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YEAR 12 *Trial Exam Paper*

2021

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	10	10	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.

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

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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

Which one of the following fuels is likely to have the highest viscosity?

A. bioethanol

B. petrodiesel

C. petrol

D. methyl stearate

Question 2

The composition of biogas varies with the source and conditions. The following table shows the typical ranges of the three main constituents.

Compound	Volume (%)
methane	50–75
carbon dioxide	25–50
nitrogen	0–10

A 49.6 L sample of biogas at standard laboratory conditions (SLC) is found to release 1300 kJ of energy.

Assuming that all the energy is coming from the methane, the % methane is closest to

A. 59%

B. 64%

C. 73%

D. 80%

Question 3

Which one of the following would be the lowest temperature for petrodiesel fuel?

A. melting point

B. auto-ignition point

C. flashpoint

D. boiling point

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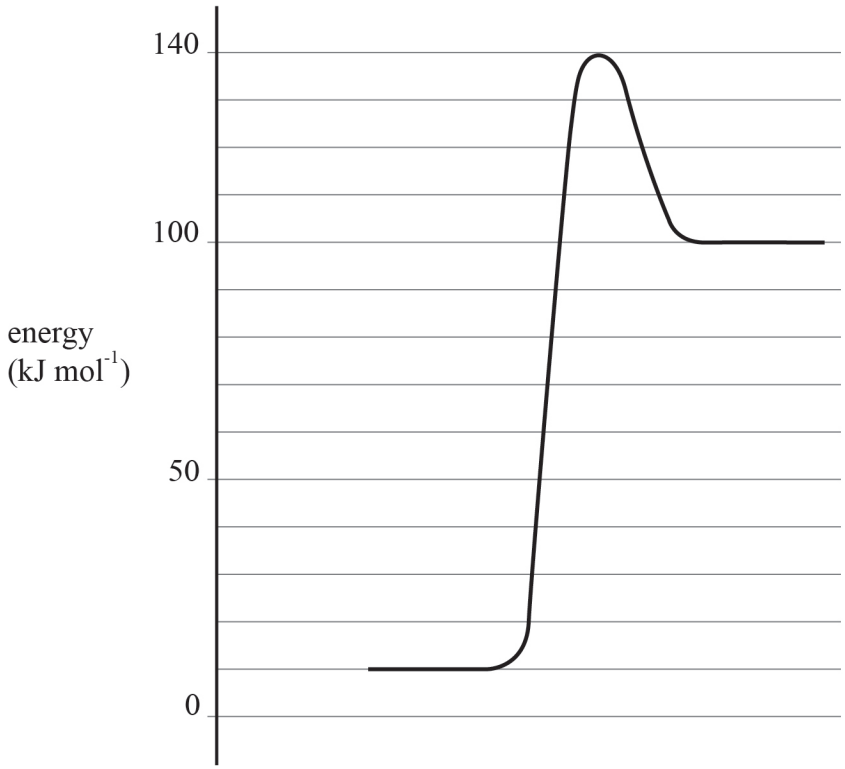
Question 4

The energy profile diagram for a particular reaction is shown below.



A catalyst is found for this reaction.

Which one of the following alternatives shows valid values for the activation energy and enthalpy of the catalysed reverse reaction?

	Activation energy (kJ mol^{-1})	ΔH (kJ mol^{-1})
A.	–40	+130
B.	+30	–90
C.	+40	–90
D.	+30	–130

Question 5

3.00 g of ethane undergoes complete combustion.

The mass of CO_2 formed and the amount of energy released are respectively

A. 3.00 g and 51.9 kJ

B. 6.00 g and 156 kJ

C. 8.80 g and 51.9 kJ

D. 8.80 g and 156 kJ

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Question 6

Marble chips, $CaCO_3$, react readily with hydrochloric acid solutions.

Which one of the following will have the fastest initial reaction rate, assuming 0.50 g of marble chips is used each time?

A. ground marble chips added to 100 mL of 1.0 M HCl at 25 °C

B. marble chips added to 200 mL of 1.0 M HCl at 25 °C

C. ground marble chips added to 50 mL of 2.0 M HCl at 30 °C

D. marble chips added to 100 mL of 1.0 M HCl at 30 °C

Use the following information to answer Questions 7–9.

Potassium permanganate reacts with oxalic acid, as represented in the following equation.

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

Potassium permanganate solution has an intense purple colour. As the reaction progresses and the MnO_4^- ions react, the purple colour disappears.

Question 7

Which one of the following could be used to monitor the progress of the reaction?

A. the time taken until a cross under the beaker is obscured by the solution

B. the increasing mass of precipitate forming as the reaction proceeds

C. the time taken until the phenolphthalein indicator changes colour

D. the change in pH that occurs as the reaction proceeds

Question 8

During this reaction

A. manganese is reduced and oxygen is oxidised.

B. manganese is reduced and carbon is oxidised.

C. manganese is oxidised and carbon is reduced.

D. hydrogen ions are reduced and carbon is oxidised.

Question 9

A 0.015 M oxalic acid solution is used to determine the concentration of a potassium permanganate solution. 20.0 mL aliquots of oxalic acid react exactly with 18.0 mL of potassium permanganate.

The concentration of the potassium permanganate is closest to

A. 0.0067 M

B. 0.0083 M

C. 0.017 M

D. 0.042 M

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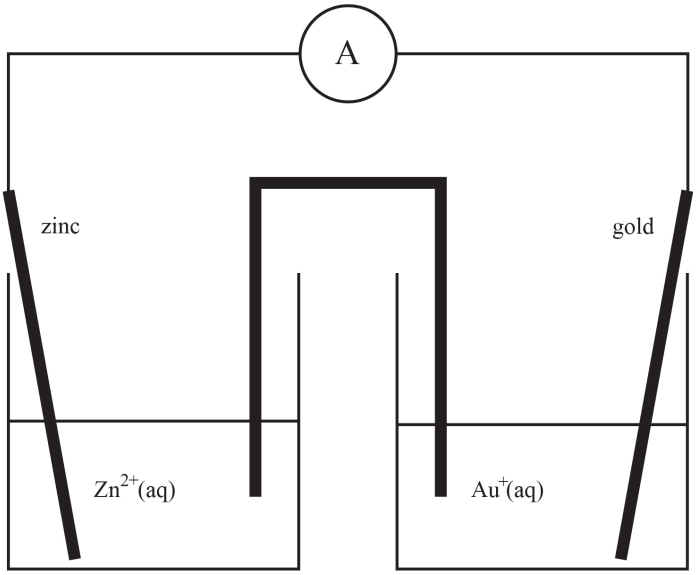
Use the following information to answer Questions 10 and 11.

A galvanic cell is constructed from a gold half-cell and a zinc half-cell. The cell is shown below.



Question 10

When this cell is operating

A. two gold atoms form ions for every zinc atom depositing on the cathode.

B. two atoms of gold deposit on the cathode for every zinc atom forming a zinc ion.

C. two atoms of zinc metal form ions for every gold atom depositing on the cathode.

D. one atom of gold forms for every zinc atom forming a zinc ion.

Question 11

The cell is allowed to discharge for 10 minutes.

Which one of the following statements about the changes at the electrodes is correct?

A. Twice as many mole of metal reacts at the positive electrode as at the negative electrode.

B. The mass loss at the anode will equal the mass gain at the cathode.

C. The mass gain at the cathode will be twice the mass loss at the anode.

D. The same number of mole of metal will react at each electrode.

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Question 12

The oxidation of sulfur dioxide, SO_2, to sulfur trioxide, SO_3, can be represented by the following equation.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_c = 4.0\ M^{-1} \text{ at } 900\ °C$$

Which one of the following equations will have a K_c numerical value of 0.25 at 900 °C?

A. $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$

B. $4SO_2(g) + 2O_2(g) \rightleftharpoons 4SO_3(g)$

C. $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

D. $SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$

Question 13

One of the roles of the protein haemoglobin is to transport oxygen from the lungs.
A simplified equation for this reversible reaction is

$$Hb_4(aq) + 4O_2(g) \rightleftharpoons Hb_4(O_2)_4(aq) \qquad \text{Reaction 1}$$

In the presence of carbon monoxide gas, the following competing equilibrium is possible.

$$Hb_4(aq) + 4CO(g) \rightleftharpoons Hb_4(CO)_4(aq) \qquad \text{Reaction 2}$$

The main reason carbon monoxide is a very dangerous gas to humans is that

A. Reaction 2 is endothermic and Reaction 1 is exothermic.

B. Reaction 2 is not reversible.

C. the value of K_c for Reaction 2 is far lower than that of Reaction 1.

D. the value of K_c for Reaction 2 is far higher than that of Reaction 1.

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Use the following information to answer Questions 14 and 15.

Aluminium metal is produced through electrolysis of molten alumina, Al_2O_3. One of the half-equations in this cell is shown below.

$$2O^{2-}(l) + C(s) \rightarrow CO_2(g) + 4e^-$$

The carbon required for the half-equation comes from the graphite electrode used.

Question 14

In this cell, the ratio between the number of mole of aluminium produced and the number of mole of CO_2 gas evolved will be

A. 1:1

B. 1:3

C. 4:3

D. 3:4

Question 15

This cell typically uses a current of around 180 000 amperes.

The mass, in kg, of aluminium produced each hour will be closest to

A. 20

B. 60

C. 90

D. 180

Question 16

Assuming inert electrodes, which of the following lists two electrolytic cells that will produce the same products?

A. 0.1 M KF(aq) and KF(l)

B. 0.1 M NaCl(aq) and 4.0 M NaCl(aq)

C. 0.1 M $CuBr_2$(aq) and $CuBr_2$(l)

D. 0.1 M $MgBr_2$(aq) and $MgBr_2$(l)

Question 17

A tertiary alcohol is an alcohol

A. that contains three carbon atoms and a hydroxyl group.

B. that can be oxidised to form a ketone.

C. where the carbon atom bonded to the hydroxyl group is bonded to three other carbon atoms.

D. containing three hydroxyl groups.

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Question 18

Which one of the following molecules cannot form geometric isomers?

A. $CH_3CH_2CH=CHCl$

B. $CH_3CH_2CH=CH_2$

C. $CH_3CH_2CH=CHCH_2CH_3$

D. $CHCl=CHCl$

Question 19

Which one of these molecules has the molecular formula C_3H_6O?

A. propan-1-ol

B. propanoic acid

C. methyl ethanoate

D. propanal

Question 20

If butan-2-ol is heated with dichromate ions, $Cr_2O_7^{2-}$, in acidic conditions, it will be gradually converted to butan-2-one. A chemist uses infrared spectroscopy to monitor this reaction.

The reaction can be judged to be complete when the

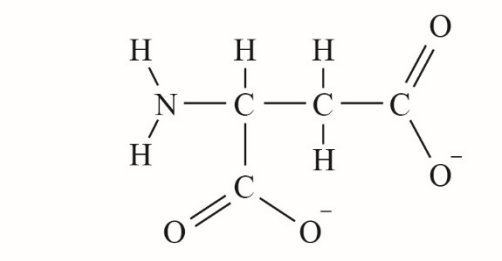
A. sharp absorption around 1750 cm^{-1} appears.

B. sharp absorption around 1750 cm^{-1} is no longer visible.

C. broad absorption around 3300 cm^{-1} is no longer visible.

D. broad absorption above 3300 cm^{-1} has moved to around 3000 cm^{-1}.

Question 21



The molecule drawn below is formed from an amino acid.

The molecule shown is

A. aspartic acid dissolved in water.

B. the zwitterion of aspartic acid.

C. aspartic acid in a pH 2 solution.

D. aspartic acid in a pH 12 solution.

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Question 22

How many hydrogen environments does the molecule $CH_3C(CH_3)_2OCOCH_3$ have?

A. 2

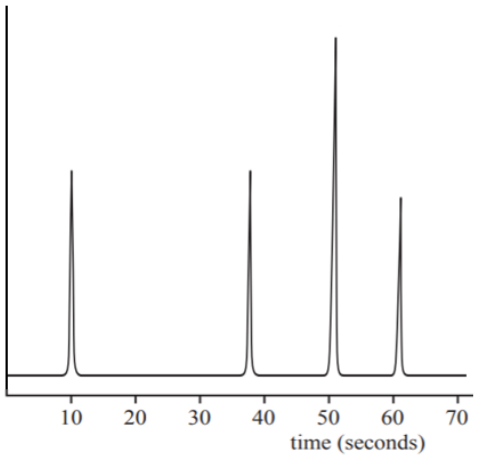
B. 3

C. 4

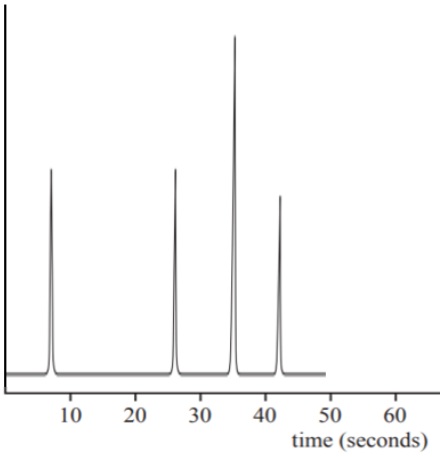
D. 5

Question 23

Chromatogram A below was produced by passing a mixture of four fatty acids through a high-performance liquid chromatography (HPLC) column. The column used a non-polar solvent.



Chromatogram A



Chromatogram B

Chromatogram B was most likely produced by

A. running the same fatty acid mixture through the same column but swapping to a polar solvent.

B. increasing the concentrations of the fatty acids and passing them through the same column.

C. applying a higher solvent flow rate to the same fatty acid mixture in the same column.

D. running a different set of fatty acids through the same column.

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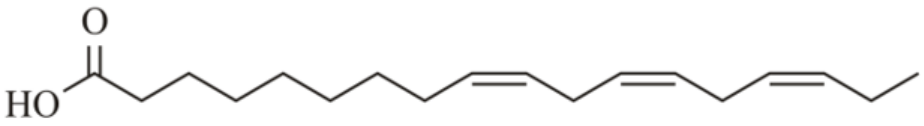
Use the following information to answer Questions 24 and 25.

A fatty acid is shown below.



Question 24

What is the molecular formula of this fatty acid?

A. $C_{17}H_{28}O_2$

B. $C_{17}H_{29}O_2$

C. $C_{18}H_{30}O_2$

D. $C_{18}H_{31}O_2$

Question 25

Compared to stearic acid, this fatty acid will have a

A. higher melting point, higher viscosity and higher susceptibility to oxidative rancidity.

B. lower melting point, higher viscosity and lower susceptibility to oxidative rancidity.

C. lower melting point, higher viscosity and higher susceptibility to oxidative rancidity.

D. lower melting point, lower viscosity and higher susceptibility to oxidative rancidity.

Question 26

0.50 g of sucrose is burned in a bomb calorimeter containing 100 g of water.

The theoretical temperature change of the calorimeter will be close to

A. 10 °C

B. 19 °C

C. 24 °C

D. 38 °C

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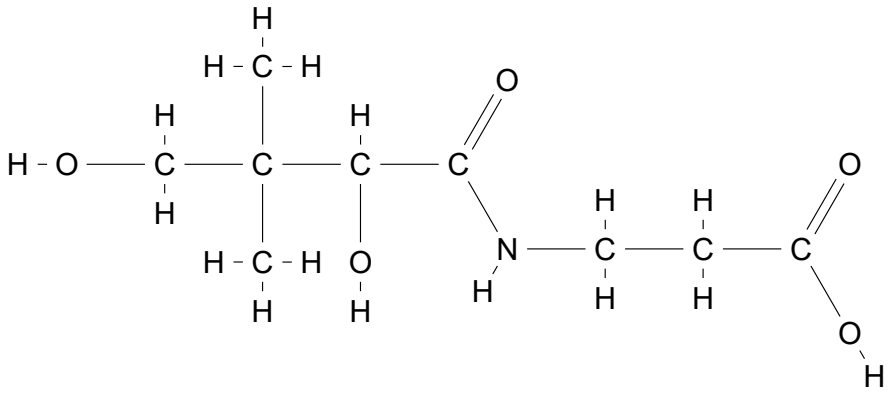
Question 27

The molecule shown below is pantothenic acid, also known as vitamin B_5. The human body uses this molecule to help manufacture red blood cells.



From its structure, it is likely that vitamin B_5

A. is not an essential vitamin for humans due to its solubility in water.

B. will be fat-soluble because it is a relatively non-polar molecule.

C. will be water-soluble because it is a relatively non-polar molecule.

D. should be consumed regularly by humans because it is not stored for long periods in the body.

Question 28

Ascorbic acid acts as a coenzyme in the body for hydroxylase reactions. Hydroxylases allow the body to convert cholesterol to bile acids, to aid the digestion of fats.

Consider the following statements.

Statement number	Statement
1	Ascorbic acid is also a protein.
2	Ascorbic acid is not permanently changed during the process.
3	Ascorbic acid is insoluble in water.
4	Ascorbic acid will not catalyse the reaction on its own.

Which one of the following sets of statements is correct?

A. statement numbers 1 and 4

B. statement numbers 2 and 3

C. statement numbers 2 and 4

D. statement numbers 1 and 2

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Use the following information to answer Questions 29 and 30

A student conducts an experiment to determine the calibration constant of a calorimeter. He measures 100 g of water carefully and adds this to the calorimeter. He does not notice, however, that the calorimeter already has 10 mL of water in it. He connects the calorimeter to an ammeter and a power supply of 5.0 V. He then passes a current through the calorimeter for 5 minutes, recording the temperature change during this time.

Question 29

Which one of the following statements best describes the impact of the extra water on the value that the student obtains for the calorimeter constant?

A. The value obtained will not be affected because the mass of the water is not relevant.

B. ΔT will be smaller than it should be, making the calibration constant higher than it should be.

C. ΔT will be smaller than it should be, making the calibration constant lower than it should be.

D. ΔT will be greater than it should be, making the calibration constant higher than it should be.

Question 30

The student is made aware of the volume problem with the first experiment, so he repeats the experiment three times using the correct volume. The thermometer, however, has a small bubble of air near the base, which leads to each reading being exactly two degrees higher than it should be.

This is an example of a

A. random error that might provide either high or low results.

B. systematic error that will lead to high results.

C. systematic error that will lead to low results.

D. systematic error that will not impact the value of ΔT

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END OF SECTION A

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 (10 marks)

E10 fuel is a blend of unleaded petrol and ethanol, where the percentage volume/volume (% v/v) of ethanol is 10%. Assume that the petrol component is entirely octane.

The table below shows the densities of both fuels.

Fuel	Density (g mL^{-1})
ethanol	0.790
octane	0.700

Consider a 1.00 L sample of E10.

a. Calculate the volume and mass of each fuel in the sample.

2 marks

Octane volume _____ Octane mass _____

Ethanol volume _____ Ethanol mass_____

b. Calculate the energy released from the complete combustion of the 1.00 L sample.

2 marks

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c. Write a balanced equation for the complete combustion of octane.

1 mark

_____

_____

d. Calculate the volume of CO_2 that will be produced at 400 °C and 100 kPa from the complete combustion of the 1.00 L sample.

3 marks

_____

_____

_____

_____

_____

e. The ethanol in E10 can be manufactured in several different ways.

i. Write a balanced chemical equation for the production of ethanol from an alkene. States are not required.

1 mark

_____

ii. Write a balanced chemical equation for the production of ethanol from glucose. States are required.

1 mark

_____

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Question 2 (11 marks)

The production of nitric acid, HNO_3, from ammonia is known as the Ostwald process. One of the steps in this process is the reaction of nitrogen monoxide with air to form brown nitrogen dioxide gas.

The equation for the reversible reaction is

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The relationship between the equilibrium constant and temperature for this reaction has been studied and some of the values are shown in the table below.

Temperature (°C)	K_c
298	3.9×10^{13}
500	6.6×10^{5}
900	4.4
1100	0.30

a. **i.** The units for K_c have not been included in the table.

What are the units for K_c?

1 mark

_____

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

1 mark

_____

iii. Is the reaction endothermic or exothermic? Justify your answer.

2 marks

_____

_____

_____

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b. Identify and explain two strategies that a manufacturer could use to improve the yield of this reaction.

4 marks

Strategy 1 _____

_____

_____

Strategy 2 _____

_____

_____

c. A sample of NO_2 gas is added to an empty reactor at 900 °C. At equilibrium the concentration of NO_2 is 0.42 M.

Calculate the concentration of O_2 gas.

3 marks

_____

_____

_____

_____

_____

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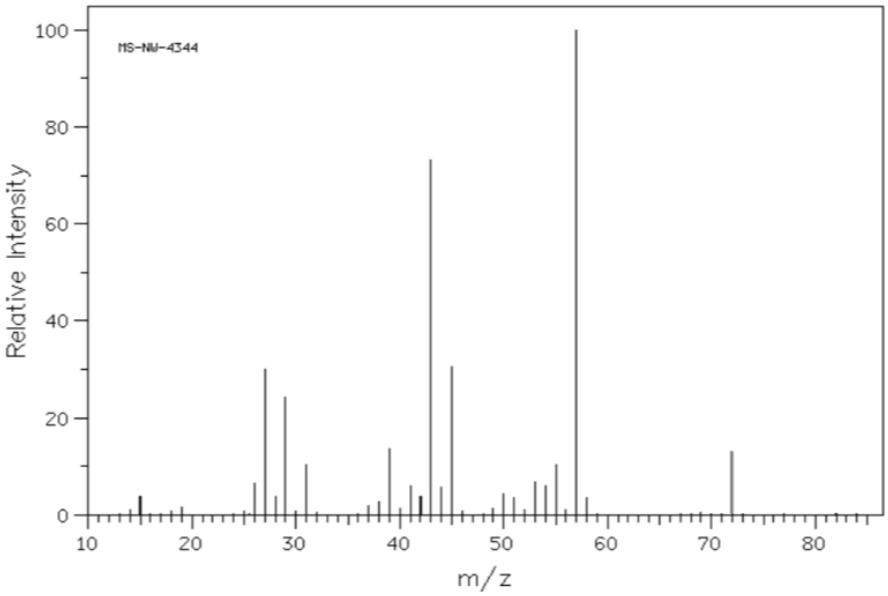
Question 3 (10 marks)

A sample of a liquid is placed in a beaker and labelled 'Substance A'. The substance contains carbon, hydrogen and oxygen only.

a. The mass spectrum of Substance A is shown below.



Source: https://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi
SDBS, National Institute of Advanced Industrial Science and Technology

i. There is a significant peak with a mass-to-charge ratio (m/z) of 27.

Suggest a fragment that could produce this peak.

1 mark

_____

ii. Use the m/z ratio of the parent molecular ion and other information supplied to draw three possible formulas for Substance A.

3 marks

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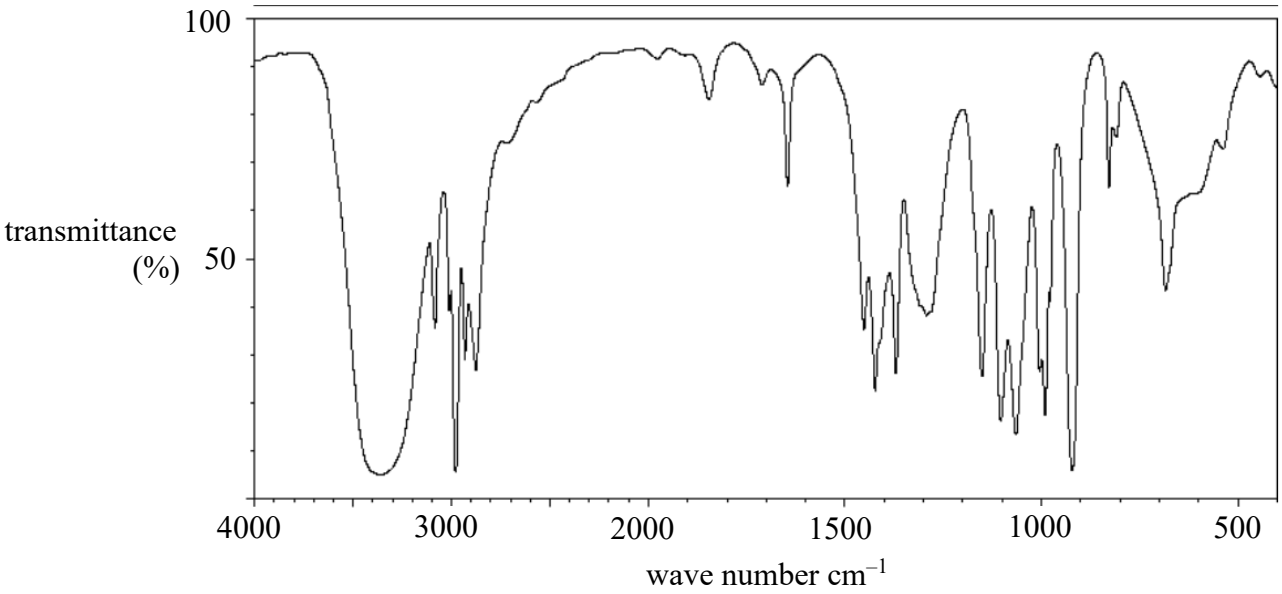
b. The infra-red (IR) spectrum of Substance A is shown below.



Source: https://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi
SDBS, National Institute of Advanced Industrial Science and Technology

State **two** conclusions that you can make about Substance A based on this spectrum. Give your reasoning for each.

2 marks

Conclusion 1 _____

_____

Conclusion 2 _____

_____

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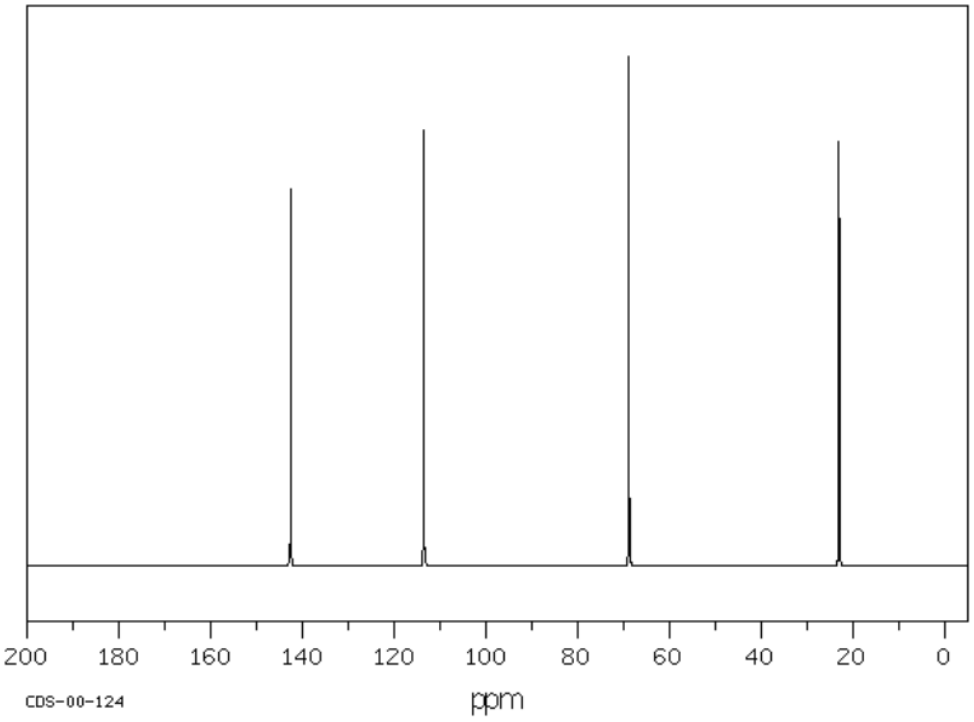
c. The ^{13}C NMR spectrum of Substance A is shown below.



Source: https://sdbs.db.aist.go.jp/sdbs/cgi-bin/cre_index.cgi
SDBS, National Institute of Advanced Industrial Science and Technology

It is also known that the ^{1}H-NMR spectrum of Substance A shows five sets of peaks.

Use all of the information provided to draw and name Substance A. Justify your choice.

4 marks

Name _____

Justification _____

_____

_____

_____

_____

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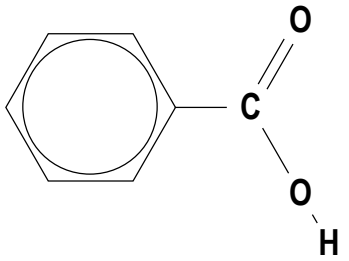
Question 4 (8 marks)

Benzoic acid is a white solid at room temperature. It is a widely used chemical and is used as an antifungal agent and a preservative in food. It is also an intermediate in the manufacture of a range of other chemicals. Its structure is shown below and its chemical formula is often shown as C_6H_5COOH.



A student uses a titration to investigate the purity of an impure sample of benzoic acid. The solubility of benzoic acid in water is low but the use of a small amount of ethanol in the volumetric flask is used to overcome this problem. The ethanol has no impact upon the titration or associated calculations.

Key pieces of the student's measurements are shown below.

Preparation of benzoic acid solution:

Mass of impure benzoic acid in sample: 6.00 g

Volumetric flask: 250 mL

Titration:

Concentration of NaOH: 0.150 M

NaOH aliquots: 20.00 mL

Titres (in mL): 18.9, 17.8, 17.9, 17.7

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

1 mark

_____

ii. Suggest a suitable indicator to use for this titration. Justify your choice, including any assumptions you have made.

2 marks

_____

_____

_____

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b. **i.** Calculate the mass of benzoic acid in the sample.

3 marks

_____

_____

_____

_____

ii. What is the percentage mass/mass (% m/m) of benzoic acid in the sample?

1 mark

_____

c. The student asks the school to purchase a supply of carefully purified water from a chemical supplier to rinse the burette immediately before conducting the titration.

Discuss the appropriateness of this step.

1 mark

_____

_____

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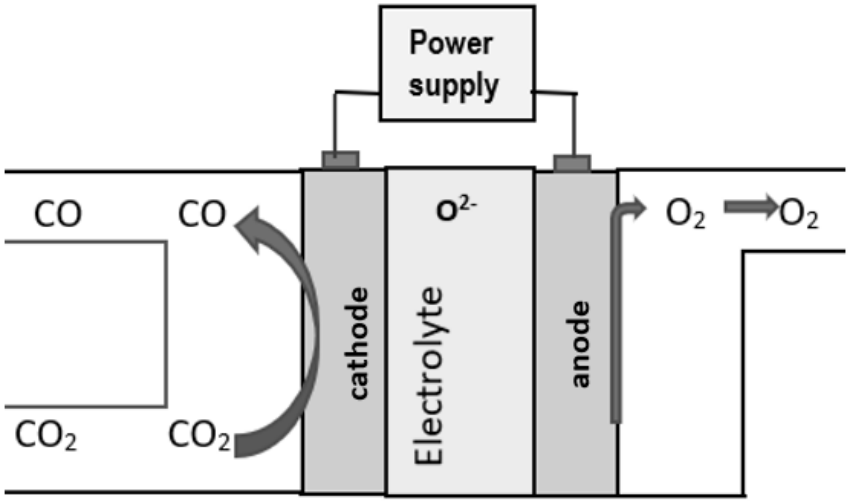
Question 5 (9 marks)

As NASA scientists ramp up preparations for manned flights to Mars, the importance of ready supplies of oxygen on Mars is becoming apparent. A team of scientists is involved in a project called 'MOXIE' (Mars Oxygen In-Situ Resource Utilization Experiment). The Martian atmosphere may have little pure oxygen but oxygen is present as carbon dioxide. MOXIE is an electrolytic cell that takes in CO_2 and uses it to produce carbon monoxide and oxygen gas. The oxygen could then be used for breathing or combustion or as a propellant. This process is one of the first commercial examples of electrolysis of a gas. A schematic diagram of the cell is shown below.



a. Use the information provided in the question and the diagram of the cell to complete the template below. States are not required because the electrolyte is not aqueous.

3 marks

Overall equation _____

Oxidation half-equation _____ Polarity _____

Reduction half-equation _____ Polarity _____

b. The cell requires an ion to move through the electrolyte to complete the circuit involved.

Identify the ion that is moving through the electrolyte and the direction in which it moves.

2 marks

_____

_____

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c. Give an example of a combustion reaction that might be useful to inhabitants of Mars.
Write a balanced equation to support your answer.

2 marks

_____

_____

d. **i.** MOXIE has been described by scientists as 'a fuel cell in reverse'.
Explain why.

1 mark

_____

_____

ii. Once a MOXIE unit is placed on location on Mars, it will require a supply of CO_2.
What is the other essential input for MOXIE to operate?

1 mark

_____

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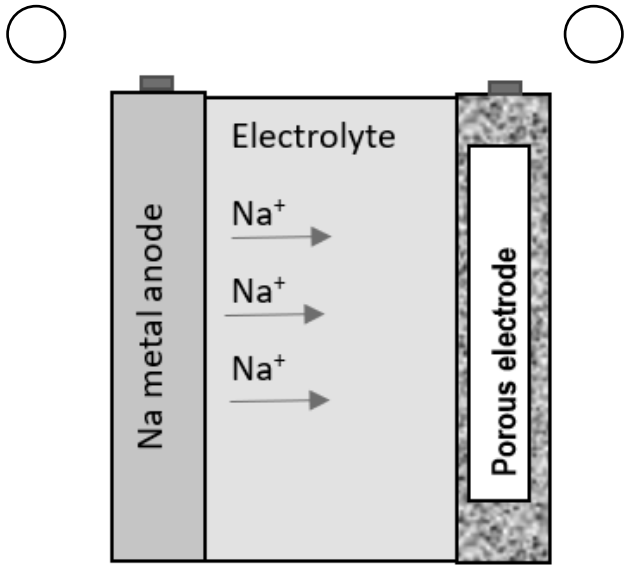
Question 6 (7 marks)

The popularity of various lithium batteries has led to the new issue of sourcing the large quantities of lithium required. One of the directions that scientists are investigating to find a solution to this problem is to substitute lithium with the more abundant sodium.

A promising cell is the sodium–air cell, shown below. For this cell:

- The reactants are sodium metal and oxygen gas from the air.
- The cell operates in alkaline conditions.
- The sole product formed is sodium hydroxide, NaOH.



a. Indicate the polarity of each electrode in the circles provided in the diagram above.

1 mark

b. Write the half-equations and overall equations for this cell. Both half-equations can be found on the electrochemical series. States are not required.

3 marks

Anode _____

Cathode _____

Overall equation _____

c. What is the standard cell voltage for this cell?

1 mark

_____

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d. Oxygen from air is a very cheap reactant in this cell but the electrode at which the oxygen reacts is expensive.

Give **two** requirements for the electrode that contribute to its high cost.

2 marks

_____

_____

_____

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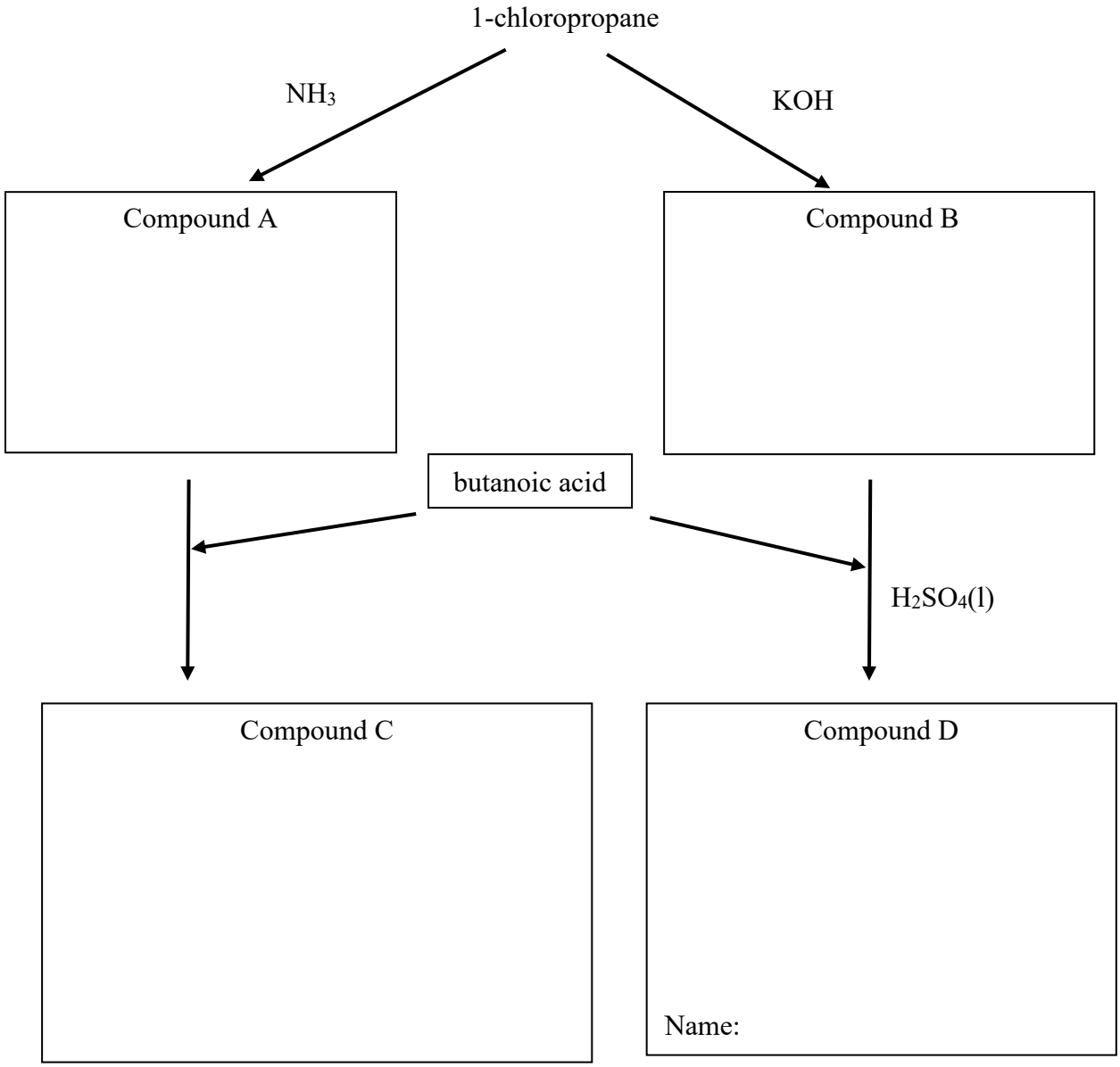
Question 7 (7 marks)

Below is a reaction pathway beginning with 1-chloropropane.



a. **i.** Write a balanced equation for the formation of Compound A from 1-chloropropane. States are not required.

1 mark

_____

ii. Draw and name a structural isomer of Compound A.

1 mark

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b. **i.** Draw the structural formula of Compound C in the box provided.

1 mark

ii. Name the class of compounds to which Compound C belongs.

1 mark

---

c. 1-chloropropane can be reacted with potassium hydroxide solution.
Draw the structural formula of Compound B in the box provided.

1 mark

d. **i.** Compound D is formed when Compound B reacts with butanoic acid.
Write the semi-structural formula of Compound D in the box provided.

1 mark

ii. Add the IUPAC name of Compound D to the box provided.

1 mark

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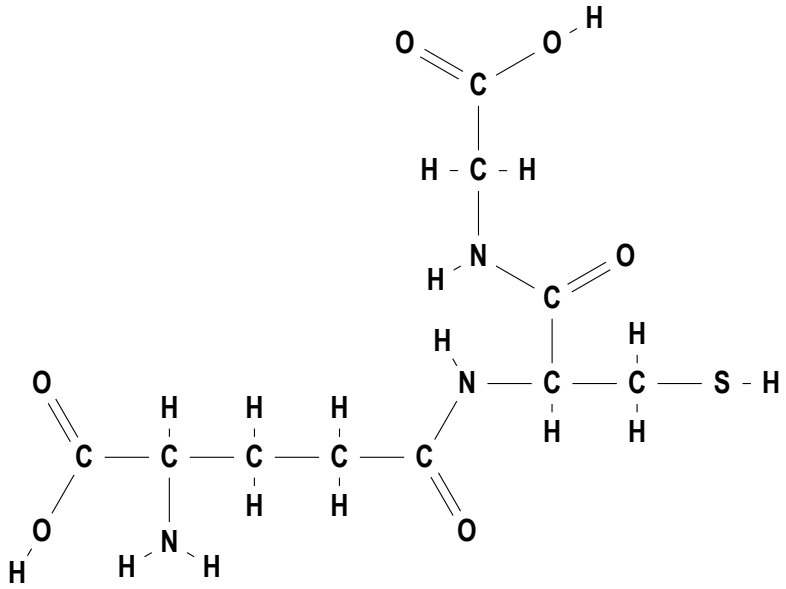
Question 8 (7 marks)

Glutathione is a tripeptide of importance to the human body. It is produced in the liver and it acts as an antioxidant, protecting cellular molecules. Its structure is shown below.



a. **i.** One of the amino acids in glutathione is glycine.

Name the other two amino acids.

2 marks

_____

ii. Explain why glutathione is a tripeptide that cannot react with similar tripeptides to form a protein.

1 mark

_____

_____

_____

iii. The relative molar masses of the two amino acids other than glycine in glutathione are 121 g mol^{-1} and 147 g mol^{-1}.

Determine the molar mass of the tripeptide.

2 marks

_____

_____

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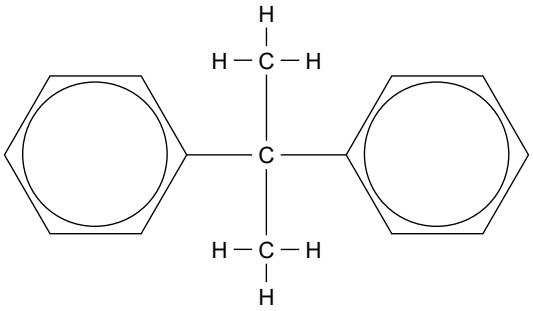
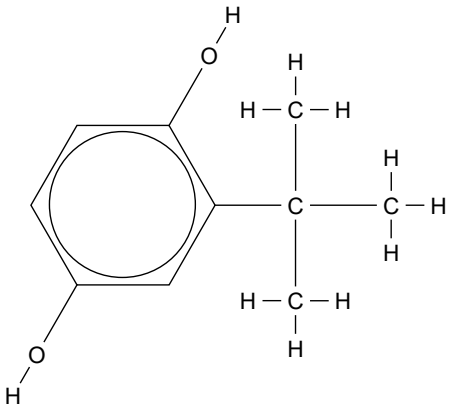
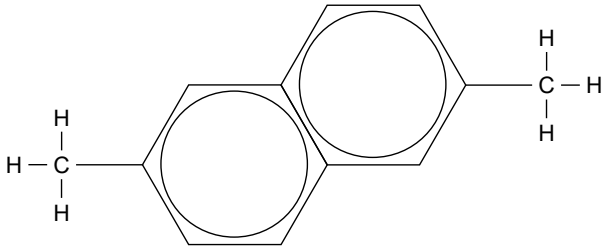
b. Three molecules are shown below. One of the molecules is an antioxidant.



Molecule A



Molecule B



Molecule C

Which one of these molecules is most likely to be the antioxidant? Justify your answer.

2 marks

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Question 9 (11 marks)

The enzyme invertase (also known as sucrase) can be used to hydrolyse sucrose to glucose and fructose.

Experiments with this reaction often use Benedict's solution to monitor the rate of the reaction. Benedict's solution does not react with sucrose but turns orange when the reaction has formed sufficient glucose.

A student sets out to test the impact of temperature on the rate of hydrolysis of sucrose. The method, results and conclusion are provided below.

Method

1. Prepare five water baths at temperatures of 20 °C, 30 °C, 40 °C, 50 °C and 60 °C.
2. Prepare five test tubes.
3. Add 2 mL of sucrose solution to each test tube.
4. Add 2 mL of buffer of pH 5 to each test tube.
5. Add 2 mL of invertase solution to each test tube.
6. Place a test tube in each water bath and start a timer.
7. Record the time for each test tube to reach a particular orange intensity.

Results

Temperature (°C)	Time taken to reach orange intensity
20	9 min 10 s
30	4 min 5 s
40	2 min 2 s
50	1 min 45 s
60	1 min 40 s

Conclusion

The optimum temperature for this reaction is 60 °C.

a. Use the data provided to state the

i. independent variable

1 mark

_____

ii. dependent variable

1 mark

_____

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b. **i.** Write an equation, in words, for the reaction occurring.

1 mark

_____

ii. Explain how Benedict's solution is able to provide an indication of the rate of this reaction.

1 mark

_____

_____

iii. Invertase can be used to hydrolyse sucrose.

Will invertase be able to successfully hydrolyse lactose? Explain your answer.

1 mark

_____

_____

c. A buffer is a solution that has a set pH. It can withstand minor additions of acids and bases to retain the same pH.

Explain why the buffer solution is added to each test tube.

2 marks

_____

_____

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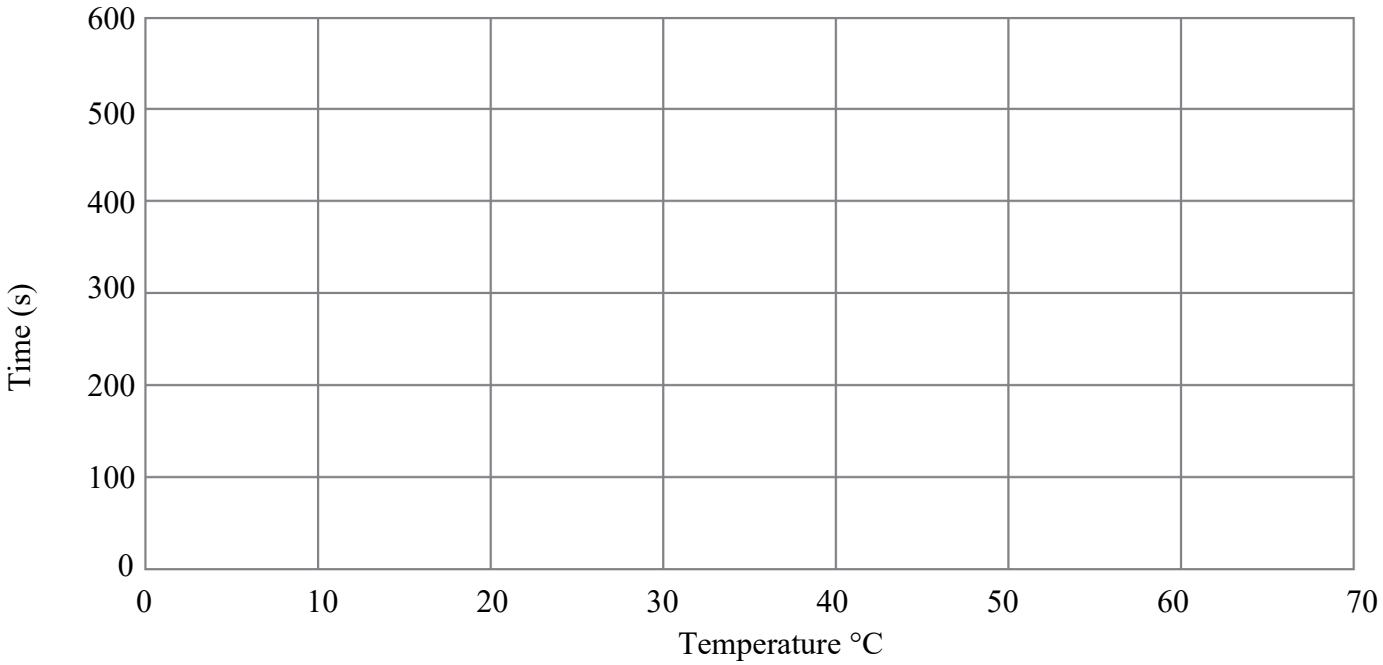
d. **i.** Use the data from the table to plot in the space provided below the time taken to reach the orange intensity against temperature.

1 mark



ii. On the same axes, show what your graph should look like theoretically.

1 mark

iii. Suggest a reason why the graph of the student's data did not match the predicted graph. In your answer, outline a modification to the procedure to address the reason you suggested.

2 marks

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Question 10 (10 marks)

Hydrogen gas is a versatile energy carrier with a wide range of potential uses. However, hydrogen is not freely available in the atmosphere as a gas. It therefore requires an energy input and a series of technologies to produce, store and then use it.

Why would we bother? Because hydrogen has several advantages over other energy carriers, such as batteries. It is a single product that can service multiple markets and, if produced using low- or zero-emissions energy sources, it can help us significantly cut greenhouse emissions.

Source: https://theconversation.com/how-hydrogen-power-can-help-us-cut-emissions-boost-exports-and-even-drive-further-between-refills-101967

As fossil fuel reserves decline, one of the alternatives being proposed for Australia is the 'hydrogen' economy, where hydrogen gas is used to power fuel cells in vehicles.

Two possible mechanisms for producing the hydrogen are

1. Steam–methane reforming: Hydrogen is formed by heating methane with steam at high temperatures. Natural gas can be used as a source of methane. The equation for the reaction is

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

2. Electrolysis of water: If an electrical current is passed through water, the water can be broken up to form hydrogen and oxygen gas. The equation is

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

a. Discuss and compare the two processes of producing hydrogen gas. In your answer, refer to the:

- likely environmental impact of each process
- sustainability of each process
- hazards or risks associated with each process.

5 marks

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b. Hydrogen is a very dangerous and difficult fuel to transport. To solve this problem, it is proposed to react the hydrogen with nitrogen to form ammonia gas.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Ammonia gas can be easily condensed to a liquid and exported to another country. The reaction is reversible, enabling the hydrogen to be reformed once it has arrived at its destination.

Discuss the chemistry of this proposal. In your answer, refer to the:

- reaction conditions that will maximise the yield of ammonia before it is transported
- advantages that ammonia offers as a way of transporting hydrogen fuel
- reaction conditions that will maximise the yield of hydrogen gas when it is reformed from ammonia.

5 marks

END OF QUESTION AND ANSWER BOOK

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