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YEAR 12 *Trial Exam Paper*

2023

CHEMISTRY

Written examination

Reading time: 15 minutes

Writing time: 2 hours 30 minutes

STUDENT NAME:

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	9	9	90
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

- Question and answer book of 35 pages
- Data book
- Answer sheet for multiple-choice questions

Instructions

- Write your **name** in the space provided above on this page and on the multiple-choice answer sheet.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination.

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

Bioethanol and biogas

A. can be produced in unlimited volumes.

B. are replaced as soon as they are used.

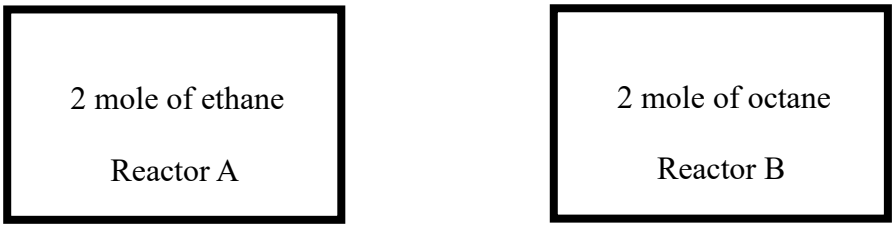
C. produce no harmful emissions when they undergo combustion.

D. can be produced from waste fruit.

Use the following information to answer Questions 2 and 3.

2 mole of ethane undergoes complete combustion in Reactor A.

2 mole of octane undergoes complete combustion in Reactor B.



Both reactors are cooled to 25 °C after the reactions are complete.

The volume of both reactors is the same.

Question 2

Compared to ethane, octane will produce

A. the same number of mole of CO_2 and the same number of mole of H_2O.

B. twice the number of mole of CO_2 and three times the number of mole of H_2O.

C. four times the number of mole of CO_2 and three times the number of mole of H_2O.

D. four times the number of mole of CO_2 and four times the number of mole of H_2O.

Question 3

After the reactors have cooled, the pressure in Reactor B due to the reaction products will be

A. equal to that of Reactor A.

B. double that of Reactor A.

C. four times greater than that of Reactor A.

D. twelve times greater than that of Reactor A.

Question 4

The efficiency of the combustion of ethanol in a particular car engine is listed as 22.0%.

The mass of ethanol required to release 1.00 MJ of usable energy in this engine will, in g, be

A. 0.154 g

B. 3.38 g

C. 33.8 g

D. 154 g

Question 5

Which of the following correctly lists the energy of combustion of ethane in different units?

	J g^{-1}	**kJ g^{-1}**	**MJ per tonne**	**kJ mol^{-1}**
A.	0.0519	51.9	5190	1560
B.	5.19×10^4	51.9	5.19×10^4	1560
C.	5.19×10^7	51.9	5190	1560
D.	5190	5190	5.19×10^4	3120

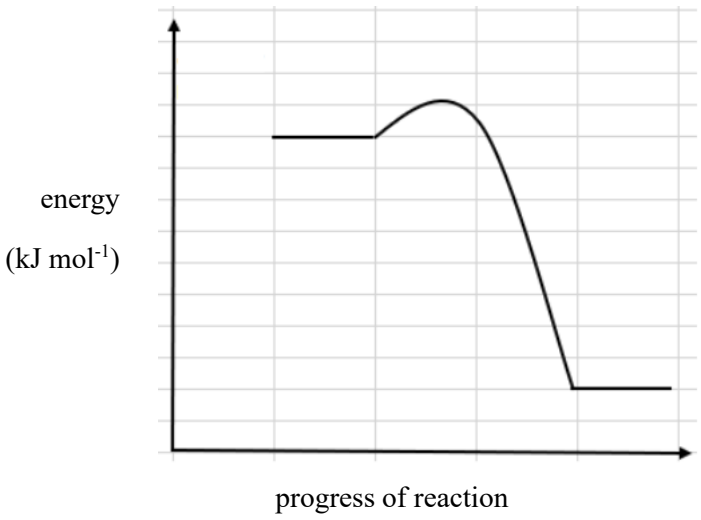
Question 6

Propane is the main component of LPG gas. It is commonly used as a fuel because it releases a significant amount of energy when combusted and, if appropriate guidelines are followed, is relatively safe to use.

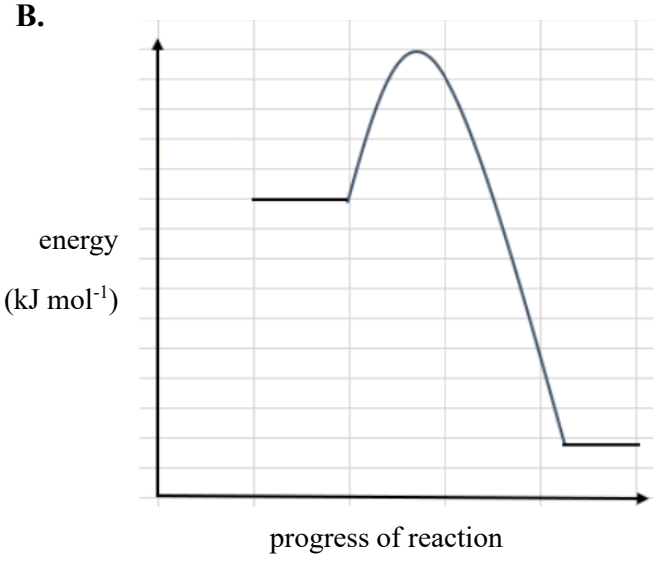
Which of the following energy profile diagrams is most likely to be that of propane?

(The same scale is used on all diagrams.)

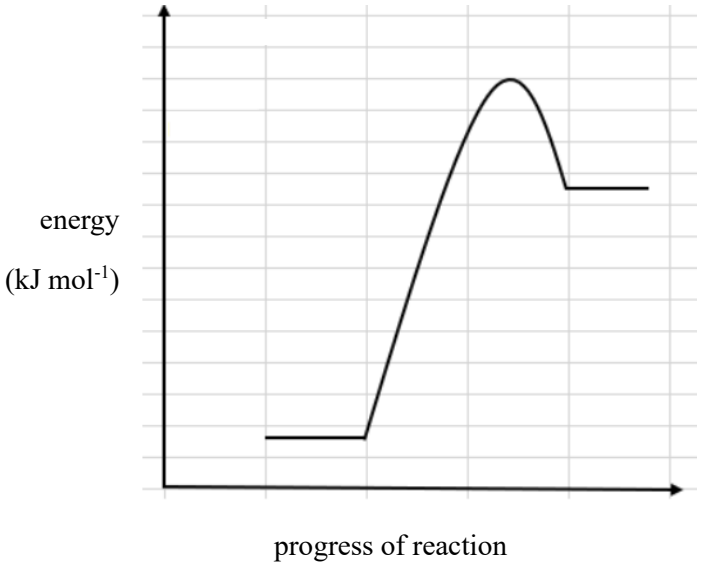
A.



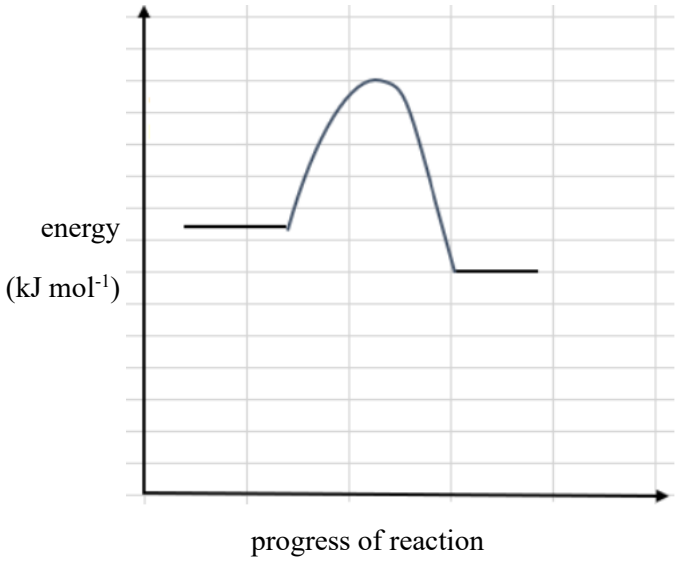
B.



C.



D.



Question 7

The equation for the production of sulfur trioxide from sulfur dioxide is

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\quad K_c = 6.2 \times 10^2\ M^{-1}$ at 300 °C

The concentrations of a mixture of the above gases are found to be

$[SO_2] = 0.8$ M, $[SO_3] = 1.6$ M and $[O_2] = 0.6$ M

For this mixture

A. the concentrations show the system needs to favour the forward reaction to reach equilibrium.

B. the concentrations show the mixture is at equilibrium.

C. the concentrations show the system needs to favour the reverse reaction to reach equilibrium.

D. the concentrations show the quoted equilibrium constant must be incorrect.

Question 8

The equation for the decomposition of ammonia gas is

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

An equilibrium mixture of the above gases is formed in a 1.0 L reactor. The concentration of all species is measured as 0.72 M.

The temperature of the system is changed. When equilibrium is re-established, the amount of ammonia is found to be 0.84 M.

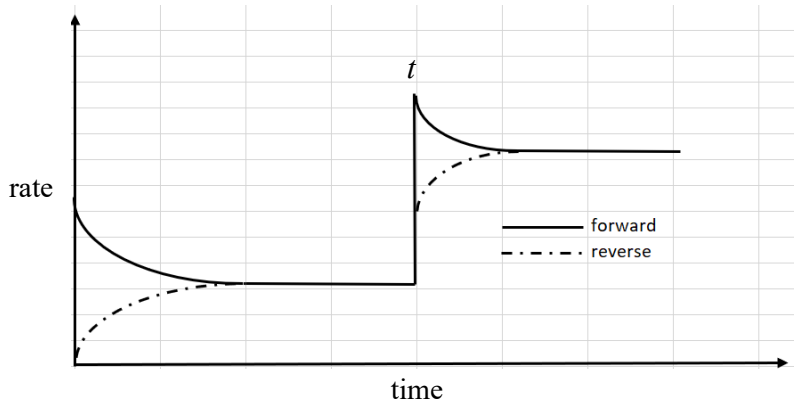
Which of the following options shows the equilibrium concentrations of the three species now present?

	$[NH_3]$	$[N_2]$	$[H_2]$
A.	0.12	0.06	0.18
B.	0.84	0.78	0.90
C.	0.84	0.66	0.54
D.	0.84	0.66	0.60

Question 9

The graph below refers to the following endothermic reaction.

$$2AB(g) \rightleftharpoons A_2(g) + 2B(g)$$



The change occurring at time *t* is

A. the addition of a catalyst.

B. an increase in temperature.

C. a decrease in temperature.

D. a decrease in volume.

Question 10

The reaction between calcium carbonate and hydrochloric acid is given by the equation below.

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

A student performs the following two experiments and measures the volume of gas produced from each experiment.

Experiment 1: 1.0 g of powdered calcium carbonate is added to 10 mL of 0.10 M HCl.

Experiment 2: 1.0 g of marble chips is added to 10 mL of 0.10 M HCl.

Marble chips are large pieces of calcium carbonate that are 95% by mass $CaCO_3$.

Which of the following options correctly describes the volume of gas produced in the experiment?

A. CO_2 gas will be evolved at a faster rate in experiment 1 but the final volume will be the same.

B. CO_2 gas will be evolved at the same rate in both experiments.

C. CO_2 gas will be evolved at a faster rate in experiment 2 and the final volume will be less.

D. CO_2 gas will be evolved at the same rate in both experiments but the final volumes will differ.

CONTINUES OVER PAGE

Question 11

The silver oxide button battery has been in use for many years. The half-equations in this cell are given by the following equations.

$$Ag_2O(s) + H_2O(l) + 2e^- \rightarrow 2Ag(s) + 2OH^-(aq) \qquad 0.34\ V$$

$$Zn(OH)_2(s) + 2e^- \rightarrow Zn(s) + 2OH^-(aq) \qquad -0.76\ V$$

The overall equation and voltage for this cell will be

A. $2Ag(s) + Zn(OH)_2(s) \rightarrow Zn(s) + Ag_2O(s) + H_2O(l)$ 1.1 V

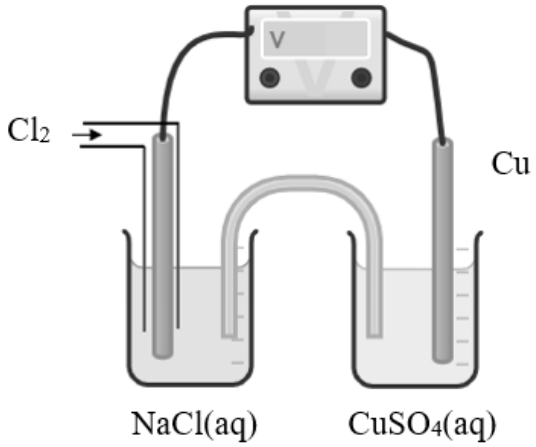
B. $Zn(s) + Ag_2O(s) + 2OH^-(aq) \rightarrow 2Ag(s) + Zn(OH)_2(s)$ 0.42 V

C. $Zn(s) + Ag_2O(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s)$ 0.42 V

D. $Zn(s) + Ag_2O(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s)$ 1.1 V

Use the following information to answer Questions 12 and 13.

The diagram below shows a galvanic cell that combines a chlorine half-cell with a copper half-cell. The circuit includes a voltmeter.



Question 12

When this cell is operational

A. copper ions are reduced and chloride ions are oxidised.

B. anions will flow from the salt bridge into the chlorine half-cell.

C. the blue colour in the copper half-cell will become less intense.

D. electrons will flow from the copper electrode to the cathode, where reduction occurs.

Question 13

If the cell is running at standard conditions, which of the following options shows the expected voltage and polarity?

	Positive electrode	Negative electrode	Voltage (V)
A.	copper	chlorine	1.02
B.	copper	chlorine	1.68
C.	chlorine	copper	1.02
D.	chlorine	copper	1.70

Question 14

A student prepares an electrolytic cell. She adds methyl orange to the solution before it is switched on and the methyl orange turns yellow. When the cell is switched on, she notices that the colour around the anode quickly changes to red, but the colour near the cathode is unchanged.

The solution the student is using could be

A. 0.1 M KBr

B. 0.1 M KCl

C. 4.0 M NaCl

D. $CuCl_2(l)$

Use the following information to answer Questions 15 and 16.

A student performing an electrolysis experiment weighs a copper electrode before the experiment and reweighs it after the cell is switched off and the electrode has been dried. The measurements are shown below.

Question 15

This electrode could have been

A. the anode in $CuSO_4(aq)$.

B. the cathode in $ZnSO_4(aq)$.

C. the cathode in $CuSO_4(l)$.

D. the cathode in $CuSO_4(aq)$.

Question 16

The change in mass could have been caused by

A. a current of 1.93 A running for 250 s.

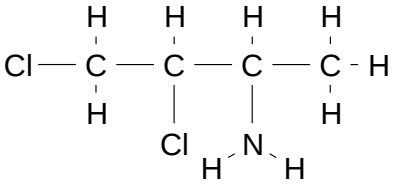
B. a current of 1.93 A running for 500 s.

C. a current of 1.93 A running for 1000 s.

D. a current of 1.93 A running for 2000 s.

Question 17

A carbon compound is drawn below.



The correct IUPAC name for this molecule is

A. 1,2-dichlorobutan-3-amine

B. 2-amino-3,4-dichlorobutane

C. 3,3-chlorobutan-2-amine

D. 3,4-dichlorobutan-2-amine

Question 18

Propanal is a liquid at room temperature. It is also soluble in water.

Which of the following options correctly shows the strongest form of intermolecular bonding in liquid propanal and in an aqueous solution of propanal?

	Main form of intermolecular bonding	
	Propanal liquid	**Propanal solution**
A.	dispersion forces	dispersion forces
B.	dipole-to-dipole bonding	dipole-to-dipole bonding
C.	dipole-to-dipole bonding	hydrogen bonding
D.	hydrogen bonding	hydrogen bonding

Question 19

The molecular formula of a compound is $C_4H_{10}O$. The ^1H NMR shows two singlet peaks and the ^{13}C NMR shows two peaks. The compound could be

A. 2-methylpropan-1-ol

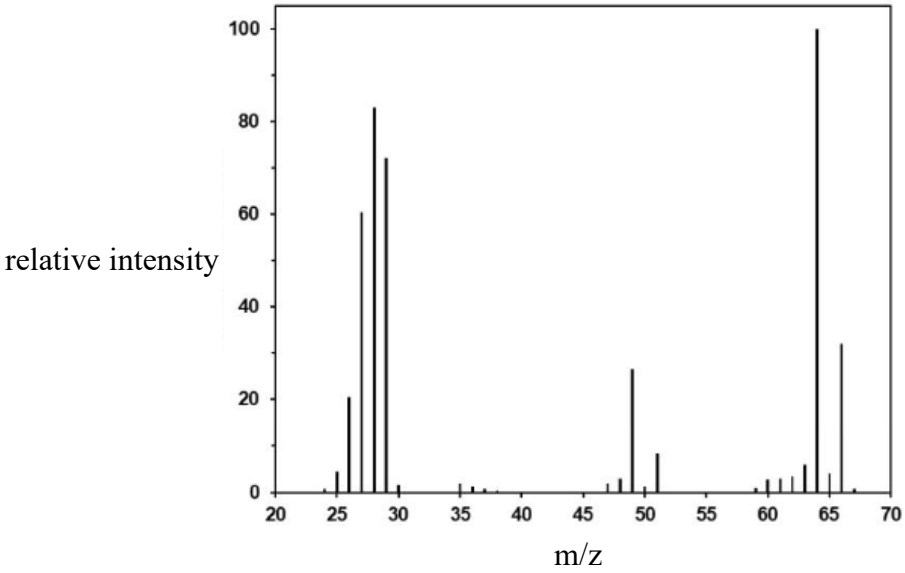
B. 2-methylpropan-2-ol

C. butan-1-ol

D. butan-2-ol

Question 20

The mass spectrum for a carbon compound is shown below.



The relative molecular mass of this compound is listed as 64.5, even though there is no specific peak at that value. The most likely explanation for this is that

A. 64.5 is a weighted mean of the masses of the parent molecular ions.

B. a mass spectrometer produces simplified print-outs.

C. the sample used in the mass spectrometer was not pure.

D. the compound must contain isotopes of carbon and hydrogen.

Question 21

Which one of the following molecules can have geometric isomers?

A. 2,3-dibromobut-2-ene

B. 1,1-dibromobut-1-ene

C. 1,1,2-tribromobut-2-ene

D. 2,3-dibromobutane

Question 22

Propanol can be oxidised by acidified potassium dichromate, $K_2Cr_2O_7$. The half-equation for the complete oxidation of propanol is

A. $C_3H_7OH(aq) + H_2O(l) \rightarrow C_2H_5CHO(aq) + 4H^+(aq) + 4e^-$

B. $C_3H_7OH(aq) + 2H^+(aq) + 2e^- \rightarrow C_2H_5COOH(aq) + H_2O(l)$

C. $C_3H_7OH(aq) + 2OH^-(aq) \rightarrow C_2H_5COOH(aq) + 4H^+(aq) + 4e^-$

D. $C_3H_7OH(aq) + H_2O(l) \rightarrow C_2H_5COOH(aq) + 4H^+(aq) + 4e^-$

Question 23

The protein bonds most affected by the addition of acid to an enzyme will be

A. peptide links between amino acids.

B. non-polar R groups that lead to dispersion forces.

C. ionic bonds between R groups.

D. covalent disulfide bonds between R groups.

Question 24

During digestion, triglycerides can be broken down to smaller molecules, transported around the body, then reassembled and stored for future energy requirements. During this process

A. the triglyceride polymers are first broken down to monomers, then polymerised again to a triglyceride.

B. hydrolysis of peptide bonds occurs first, followed by a condensation reaction to reform the triglyceride.

C. hydrolysis of ester bonds occurs first, followed by a condensation reaction to reform the triglyceride.

D. hydrolysis of the ester bonds occurs first, then the fatty acids are oxidised to release energy.

Use the following information to answer Questions 25 and 26.

100 g of water is added to a bomb calorimeter. The temperature of the calorimeter is allowed to settle.

A 0.368 g sample of pure plant oil is then burned in excess oxygen in the calorimeter. The temperature changes from 18.4 °C to 29.7 °C.

The experiment is then repeated with a sample of the same oil. The mass of oil used the second time is measured as 0.288 g.

Question 25

The calibration factor, in J $°C^{-1}$, of the calorimeter is

A. 1.20

B. 868

C. 1200

D. 3270

Question 26

When the experiment is repeated, it is expected that the temperature change will be

A. the same as that in the previous experiment, as the oil used is the same.

B. 8.8 °C

C. 12.6 °C

D. 14.4 °C

Question 27

Consider the following statements about coenzymes:

I Coenzymes are denatured above 40 °C.

II Many coenzymes are derived from vitamins.

III Coenzymes can act as carriers of electrons or specific groups of atoms.

IV Coenzymes are not changed during a reaction.

Which of the statements above are correct?

A. I and II only

B. II and III only

C. II and IV only

D. III and IV only

Question 28

The number of carbon-to-carbon double bonds in a triglyceride formed from one molecule of stearic acid and two molecules of arachidonic acid will be

A. 1

B. 4

C. 6

D. 8

Question 29

Consider the information given in the table below.

	Energy (kJ g^{-1})	**Sweetness rating**
Aspartame	16	188
Sucrose	16	1

A brand of biscuits contains 14 g of sucrose per 100 g of biscuit.

The manufacturer decides to replace the sucrose with aspartame, and adds the exact mass of aspartame that is required to achieve the same sweetness as the biscuit containing sucrose. The amount of energy provided by the aspartame in a 100 g sample of the new biscuit, in kJ, will be closest to

A. 1.2

B. 2.5

C. 1200

D. 1600

Question 30

A class investigating the heat of combustion of alcohol fuels uses a series of alcohol burners with a different alcohol in each burner. A student notices that the length of the wick in each burner varies considerably.

The varying lengths of the wicks

A. is unlikely to have any effect on the results obtained.

B. will be a source of random error in the experiment.

C. will introduce a systematic error to the experiment.

D. will make the results invalid.

END OF SECTION A

CONTINUES OVER PAGE

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 (12 marks)

Linoleic acid is an essential fatty acid that humans can source from oils contained in plants such as safflower and sunflower seeds.

When converted to a methyl ester (methyl linoleate), the heat of combustion is listed as 11 700 kJ mol^{-1}.

a. **i.** Draw the structure of a molecule of methyl linoleate.

2 marks

ii. Linoleic acid is described as an omega-6 fatty acid. What does this mean?

1 mark

_____

_____

b. **i.** Write a balanced equation for the complete combustion of methyl linoleate at standard laboratory conditions (SLC).

2 marks

ii. Determine the mass of methyl linoleate that is required to release 1.00 MJ of energy.

2 marks

iii. Determine the volume of CO_2 produced at 280 °C and 245 kPa from the ester combustion in **part b.ii.**

2 marks

c. Sunflower oil is digested in the small intestine in the presence of lipase.

i. Which bonds in sunflower oil are broken during digestion?

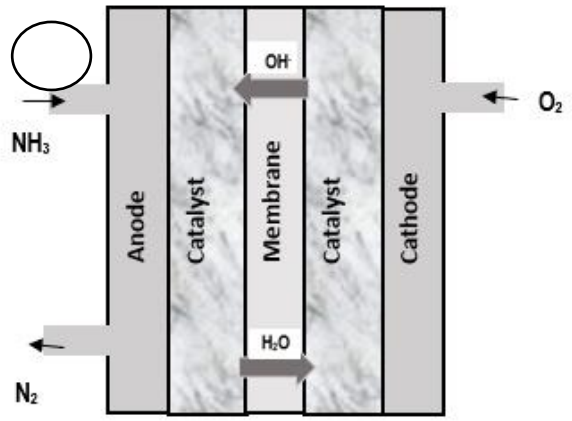
1 mark

ii. Digestion of triglycerides is aided by the secretion of bile into the small intestine. Explain the role of bile.

2 marks

Question 2 (9 marks)

The use of hydrogen gas in fuel cells is one of the alternatives being investigated to replace the use of fossil fuels. One of the drawbacks, however, is the difficulty of transporting hydrogen safely. One possible solution is to convert hydrogen gas to ammonia and use the ammonia in a fuel cell. The diagram below shows the design of an ammonia-based fuel cell.



a. The fuel cell operates in an alkaline environment. Below is the half-equation for the reaction at the anode.

$$2NH_3(g) + 6OH^-(aq) \rightarrow N_2(g) + 6H_2O(l) + 6e^-$$

i. Write the other half-equation for this cell.

1 mark

_____

_____

ii. Write the overall equation for the reaction occurring.

2 marks

_____

_____

b. **i.** In the circle provided on the diagram, indicate the polarity of the ammonia half-cell.

1 mark

ii. What is the change in oxidation state of the nitrogen atoms in this cell?

1 mark

_____

c. This cell cannot be recharged. Explain whether this is a significant problem.

1 mark

_____

_____

d. **i.** Give one advantage of the use of ammonia over hydrogen in a fuel cell.

1 mark

_____

_____

ii. Give two properties required by electrodes used in most fuel cells.

2 marks

_____

_____

_____

Question 3 (10 marks)

Steam reforming is a common method used to produce hydrogen gas from methane. Carbon monoxide is one of the products of the first reaction shown below. It can be reacted with water to further produce hydrogen gas.

Reaction 1: $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +206$ kJ mol^{-1}

(conditions used: $P = 2000$ kPa, excess steam, nickel catalyst that is placed in thin layers in long tubes)

Reaction 2: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ $\Delta H = -41$ kJ mol^{-1}

(conditions used: $P = 8000$ kPa, metal oxide catalyst)

a. One variable that chemists often manipulate in reversible reactions is temperature.

For both reactions, explain the effect of a temperature increase on the rate and yield.

4 marks

Reaction 1 _____

_____

_____

Reaction 2 _____

_____

_____

b. Another variable that chemists often manipulate in reversible reactions is pressure.
For both reactions, explain the effect of a pressure increase on the rate and yield.

4 marks

Reaction 1 _____

_____

_____

Reaction 2 _____

_____

_____

c. The stated conditions for Reaction 1 suggest that other strategies could be used to improve the reaction yield. Identify two other strategies that could be used and justify why each strategy would be effective.

2 marks

Strategy 1 _____

Explanation _____

_____

_____

Strategy 2 _____

Explanation _____

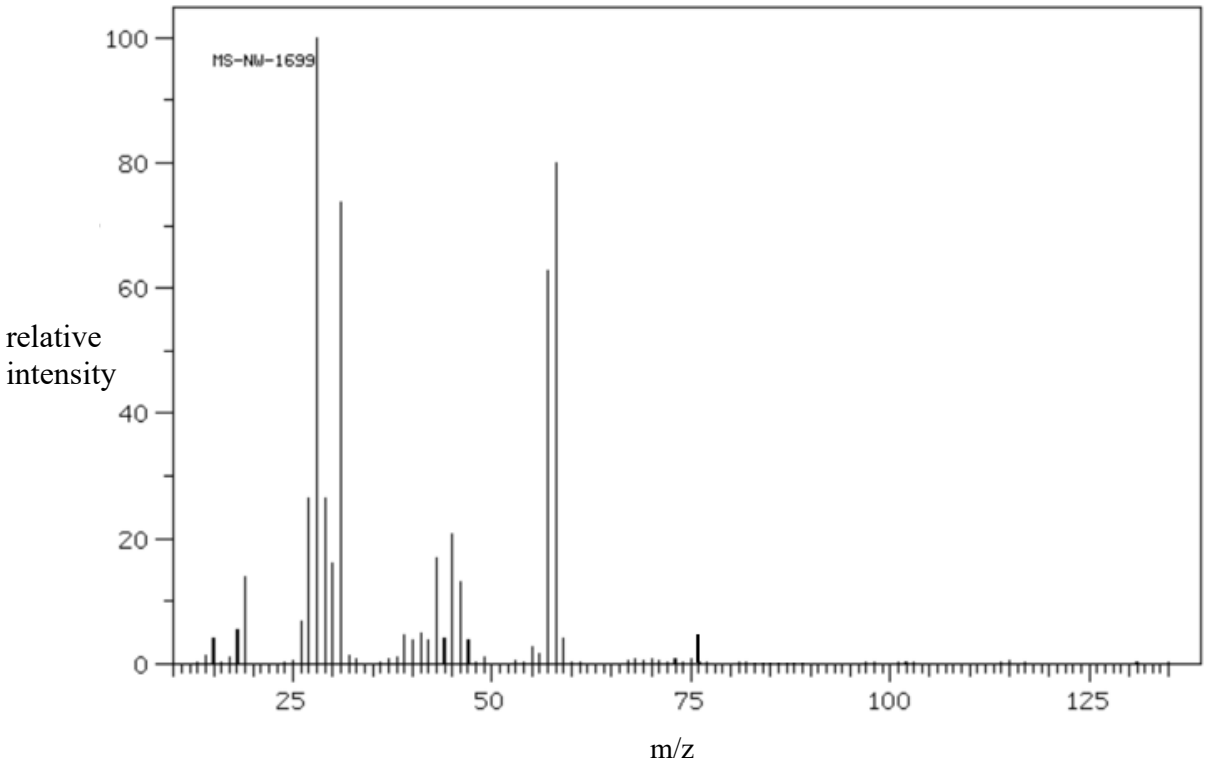
_____

_____

Question 4 (10 marks)

A sample of an organic compound with an empirical formula of $C_3H_8O_2$ is labelled as Compound A and tested in several instruments.

The mass spectrum of Compound A is shown below.



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

a. **i.** Write the molecular formula of Compound A. Justify your answer.

1 mark

_____

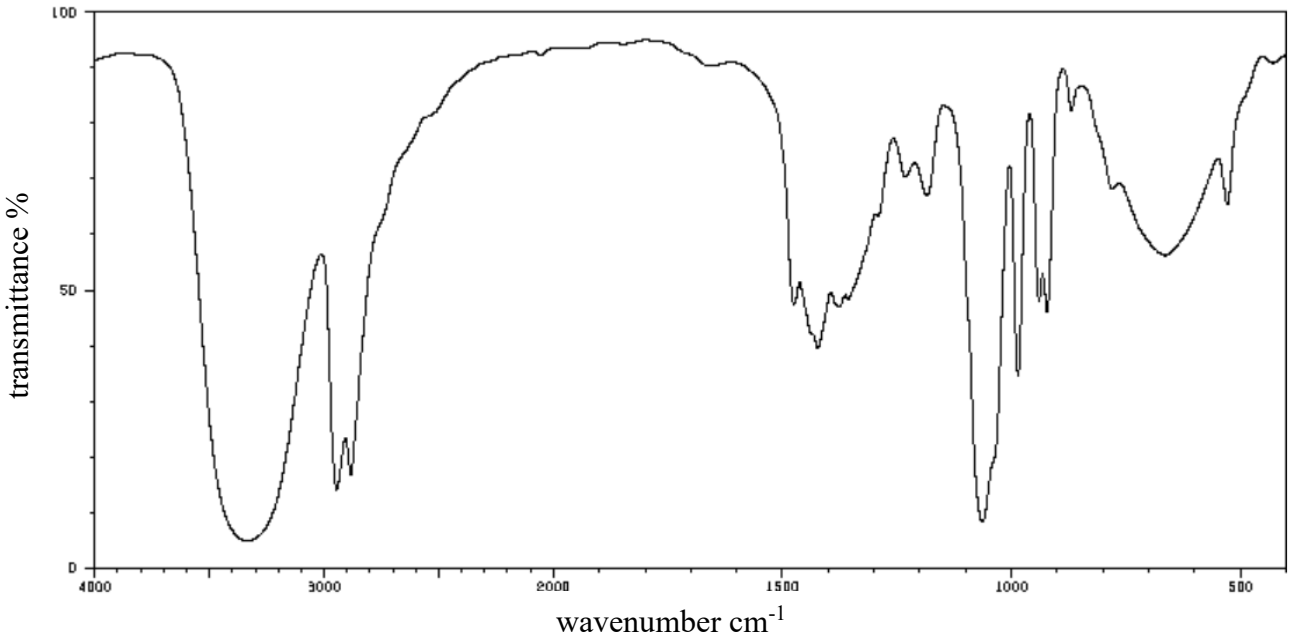
_____

ii. Suggest a fragment that might have produced the peak with the m/z ratio of 31.

1 mark

_____

b. The infrared spectrum of Compound A is shown below.



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

State two conclusions that you can draw from this spectrum about the structure of Compound A.

2 marks

_____

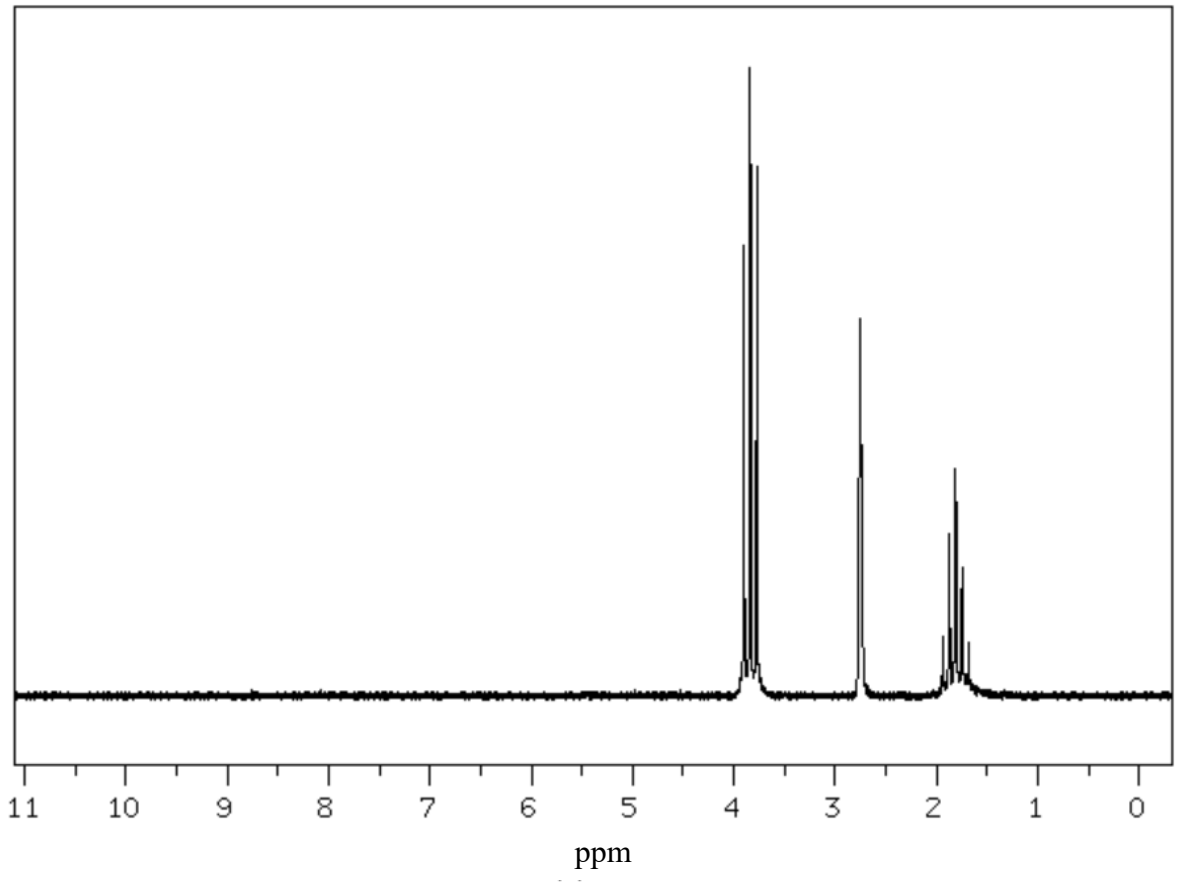
_____

_____

c. Draw two possible structures of Compound A.

2 marks

d. The ^{1}H NMR for Compound A is shown below.



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

The splitting patterns are, from left to right, triplet, singlet, and quintet.

i. Use the data provided in this question to draw the structure of Compound A and provide its IUPAC name.

2 marks

Name _____

ii. Explain how you arrived at the structure you have drawn.

2 marks

_____

_____

_____

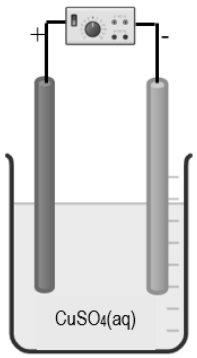
_____

CONTINUES OVER PAGE

Question 5 (10 marks)

Copper is found in the ground in compounds such as $CuFeS_2$. The copper is refined from this ore by removing the iron and the sulfur to form a raw form of copper, known as blister copper. Blister copper is around 98% copper. It also contains traces of gold metal that can be extracted commercially.

The final step in the production of copper is to place the blister copper in an electrolytic cell as the anode. The electrolyte is an aqueous copper solution, such as $CuSO_4$, and the cathode is an iron sheet. The set-up used is shown in the diagram below.



a. The electrochemical series can be used to predict the products of this cell.

i. List all the possible half-equations (as they appear in the electrochemical series) that could occur in this cell.

2 marks

_____

_____

_____

_____

_____

ii. Use the half-equations listed in **part a.i.** to write the half-equations that will occur when the cell is switched on, and the subsequent overall equation.

3 marks

Anode half-equation _____

Cathode half-equation _____

Overall equation _____

b. The gold in the blister copper is valuable. Suggest how it could be collected from this cell.

1 mark

_____

_____

_____

c. A 1.00 kg sheet of blister copper is used as an anode. Calculate how long it will take, in hours, for the copper in the sheet to be completely consumed in the cell when the current is maintained at 360 A.

4 marks

_____

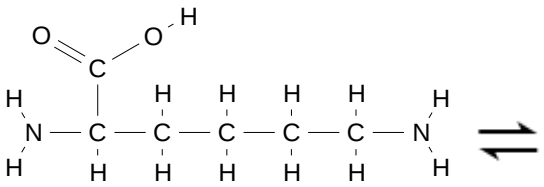
_____

_____

_____

Question 6 (10 marks)

The diagram below starts with the structure of the 2-amino acid lysine. Lysine is an important amino acid in the body, playing a role in the digestion of fatty acids and an important role in the synthesis of proteins.



lysine

a. Medical journals state that lysine comes in two forms: L-lysine and D-lysine. Only L-lysine is active in the human body.

i. Explain how lysine can have two forms.

2 marks

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_____

_____

ii. Suggest a reason for L-lysine being more active as an enzyme in the body than D-lysine.

1 mark

_____

_____

b. **i.** In the box provided on the previous page, draw the zwitterion of lysine.

1 mark

ii. In the box provided on the previous page, draw the structure of lysine in a solution of pH 2.

1 mark

iii. In the box provided on the previous page, draw the structure of lysine in a solution of pH 12.

1 mark

c. The presence of lysine in a protein structure leads to relatively strong bonding between different sections of a particular protein molecule.

Refer to the structure of lysine to explain how it contributes to the tertiary structure of a protein.

2 marks

_____

_____

_____

d. Draw a dipeptide formed from the reaction between lysine and serine.

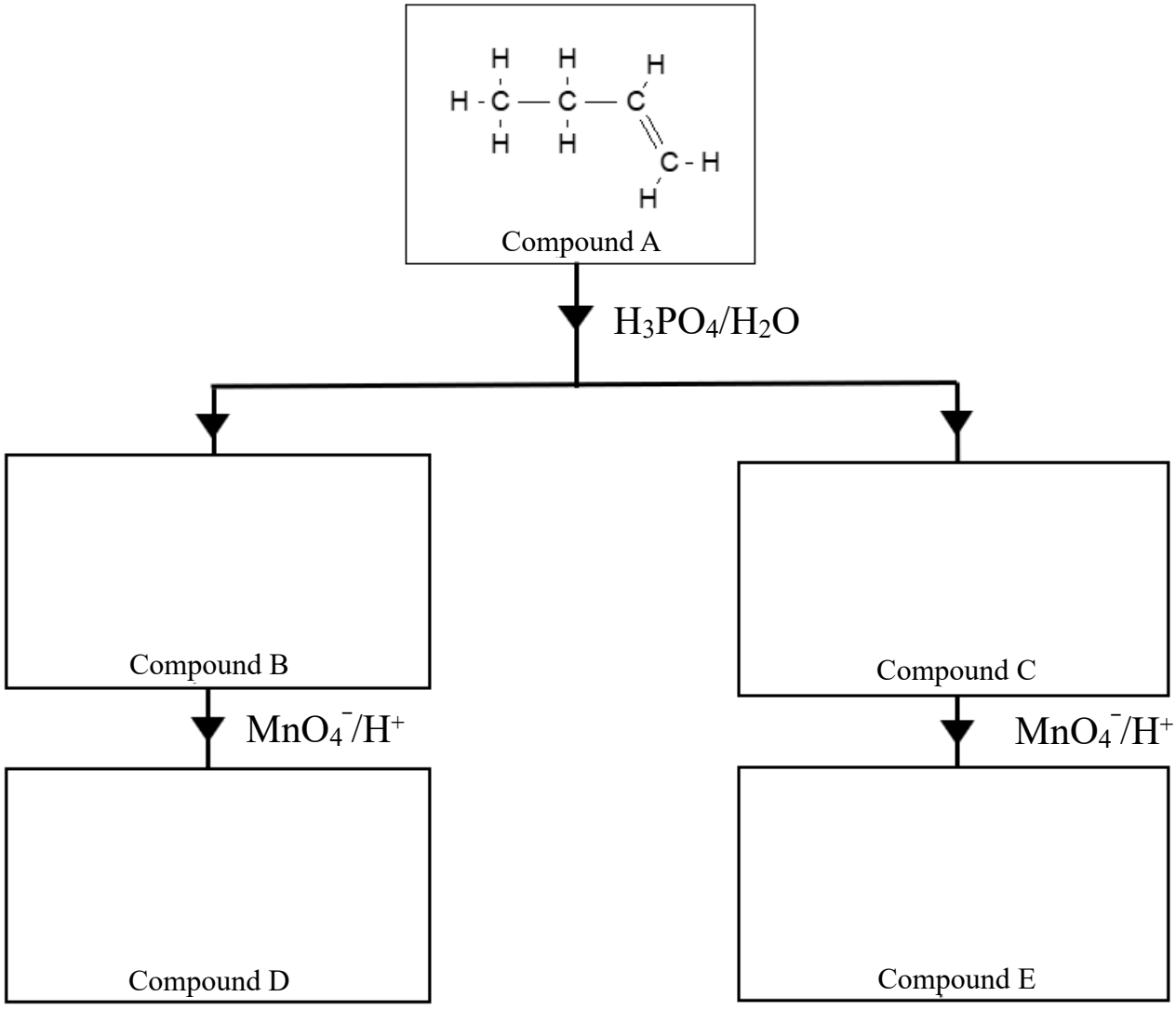
2 marks

Question 7 (10 marks)

A reaction pathway is shown below. A sample of Compound A is heated with steam and phosphoric acid.

Two different products are formed in the reaction, Compound B and Compound C. These two products are separated and both are heated with acidified potassium permanganate until no further reaction is observed. This forms Compound D and Compound E.

Compound D and Compound E are both tested by adding them to 1.0 M sodium hydroxide solution. An acid-base indicator shows that no reaction occurred with Compound D but a reaction did occur with Compound E.



a. Use the boxes provided to draw the structures of Compounds B, C, D and E.

4 marks

b. **i.** Write a balanced half-equation for the reaction of acidified MnO_4^- ions to form Mn^{2+} ions.

1 mark

_____

_____

ii. Write an overall equation for the reaction of Compound A to form Compound C.

1 mark

_____

_____

c. **i.** What type of reaction is the formation of Compound C from Compound A?

1 mark

_____

ii. What type of reaction is the formation of Compound E from Compound C?

1 mark

_____

d. An ester can be formed from the reaction between Compound C and Compound E if sulfuric acid is included as a catalyst.

Draw and name the ester formed in this reaction.

2 marks

Question 8 (10 marks)

A student sets up an experiment to investigate the impact of different acid-base indicators on the mean titre obtained in a titration. Key aspects of the student's report are listed below.

Aim: To investigate the impact of varying the acid-base indicator used in a titration.

Hypothesis: That any indicator will provide precise and accurate results if enough care is taken when conducting the titration.

Burette: Propanoic acid solution of unknown concentration.

Flasks under burette: 25.00 mL aliquots of 0.120 M NaOH solution. The solution of NaOH has been purchased from a certified testing laboratory.

Titres recorded using methyl orange indicator:

Run	Initial volume (mL)	Final volume (mL)
1	50.00	39.80
2	39.80	25.10
3	25.10	14.20

Titres recorded using phenolphthalein indicator:

Run	Initial volume (mL)	Final volume (mL)
1	50.00	32.10
2	32.10	14.10
3	50.00	32.00

Titres obtained using bromophenol blue indicator:

Run	Initial volume (mL)	Final volume (mL)
1	50.00	37.80
2	37.80	27.60
3	27.60	18.10

Conclusion: The reaction of propanoic acid and sodium hydroxide is not suitable for titration experiments.

a. For this investigation, identify the

i. independent variable.

1 mark

_____

ii. dependent variable.

1 mark

_____

b. **i.** Write a balanced equation for the reaction between propanoic acid and sodium hydroxide.

1 mark

_____

ii. Propanoic acid is an example of a weak acid.

Will this affect the titre obtained? Justify your answer.

1 mark

_____

c. Sodium hydroxide is not considered a good primary standard. Explain why, including an equation to support your answer.

2 marks

_____

_____

_____

d. Discuss the student's conclusion. In your answer, include:

- an alternative hypothesis and conclusion that you might draw from this experiment
- an explanation of which indicator theory suggests is the most appropriate for this titration.

4 marks

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Question 9 (9 marks)

Scientists rely on catalysts for the viable production of a vast range of commercial products. The chemistry of how catalysts work is not always well understood, and it is not easy to predict what might work as a catalyst for a particular process. While scientists often harness inorganic catalysts, the human body uses enzymes as natural catalysts for many biochemical reactions.

> A plastic-degrading enzyme and an engineered bacterial strain have just been launched into space with an important mission: to convert waste plastics to upcycled materials during spaceflight.
>
> Currently orbiting Earth on board the International Space Station (ISS), engineered variants of *Pseudomonas putida* and the PETase enzyme are part of an experiment to see how biological plastic degradation and upcycling performs in low Earth orbit. And the experiment will proceed entirely on its own in a custom payload designed for autonomous cultivation and sampling.

Source: Enzymes and Bacteria Sent on Mission To Upcycle Plastics, Connor O'Neil, *NREL Transforming Energy,* <https://www.nrel.gov/news/program/2022/enzymes-and-bacteria-sent-on-mission-to-upcycle-plastics.html>

a. Hydrogen peroxide, H_2O_2, can decompose slowly in water and oxygen gas. If pieces of liver are added to a solution of hydrogen peroxide, the catalase in liver acts as a catalyst for the reaction. It is also known that manganese dioxide, MnO_2, is a catalyst for the reaction.

Use the decomposition of hydrogen peroxide as an example to discuss the action of a catalyst and to compare the properties of an inorganic catalyst with those of an enzyme. In your answer, refer to:

- the function of a catalyst
- the similarities between inorganic catalysts and enzymes
- the differences between inorganic catalysts and enzymes.

5 marks

b. Casein protein is found in the milk of all mammals. It provides a source of protein for the young of the species.

Use casein protein as an example to explain the difference between hydrolysis and denaturation. In your answer, refer to:

- the process of hydrolysis and its effect on bonding in casein
- the process of denaturation and its effect on bonding in casein.

4 marks

END OF QUESTION AND ANSWER BOOK