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

6092/01

Paper 1 Multiple Choice

26 August 2024

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and register number on the Multiple Choice Answer Sheet provided.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on the question paper.
A copy of the Periodic Table is printed on page 16.
The use of an approved scientific calculator is expected, where appropriate.

1 A laboratory assistant has a mixture of solid sulfur and solid carbon.
Sulfur is very soluble in carbon disulfide (boiling point 46°C) and slightly soluble in water. Carbon is insoluble in both solvents.

A sample of the mixture is shaken with water. This is P.
Another sample of the mixture is shaken with carbon disulfide. This is Q.

Which procedure is used to prepare a pure sample of sulfur?

A P is distilled and the distillate is evaporated to dryness to obtain sulfur.

B P is filtered and the filtrate is allowed to evaporate to dryness to obtain sulfur.

C Q is filtered and the residue is allowed to evaporate to dryness to obtain sulfur.

D Q is filtered and the filtrate is allowed to evaporate to dryness to obtain sulfur.

2 A student was given 4.0 g of magnesium carbonate powder and 100 cm^3 of 0.1 mol/dm^3 hydrochloric acid. He wants to determine the rate of reaction by measuring the change in mass of the reaction mixture.

Which apparatus is **not** likely to be used in this experiment?

A conical flask

B electronic mass balance

C stopwatch

D test-tube

3 In which situations do the particles move closer together?

1 A gas is heated from 0 °C to 25 °C.

2 The pressure of a gas is increased.

3 Steam condenses to form water.

4 Water evaporates at room temperature.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

4 Two bottles are placed close together inside a large container at a temperature of 90 °C. One bottle contains 1.0 g of sulfur dioxide, the other bottle contains 1.0 g of ethanol.

compound	melting point /°C	boiling point /°C
ethanol	–114	78
sulfur dioxide	–72	–10

A detector is placed in the container 2.0 m away from the two bottles. The two bottles are opened at the same time.

Which row is correct?

	compound that reaches detector first	explanation
A	ethanol	ethanol has a lower M_r than sulfur dioxide
B	ethanol	liquids diffuse faster than gases
C	sulfur dioxide	gases diffuse faster than liquids
D	sulfur dioxide	ethanol has a higher M_r than sulfur dioxide

5 The letters X, Y and Z represent different atoms.

$^{37}_{17}X$ $^{37}_{18}Y$ $^{38}_{18}Z$

Which statement is correct?

A X and Y are the same element.

B X and Y have same number of neutrons.

C Y and Z have the same number of electrons.

D Z has more neutrons than X.

6 Why does magnesium oxide have a higher melting point than sodium chloride?

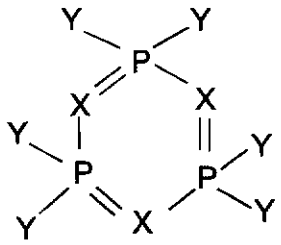
A There are more delocalised electrons in magnesium than sodium.

B There are more ions in magnesium oxide than in sodium chloride.

C The electrostatic forces of attraction between magnesium and oxide ions are stronger than those between sodium and chloride ions.

D The intermolecular forces of attraction between magnesium oxide are stronger than those between sodium chloride.

7 A stable molecule containing atoms of phosphorus, X, and Y have the following structure.



What elements could X and Y be?

	X	Y
A	C	H
B	N	Cl
C	O	Cl
D	Si	H

8 Which statement is true regarding diamond and graphite?

A Both can conduct electricity.
B Both have the same colour.
C Both have the same crystalline form.
D Both produce carbon dioxide and water vapour when completely burned in oxygen.

9 A compound contains 52% carbon, 13% hydrogen and 35% oxygen by mass.

What is the empirical formula of the compound?

A CH_3COOH **B** CH_3OH

C C_2H_5OH **D** $C_4H_{13}O_2$

10 Ethane burns in oxygen according to the chemical equation:

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

4 dm^3 of ethane and 16 dm^3 of oxygen were ignited in a reaction vessel. After the reaction, the reaction vessel was cooled down to room temperature.

What is the final volume of gases present in the vessel?

A 8 dm^3

B 10 dm^3

C 20 dm^3

D 22 dm^3

11 68 g of hydrogen peroxide is dissolved in water to form an aqueous solution. The solution is heated and decomposed in the presence of manganese(IV) oxide to give 3.6 dm^3 of oxygen gas as follows.

$$2H_2O_2 \rightarrow O_2 + 2H_2O$$

What is the percentage purity of hydrogen peroxide?

A 2.5% **B** 5.0% **C** 10.0% **D** 15.0%

12 Which two oxides will react with sodium hydroxide solution?

A calcium oxide and zinc oxide

B phosphorus(III) oxide and lead(II) oxide

C copper(II) oxide and sulfur dioxide

D sulfur dioxide and magnesium oxide

13 Which statement about the reaction between ammonium carbonate and dilute hydrochloric acid is **false**?

A Ammonium chloride is produced.

B Ammonia gas is produced.

C The gas evolved turned damp blue litmus paper red.

D Water is produced.

14 Which salt can be prepared by adding excess carbonate to dilute acid?

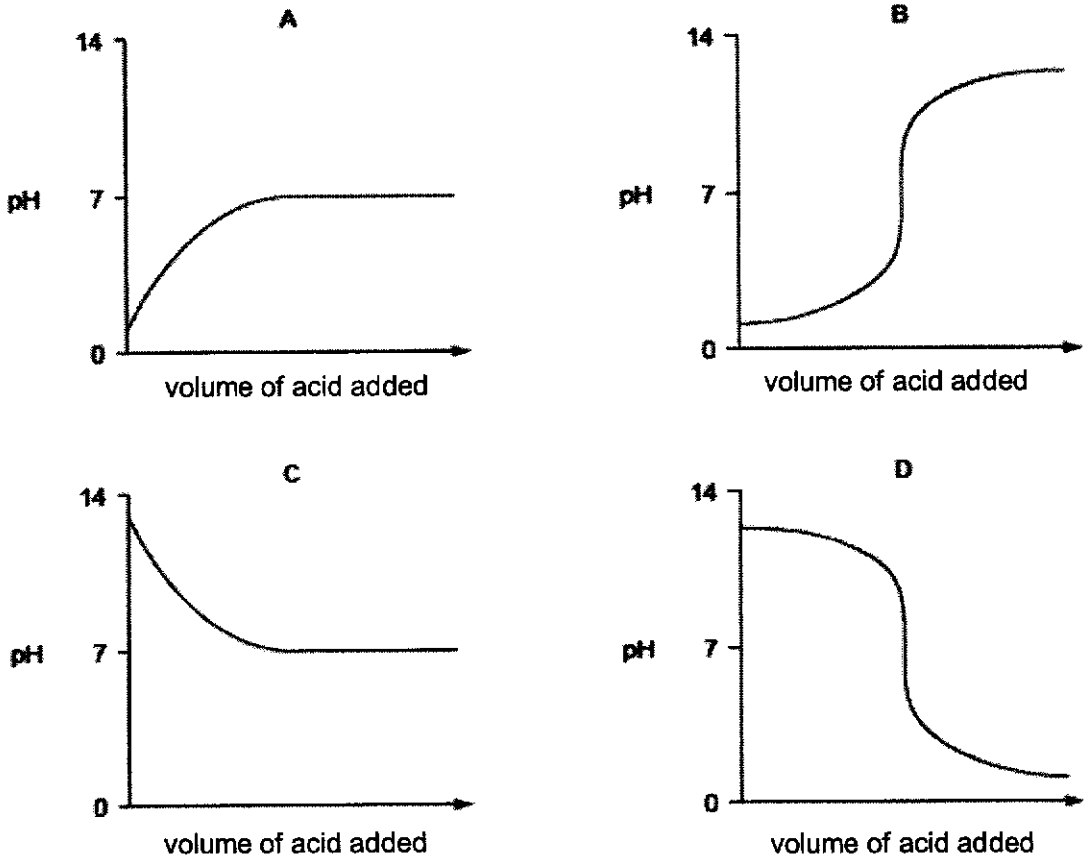
A lead(II) chloride

B magnesium chloride

C potassium nitrate

D sodium sulfate

15 Which graph shows the changes in pH as an excess of hydrochloric acid is added to aqueous sodium hydroxide?



16 Calcium nitrate solution is added to filtered tap water.

A white precipitate forms.

Which ion present in the tap water causes the precipitate to form?

A chloride

B magnesium

C potassium

D sulfate

17 Which statement about the manufacture of ammonia in the Haber process is **incorrect**?

A A 100% yield of ammonia will not be obtained in the reaction.

B High pressure is used to increase the yield of ammonia.

C Iron is used to increase the yield of ammonia.

D Nitrogen is obtained from fractional distillation of liquid air.

18 A solution of compound Z reacts with sodium hydroxide solution to form a white precipitate that is insoluble in excess sodium hydroxide solution.

Aluminium powder is then added. The mixture is heated and a gas that turns damp red litmus paper blue is given off.

What could the identity of Z be?

A aluminium chloride

B ammonium chloride

C calcium nitrate

D zinc nitrate

19 Which reagent could be used to distinguish between dilute sulfuric acid and dilute hydrochloric acid?

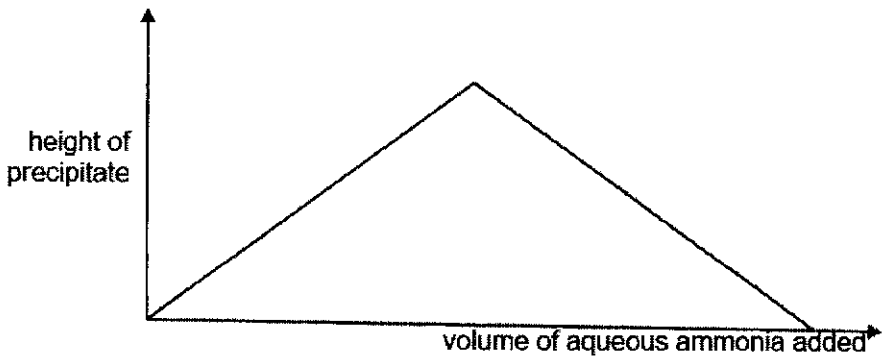
A barium nitrate solution

B calcium carbonate

C universal indicator

D sodium hydroxide solution

20 An aqueous solution of a salt is placed in a test-tube and aqueous ammonia is gradually added. The height in the test-tube is plotted against the volume of aqueous ammonia added.



What could the identity of this solution be?

A aluminium chloride

B calcium nitrate

C copper(II) chloride

D iron(II) sulfate

21 In an experiment, 10.0 cm^3 of 1.0 mol/dm^3 of aqueous iron(II) sulfate was mixed with 10.0 cm^3 of 1.0 mol/dm^3 of aqueous sodium hydroxide.

$$FeSO_4(aq) + 2NaOH(aq) \rightarrow Fe(OH)_2(s) + Na_2SO_4(aq)$$

What did the reaction flask contain when the reaction was complete?

A A green precipitate only.

B A green precipitate in a colourless solution.

C A white precipitate in a green solution.

D A green precipitate in a green solution.

22 In which substance does the sulfur atom have the same oxidation number as the sulfur atom in SO_2?

A H_2SO_4 **B** K_2SO_3 **C** Na_2S **D** $Na_2S_2O_3$

23 During electrolysis, 0.02 mol of chromium is deposited on the cathode when 0.08 mol of electrons is passes through a molten electrolyte containing chromium.

Which substance could be the electrolyte?

A $CrBr_2$

B $CrCl_4$

C Cr_2O_3

D $CrSO_4$

24 Three statements about fuel cells are given.

1 A hydrogen-oxygen fuel cell requires a continuous input of fuel and oxygen.

2 In a hydrogen-oxygen fuel cell, hydrogen is burned in oxygen to produce electricity.

3 When a hydrogen-oxygen fuel cell is operating, water is the only chemical product.

Which statements are correct?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

25 Potassium, rubidium and sodium are in Group 1 of the Periodic Table.

Which statement about these three elements is correct?

A Rubidium is the strongest reducing agent.

B Sodium loses its valence electron most easily.

C Rubidium has a greater tendency to form negative ions than potassium.

D The reaction between sodium and water is the most violent.

26 Some properties of elements in Group 17 and the reasons for these properties are shown.

Which row correctly shows the reason for its corresponding property?

	property	reason
A	bromine displaces iodine from potassium iodide solution	iodine is more reactive than bromine
B	going down the group, the boiling point of the halogens increases	as molecular size increases, the intermolecular forces of attraction become stronger
C	going down the group, the oxidising property of the halogens decreases	as atomic size increases, it is more difficult for the atom to lose an electron
D	going down the group, the reactivity of the halogens decreases	as atomic size increases, it is more difficult for the nucleus to attract seven more electrons

27 Which statement about noble gases is **incorrect**?

A They are colourless gases at room temperature and pressure.

B They are insoluble in water.

C They are used to provide an inert atmosphere for processes like welding.

D They exist as diatomic molecules.

28 Which statement best supports that an unknown element could be a transition metal?

A The element burns in air to form a white residue.

B The element forms chlorides with the chemical formulae XCl_2 and XCl_3.

C The element forms ionic compounds that are soluble in water.

D The oxide of the element can react with acids.

29 The table below shows the reactions that manganese undergoes.

reaction with	observation
dilute acid	hydrogen gas produced
cold water	no visible reaction
steam	hydrogen gas is produced

Which row gives the correct arrangement of the metals in order of increasing reactivity?

A calcium, manganese, lead

B lead, calcium, manganese

C lead, manganese, calcium

D manganese, calcium, lead

30 The list shows the position of metal Y in the reactivity series of metals.

Na Al Zn Fe Y Cu Ag

Which methods could be used to extract metal Y from its oxide?

1 electrolysis of the molten metal oxide

2 heating the metal oxide with hydrogen

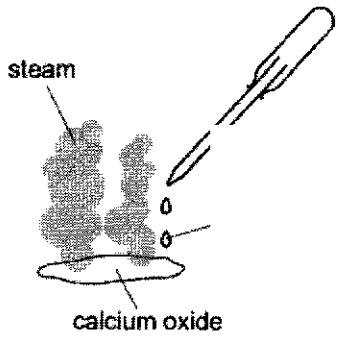
3 heating the metal oxide with zinc

A 1, 2 and 3 **B** 1 and 2 only **C** 2 only **D** 2 and 3 only

31 The diagrams show four chemical reactions.

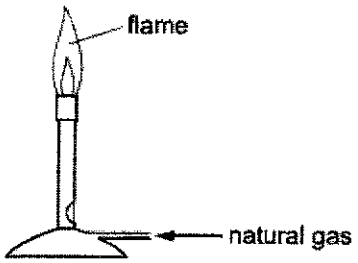
Which reaction is endothermic?

A



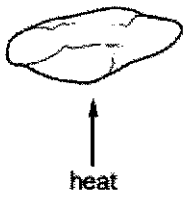
addition of water to calcium oxide

B



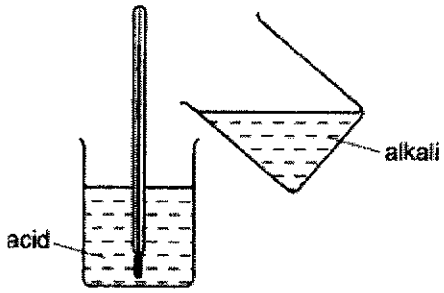
combustion of natural gas

C



thermal decomposition of limestone

D



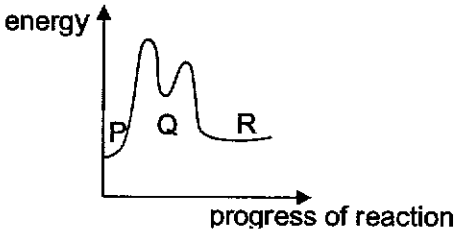
reaction of acid with alkali

32 In the conversion of compound P into compound R, it was found that the reaction proceeded by way of compound Q, which could be isolated. The steps involved were:

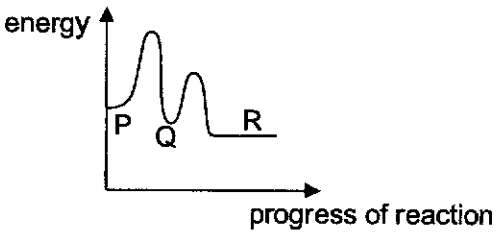
$P \rightarrow Q$; ΔH = negative
$Q \rightarrow R$; ΔH = positive

Which reaction profile agrees with this data?

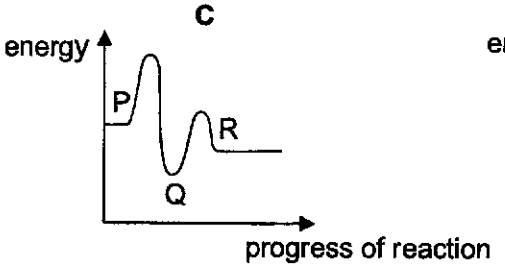
A



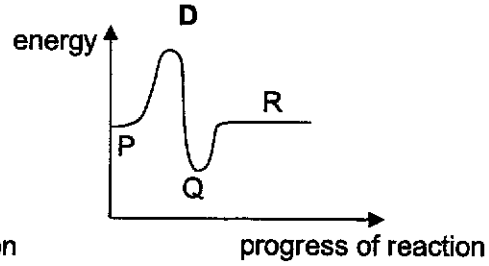
B



C

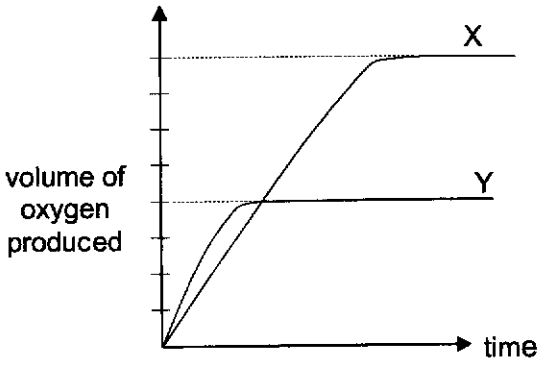


D



33 Graphs X and Y represent the results of two experiments demonstrating the catalytic decomposition of hydrogen peroxide.

Which set of values for hydrogen peroxide in each experiment would give the results shown?



	X		Y	
	volume (cm^3)	concentration (mol/dm^3)	volume (cm^3)	concentration (mol/dm^3)
A	50	2.0	100	1.0
B	100	1.0	50	2.0
C	100	1.0	200	0.5
D	400	0.5	100	1.0

34 In the fractional distillation of crude oil, different fractions are obtained at the top and bottom of the fractionating column.

Which properties do the fraction obtained at the top of the fractionating column have, compared with the fraction obtained at the bottom?

1 more viscous

2 burns more easily

3 lower boiling point

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

35 The complete combustion of 20 cm^3 of a gaseous alkane requires 100 cm^3 of oxygen. Both volumes are measured at room temperature and pressure.

What could be the identity of this alkane?

A butane

B ethane

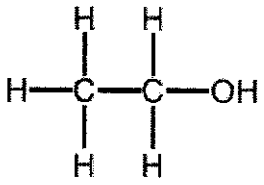
C methane

D propane

36 Compound W has the empirical formula C_2H_5O and decolourises acidified potassium manganate(VII).

Which structure(s) could be compound W?

1



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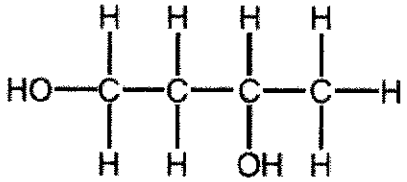

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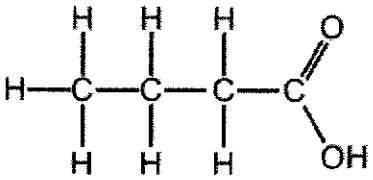

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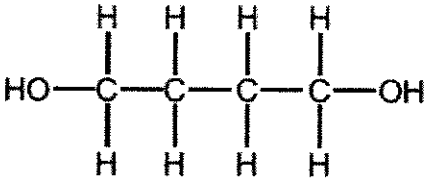
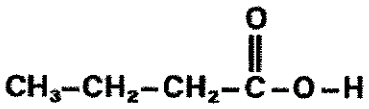


A 1 only **B** 3 only **C** 2 and 4 only **D** 1, 2 and 4

37 The diagrams show the structures of four organic molecules.

1



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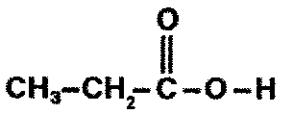
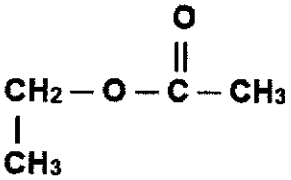
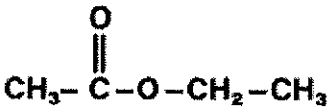


3



4



Which structures are isomers of one another?

A 1 and 2 only **B** 1 and 3 only **C** 3 and 4 only **D** 1, 3 and 4

38 The polymer, poly(ethene) is formed from its monomer, ethene.

What do poly(ethene) and ethene have in common?

1 chemical properties

2 empirical formula

3 percentage composition

4 relative molecular mass

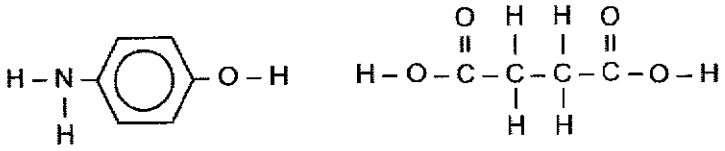
A 1 and 2 only

B 2 and 3 only

C 2 and 4 only

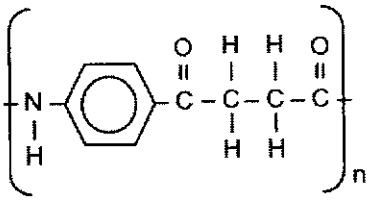
D 2, 3 and 4 only

39 The structure of two monomers are shown below.

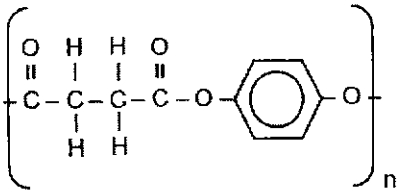


Which structure could be a polymer formed between the two monomers?

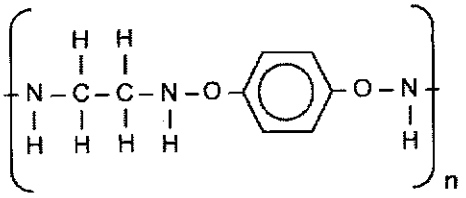
A



B



C



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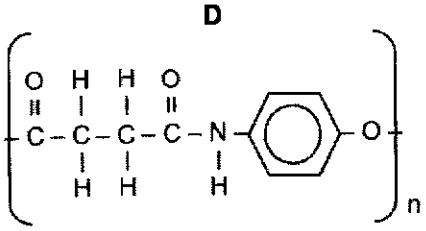
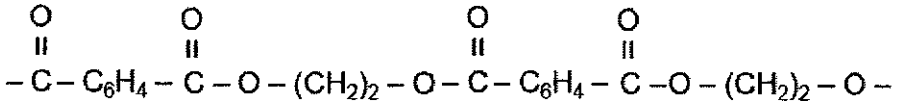


40 The polymer below is broken down into its monomers by hydrolysis using acid as a catalyst.



Which monomers are obtained from the hydrolysis reaction?

1 HOC_6H_4OH

2 $HOOC(CH_2)_2COOH$

3 $HO(CH_2)_2OH$

4 $HOOCC_6H_4COOH$

A 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

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		Key: proton (atomic) number; atomic symbol; name; relative atomic mass									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 –

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, $L = 6.02 \times 10^{23}\ mol^{-1}$.

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.

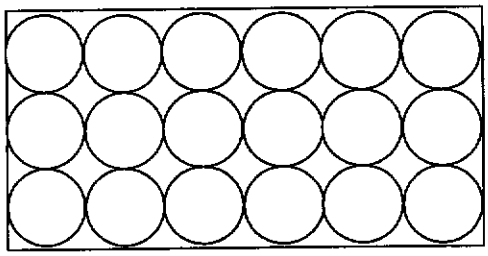
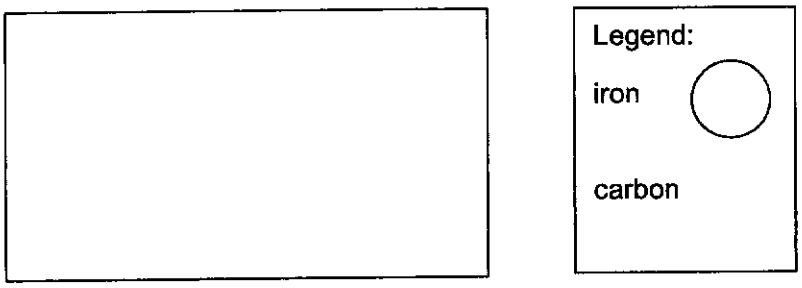


Fig. 2.1

(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.

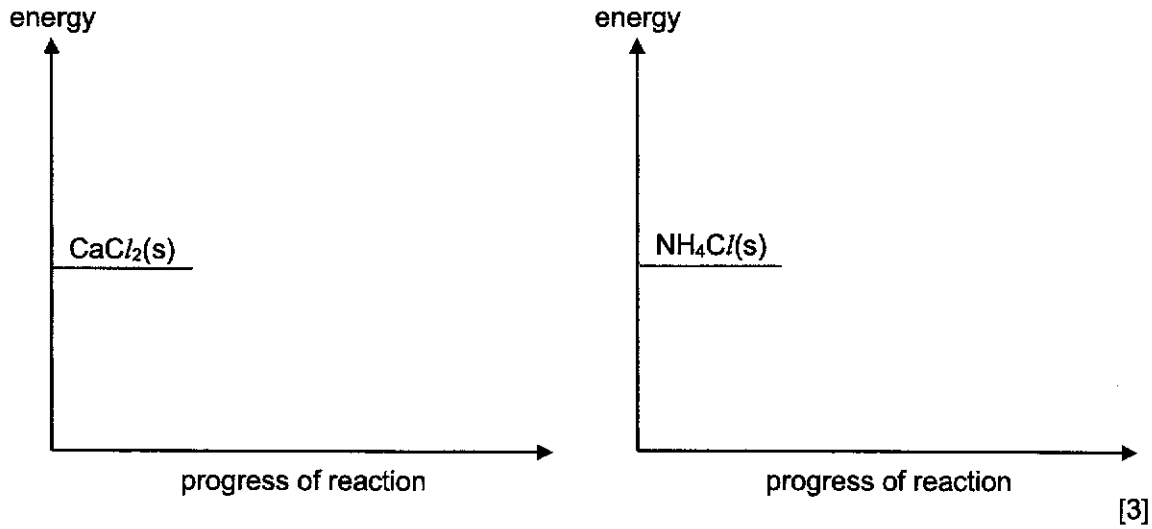
(a) Fill in the blanks in the table above. [2]

(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.

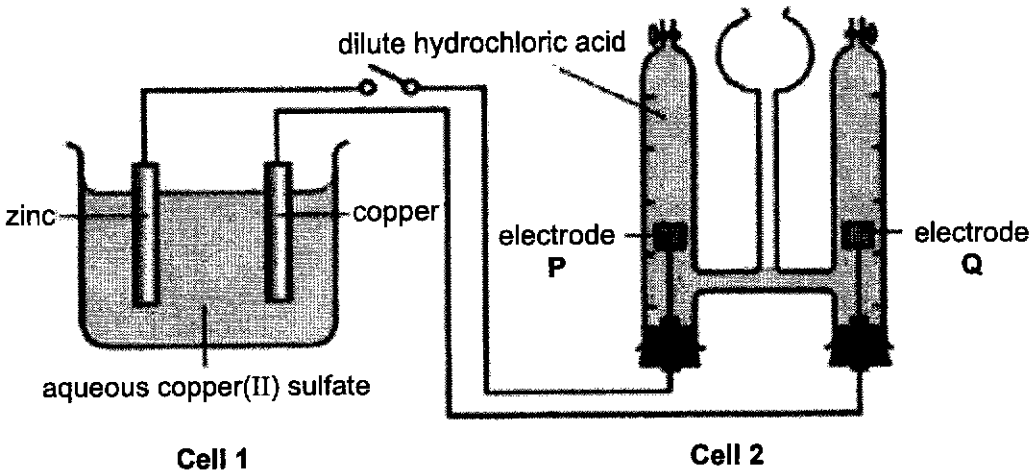


Fig. 5.1

(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.

.....

.....

.....

..... [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.

.....

.....

.....

.....

.....

..... [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**.

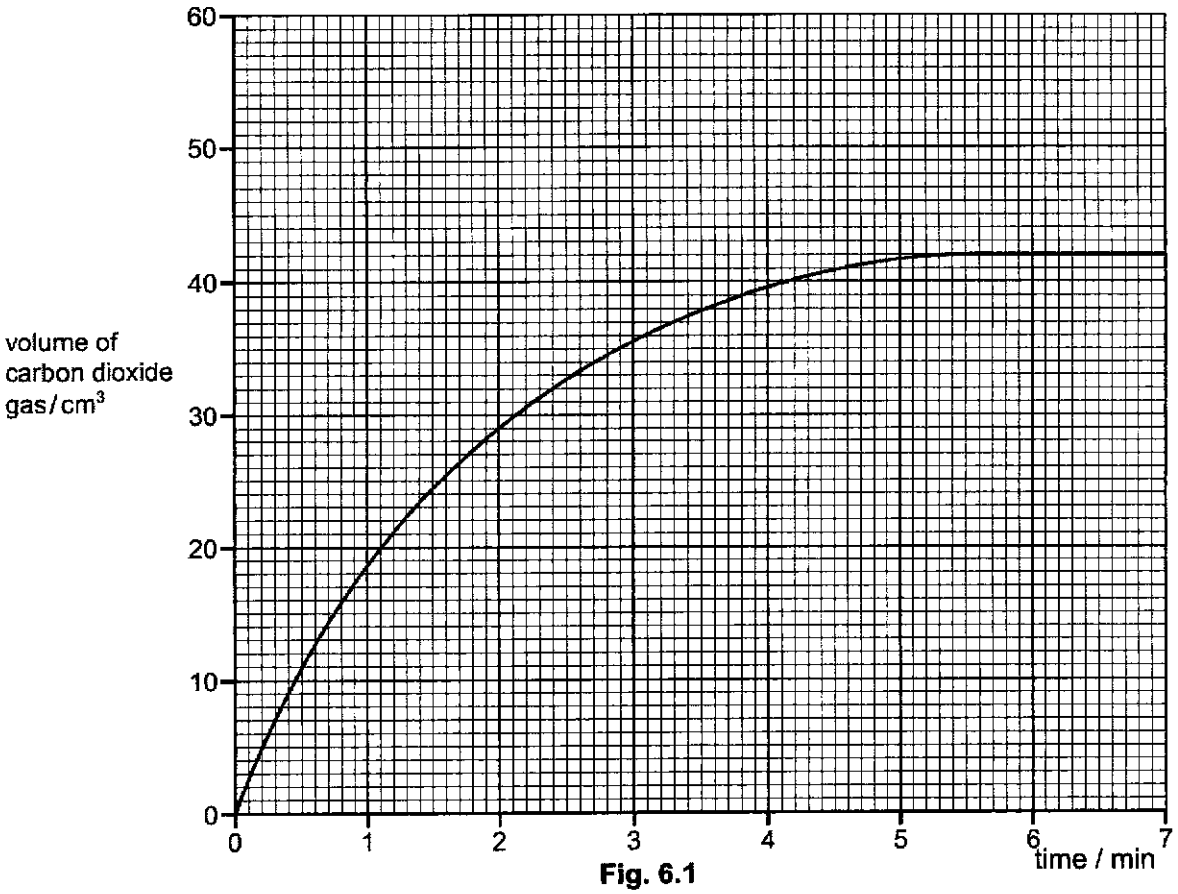


Fig. 6.1

(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**.

.....

.....

.....

.....

.....

.....

..... [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.

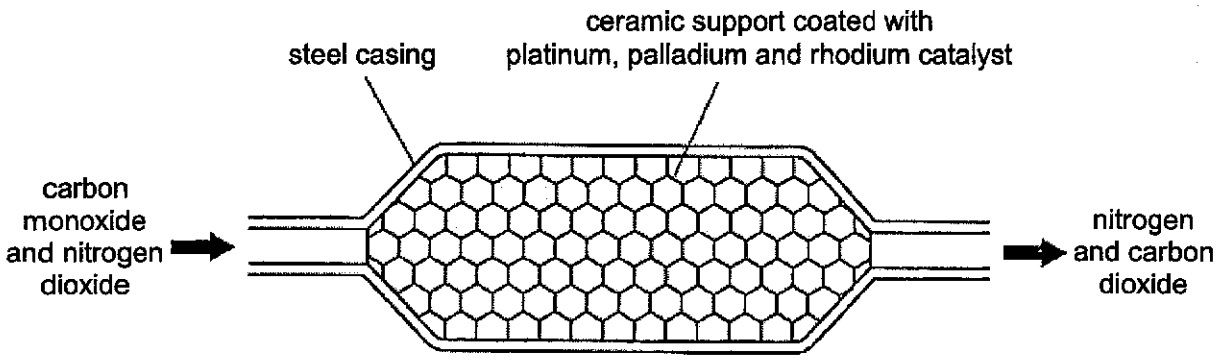


Fig. 7.1

(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.

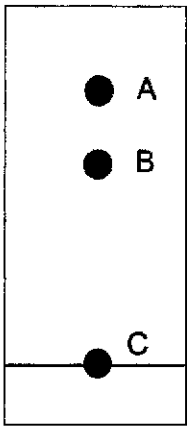


Fig. 8.1

(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.

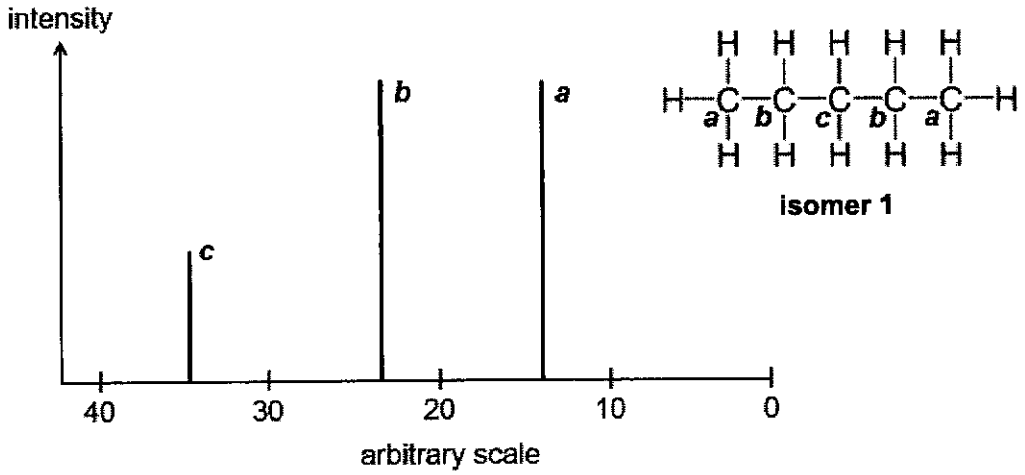


Fig. 9.1

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.

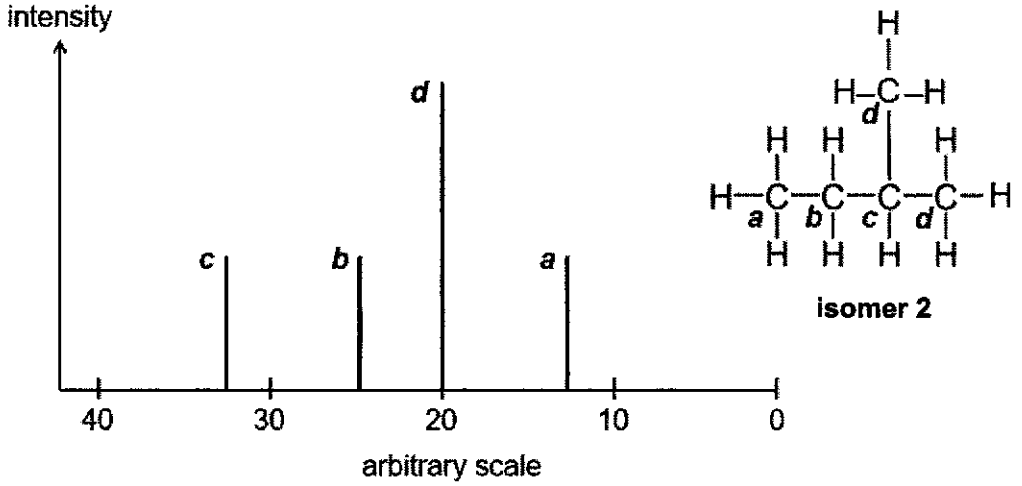


Fig. 9.2

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.

.....

.....

.....

.....

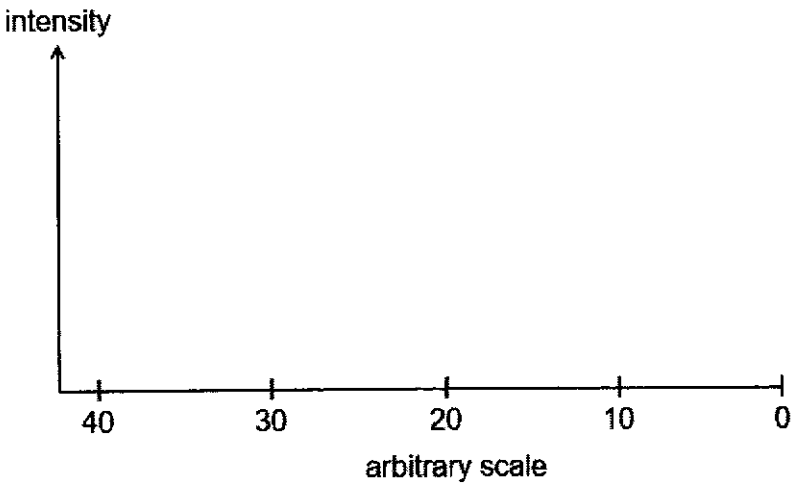
.....

..... [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

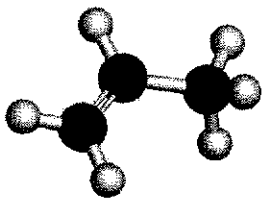
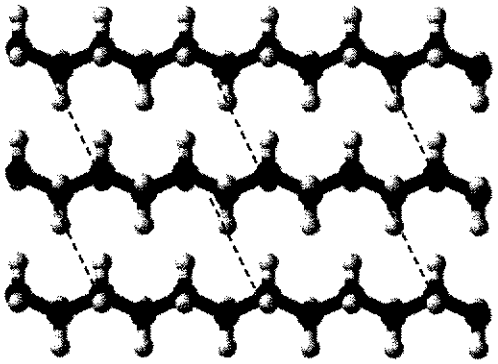
Section B

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.

.....

.....

.....

.....

.....

..... [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.

.....

.....

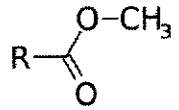
.....

..... [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, $L = 6.02 \times 10^{23} mol^{-1}$.

CHIJ SECONDARY

Sec 4 Preliminary Examination 2024

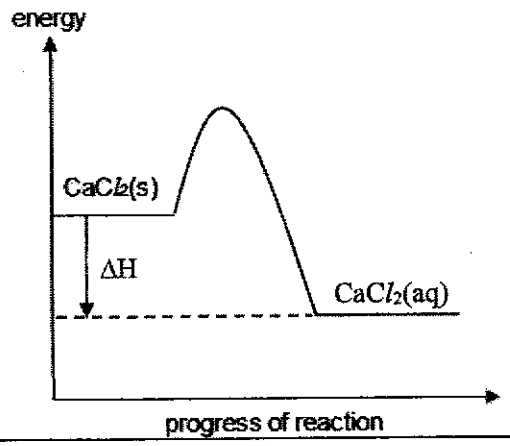
Chemistry 6092 **Mark Scheme**

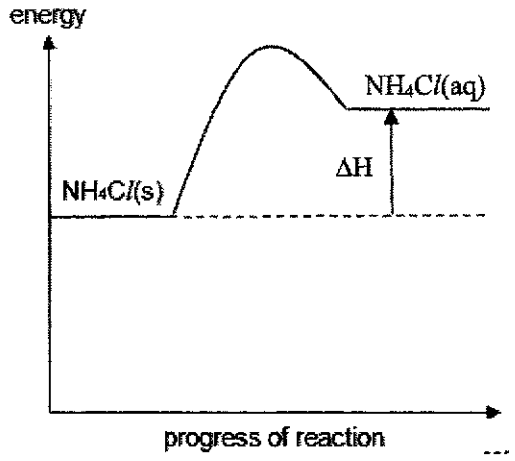
Paper 1 (40 marks)

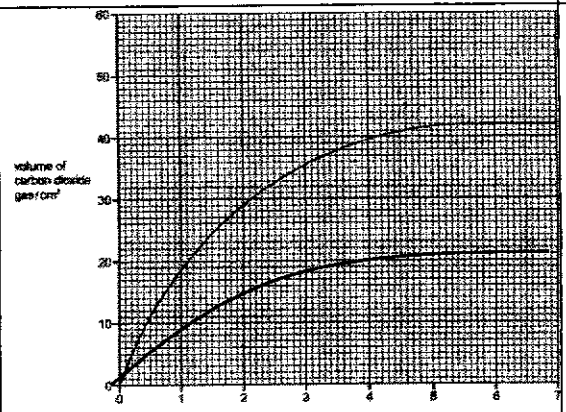
No	Answer	No	Answer	No	Answer	No	Answer
1	D	11	D	21	D	31	C
2	D	12	B	22	B	32	C
3	C	13	B	23	B	33	D
4	A	14	B	24	C	34	D
5	C	15	D	25	A	35	D
6	C	16	D	26	B	36	C
7	B	17	C	27	D	37	B
8	D	18	C	28	B	38	B
9	C	19	A	29	C	39	D
10	B	20	C	30	A	40	D

Paper 2
Section A (70 marks)

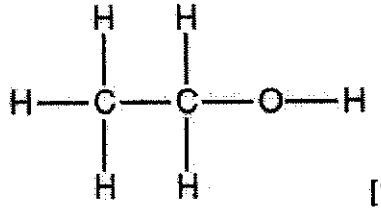
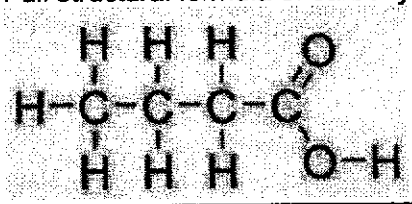
Question			Answers	Marks	Total
1	(a)		C	1	5
	(b)		B	1	
	(c)		C	1	
	(d)		A	1	
	(e)		D and E	1	
2	(a)		[1]: size [1]: composition	2	8
	(b)	(i)	The <u>iron and carbon atoms</u> are <u>physically combined</u> / not chemically combined together.	1	
		(ii)	Steel has <u>atoms of different sizes</u> that <u>disrupts the regular arrangement</u> of the metal [1] causing the <u>layers of atoms</u> to <u>slide</u> over each other less easily. [1]	2	
	(c)		There are <u>free moving electrons</u> to carry charge. Steel is made up of positive ions in a "sea of mobile(delocalised) electrons" 'Sea of delocalised 'electrons move to conduct electricity	1	

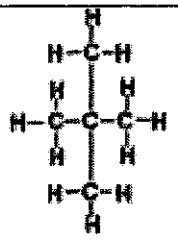
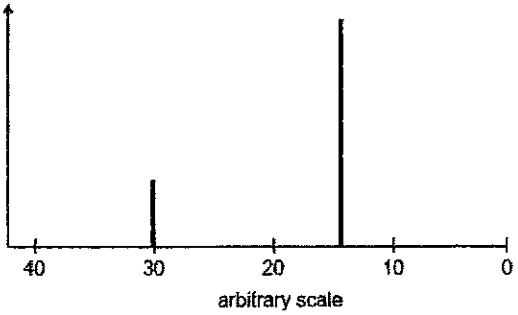
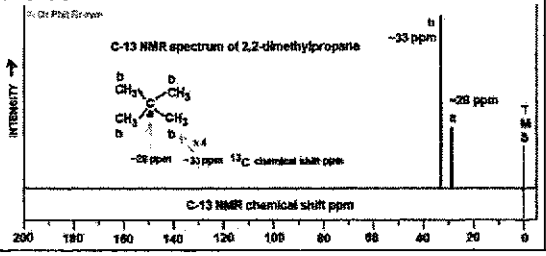
Question			Answers	Marks	Total
	(d)		Chromium is more reactive than iron [1] and corrodes/oxidises in place of iron. [1]	2	
3	(a)	(i)	Energy absorbed = 4C-Cl + 4O-H = 4(340) + 4(460) = 3200 kJ	1	5
		(ii)	ΔH = energy absorbed + energy released -130 = +3200 – [2C=O + 4H-Cl] -130 = +3200 – [2(805) + 4H-Cl] 4H-Cl = 1720 H-Cl = 430 kJ/mol	1	
	(b)		There is more energy released [1] in forming the C=O and H-Cl bonds / bonds in CO_2 and HCl [1] than energy taken in to break the C-Cl and O-H bonds / bonds in CCl_4 and H_2O. [1] OR Energy released/given out in forming the C=O and H-Cl bonds / bonds in CO_2 and HCl [1] is more[1] than energy taken in /absorbed to break the C-Cl and O-H bonds / bonds in CCl_4 and H_2O. [1]	3	
4	(a)		Ammonium chloride: hydrochloric acid; ammonium carbonate/aqueous ammonia *[reject: ammonium hydroxide]* Calcium sulfate: sulfuric acid [1]: 1-2 correct, [2]: all 3 correct	2	6
	(b)		An insoluble layer of calcium sulfate forms over the calcium carbonate, preventing further reaction.	1	
	(c)			3	

Question			Answers	Marks	Total
			 [1/2]: correct shape of each graph [1/2]: correct arrow direction with ΔH label for each graph [1/2]: correct formula and state symbol of each product		
5	(a)	(i)	Zn electrode: $Zn \rightarrow Zn^{2+} + 2e^-$ [1] Cu electrode: $Cu^{2+} + 2e^- \rightarrow Cu$ [1]	2	9
		(ii)	Any 2: • The zinc electrode decreases in size • The copper electrode increases in size/ a reddish-brown solid forms on the copper electrode • The electrolyte/solution changes from blue to colourless	2	
	(b)		Any value between 1.20 to 1.40V [1] (actual: 1.36V) The difference in reactivity between zinc and silver is greater than the difference in reactivity between zinc and copper. [1]	2	
	(c)		Volume at O should be $8cm^3$ [1] Every 2 points is 1 mark: P: $2H^+ + 2e^- \rightarrow H_2$ Q: $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ [1] From the equations for every 4 moles of electrons that pass through electrolysis, 2 moles of hydrogen are produced at the cathode and 1 mole of oxygen is produced at the anode. [1] OR Overall reaction is $4OH^- + 4H^+ \rightarrow 2H_2 + O_2 + 2H_2O$ Mole ratio of H_2:O_2 is 2:1, the volume ratio of H_2:O_2 is also 2:1 [1]	3	

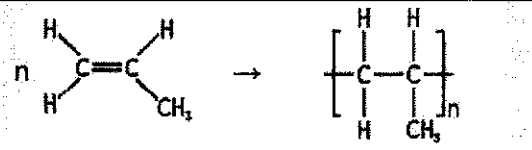
			Answers	Marks	Total
6	(a)		Volume of CO_2 = 42 cm^3	1	
	(b)		no. of moles of CO_2 = 42/1000 ÷ 24 = 0.00175 mol [1] no. of moles of HCl = 0.00175 × 2 = 0.0035 mol volume of HCl = 0.0035 ÷ 0.10 = 0.035 dm^3 = <u>35 cm^3</u> [1]	2	
	©	(i)		1	
		(ii)	$MgCO_3 + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2O + CO_2$	1	11
	(d)		In experiment 3, the higher temperature <u>leads to the particles possessing more kinetic energy</u> / <u>move faster</u> [1] frequency of collisions increases. Further more particles possess <u>energy greater than or equal to the activation energy</u>. [1] The <u>frequency of effective collisions</u> increases, [1] resulting in a <u>faster rate(or an increase in rate)</u> of reaction. [1]	4	
	(d)		Ethanoic acid is a weak acid, which only <u>partially ionises in water</u>, producing a <u>low concentration of hydrogen ions</u> than hydrochloric acid. [1] Hydrochloric acid is a strong acid which ionises completely in water to produce a high concentration of hydrogen ions[1]	2	

			Answers	Marks	Total
7	(a)		CO: binds to haemoglobin in blood, preventing flow of oxygen around the body, leading to breathing difficulties (or loss of consciousness and even death [1] OR CO binds irreversibly with the haemogobin in red blood cells. This lowers the ability of the hemoglobin to transport oxygen to the rest of the body. This can result in loss of consciouness and death. NO_2: cause acid rain, which can corrode limestone buildings/kill aquatic life/kill plants [1]	2	8
	(b)		CO: Lean burn engines have more air, so the petrol tends to undergo complete combustion to form CO_2 instead of CO / less likely to undergo incomplete combustion to form CO [1] NO_2: Lean burn engines have lower operating temperature, so nitrogen and oxygen in the air are less likely to react to form oxides of nitrogen [1] OR NO2 is formed when nitrogen reacts with oxygen at high temperature.	2	
	(c)	(i)	Catalysts provide an alternate pathway of lower activation energy allowing the reaction to proceed faster.	1	
		(ii)	CO is oxidised as the oxidation state of C increases from +2 in CO to +4 in CO_2 [1] NO_2 is reduced as the oxidation state of N decreases from +4 in NO_2 to 0 in N_2 [1] OR Carbon in CO is oxidised as the oxidation state of C increases from +2 in CO to +4 in CO_2 [1] Nitrogen in NO_2 is reduced as the oxidation state of N decreases from +4 in NO_2 to 0 in N_2 [1]	2	
		(iii)	The catalytic converter still produces carbon dioxide, which causes global warming.	1	

8	**(a)**		Ethyl butanoate	1	
	(b)		Full structural formula of alcohol:  [1] Full structural formula of carboxylic acid:  [1]	2	
	(c)		Test: Add reactive metal/carbonate [1] Outcome: If effervescence is observed, it is the acid. If there is no visible change, it is the alcohol. [1] OR Test: Add acidified $KMnO_4$ [1] Outcome: If it turns from purple to colourless, it is the alcohol. If there is no visible change, it is the acid. [1]	2	**8**
	(d)	**(i)**	C [1] Ethyl butanoate is <u>insoluble in water</u>, while alcohols and carboxylic acids are soluble in water. [1]	2	
		(ii)	If the ethyl butanoate freezes or boils at a fixed temperature, it is pure.	1	
9	**(a)**		^{12}C and ^{13}C both have 6 protons (and 6 electrons), [1] but ^{12}C has 6 neutrons while ^{13}C has 7 neutrons. [1]	2	
	(b)		There are 2 carbon atoms of the same 'type' ***d*** compared to carbon atoms ***a***, ***b*** and ***c***, which only have 1 each. [1] Because both carbon atoms ***d*** are attached to a $-C_3H_7$ alkyl group. [1]	2	
	(c)		The closer the carbon atom is to the end of the carbon chain, the lower its position on the arbitrary scale. [1] The terminal carbon, C_a, has the lowest value at 14 for isomer 1 and 12 for isomer 2. [1] The next carbon atom, C_b, has the second lowest value at 23 for isomer 1 and 25 for isomer 2 / the carbon atom in the centre of each molecule, C_c, has the highest value at 34 for isomer 1 and 32 for isomer 2. [1] OR	3	**10**

			The more alkyl groups attached to the carbon atom, the higher its position on the arbitrary scale. [1] The terminal carbon, C_a, has the lowest value at 14 for isomer 1 and 12 for isomer 2. [1] Carbon atoms with two alkyl groups attached, C_b, have the next lowest values at 23 for isomer 1 and 25 for isomer 2 / the carbon atom, C_c in isomer 2, with three alkyl groups has the highest value at 32. [1]		
	(d)	(i)		1	
		(ii)	intensity  Every 2 correct features is 1 mark: • 2 peaks • 1 peak around 10-20 • 1 peak around 30-34 • 1 peak should be 4x the intensity of the other peak (does not matter which one) Actual:  	2	

Section B (10 marks)

			Answers	Marks	Total
10	(a)	(i)	Addition polymerisation occurs when unsaturated monomers/alkenes/many small molecules join together without losing any molecules.	1	10
		(ii)		2	

			Answers	Marks	Total
	(b)		Propene has a simple molecular structure while polypropene has a macromolecular structure. [1] Polypropene has stronger intermolecular forces of attraction between its molecules than propene, [1] that requires more energy to overcome, hence polypropene has a higher melting point. [1]	3	
	(c)		Polypropene can have a range of relative molecular masses, depending on how many monomers were used to make the polymer.	1	
	(d)	(i)	The plastics are pulled into long thin strands, then cut into pellets to make new products.	1	
		(ii)	Any 2: • Different plastics may have different costs incurred in the recycling process. • Some recycled plastics have lower market value and may not be worth recycling compared to others. • Some plastics may result in more toxic chemicals produced during recycling, so the wastewater needs to be treated.	2	
11	(a)	(i)	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ [1] Every 2 underlined points is 1 mark: Glucose undergoes fermentation at 37°C, with yeast as the catalyst, in the absence of oxygen, to form ethanol. [2]	3	10
		(ii)	The carbon dioxide produced from the combustion of bioethanol [1] is offset by the carbon dioxide the biomass take in during photosynthesis. [1]	2	
	(b)	(i)	Advantages: • Biodiesel is produced at a lower temperature of 60°C compared to diesel at 600°C. [1] • Biodiesel can be obtained from recycled fat and oil, which is more sustainable than diesel, which is obtained from crude oil, a non-renewable resource. [1] Disadvantage: Diesel is obtained in a higher yield of 29% compared to biodiesel, with yield of only 11%. [1]	3	
		(ii)	Add aqueous bromine to the biodiesel sample. [1] If it contains fats, there is no visible change. If it contains oils, the reddish-brown aqueous bromine decolourises. [1]	2	