SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

Glycogen breaks down into

A. glycerol.
B. amino acids.
C. triglycerides.
D. monosaccharides.

Question 2

Using large sample sizes in an experiment increases

A. reliability.
B. precision.
C. validity.
D. uncertainty.

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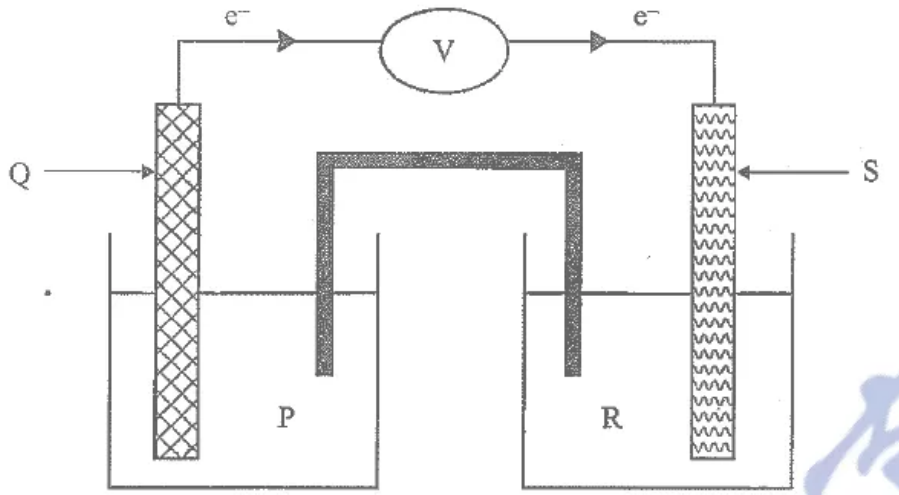
Question 3

A diagram of an electrochemical cell is shown below.



Which of the following gives the correct combination of the electrode in the oxidation half-cell and the electrolyte in the reduction half-cell?

	Electrode (oxidation half-cell)	Electrolyte (reduction half-cell)
A.	S	P
B.	S	R
C.	Q	R
D.	Q	P

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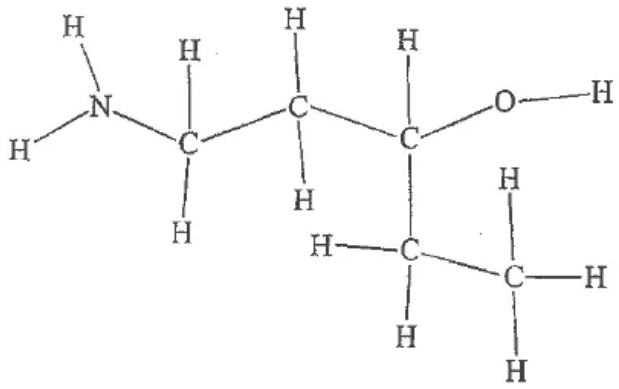
Question 4



What is the IUPAC name of the molecule shown above?

A. 3-hydroxy-3-ethyl-propan-1-amine

B. 3-amino-1-methylpropan-1-ol

C. 3-hydroxypentan-1-amine

D. 1-aminopentan-3-ol

Question 5

The metabolic process that produces water is

A. the digestion of fats.

B. cellular respiration.

C. the hydrolysis of starch.

D. the breakdown of protein into amino acids.

Question 6

Which one of the following pairs of statements is correct for both electrolysis cells and galvanic cells?

	Electrolysis cell	Galvanic cell
A.	Both electrodes are always inert.	Both electrodes are always made of metal.
B.	Electrical energy is converted to chemical energy.	The voltage of the cell is independent of the electrolyte concentration.
C.	Chemical energy is converted to electrical energy.	The products are dependent on the half-cell components.
D.	The products are dependent on the half-cell components.	Chemical energy is converted to electrical energy.

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Question 7

How many structural isomers have the molecular formula C_3H_6BrCl?

A. 4
B. 5
C. 6
D. 7

Question 8

Which one of the following is the most correct statement about fuel cells and secondary cells?

A. Fuel cells can be recharged like secondary cells.
B. Fuel cells produce thermal energy, whereas secondary cells do not produce thermal energy.
C. The anode in a fuel cell is positive, whereas the anode in a secondary cell is negative.
D. Fuel cells deliver a constant voltage during their operation, whereas secondary cells reduce in voltage as they discharge.

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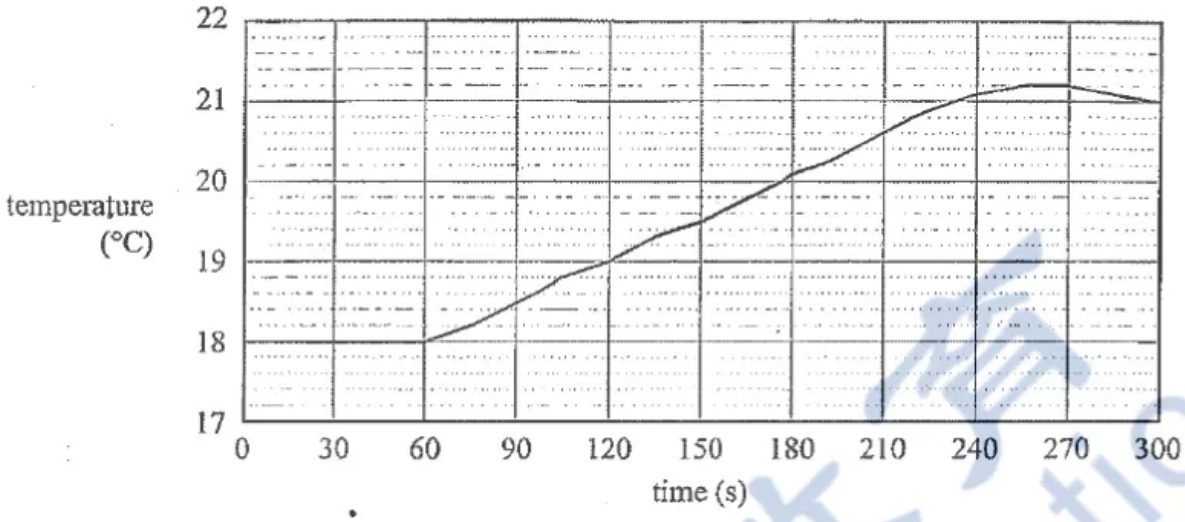
Use the following information to answer Questions 9 and 10.

A solution calorimeter containing 350 mL of water was set up. The calorimeter was calibrated electrically and the graph of the results is shown below.

Graph of temperature versus time during electrical calibration of solution calorimeter



The calorimeter was calibrated using a current of 2.7 A, starting at 60 s. The current was applied for 180 s and the applied voltage was 5.4 V.

Question 9

What is the calibration factor for this calorimeter?

A. 125 J °C^{-1}
B. 820 J °C^{-1}
C. 847 J °C^{-1}
D. 875 J °C^{-1}

Question 10

This type of calorimeter

A. has no heat loss.
B. can be used for bomb calorimetry.
C. requires electrical calibration in order to determine the calibration factor.
D. measures energy changes that can be measured in a bomb calorimeter.

D is the most suitable choice in this question

Question 11

Which one of the following statements is correct?

A. Crude oil can be classified as a biofuel because it originally comes from plants.

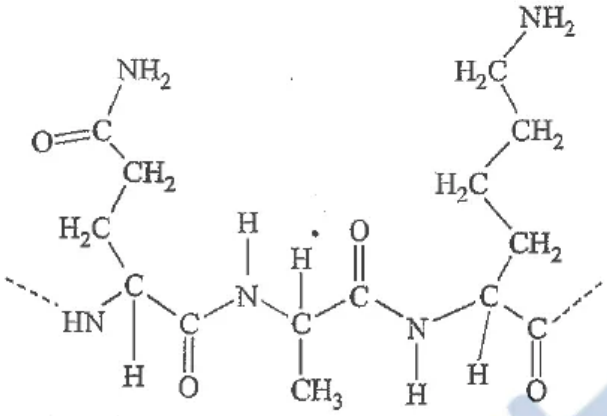
B. Methane, CH_4, can be classified as a fossil fuel because it has major environmental impacts.

C. Ethanol, CH_3CH_2OH, can be classified as a fossil fuel because it can be produced from crude oil.

D. Hydrogen, H_2, can be classified as a biofuel because, when it combusts, it does not produce carbon dioxide, CO_2.

Question 12

The diagram below represents a section of an enzyme.



The diagram can be described as a

A. secondary structure consisting of glutamine, glycine and lysine.

B. primary structure consisting of asparagine, glycine and lysine.

C. secondary structure consisting of asparagine, alanine and lysine.

D. primary structure consisting of glutamine, alanine and lysine.

Question 13

Hydrogen, H_2, fuel cells and H_2-powered combustion engines can both be used to power cars. Three statements about H_2 fuel cells and H_2-powered combustion engines are given below:

I Neither H_2 fuel cells nor H_2-powered combustion engines produce greenhouse gases.

II Less H_2 is required per kilometre travelled when using an H_2-powered combustion engine than when using H_2 fuel cells.

III More heat per kilogram of H_2 is generated in an H_2-powered combustion engine than in H_2 fuel cells.

Which of the statements above are correct?

A. II only

B. I and II only

C. III only

D. I and III only

Use the following information to answer Questions 14 and 15.

The magnitude of the equilibrium constant, K_c, at 25 °C for the following reaction is 640.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.3 \text{ kJ mol}^{-1}$$

Question 14

For the reaction $\frac{1}{3}N_2(g) + H_2(g) \rightleftharpoons \frac{2}{3}NH_3(g)$, the magnitude of K_c at 25 °C is

A. 9 and $\Delta H = -30.8$ kJ mol^{-1}
B. 213 and $\Delta H = -30.8$ kJ mol^{-1}
C. 640 and $\Delta H = -30.8$ kJ mol^{-1}
D. 640 and $\Delta H = -92.3$ kJ mol^{-1}

Question 15

For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

A. a catalyst increases the number of collisions between the reactants.
B. the rate of the forward reaction increases when the temperature increases.
C. a catalyst reduces the activation energy of the forward and backward reactions by the same proportion.
D. the activation energy of the forward reaction is greater than the activation energy of the reverse reaction.

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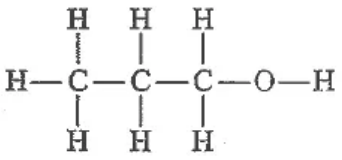
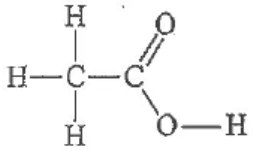
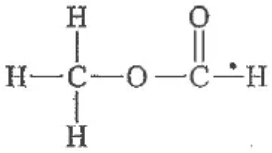
Question 16

The following table provides information about three organic compounds, X, Y and Z.

Compound	Structural formula	Molar mass ($g\ mol^{-1}$)	Boiling point (°C)
X		60	97
Y		60	118
Z		60	?

Which one of the following is the best estimate for the boiling point of Compound Z?

A. 31 °C
B. 101 °C
C. 114 °C
D. 156 °C

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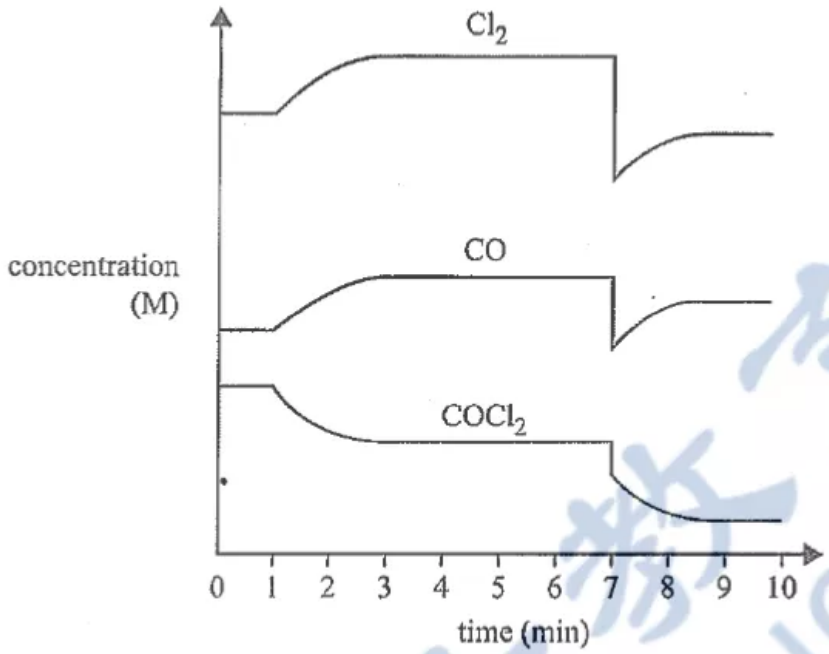
Question 17

The following equation represents the reaction between chlorine gas, Cl_2, and carbon monoxide gas, CO.

$$Cl_2(g) + CO(g) \rightleftharpoons COCl_2(g) \qquad \Delta H = -108 \text{ kJ mol}^{-1}$$

The concentration–time graph below represents changes to the system.



Which of the following identifies the changes to the system that took place at 1 minute and at 7 minutes?

	1 minute	7 minutes
A.	increase in temperature	increase in volume
B.	decrease in temperature	decrease in volume
C.	decrease in temperature	increase in volume
D.	increase in temperature	decrease in volume

Question 18

An experiment was carried out to determine the enthalpy of combustion of propan-1-ol. Combustion of 557 mg of propan-1-ol increased the temperature of 150 g of water from 22.1 °C to 40.6 °C.

The enthalpy of combustion is closest to

A. -2742 kJ mol^{-1}

B. -1208 kJ mol^{-1}

C. -1250 kJ mol^{-1}

D. -1540 kJ mol^{-1}

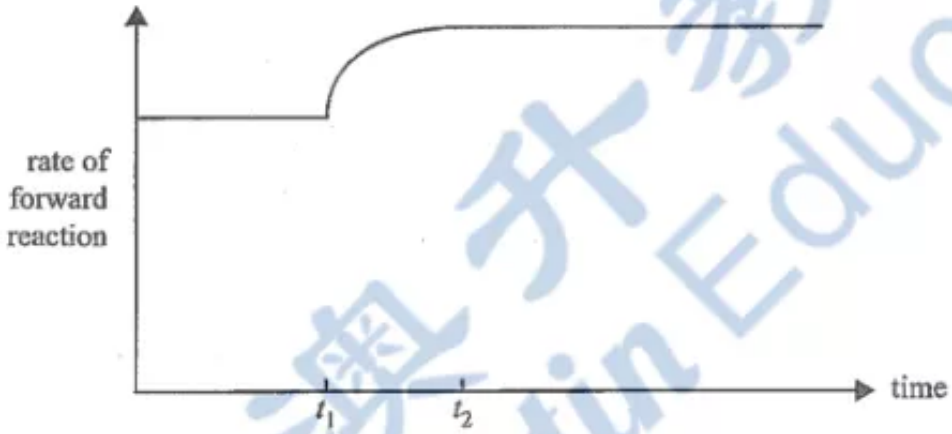
Question 19

Nitrogen dioxide, NO_2, and dinitrogen tetroxide, N_2O_4, form an equilibrium mixture represented by the following equation.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57.2 \text{ kJ mol}^{-1}$$

brown colourless

A change was made at time t_1 to an equilibrium mixture of NO_2 and N_2O_4, which achieved a new equilibrium at time t_2. A graph showing the rate of the forward reaction is shown below.



Which one of the following describes the change that was made to the initial equilibrium system and the colour change that occurred between t_1 and t_2?

A. The temperature was increased and the colour lightened.

B. The temperature was increased and the colour darkened.

C. The temperature was decreased and the colour lightened.

D. The temperature was decreased and the colour darkened.

Question 20

Consider the following changes that could be applied to the operating parameters for a chromatogram set up to carry out high-performance liquid chromatography (HPLC) with a polar stationary phase and a non-polar mobile phase:

I decreasing the viscosity of the mobile phase

II using a more tightly packed stationary phase

III using a mobile phase that is more polar than the stationary phase

Which of the changes would be most likely to reduce the retention time of a sugar in the HPLC?

A. I only

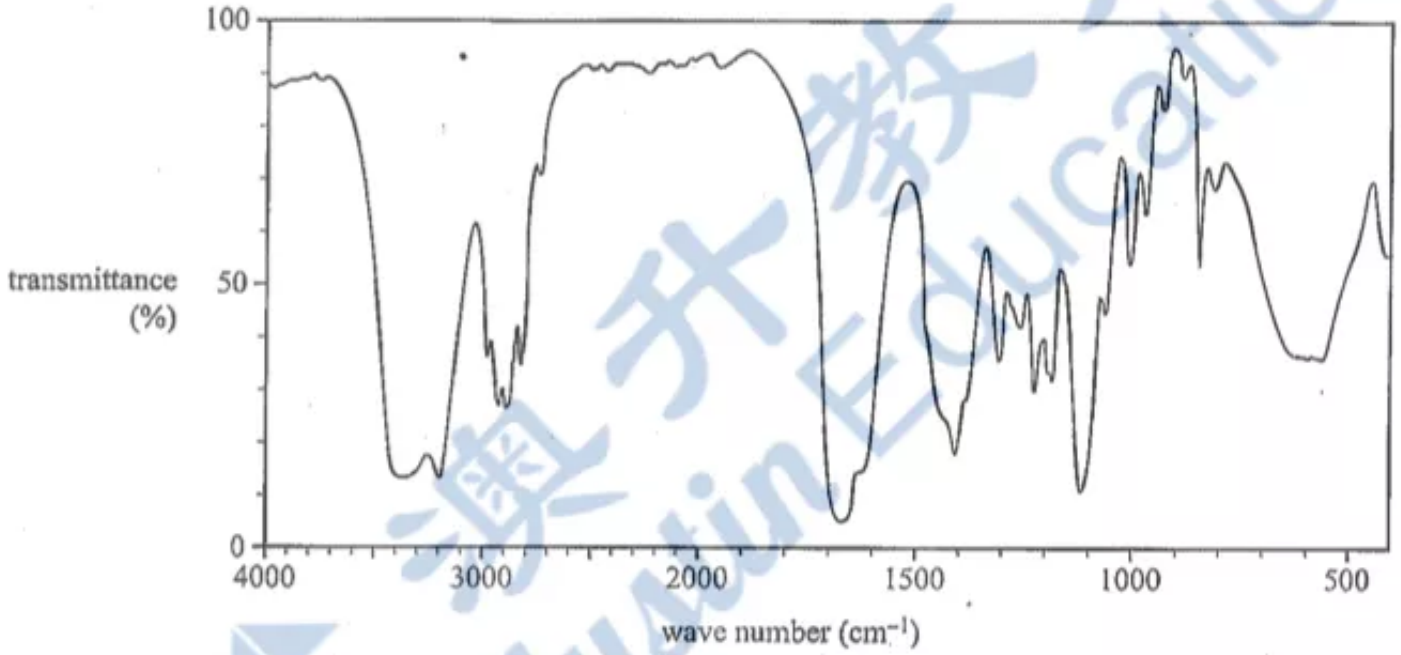
B. I and III only

C. III only

D. II and III only

Question 21

The infra-red (IR) spectrum of an organic compound is shown below.



Data: SDBS Web, <https://sdbs.db.aist.go.jp>, National Institute of Advanced Industrial Science and Technology

Referring to the IR spectrum above, the compound could be

A. $CH_3CH_2COOCH_3$

B. $CH_3CH_2CH_2CHO$

C. $NH_2CH_2CH_2CONH_2$

D. $NH_2CH_2CH_2CHOHCH_3$

Question 22

The combustion of which fuel provides the most energy per 100 g?

A. pentane ($M = 72$ g mol^{-1}), which releases 49 097 MJ tonne^{-1}

B. nitromethane ($M = 61$ g mol^{-1}), which releases 11.63 kJ g^{-1}

C. butanol ($M = 74$ g mol^{-1}), which releases 2670 kJ mol^{-1}

D. ethyne ($M = 26$ g mol^{-1}), which releases 1300 kJ mol^{-1}

Use the following information to answer Questions 23 and 24.

A solution of citric acid, $C_3H_5O(COOH)_3$, was analysed by titration.

25.0 mL aliquots of the $C_3H_5O(COOH)_3$ solution were titrated against a standardised solution of 0.0250 M sodium hydroxide, NaOH. Phenolphthalein indicator was used and the average titre was found to be 24.0 mL.

Question 23

Based on the titration, the concentration of $C_3H_5O(COOH)_3$ in the solution was

A. 8.0×10^{-3} M

B. 8.7×10^{-3} M

C. 2.6×10^{-2} M

D. 7.2×10^{-2} M

Question 24

Which one of the following would have resulted in a concentration that is higher than the actual concentration?

A. The pipette was rinsed with NaOH solution.

B. The pipette was rinsed with $C_3H_5O(COOH)_3$ solution.

C. The conical flask was rinsed with NaOH solution.

D. The conical flask was rinsed with $C_3H_5O(COOH)_3$ solution.

Question 25

Petrodiesel is made up of a number of different molecules, including $C_{12}H_{26}$. Biodiesel often contains $C_{11}H_{22}O_2$.

When comparing $C_{12}H_{26}$ and $C_{11}H_{22}O_2$, which one of the following statements is correct?

A. $C_{12}H_{26}$ has a higher viscosity due to the dispersion forces between the molecules.

B. $C_{12}H_{26}$ is less hygroscopic as it has only dispersion forces between the molecules.

C. $C_{11}H_{22}O_2$ has a higher energy content when it combusts as it contains oxygen atoms.

D. $C_{11}H_{22}O_2$ produces more carbon dioxide per mole when it combusts due to its higher molecular weight.

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Question 26

The following reactions occur in a primary cell battery.

$$Zn + 2OH^- \rightarrow ZnO + H_2O + 2e^-$$
$$2MnO_2 + 2e^- + H_2O \rightarrow Mn_2O_3 + 2OH^-$$

Which one of the following statements about the battery is correct?

A. The reaction produces heat and Zn reacts directly with MnO_2.
B. The reaction produces heat and Zn does not react directly with MnO_2.
C. The reaction does not produce heat and Zn reacts directly with MnO_2.
D. The reaction does not produce heat and Zn does not react directly with MnO_2.

Use the following information to answer Questions 27 and 28.

The heat of combustion of ethanoic acid, $C_2H_4O_2$, is -876 kJ mol^{-1} and the heat of combustion of methyl methanoate, $C_2H_4O_2$, is -973 kJ mol^{-1}. The auto-ignition temperature (the temperature at which a substance will combust in air without a source of ignition) of ethanoic acid is 485 °C and the auto-ignition temperature of methyl methanoate is 449 °C.

Question 27

Which one of the following pairs is correct?

	Compound with the lower chemical energy per mole	Compound with the lower activation energy of combustion per mole
A.	ethanoic acid	methyl methanoate
B.	ethanoic acid	ethanoic acid
C.	methyl methanoate	methyl methanoate
D.	methyl methanoate	ethanoic acid

Question 28

If 0.1 mol of ethanoic acid and 0.1 mol of methyl methanoate were completely combusted in two separate closed vessels under identical conditions, the Maxwell-Boltzmann distribution of the product gases from the combustion of ethanoic acid would be

A. broader than the Maxwell-Boltzmann distribution of the methyl methanoate product gases and the chemical energy of the product gases would be identical.
B. narrower than the Maxwell-Boltzmann distribution of the methyl methanoate product gases and the chemical energy of the product gases would be identical.
C. broader than the Maxwell-Boltzmann distribution of the methyl methanoate product gases and the chemical energy of the ethanoic acid product gases would be higher.
D. narrower than the Maxwell-Boltzmann distribution of the methyl methanoate product gases and the chemical energy of the ethanoic acid product gases would be higher.

Question 29

Which of the following combinations of bonds can be broken during the breakdown of a protein that a person has eaten?

A. covalent bonds in the secondary structure and hydrogen bonds in the primary structure
B. covalent bonds in the tertiary structure and hydrogen bonds in the secondary structure
C. covalent bonds in the secondary structure and hydrogen bonds in the tertiary structure
D. covalent bonds in the quaternary structure and hydrogen bonds in the primary structure

Question 30

Consider the following half-equation.

$$ClO_2(g) + e^- \rightleftharpoons ClO_2^-(aq)$$

It is also known that:

- $ClO_2(g)$ will oxidise HI(aq), but not HCl(aq)
- $Fe^{3+}(aq)$ will oxidise HI(aq), but not $NaClO_2(aq)$.

Based on this information, $Fe^{2+}(aq)$ can be oxidised by

A. $Cl_2(g)$ and $I_2(aq)$.
B. $Cl_2(g)$, but not $ClO_2(g)$.
C. $ClO_2(g)$ and $Cl_2(g)$, but not $I_2(aq)$.
D. $Cl_2(g)$, $ClO_2(g)$ and $I_2(aq)$.

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SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, $NaCl(s)$.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

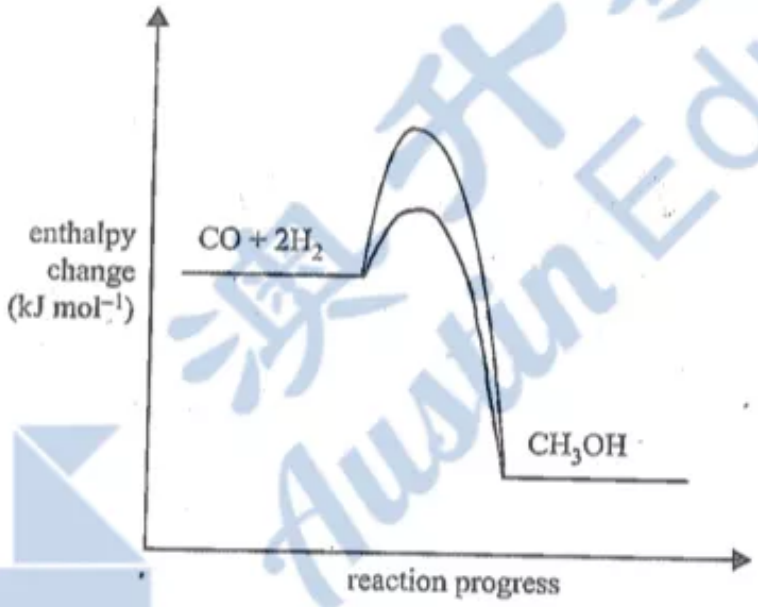
Question 1 (9 marks)

Methanol is a very useful fuel. It can be manufactured from biogas.

The main reaction in methanol production from biogas is represented by the following equation.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H < 0$$

This reaction requires the use of a catalyst to maximise the yield of methanol produced in optimum conditions. The energy profile diagram below represents the uncatalysed reaction.



a. On the energy profile diagram above, sketch how the catalyst would alter the reaction pathway. 1 mark

b. i. **How** does the reaction temperature affect the yield of methanol from biogas? In your answer, refer to Le Chatelier's principle. 2 marks

- Exothermic reaction
- Increasing temp → LCP system responds by favouring endothermic
- favour backward → decrease yield

ii. How does the reaction pressure affect the yield of methanol from biogas? In your answer, refer to Le Chatelier's principle. 2 marks

- Fewer particles on Product side
- Increasing pressure → by LCP: system responds by favouring fewer side
- favour forward → increase yield

c. Write the expression for the equilibrium constant, K_c, for this reaction. 1 mark

$$K_c = \frac{[CH_3OH_{(g)}]}{[H_{2(g)}]^2 \cdot [CO_{(g)}]}$$

d. 0.760 mol of carbon monoxide, CO, and 0.525 mol of hydrogen, H_2, were allowed to reach equilibrium in a 500 mL container. At equilibrium the mixture contained 0.122 mol of methanol.

Calculate the equilibrium constant, K_c. "I<E" 3 marks

(n)

	CO	$2H_2$	CH_3OH
I	0.760	0.525	0
C	−0.122	−0.244	+0.122
E	0.638	0.281	0.122

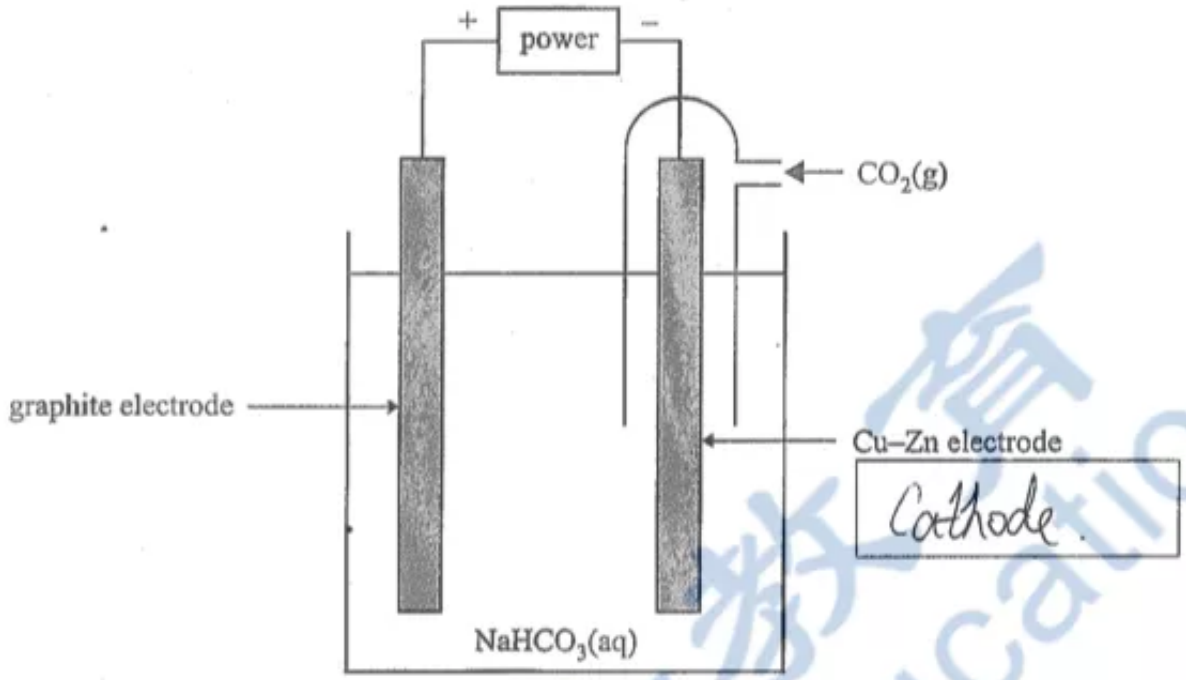
$$\frac{\frac{0.122}{0.5}}{\left(\frac{0.281}{0.5}\right)^2 \cdot \frac{0.638}{0.5}} = 0.605\ M^{-2}$$

unit

Question 2 (8 marks)

The electrolysis of carbon dioxide gas, CO_2, in water is one way of making ethanol, C_2H_5OH.

The diagram below shows a CO_2–H_2O electrolysis cell. The electrolyte used in the electrolysis cell is sodium bicarbonate solution, $NaHCO_3(aq)$.



The following half-cell reactions occur in the CO_2–H_2O electrolysis cell.

$$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq) \qquad E^0 = +0.40\ V$$
$$2CO_2(g) + 9H_2O(l) + 12e^- \rightleftharpoons C_2H_5OH(l) + 12OH^-(aq) \qquad E^0 = -0.33\ V$$

a. Identify the Cu–Zn electrode as either the anode or the cathode in the box provided in the diagram above. 1 mark

b. Determine the applied voltage required for the electrolysis cell to operate. 1 mark

0.73V

c. Write the balanced equation for the overall electrolysis reaction. 1 mark

$2CO_{2(g)} + 3H_2O_{(l)} \rightarrow C_2H_5OH_{(l)} + 3O_{2(g)}$

d. **Identify** the oxidising agent in the electrolysis reaction. Give your reasoning using oxidation numbers. 2 marks

- $CO_2(g)$ is the oxidising agent
- CO_2 : C +4

C_2H_5OH : C −2

e. A current of 2.70 A is passed through the CO_2–H_2O electrolysis cell. The cell has an efficiency of 58%.

Calculate the time taken, in minutes, for this cell to consume 6.05×10^{-3} mol of $CO_2(g)$. 3 marks

$n(CO_2) : n(e^-) = \frac{I \times t}{F}$

$\frac{6.05 \times 6 \times 10^{-3}}{58\%} = \frac{2.7 \times t}{96500}$

$t = 2236.8s \rightarrow 37.3$ mins

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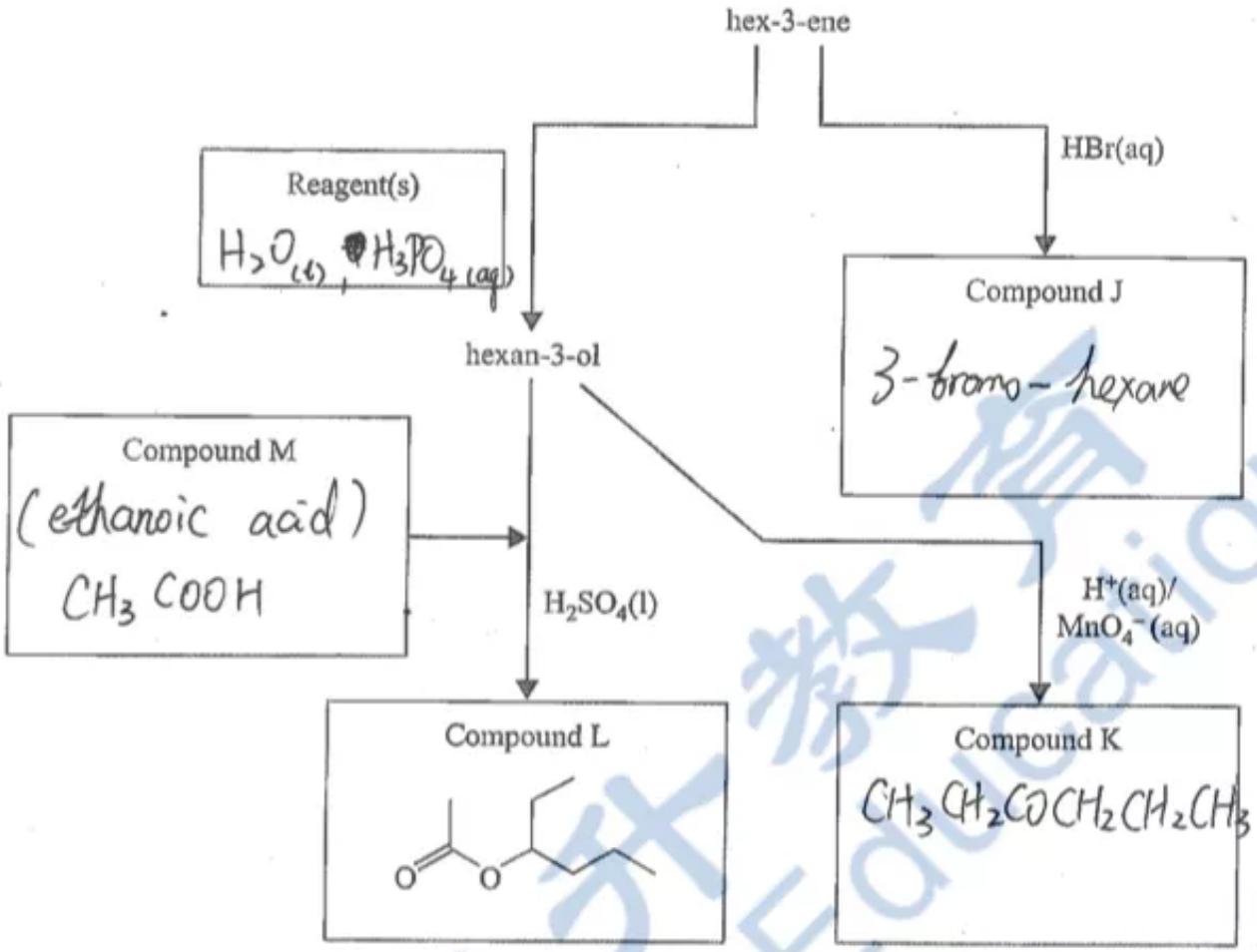
Question 3 (7 marks)

Below is a reaction pathway beginning with hex-3-ene.



a. Write the IUPAC name of Compound J in the box provided. 1 mark

b. State the reagent(s) required to convert hex-3-ene to hexan-3-ol in the box provided. 1 mark

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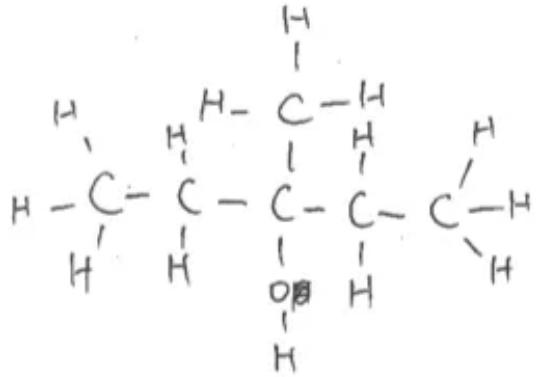
c. Draw the structural formula for a tertiary alcohol that is an isomer of hexan-3-ol.



d. Hexan-3-ol is reacted with Compound M under acidic conditions to produce Compound L.

Draw the semi-structural formula for Compound M in the box provided on page 20. 1

e. **i.** Draw the semi-structural formula for Compound K in the box provided on page 20. 1

ii. Name the class of organic compound (homologous series) to which Compound K belongs. 1

Ketone

f. What type of reaction produces Compound K from hexan-3-ol? 1

Oxidation

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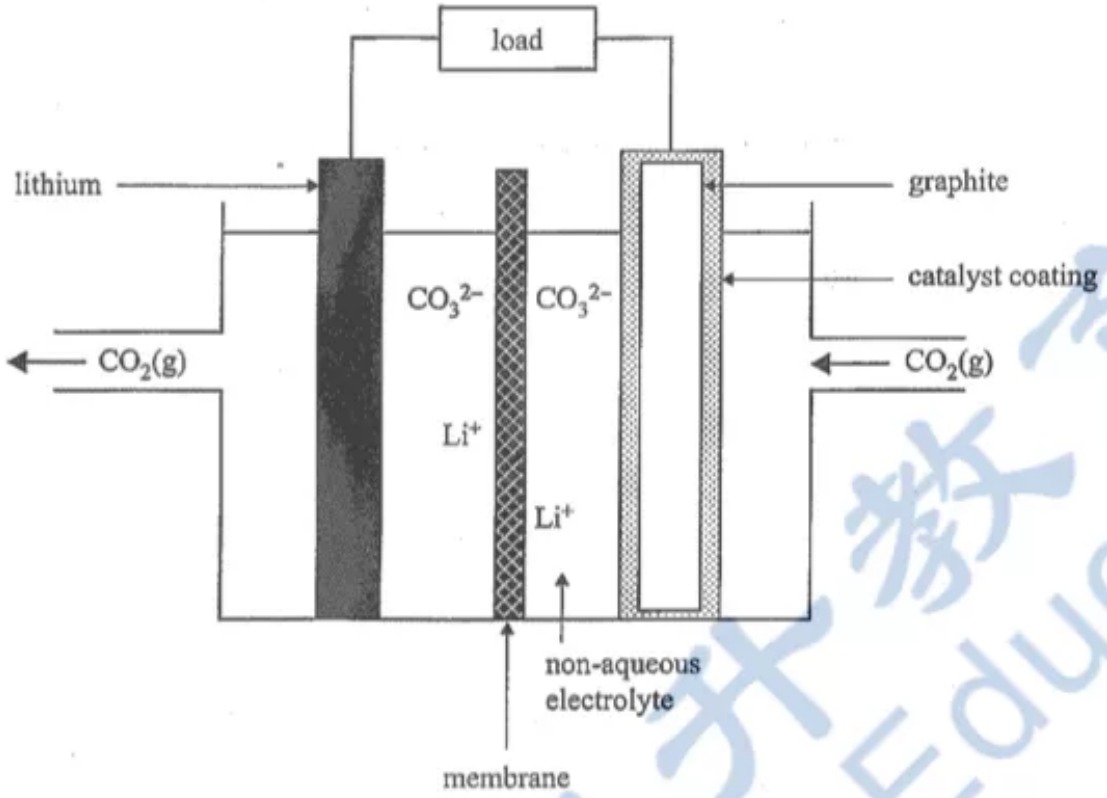
tion 4 (7 marks)

ırch scientists are developing a rechargeable lithium–carbon dioxide, Li–CO_2, battery. The **rgeable Li–CO_2** battery is made of lithium metal, carbon in the form of graphite (coated with a **'st) and a** non-aqueous electrolyte that absorbs CO_2.

gram of the rechargeable Li–CO_2 cell is shown below. One Li–CO_2 cell generates 4.5 V.



When the Li–CO_2 cell generates electricity, the **two half-cell reactions are**

$$4Li^+ + 3CO_2 + 4e^- \rightarrow 2Li_2CO_3 + C$$

$$Li \rightarrow Li^+ + e^-$$

Write the equation for the overall recharge reaction. 1 mark

$2Li_2CO_3 + C \rightarrow 4Li + 3CO_2$

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b. During discharge, lithium carbonate, Li_2CO_3, deposits break away from the electrode.

Describe how this might affect the performance of the battery. 2

- Products of discharge need to remain in vicinity to electrode to allow recharge cycle.
- deposits breaking away means battery will gradually lose its recharging capacity.

c. Explain why it is unsafe to use an aqueous electrolyte in the design of the Li–CO_2 battery. Include appropriate equations in your answer. 3

① A possible reaction will be:

$2Li_{(s)} + 2H_2O_{(l)} + 2Li^+_{(aq)} + H_{2(g)} + 2OH^-_{(aq)}$

② This is a spontaneous reaction and will readily happen and release large amount of heat

③ A vigorous release of H_2 is dangerous

d. Could the Li–CO_2 battery be used to reduce the amount of CO_2(g) in the atmosphere? Give your reasoning. 1

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stion 5 (9 marks)

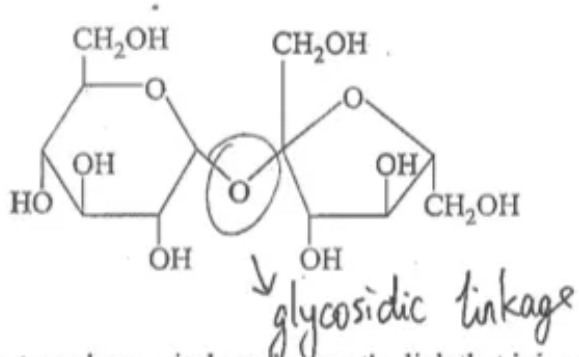
anas provide essential vitamins and minerals, such as vitamin B_6 and vitamin C, along with dietary fibre energy. During the ripening process, the banana changes in appearance, texture and taste.

pe banana contains a high amount of glucose, whereas an unripe banana contains up to 80% starch.

Write a balanced equation for cellular respiration. 1 mark

$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{(g)} + 6H_2O_{(l)}$

The structure of a disaccharide found in a ripe banana is shown below.



i. On the structure above, circle and name the link that joins the two sugar units that make up the disaccharide. 1 mark

ii. Name the two sugar units that make up this disaccharide. 1 mark

glucose + fructose

iii. Banana skins are primarily composed of cellulose.

Suggest why cellulose cannot be used as a source of energy in the human body. 1 mark

lack of proper enzyme to digest

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c. The table below shows the amount of each nutrient in 100 g of banana.

Nutrient	Per 100 g
protein	1.1 g
carbohydrates	22.8 g
fat	0.3 g
dietary fibre	2.6 g

An athlete uses 300 kJ of energy for a five-minute run. A typical ripe banana has an average mass of 116 g after it is peeled.

How many typical ripe bananas, correct to two decimal places, would the athlete need to consume to replace the energy used during the run? Show your working. 3

E from one banana:

$\frac{1.1\times17 + 22.8\times16 + 0.3\times37}{100} \times 116 = 457.736\text{ kJ}$

$\frac{300}{457.736} = 0.66$

d. During the ripening process, the enzyme amylase breaks down starch molecules into disaccharides and monosaccharides.

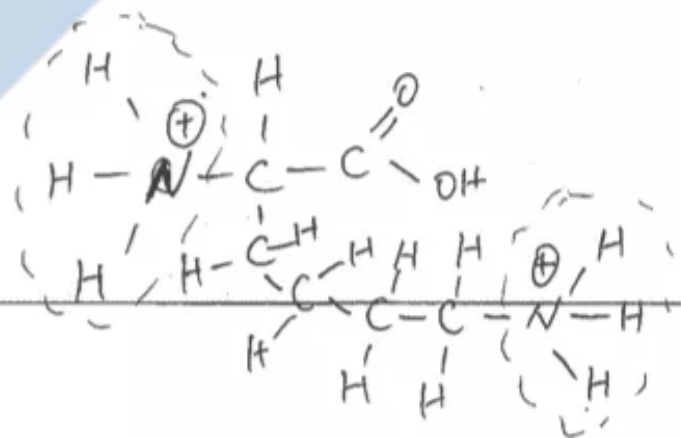
i. What name is given to this type of reaction? 1

hydrolysis

ii. The amino acid lysine is present in the primary sequence of amylase.

Draw the structural formula for the amino acid lysine in a low-pH solution. 1

At low pH



ion 6 (8 marks)

ıne gas, CH_4, can be captured from the breakdown of waste in landfills. CH_4 is also a primary ɔnent of natural gas. CH_4 can be used to produce energy through combustion.

Write the equation for the incomplete combustion of CH_4 to produce carbon monoxide, CO. 1 mark

$2CH_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{(g)} + 4H_2O_{(l)}$

f 20.0 g of CH_4 is kept in a 5.0 L sealed container at 25 °C, what would be the pressure in the ontainer? 2 marks

$PV = nRT \qquad P = \frac{\frac{20}{16} \times 8.31 \times 298}{5} = 6.2 \times 10^2 \text{ kPa}$

A Bunsen burner is used to heat a beaker containing 350.0 g of water. Complete combustion of 0.485 g f CH_4 raises the temperature of the water from 20 °C to 32.3 °C.

Calculate the percentage of the Bunsen burner's energy that is lost to the environment. 3 marks

$\frac{mc\Delta T}{0.485 \times 55.6} = \frac{350 \times 4.18 \times 12.3 \div 1000}{0.485 \times 55.6} = 0.667$

$\text{loss\%} = (1 - 0.667) \times 100\% = 33\%$

Compare the environmental impact of CH_4 obtained from landfill to the environmental impact of CH_4 btained from natural gas. 2 marks

- The pollutants (SO_2, NO_2, etc) produced are less in quatity from CH_4 produced from landfill
- less net CO_2 will be produced if CH_4 is obtained from landfill as CO_2 can be balanced by photosynthesis.

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Question 7 (15 marks)

Inside the shell of an egg is egg white that encircles egg yolk. The nutrition information for egg yolk and egg white is given in Table 1.

Table 1

Nutrient	Per 100 g of egg yolk	Per 100 g of egg white
energy	1437 kJ	184 kJ
fat	27.0 g	trace amounts
carbohydrate	0.0 g	0.0 g
protein	16.4 g	10.8 g

a. Poaching an egg involves cracking an egg and carefully placing the contents in a pan of hot water. This allows the egg white to solidify around the egg yolk.

Using your knowledge of chemistry, explain why vinegar is sometimes added to the water to produce a poached egg with a runny yolk. 3

- vinegar = acid
- low pH environment may affect tertiary by disrupting ionic interaction between amino acid residues
- Acid also interact with intermolecular bonds and can disrupt H-bonding in secondary and tertiary structure
- these alter overall protein structure, leads to denaturation of protein in yolk which will prevent formation of regular protein structure in yolk.

The composition of fatty acids found in an egg yolk sample is given in Table 2. The melting points for the first three fatty acids are provided.

Table 2

Fatty acid	Percentage (%)	Melting point (°C)
palmitic	25.9	63
stearic	9.1	69
palmitoleic	3.4	0
oleic	40.9	
linoleic	16.3	
linolenic	2.9	
arachidonic	1.5	

i. The composition of fatty acids in an egg yolk was determined by reacting the fatty acids with methanol to produce methyl esters and then analysing the methyl esters using chromatography.

Explain, using the principles of chromatography, how each fatty acid in the egg yolk sample can be identified and the percentage determined. 3 marks

- by having mobile phase and stationary phase with distinct chemical properties (e.g polar, non-polar), the rate of ~~also~~ adsorb/desorb of different acids will be different
- This results in different retention time, and by running another identical test with standards, this time can be compared and type of acid identified.
- A calibration curve can be plotted using standards of different conc. and match peak area (detector response) to identify quantitative percentage of sample.

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ii. Identify the fatty acid in Table 2 that would have the lowest flash point. Explain your answer in terms of both the:
- melting point trends shown in Table 2
- structure and bonding of the fatty acids. 4

arachidonic acid. 1 point
By comparing palmitic and palmitoleic acid, the melting point will be significantly reduced by one C=C bond, in ~~contact~~ contrast comparing stearic and palmitic acid, ~~increas~~ melting pointing is slightly increased with increasing molar mass only 2 points As melting point reflect intermolecular steric Therefore arachidonic acid will have the lowest intermolecular force because it has the most C=C, hence ~~it~~ the lowest flash point 1 point

c. i. Give the molecular formula and the molar mass of the triglyceride formed from three palmitoleic acid molecules. 2

$C_{51}H_{62}O_6$
$M = 12\times51+62+6\times16$
$= 770\ g/mol$

ii. Calculate the mass of iodine, I_2, in grams, that reacts in an addition reaction with 100.0 g of the triglyceride formed from three palmitoleic acid molecules. 3

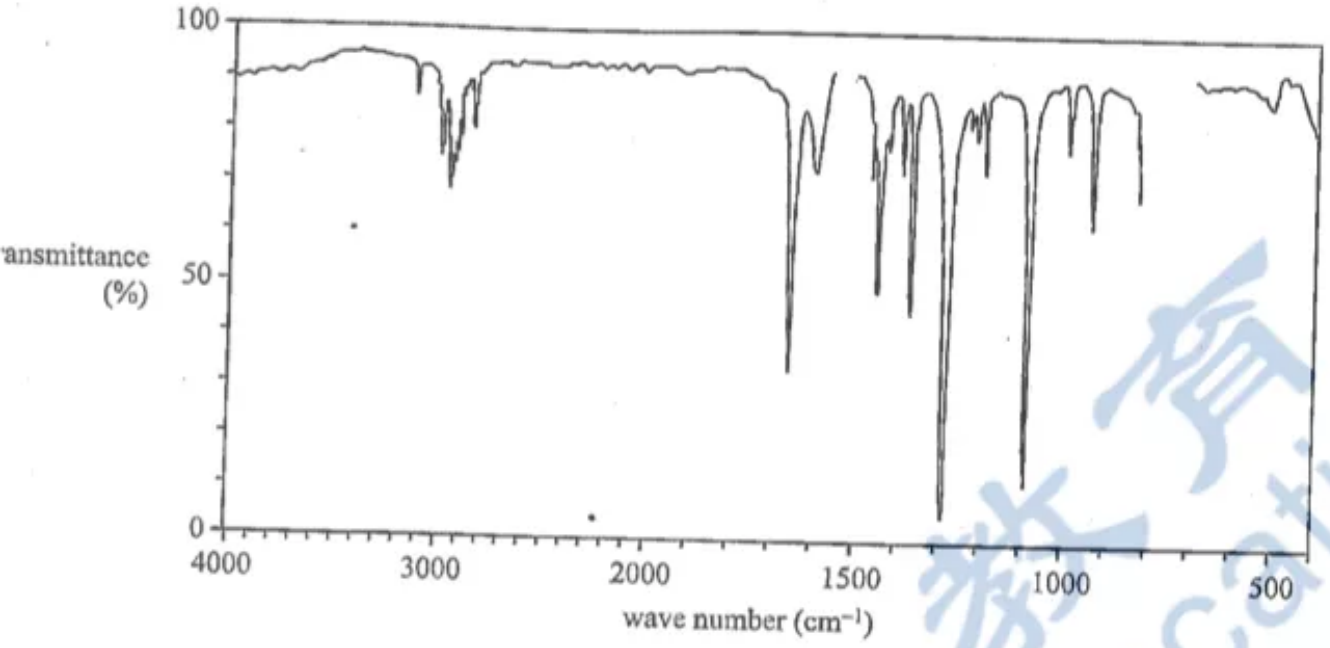
∵ For one ~~pa~~ palmitoleic acid, there is one C=C bond
∴ $\frac{100}{770}\times3\ n(C=C) = \frac{100}{770}\times3$
For one C=C bond, one I_2 molecule is needed
∴ $m(I_2) = 253.8\times n(C=C)$
$= 98.88\ g$

stion 8 (7 marks)

unknown organic compound has a molecular formula of C_4H_8O.

compound is **non-cyclic** and contains a **double bond.**

infra-red (IR) spectrum of the molecule is shown below.



Data: SDBS Web, <https://sdbs.db.aist.go.jp>, National Institute of Advanced Industrial Science and Technology

What does the region 3100–4000 cm^{-1} indicate about the bonds in C_4H_8O? Give your reasoning. 2 marks

- presence of C–H bond
- lack of –OH (board band)

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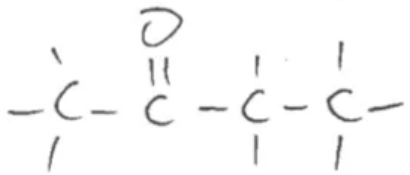
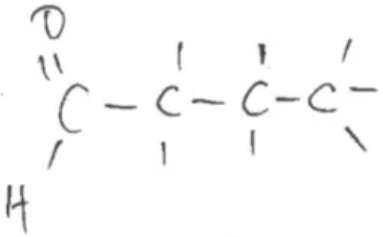
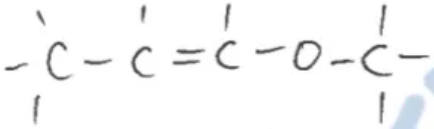
b. The ^{13}C NMR spectrum of the unknown compound has four distinct peaks.

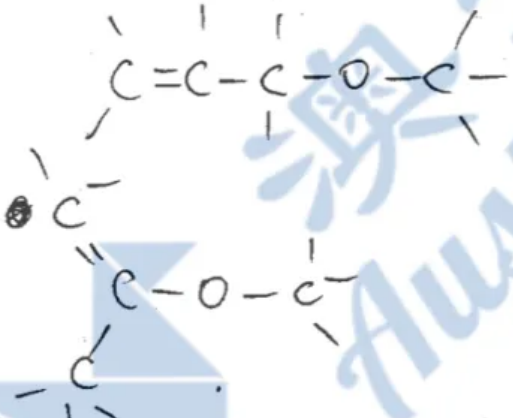
Draw **two** possible structural formulas of the unknown compound using the information provided. 2

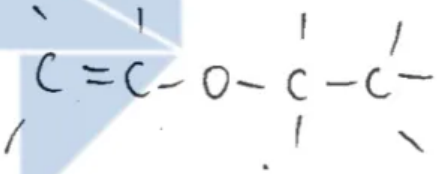
Any two of the following:











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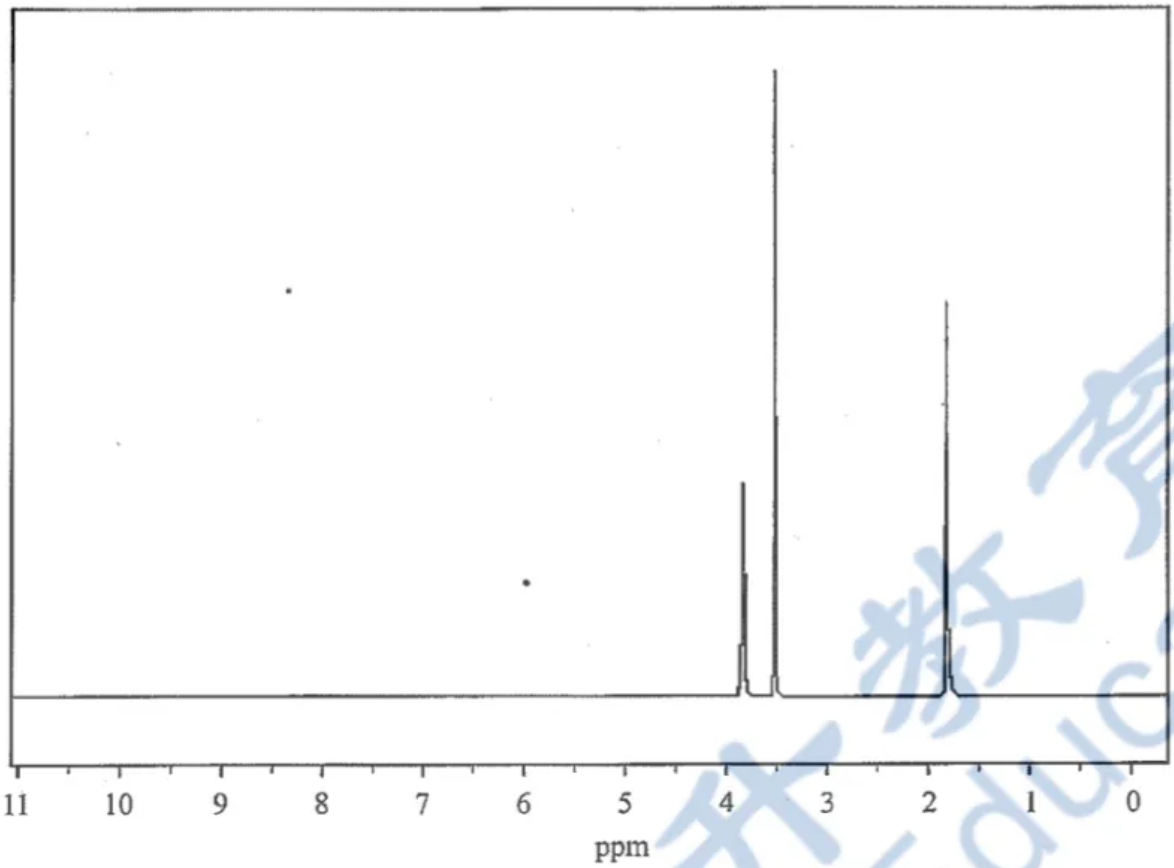
The high-resolution ^{1}H NMR spectrum of the unknown compound has three single peaks, as shown below.



Data: SDBS Web, <https://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

Chemical shift (ppm)	Relative peak area
1.82	3
3.53	3
3.85	2

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Refer to the ^{1}H NMR spectrum and the table of spectrum information provided on page 32.

Identify three pieces of information about the unknown compound and indicate how each would assist in determining its structure.

1. 3 peak ⇒ 3 different hydrogen environment

2. 3 single peak → no adjacent H on neighbouring carbons for all H environment

3. Relative peak area ~~is~~ indicate no. of H in each environment is 3:3:2

4 chemical shift indicate the type of H environment

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tion 9 (13 marks)

dent decided to investigate the effect of temperature on the rate of the following reaction.

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

f the student's experimental report is provided below.

ct of temperature on the rate of production of carbon dioxide gas

nd out how temperature affects the rate of production of carbon dioxide gas, CO_2, when a solution of ochloric acid, HCl, is added to chips of calcium carbonate, $CaCO_3$

iod

ut 0.6 g of $CaCO_3$ chips into a conical flask.

ut a reagent bottle containing 2 M HCl into a water bath at 5 °C.

hen the temperature of the HCl solution has stabilised at 5 °C, use a pipette to put 10.0 mL of the HCl lution into the conical flask containing the $CaCO_3$ chips.

t a balloon over the conical flask and begin timing.

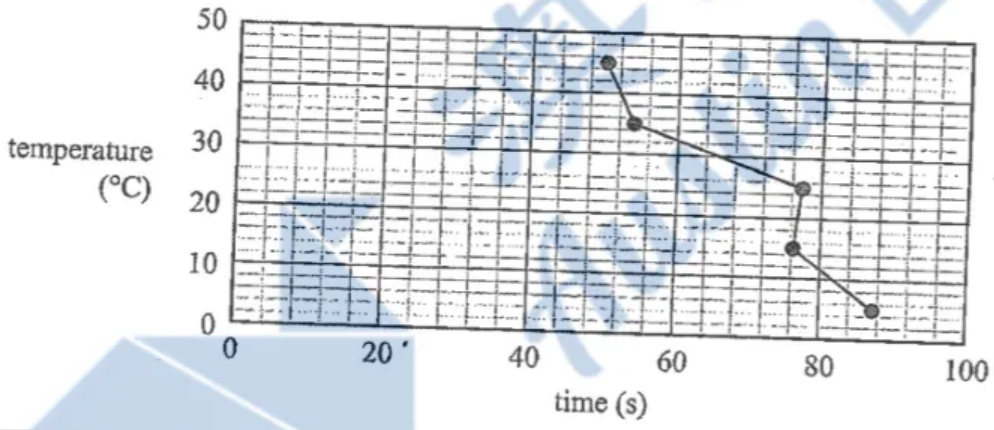
hen the top of the balloon has inflated so that it is 10 cm over the conical flask, stop timing and record the ne.

peat steps 1–5 using temperatures of 15 °C, 25 °C, 35 °C and 45 °C.

ts

llowing graph gives the experimental results.

Graph of experimental results



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a. What does the student need to do to ensure that they comply with all applicable safety guidelines during the investigation? 2

1) proper PPE

2) perform experiment in fume hood.

b. What is the independent variable?

Temperature.

c. What is the dependent variable and how is it measured? 2

- Rate of reaction
- measured via time taken to release a fixed amount of gas

d. **i.** Predict the relationship between the independent variable and the dependent variable. Explain your prediction. 3

1) Higher temperature → high rate of reaction

2) ↳ increasing frequency of collision of reactants and increasing proportion of successful collision

3) so higher overall rate of successful collision

ii. Is the graph of the student's results consistent with your prediction? Give your reasoning. 1

Yes, there is an overall trend of longer time associated with lower temperature despite the potential outliner at 25°C

Identify **two** ways in which the graph could have been presented differently to better illustrate the **relationship** between the independent variable and the dependent variable. 2 marks

1) reverting y, x-axis to have independent variable at ox-axis

2) Draw a best line of fit instead of connecting all the point

Identify **two** changes that could be made to the experimental method to improve the precision of the results if the experiment was repeated. For each change, explain how it would improve precision. 2 marks

1) replacing ballon with ~~syrer~~ gas synerge to reflect volume change more preisely

2) Change weight scale to ~~one~~ one with higher precision

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stion 10 (7 marks)

ıalytical chemistry deals with methods for determining the chemical composition of samples of ıtter. A qualitative method yields information about the identity of atomic or molecular species or the ıctional groups in the sample …

ıalytical methods are often classified as being either *classical* or *instrumental*.

Source: DA Skoog, FJ Holler and SR Crouch, *Principles of Instrumental Analysis*, 6th edition, Thomson Brooks/Cole, Belmont (CA), 2007, p. 1

sical methods include qualitative analysis, such as treating a compound with reagents to observe 'eaction, and quantitative methods, such as volumetric analysis, where the amount of a compound is 'mined by its reaction with a standard reagent.

umental methods include a variety of spectroscopy, such as IR spectroscopy and NMR spectroscopy.

Explain how the classical methods of analytical chemistry can be used to determine information about alcohols. In your answer, refer to:

- qualitative analysis and how it can be used to determine whether a compound is an alcohol and, if it is, the type of alcohol
- quantitative analysis.

3 marks

First using IR to determine the presence of OH group
then NMR → using peaks to get hydrogen environment
to cross-checking with molecule information
acquired from IR

quantitative analysis:
volumetric analysis / redox titration
or HPLC

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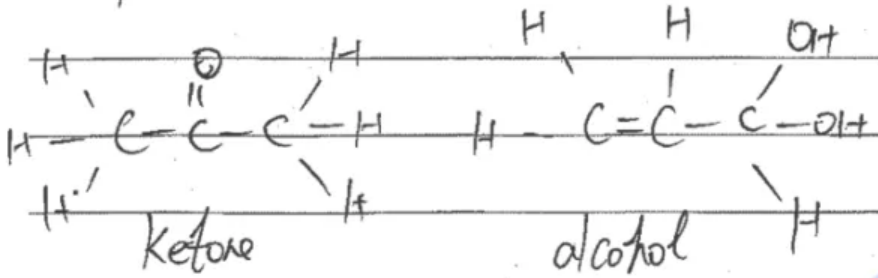
b. C_3H_6O can exist as a ketone or as a primary alcohol.

Explain how the principles of IR spectroscopy and ^1H NMR spectroscopy lead to different spectra for the ketone and primary alcohol isomers of C_3H_6O, which can then be used to differentiate between the two molecules.

Two possible structure:



Difference in IR:

for ketone: no peak at ~2500 cm^{-1}

for primary alcohol: peak at ~2500 cm^{-1} for OH group

Differenc in ^1H NMR:

for ketone: number of H environment will be 2, no peak split, same peak area

for alcohol: 4 peaks (4 H environment), will have split, peak area 2:1:2:1