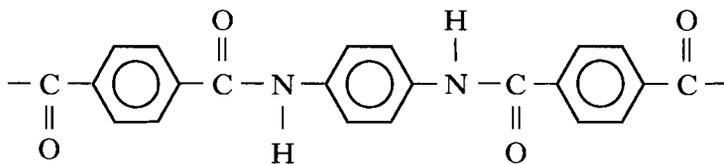
Name the type of bond involved **and** draw a dotted line to show the position of one such bond between the above chains.

1

(4)

[Turn over

11. The steel structures of oil rigs can be sacrificially protected from corrosion by attaching aluminium blocks to them.

(a) Name another metal which could be used to protect the steel in the same way.

1

(b) During sacrificial corrosion, aluminium reacts as shown by the following equation.

$$Al(s) \rightarrow Al^{3+}(aq) + 3e^-$$
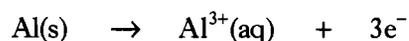
If the average current flowing from the aluminium to the oil rig is 1·05 A, calculate the mass of aluminium which would be lost from each block over a period of twenty five years.

(Show your working clearly.)

3

(4)

12. Various fuels are used to power modern vehicles.

(*a*) Most cars run on petrol.

(i) Unleaded petrol must be used if a car is fitted with a catalytic converter.

Why is this necessary?

1

(ii) Different blends are made for different times of year.

Suggest why the winter blend contains more hydrocarbons of low relative formula mass.

1

(*b*) Diesel engines produce less nitrogen dioxide than petrol engines.

Give a reason for this.

1

(*c*) Some vehicles are designed to run on liquefied petroleum gas (LPG).

What are the **two** main components of LPG?

1

(4)

[Turn over

13. The elements lithium to neon make up the second period of the Periodic Table.

(a) Which **two** elements in the period exist as covalent networks?

1

(b) Explain the trend in covalent radius in crossing the period from left to right.

2

(c) Write the equation corresponding to the enthalpy of electron gain for fluorine.

1

Marks

13. (continued)

(*d*) A chemist attempted to make lithium hydride directly by bubbling hydrogen
through liquid lithium. Part of the apparatus used is shown.

hydrochloric acid

hydrochloric
acid + zinc

calcium oxide
lumps

excess
hydrogen
removed by
burning
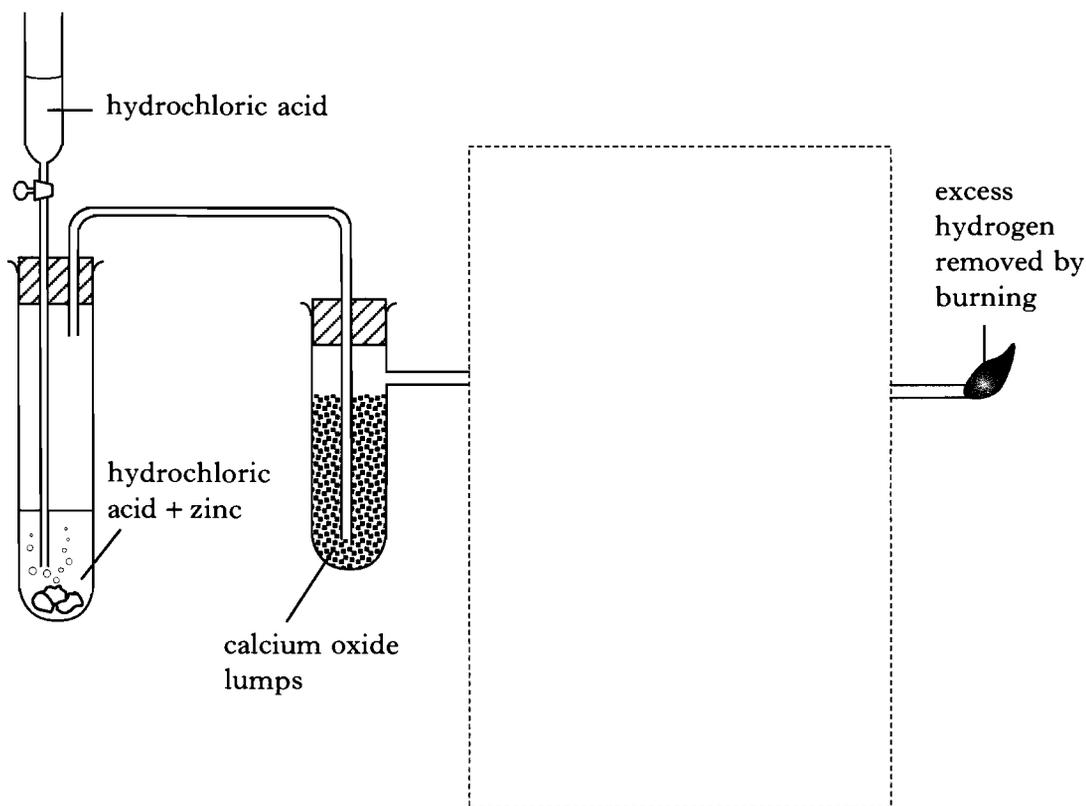
(i) What is the purpose of the calcium oxide?

1

(ii) Using suitable labels, complete the diagram within the dotted area to
show how the reaction could be carried out.

1

(6)

[Turn over

14. Iodine dissolves only slightly in water, the process being endothermic. With excess iodine present, the following equilibrium is set up.

$$I_2(s) \quad + \quad aq \quad \rightleftharpoons \quad I_2(aq) \quad \Delta H \text{ positive}$$

The concentration of dissolved iodine was measured over a period of time.
The graph below was obtained as the iodine dissolved.
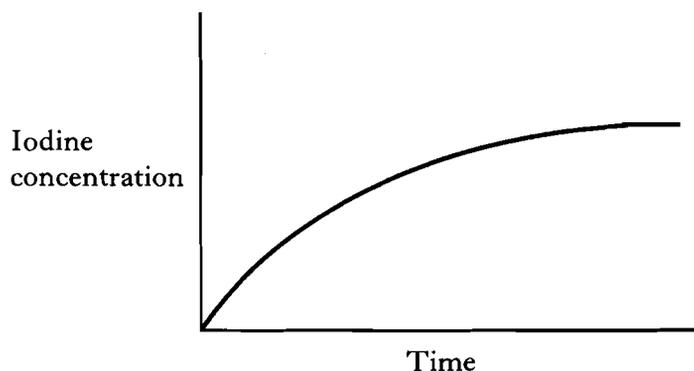
(*a*) Add a curve to show how the iodine concentration would change with time if the measurements were repeated at a higher temperature.

1

(*b*) The dissolved iodine reacts with water as follows.

$$I_2(aq) \quad + \quad H_2O\,(\ell) \quad \rightleftharpoons \quad 2H^+(aq) \quad + \quad I^-(aq) \quad + \quad IO^-(aq)$$

(i) Complete the table to show the effect on the equilibrium of adding each of the solids.

Solid	Effect on equilibrium position
potassium iodide	
potassium sulphate	

2

(ii) Why does the position of equilibrium move to the right when solid potassium hydroxide is added?

Marks

15. Phosphoric acid is an important chemical with many applications in industry.

Some phosphoric acid is converted to sodium phosphate. This forms an alkaline solution in water and is used as a cleaning agent.

(*a*) Write the formula for phosphoric acid.

1

(*b*) Explain fully why solutions of sodium phosphate are alkaline.

2

(*c*) Calculate the concentration of hydroxide ions, in $mol\,l^{-1}$, in a sodium phosphate solution of pH 11.

1

(4)

[Turn over

Page nineteen

16. Pentlandite is an important source of nickel. Part of the extraction process is shown in the following flow diagram.

```
            ┌──────────────────────┐
            │  nickel sulphide and  │
            │    copper sulphide    │
            └──────────────────────┘
                      │
                      ▼
   O₂ ───────▶ ┌──────────────┐ ───────▶  gas X
               │  Process A   │
               └──────────────┘
                      │
                      ▼
            ┌──────────────────────┐
            │   nickel oxide and    │
            │     copper oxide      │
            └──────────────────────┘
                      │
                      ▼
 CO at ─────▶ ┌──────────────┐ ───────▶  gas Y
 350 °C       │  Process B   │
              └──────────────┘
                      │
                      ▼
            ┌──────────────────────┐
            │   nickel and copper   │
            └──────────────────────┘
                      │
                      ▼
 CO at ─────▶ ┌──────────┐ ──▶ ┌──────────────┐ ──▶ ┌──────────────┐ ──▶  CO
 60 °C        │ Process C │     │ nickel carbonyl,│   │  Process D   │
              └──────────┘     │   Ni(CO)₄       │   │ Heat to 180 °C│
                   │            │   bp 43 °C      │   └──────────────┘
                   ▼            └──────────────┘          │
            ┌──────────┐                                  ▼
            │  copper   │                          ┌──────────────┐
            └──────────┘                          │    nickel     │
                                                  └──────────────┘
```
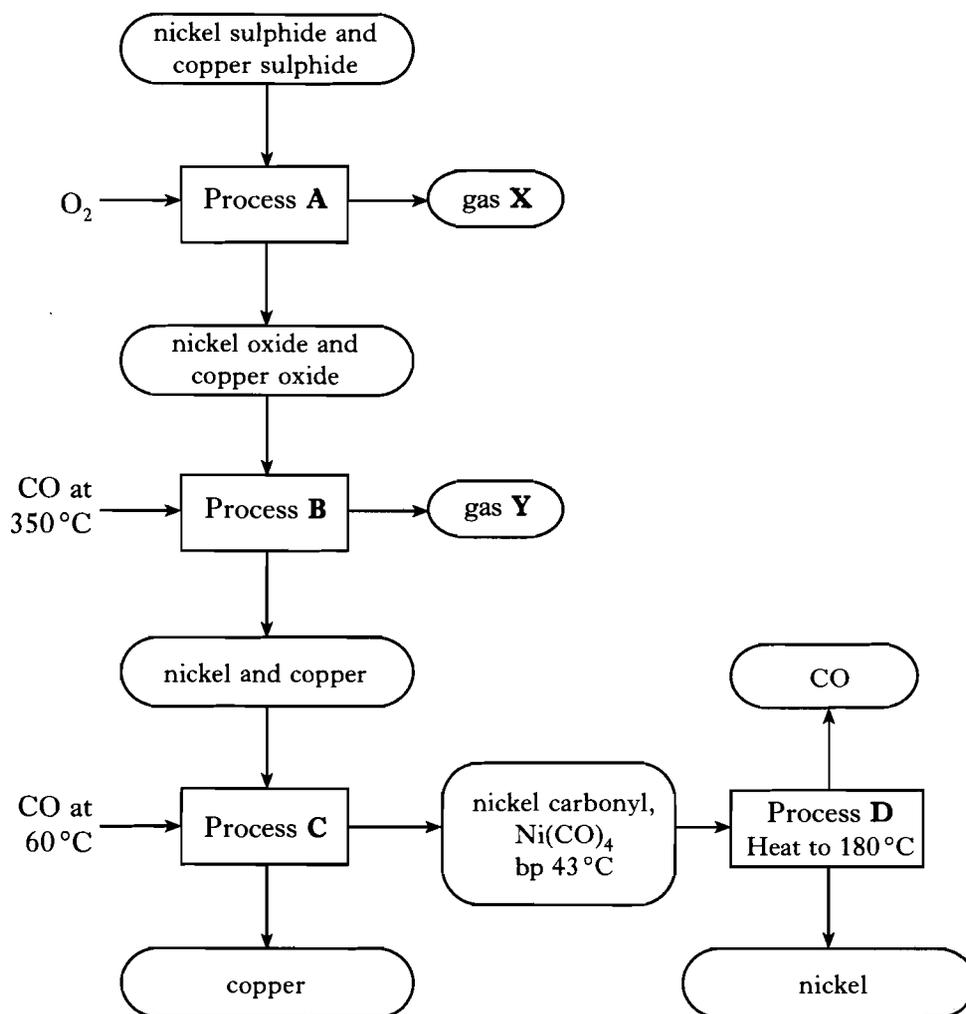
(a) (i) Name gas **X**.

1

(ii) Name gas **Y**.

1

16. (continued)

(b) Write a balanced equation for the reaction taking place in Process **C**.

1

(c) State the kind of bonding in Ni(CO)$_4$.

1

(d) Nickel carbonyl forms as a product in Process **C** but **not** in Process **B**. Give a reason for this.

1

(5)

[Turn over

17. Hess's Law states that: "The total enthalpy change of a chemical reaction is independent of the intermediate steps between reactants and products."

It can be verified using the enthalpy changes for the reaction between sodium hydroxide and hydrochloric acid.

Reaction 1 $NaOH(s) \ + \ aq \ \longrightarrow \ NaOH(aq)$

Reaction 2 $NaOH(aq) \ + \ HCl(aq) \ \longrightarrow \ NaCl(aq) \ + \ H_2O(\ell)$
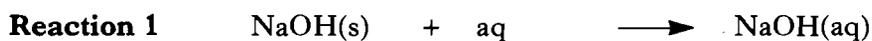
(a) Write an equation for a third reaction which, when taken with the above two, could be used to verify Hess's Law.

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

(b) A pupil carried out Reaction 2 by adding $50\,cm^3$ NaOH(aq) to $50\,cm^3$ HCl(aq). Each solution had a concentration of $2\cdot0\,mol\,l^{-1}$. The temperature rise was $13\cdot5\,°C$.

   (i) What measurements would the pupil have to make to obtain the temperature rise?

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

   (ii) Use the results for Reaction 2 to calculate the enthalpy of neutralisation.

<div align="right">2</div>

17. (continued)

    (*c*) The enthalpy changes involved in Reaction 1 can be shown by the following diagram which is not drawn to scale.

$$Na^+(g) \quad + \quad OH^-(g)$$

A
$+ 805 \cdot 5 \text{ kJ}$

hydration
enthalpy
$- 850 \text{ kJ}$

$NaOH(s)$

$$Na^+(aq) \quad + \quad OH^-(aq)$$
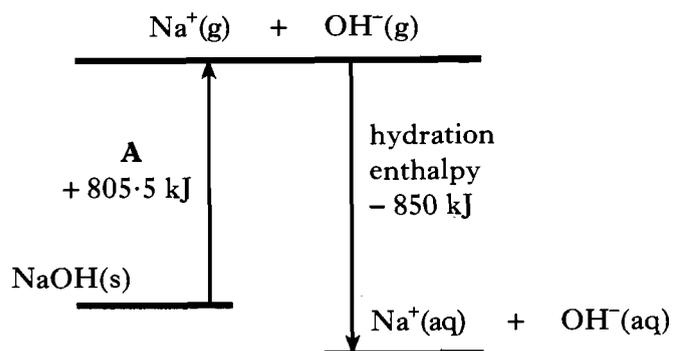
    (i) Name the enthalpy change involved in process **A**.

1

    (ii) Calculate the enthalpy of solution of NaOH(s), in kJ mol^{-1}.

1

(6)

[Turn over

18. Germanium forms a series of hydrides with general formula Ge_nH_{2n+2}.

(a) Draw a diagram to show the **shape** of the germane molecule, GeH_4.

<div align="right">

Marks

1

</div>

(b) The formation of germane can be represented by the following reaction.

$$Ge(s) \quad + \quad 2H_2(g) \quad \rightarrow \quad GeH_4(g)$$
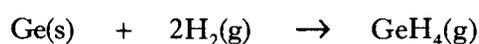
Calculate the enthalpy of formation of germane given the following information.

The enthalpy of sublimation of germanium is 376 kJ mol^{-1}.

The mean $Ge-H$ bond enthalpy is 285 kJ mol^{-1}.

You will also require information given on page 11 of the data booklet.

(Show your working clearly.)

<div align="right">

3

</div>

(c) All of the germanium hydrides burn to form an oxide of germanium (GeO_2) and water.

Write an equation to represent the enthalpy of combustion for the second member of the homologous series.

<div align="right">

1

(5)

</div>

19. Triglycerides are important in our diet. Three are shown below.

$CH_3(CH_2)_{10}COOCH_2$ $CH_3(CH_2)_{14}COOCH_2$ $CH_3(CH_2)_7CH = CH(CH_2)_{11}COOCH_2$

$CH_3(CH_2)_{10}COOCH$ $CH_3(CH_2)_{14}COOCH$ $CH_3(CH_2)_7CH = CH(CH_2)_{11}COOCH$

$CH_3(CH_2)_{10}COOCH_2$ $CH_3(CH_2)_{14}COOCH_2$ $CH_3(CH_2)_7CH = CH(CH_2)_{11}COOCH_2$

   glyceryl trilaurate   glyceryl tripalmitate   glyceryl trierucate
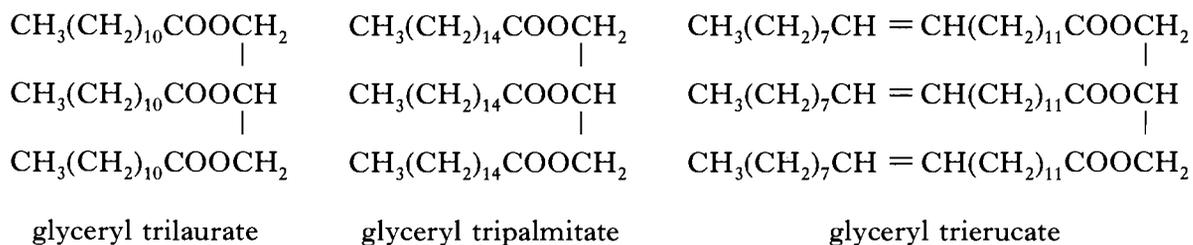
(a) Why are triglycerides an important part of our diet?

                                      1

(b) Glyceryl trilaurate is a liquid at 25 °C, but glyceryl tripalmitate is a solid at the same temperature.

Why does the triglyceride with the greater molecular mass have the higher melting point?

                                      1

(c) Explain why glyceryl trierucate is a liquid at 25 °C, whereas glyceryl tripalmitate is a solid at that temperature even though it has a smaller molecular mass.

                                      2

                                      (4)

[Turn over

20. Sulphur dioxide is added to wine as a preservative. A mass of 20 to 40 mg of sulphur dioxide per litre of wine will safeguard the wine without affecting its taste.

The concentration of sulphur dioxide in white wine may be found by titration with a standard solution of iodine.

(a) Describe clearly, with full experimental detail, how 0.05 mol l^{-1} iodine solution would be diluted to give $250\,cm^3$ of 0.005 mol l^{-1} solution.

2

(b) The equation for the reaction which takes place is:

$$SO_2(aq) + I_2(aq) + 2H_2O(\ell) \rightarrow 4H^+(aq) + SO_4^{2-}(aq) + 2I^-(aq)$$
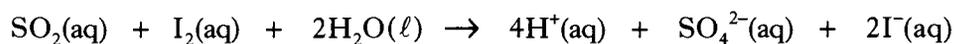
(i) The indicator used in this reaction causes a change from blue to colourless at the end point.
Name a substance which could be used as this indicator.

1

(ii) Write the ion-electron equation for the reduction reaction taking place.

1

20. (continued)

(c) In one particular titration, it was found that the sulphur dioxide in $100 \, cm^3$ of wine reacted with $11 \cdot 2 \, cm^3$ of $0 \cdot 005 \, mol \, l^{-1}$ iodine solution.

Calculate the concentration of sulphur dioxide, in $mg \, l^{-1}$, present in the wine.

3

(7)

[Turn over

21. Nuclear magnetic resonance spectroscopy (n.m.r.) is a widely used analytical chemical technique. Detailed information can be obtained about the numbers of hydrogen atoms and their environment within a molecule.

The molecules under investigation are placed in a powerful magnetic field and a band of radio frequencies is applied. The emitted radiation is analysed for absorptions due to the hydrogen-1 isotope.

The height of the absorption peak produced is directly proportional to the number of hydrogen atoms in a particular environment.

Each different environment produces absorptions at slightly different frequencies. The position of each absorption is given as a "chemical shift" from the position at which the hydrogen atoms in a reference standard absorb.

Hydrogen atom environment	Chemical shift relative to reference standard
$-CH_3$ (in an alkane)	0·9
$-CH_2-$ (in an alkane)	1·3
$-CH-$ (in an alkane)	2·0
CH_3-O- (in an alkanol)	3·8
$-O-H$ (in an alkanol)	5·0

Marks

21. (continued)

An n.m.r. spectrum of methylpropane is as follows.

$$CH_3-\overset{\displaystyle CH_3}{\underset{\displaystyle H}{C}}-CH_3$$
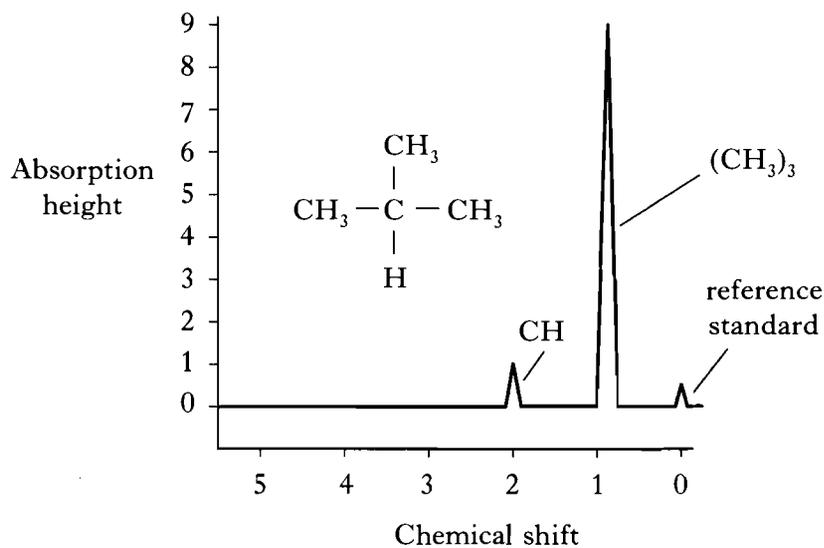
(a) Draw a structural formula in the dotted box for the molecule which gives the n.m.r. spectrum shown.
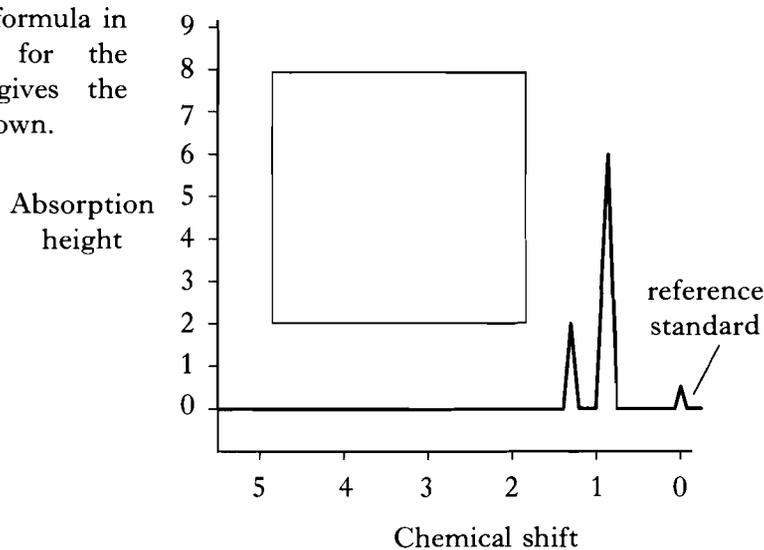
1

(b) Complete the diagram to show the n.m.r. spectrum for methanol.
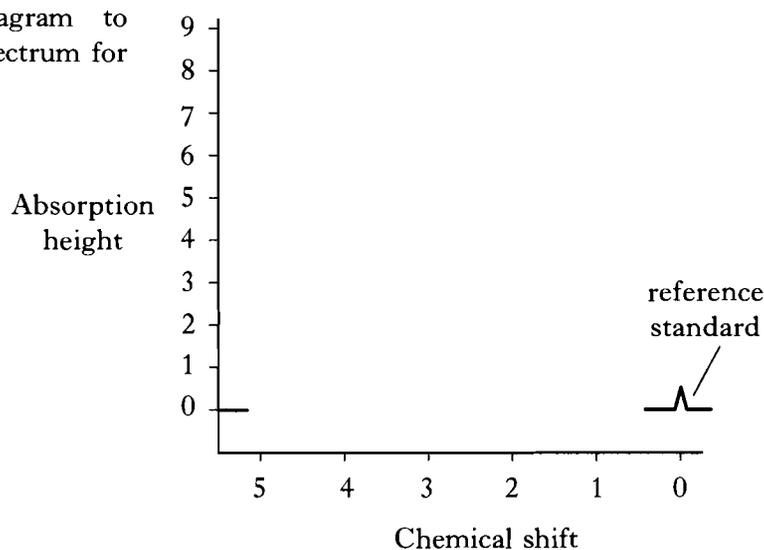
1

(2)

[Turn over for Question 22 on *Page thirty*

22. Many of the properties of water arise from the presence of polar $O-H$ bonds which make the water molecules polar. Carbon dioxide contains polar $C=O$ bonds but its molecules are not polar.

   (*a*) Explain this difference with the aid of diagrams of each molecule, showing polarities.

2

   (*b*) Water is unusual in that the solid form (ice) is less dense than the liquid form.

      Explain why water behaves in this way.

2

(4)

[END OF QUESTION PAPER]