O

CONVENT OF THE HOLY INFANT JESUS SECONDARY
Preliminary Examination in preparation for
the General Certificate of Education Ordinary Level 2024

CANDIDATE NAME			
CLASS		REGISTER NUMBER	

CHEMISTRY 6092/02

Paper 2 **22 August 2024**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

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Section A

Answer **all** questions.
The total mark for this section is 70.

1 Some ionic equations, **A** to **F**, are shown.

A $H^+ + OH^- \rightarrow H_2O$

B $Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3$

C $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$

D $Na^+ + e^- \rightarrow Na$

E $2Cl^- \rightarrow Cl_2 + 2e^-$

F $NH_4^+ + OH^- \rightarrow H_2O + NH_3$

Each letter may be used once, more than once or not at all.

Give the letter, **A** to **F**, for the equation which represents

(a) a displacement reaction. ……..…….. [1]

(b) a precipitation reaction. ……..…….. [1]

(c) a redox reaction. ……..…….. [1]

(d) a neutralisation reaction. ……..…….. [1]

(e) Give the letters of the two equations that, when combined, represent a decomposition reaction.

…….…….. and ……..……. [1]

[Total: 5]

2 Steel is an alloy of iron which contains carbon. There are many different types of steel that can be used for different purposes.

Fig. 2.1 shows the arrangement of atoms in pure iron.

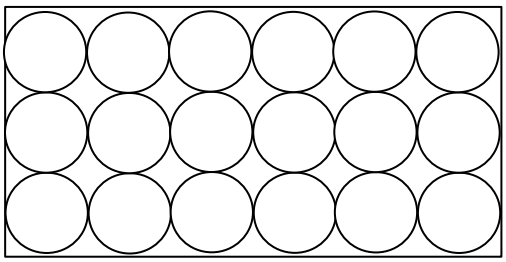
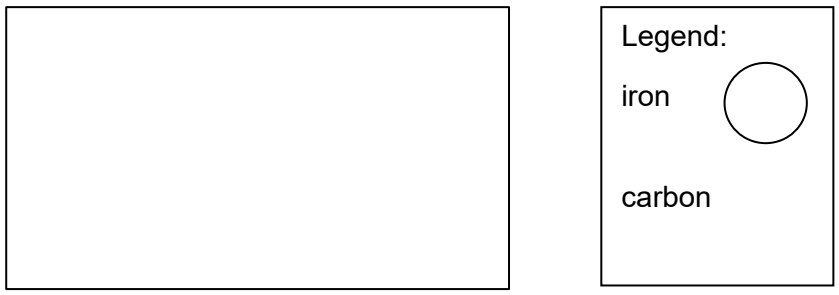


Fig. 2.1

(a) In the diagram below, draw the arrangement of atoms in steel. You should complete the legend provided.



[2]

(b) Use your diagram and Fig. 2.1 to explain why

(i) steel is a mixture of elements.

……..……...…….....

……..……... [1]

(ii) steel is harder than pure iron.

……..……...…….....

……..……...…….....

……..……... [2]

(c) Describe how the particles in steel allow it to conduct electricity.

……..……..……..

……..……..….. [1]

(d) Stainless steel is a type of steel that also contains chromium. Chromium can displace iron from its salt solution.

Explain how the addition of chromium prevents stainless steel from rusting.

……..

……..

……..…. [2]

[Total: 8]

3 The equation for the reaction between tetrachloromethane gas and steam is shown below.

$$CCl_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4HCl(g) \quad \Delta H = -130kJ$$

Table 3.1 shows some bond energies.

Table 3.1

bond	C–C*l*	H–O	C=O
bond energy in kJ / mol	340	460	805

(a) Using the information provided, calculate

(i) the energy absorbed to break the bonds in the reactants.

energy absorbed ……. kJ [1]

(ii) the bond energy for the H–C*l* bond, in kJ/mol.

bond energy ……. kJ/mol [1]

(b) Explain, in terms of bond-breaking and bond-making, why the overall enthalpy change of this reaction is negative.

……..

……..

……..

……..…. [3]

[Total: 5]

4 Table 4.1 shows some information about three different types of salts and the temperature change when they dissolve in water.

Table 4.1

name of salt	name of acid used to make the salt	name of other compound used to make the salt	temperature change when salt dissolves in water (°C)
calcium chloride	hydrochloric acid	calcium carbonate	+5
ammonium chloride			–20
calcium sulfate		calcium nitrate	N.A.

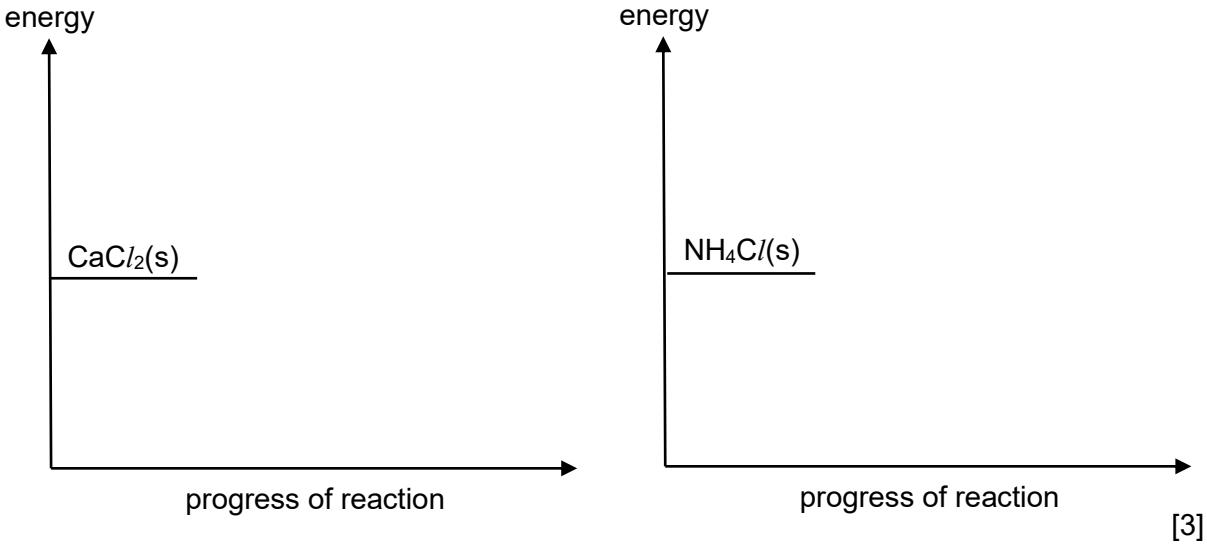
(a) Fill in the blanks in the table above. [2]

(b) Explain why calcium carbonate cannot be reacted with the acid you suggested in **(a)** to produce calcium sulfate.

……..……..

……..…… [1]

(c) Complete the energy profile diagrams to show the products and enthalpy changes when calcium chloride, $CaCl_2$, and ammonium chloride, NH_4Cl, are dissolved in water.



[3]

[Total: 6]

5 Fig. 5.1 gives the experimental setup of two cells. Both electrodes **P** and **Q** are made of graphite.

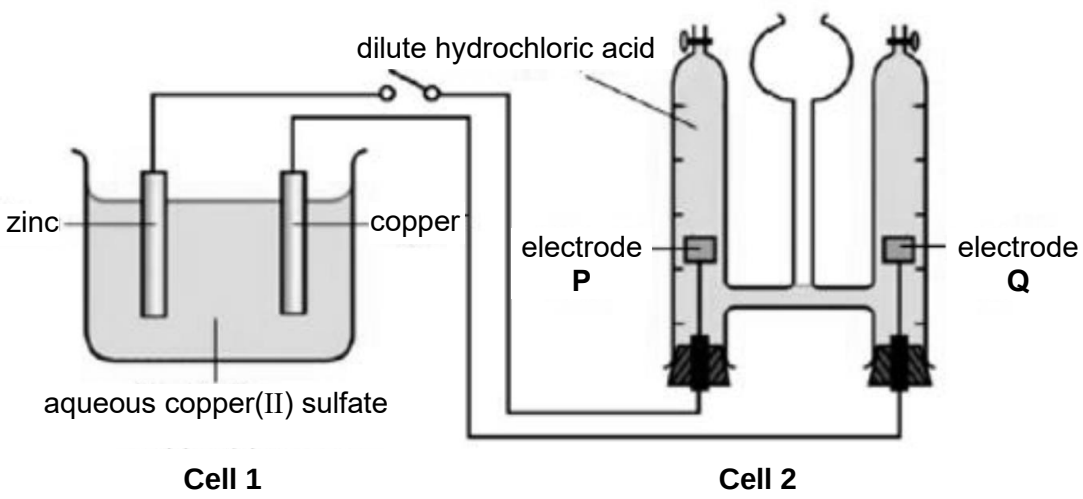


Fig. 5.1

(a) **(i)** Write the half-equations for the reactions occurring at the zinc and copper electrodes in **Cell 1**.

zinc electrode: ……...

copper electrode: ……. [2]

(ii) Hence, describe the expected observations in **Cell 1**.

……..……...…….....

……..……...…….....

……..……...…….....

……..……...…….... [2]

(b) The voltage of **Cell 1** was found to be 1.10 V.

Suggest the voltage if the copper electrode in **Cell 1** was replaced with silver. Explain your reasoning.

……..

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……..…. [2]

(c) After a few minutes, 16 cm^3 of gas was collected electrode **P** in **Cell 2**. Electrode **P** is the negative electrode while electrode **Q** is the positive electrode.

What volume of gas would you expect at electrode **Q**? Include half-equations to support your answer.

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……..

…….…. [3]

[Total: 9]

6 A student investigates the reaction of excess magnesium carbonate with 0.10 mol/dm^3 of hydrochloric acid at 25°C (**experiment 1**).

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

Fig. 6.1 shows the volume of carbon dioxide gas released as the reaction proceeds for **experiment 1**.

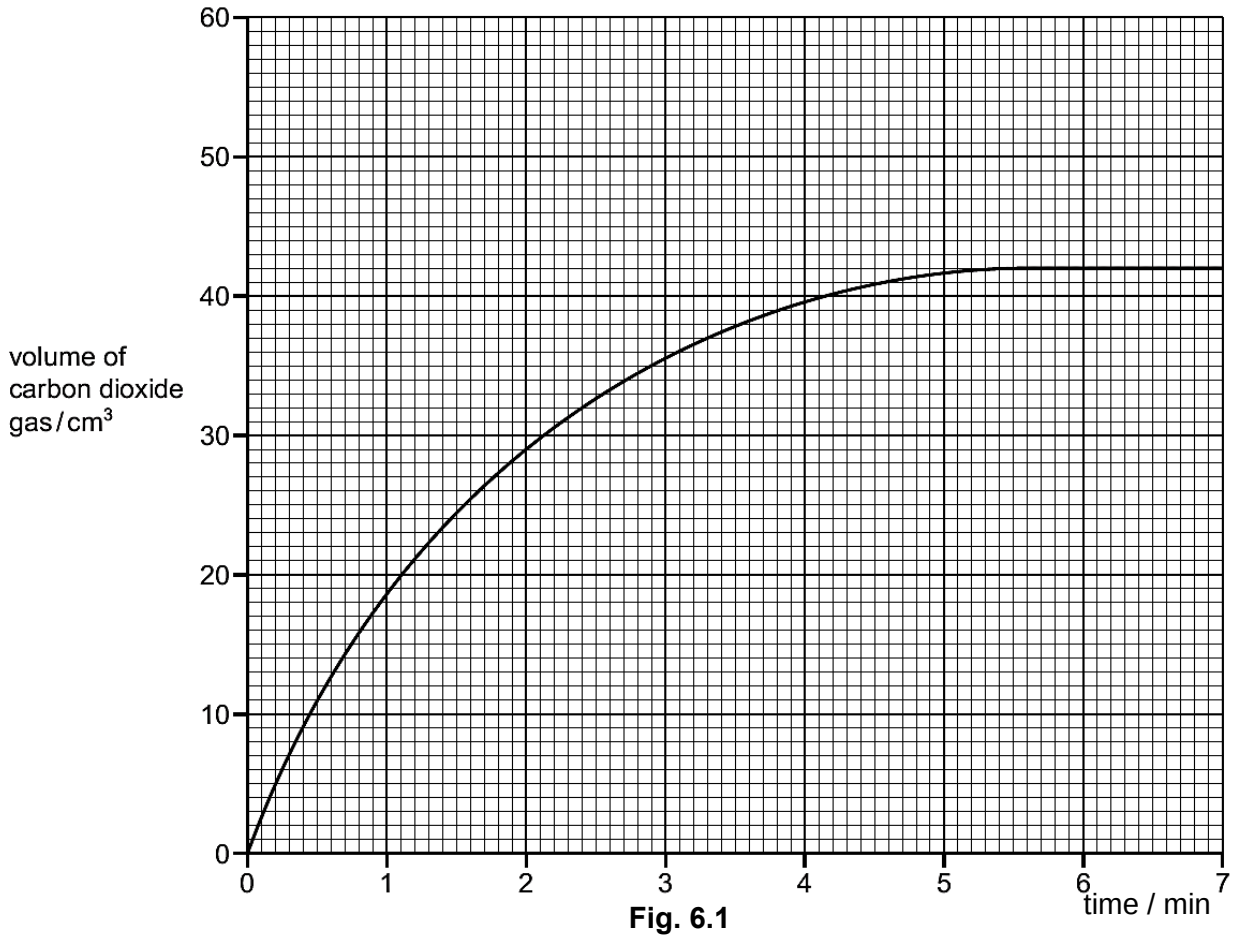

Fig. 6.1

(a) From Fig. 6.1, determine the volume of carbon dioxide gas obtained from this reaction.

volume of carbon dioxide …….. cm^3 [1]

(b) Hence, calculate the volume of 0.10 mol/dm^3 of hydrochloric acid used in the experiment. (1 mole of any gas occupies 24 dm^3 at room temperature and pressure)

volume of hydrochloric acid …….. cm^3 [2]

(c) The student carried out three more experiments to determine the time taken for each reaction to finish. The data obtained is shown in Table 6.1.

Table 6.1

experiment	acid used	concentration of acid (mol/dm^3)	temperature (°C)
1	hydrochloric acid	0.10	25
2	hydrochloric acid	0.05	25
3	hydrochloric acid	0.10	40
4	ethanoic acid	0.10	25

(i) On the same axes in Fig. 6.1, sketch the graph expected for **experiment 2**. [1]

(ii) Write the chemical equation for the reaction taking place in **experiment 4**.

……..……...……..... [1]

(d) Explain, in terms of collisions between reacting particles, how the rate of reaction for **experiment 3** would differ from **experiment 1**.

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……..

……..

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……..…. [4]

(e) Explain why the rate of reaction for **experiment 4** is slower than in **experiment 1**.

……..

……..

……..…. [2]

[Total: 11]

7 ‘Lean burn’ engines are a type of car engine with different conditions from a normal car engine. Table 7.1 shows some information about ‘lean burn’ engines compared to normal car engines.

Table 7.1

type of engine	amount of air mixed with petrol	operating temperature	concentration of carbon monoxide in exhaust gases	concentration of nitrogen dioxide in exhaust gases
normal	less air	higher	higher	higher
‘lean burn’	more air	lower	lower	lower

(a) Describe how carbon monoxide and nitrogen dioxide are harmful to humans and the environment respectively.

……..

……..

……..

……..…. [2]

(b) Considering how each gas is produced in the car engine, suggest why ‘lean burn’ engines produce less carbon monoxide and nitrogen dioxide compared to normal car engines.

……..

……..

……..

……..…. [2]

(c) Cars have catalytic converters fitted to reduce the problems caused by some of the exhaust gases. The structure of a catalytic converter is shown in Fig. 7.1.

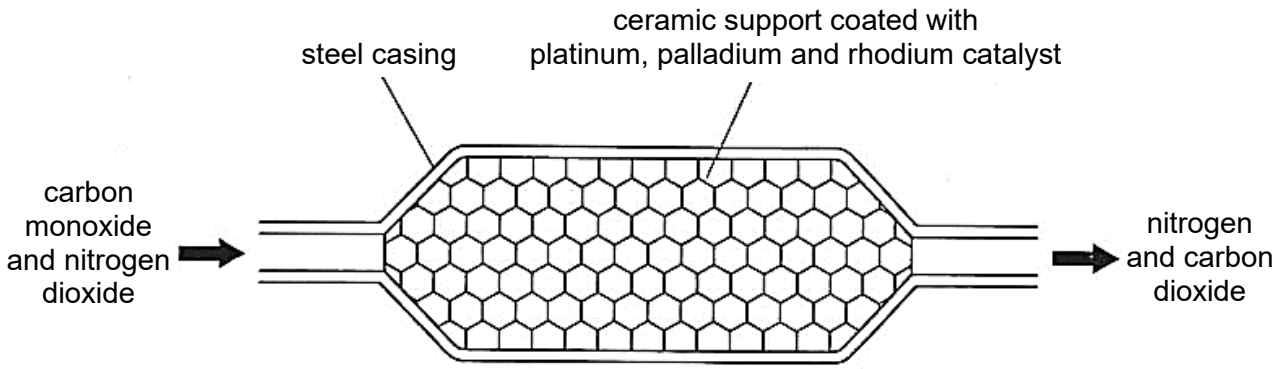

Fig. 7.1

(i) Explain the effect of the catalyst on the rate of reaction.

……..……..……

……..…….... [1]

(ii) In terms of oxidation states, explain why this is a redox reaction.

……..……..……

……..……..……

……..……..……

……..…….... [2]

(iii) Explain why the catalytic converter does **not** solve all the environmental problems caused by the pollutant gases in the exhaust emissions from cars.

……..……..……

……..…….... [1]

[Total: 8]

8 An ester that has a pineapple-like aroma, and is used as a flavour enhancer in drinks, has the structural formula $CH_3CH_2CH_2COOCH_2CH_3$.

(a) State the name of this ester.

……..…….…. [1]

(b) Draw the full structural formulae of the alcohol and carboxylic acid used to make this ester.

full structural formula of alcohol:

full structural formula of carboxylic acid:

[2]

(c) Besides using litmus or universal indicator, describe another test you could carry out in the laboratory to distinguish the alcohol from the carboxylic acid.

……..……..

……..…….

……..……..…. [2]

(d) The conversion of the alcohol and carboxylic acid into this ester can be monitored using paper chromatography, with water as the solvent.

A small sample of the reacting mixture was extracted during the chromatography process. Fig. 8.1 shows the resulting chromatogram.

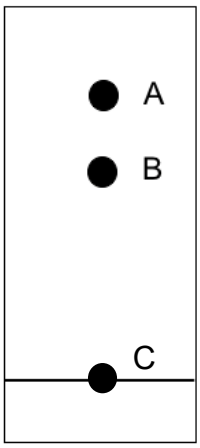

Fig. 8.1

(i) Suggest which of the three dots, **A**, **B** and **C**, represent the ester. Explain your reasoning.

…..……..…….

……..……..……..…….... [2]

(ii) Describe a test that you can carry out to determine that the ester obtained is pure.

…..……..…….

……..……..……..…….... [1]

[Total: 8]

9 Nuclear Magnetic Resonance (NMR) spectroscopy

NMR spectroscopy is a technique used to provide information about individual functional groups present in an organic compound, and can be used to identify molecular structures.

One common type of NMR is carbon-13 spectroscopy, which detects the ^{13}C isotopes present in a sample. The main carbon isotope, ^{12}C, does not produce a signal.

^{13}C NMR spectra of the isomers of C_5H_{12}

In the straight-chain isomer of C_5H_{12}, **isomer 1**, there are three 'types' of carbon atoms, which can be identified based on their position in the carbon chain:

- the two terminal carbon atoms, labelled ***a***, are the same 'type' because they are bonded to three hydrogen atoms and one butyl group, $–C_4H_9$;
- the next two carbon atoms, labelled ***b***, are the same 'type' because they are bonded to two hydrogen atoms, one methyl group, $–CH_3$, and one propyl group, $–C_3H_7$;
- the carbon atom in the centre, labelled ***c***, is the last 'type' because it is bonded to two hydrogen atoms and two ethyl groups, $–C_2H_5$;

These three 'types' of carbon atoms give rise to three distinct peaks in the NMR spectrum as shown in Fig. 9.1.

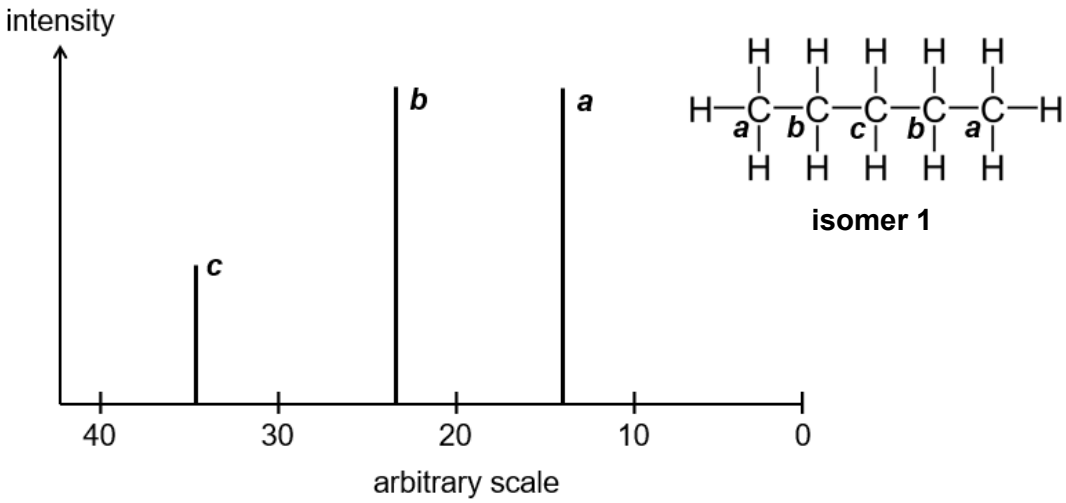

Fig. 9.1

The intensity of each peak corresponds to the number of each 'type' of carbon atom in the structure. Because there are two carbon atoms of 'type' ***a***, two carbon atoms of 'type' ***b***, and one carbon atom of 'type' ***c***, peaks ***a*** and ***b*** are twice the intensity of peak ***c***.

The alkyl groups, position on the arbitrary scale and relative intensity of the peak corresponding to each carbon atom in **isomer 1** is shown in Table 9.1

Table 9.1

'type' of carbon atom	alkyl group(s) attached to the carbon atom	position on the arbitrary scale	relative peak intensity
a	$–C_4H_9$ (terminal carbon)	14	2
b	$–CH_3$ and $–C_3H_7$	23	2
c	$–C_2H_5$ and $–C_2H_5$	34	1

The ^{13}C NMR spectra and table of information for another isomer of C_5H_{12}, **isomer 2**, are shown in Fig. 9.2 and Table 9.2.

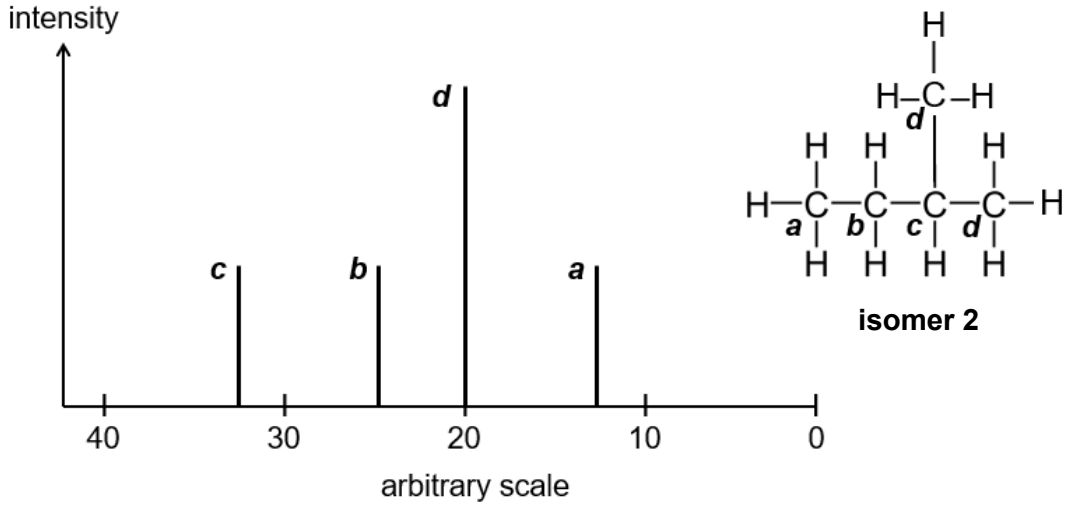

Fig. 9.2

Table 9.2

'type' of carbon atom	alkyl group(s) attached to the carbon atom	position on the arbitrary scale	relative peak intensity
a	$-C_4H_9$ (terminal carbon)	12	1
b	$-CH_3$ and $-C_3H_7$	25	1
c	$-CH_3$, $-CH_3$ and $-C_2H_5$	32	1
d	?	20	2

(a) With specific reference to the number of sub-atomic particles, explain why ^{12}C and ^{13}C are isotopes.

……

……

…… [2]

(b) With reference to Fig. 9.2 and Table 9.2, explain why carbon atom ***d*** in **isomer 2** has a relative peak intensity of 2.

Your answer should include the information missing in Table 9.2.

……

……

……

…… [2]

(c) Use the information provided to describe how the position of the carbon atom in its structure affects the position of its peak on the arbitrary scale.

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……

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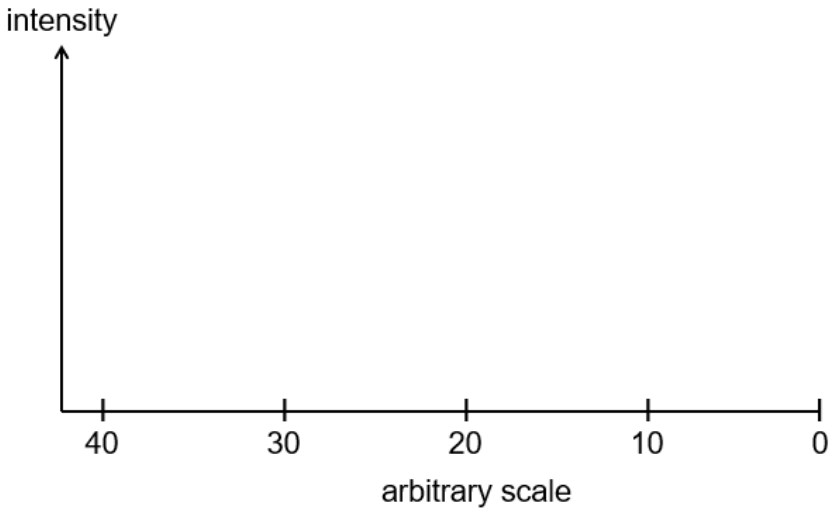
……

…… [3]

(d) **(i)** Draw the full structural formula of the third isomer of C_5H_{12}.

[1]

(ii) Hence, using the information provided, predict and sketch the ^{13}C NMR spectrum of the third isomer of C_5H_{12}.



[2]

[Total: 10]

CANDIDATE NAME

CLASS

REGISTER NUMBER

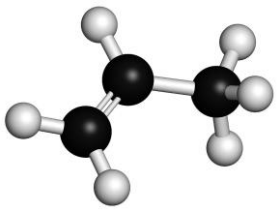
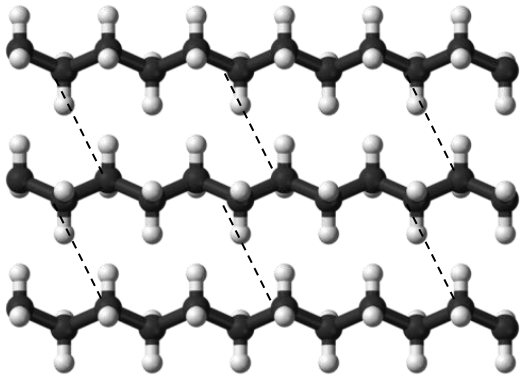
Section B

Answer **one** question from this section.
The total mark for this section is 10.

10 Propene undergoes addition polymerisation to form polypropene. Polypropene can be made into many plastic items, especially for medical use because it can withstand high temperatures.

Some information about propene and polypropene are shown in Table 10.1 below.

Table 10.1

	propene	polypropene
melting and boiling points	melts at –185°C, boils at –48°C	melts between 150°C to 170°C
relative molecular mass	42	800 to 1200
structure		

(a) (i) Explain what is meant by the term *addition polymerisation*.

……..……..

……..…… [1]

(ii) Write the chemical equation for the addition polymerisation of propene to form polypropene, showing their structural formulae.

[2]

(b) Use ideas about bonding and structure to explain the difference in melting points between propene and polypropene.

……

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……

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……

…….…… [3]

(c) From the information provided, explain why polypropene does not have a fixed melting point.

……

…….…… [1]

(d) The Resin Identification Coding (RIC) System is a set of symbols appearing on plastic products that identify the plastic resin out of which the product is made.

Table 10.2 shows the RIC of polypropene and polyethene. The higher the number, the more difficult, and hence less cost-effective, the polymer is to recycle.

Table 10.2

polypropene (PP)	high density polyethene (HDPE)
	

(i) The physical method of recycling plastics like polypropene and polyethene involves melting and cooling the plastics. Describe the next steps of physical recycling.

……..……..

……..…… [1]

(ii) Discuss the economic and environmental issues of recycling plastics that might cause different plastics to have different RIC numbers.

……..……..

……..……..

……..……..

……..…… [2]

[Total: 10]

11 Globally, the demand for biofuels is growing, and it is important that the production of these biofuels is environmentally and economically sustainable. Some common biofuels that are widely used include bioethanol and biodiesel.

(a) Bioethanol is a fuel obtained from biomass such as sugarcane. It is widely used in Brazil, where it is mandatory to blend ethanol with petrol for use in vehicles.

(i) Briefly describe how bioethanol is obtained from biomass such as sugarcane. Include a chemical equation in your answer.

……..……..

……..……..

……..……..

……..……..

……..……..

……..…… [3]

(ii) Explain why bioethanol is often known as a carbon-neutral fuel.

……..……..

……..……..

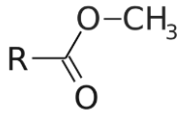
……..……..

……..…… [2]

(b) Biodiesel is the most common biofuel used in Europe. Biodiesel is produced from oils or fats using a process called transesterification, and is similar in composition to diesel.

Some information comparing diesel and biodiesel are shown in Table 11.1.

Table 11.1

property	diesel	biodiesel
source	obtained from fractional distillation of crude oil at 600°C	mixing methanol and recycled fat/oil at 60°C, with H_2SO_4 catalyst
approximate yield	29%	11%
general structure	long-chain alkanes	 ***R**: long-chain alkyl group*

(i) Using information from Table 11.1, discuss the advantages and disadvantages of using biodiesel over diesel.

……..……..

……..……..

……..……..

……..……..

……..……..

……..……..

……..…… [3]

(ii) Biodiesel can either be made from saturated animal fats or unsaturated vegetable oils that provide the long-chain alkyl group, **R**.

Describe a test you could carry out to determine whether **R** in a particular biodiesel sample was produced from animal fats or vegetable oil.

……..……..

……..……..

……..……..

……..…… [2]

[Total: 10]

End of Paper

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The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.