

Student name

CHEMISTRY

Units 3 & 4

Trial Examination

QUESTION AND ANSWER BOOK

Time allowed is 2 hours 30 minutes

Structure of book

Section	Number of questions	Number of marks
A	30	30
B	11	90
Total		120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape, mobile phones and/or any other unauthorised electronic devices.
- A copy of the official VCAA Data Book (printed or photocopied) can be brought into the trial examination.

Materials supplied

- Question and answer book of 22 pages, with a detachable answer sheet for multiple-choice questions inside the front cover.

Instructions

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

At the end of the examination

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

STAV Publishing

2021

CHEMISTRY

Units 3 & 4 Trial Examination

MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:	
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INSTRUCTIONS:**USE PENCIL ONLY**

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries.
- If you make a mistake, **ERASE** it – **DO NOT** cross it out.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- Mark your answer by **SHADING** the letter of your choice.

	ONE ANSWER PER LINE		ONE ANSWER PER LINE
1	☐ A ☐ B ☐ C ☐ D	16	☐ A ☐ B ☐ C ☐ D
2	☐ A ☐ B ☐ C ☐ D	17	☐ A ☐ B ☐ C ☐ D
3	☐ A ☐ B ☐ C ☐ D	18	☐ A ☐ B ☐ C ☐ D
4	☐ A ☐ B ☐ C ☐ D	19	☐ A ☐ B ☐ C ☐ D
5	☐ A ☐ B ☐ C ☐ D	20	☐ A ☐ B ☐ C ☐ D
6	☐ A ☐ B ☐ C ☐ D	21	☐ A ☐ B ☐ C ☐ D
7	☐ A ☐ B ☐ C ☐ D	22	☐ A ☐ B ☐ C ☐ D
8	☐ A ☐ B ☐ C ☐ D	23	☐ A ☐ B ☐ C ☐ D
9	☐ A ☐ B ☐ C ☐ D	24	☐ A ☐ B ☐ C ☐ D
10	☐ A ☐ B ☐ C ☐ D	25	☐ A ☐ B ☐ C ☐ D
11	☐ A ☐ B ☐ C ☐ D	26	☐ A ☐ B ☐ C ☐ D
12	☐ A ☐ B ☐ C ☐ D	27	☐ A ☐ B ☐ C ☐ D
13	☐ A ☐ B ☐ C ☐ D	28	☐ A ☐ B ☐ C ☐ D
14	☐ A ☐ B ☐ C ☐ D	29	☐ A ☐ B ☐ C ☐ D
15	☐ A ☐ B ☐ C ☐ D	30	☐ A ☐ B ☐ C ☐ D

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 mark will be given if more than one answer is completed for any question.

Question 1

Repeating measurements of a quantity and taking an average can reduce the effects of

- A. only systematic errors.
- B. only random errors.
- C. both random and systematic errors.
- D. neither random or systematic errors.

Question 2

In a school chemistry laboratory, which of the following items of equipment has the **greatest** relative uncertainty in a measurement?

- A. A 50 mL burette when used to measure 25 mL of de-ionised water.
- B. A 50 mL pipette when used to measure 25 mL of de-ionised water.
- C. A 50 mL graduated cylinder when used to measure 25 mL of de-ionised water.
- D. An analytical balance when used to weigh 25 g of de-ionised water.

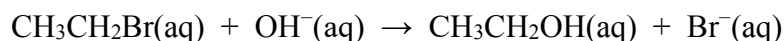
Question 3

In an endothermic reaction

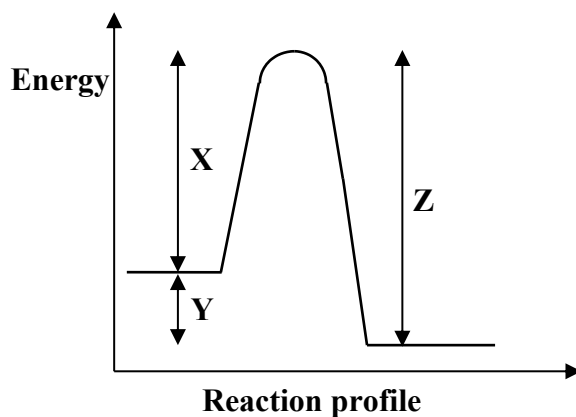
- A. bonds are stronger in the products and energy content is higher in the products.
- B. bonds are weaker in the products and energy content is higher in the products.
- C. bonds are stronger in the products and energy content is lower in the products.
- D. bonds are weaker in the products and energy content is lower in the products.

Questions 4 and 5 relate to the following information.

The following reaction can occur to completion.



The energy change during this reaction is illustrated in the energy profile shown below.



Question 4

A reaction can occur between the reactant particles

- A. every time they collide.
- B. only when they collide with exactly the energy X.
- C. only when they collide with an energy equal to $Y - Z$.
- D. only when they collide with an energy greater than or equal to energy X.

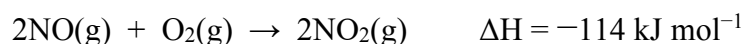
Question 5

A catalyst appropriate for this reaction will affect the value of

- A. X only
- B. Y only
- C. X and Z
- D. X, Y and Z

Question 6

Which one of the following statements about the reaction below is correct?



- A. 114 kJ of energy are absorbed for every mole of NO reacted.
- B. 114 kJ of energy are released for every mole of NO reacted.
- C. 57 kJ of energy are absorbed for every mole of NO reacted.
- D. 57 kJ of energy are released for every mole of NO reacted.

Question 7

The table below shows the heat of combustion of some primary alcohols.

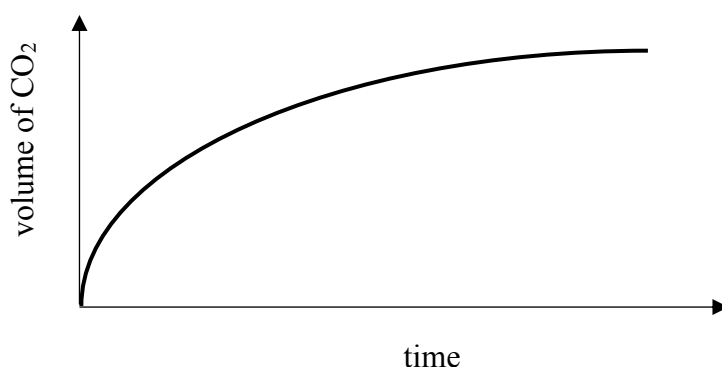
Number of C atoms in primary alcohols	Heat of combustion kJ mol^{-1}
1	726
3	2021
5	3331
7	4638

What mass of water, in kg, could be heated from 20.0°C to 45.0°C by the complete combustion of 1.0 g of heptan-1-ol?

- A. 0.032 kg
- B. 0.044 kg
- C. 0.36 kg
- D. 0.38 kg

Question 8

The reaction between excess calcium carbonate and hydrochloric acid can be followed by measuring the volume of carbon dioxide produced with time. The results of one such reaction are shown below.

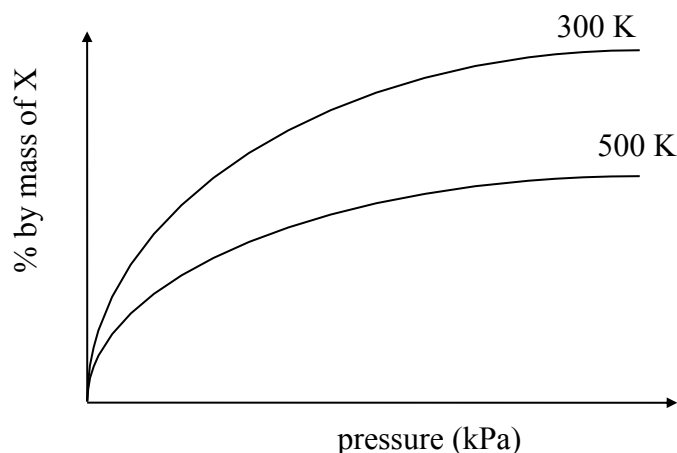


How does the rate of this reaction change with time and what is the **main** reason for this change?

- A. The rate increases with time because the calcium carbonate particles get smaller.
- B. The rate increases with time because the acid becomes more dilute.
- C. The rate decreases with time because the calcium carbonate particles get smaller.
- D. The rate decreases with time because the acid solution becomes more dilute.

Question 9

The graph below shows how the percentage, by mass, of a substance X in an equilibrium mixture varies with pressure at temperatures of 300 K and 500 K.

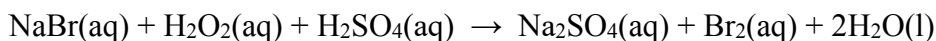


In which of the following equilibria could the underlined species be substance X?

- A. $\underline{\text{N}_2}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}); \quad \Delta H = +176 \text{ kJ mol}^{-1}$
- B. $4\underline{\text{NH}_3}(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{l}); \quad \Delta H = -907 \text{ kJ mol}^{-1}$
- C. $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\underline{\text{NO}_2}(\text{g}); \quad \Delta H = +58 \text{ kJ mol}^{-1}$
- D. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\underline{\text{NH}_3}(\text{g}); \quad \Delta H = -92 \text{ kJ mol}^{-1}$

Question 10

In the reaction represented by the following equation, which element is being reduced?



- A. oxygen
- B. hydrogen
- C. sulfur
- D. bromine

Question 11

This reaction occurs in a galvanic cell: $\text{Mg}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$

What reaction takes place at each electrode?

	Anode	Cathode
A.	$\text{Ag}(\text{s}) \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$
B.	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	$\text{Mg}(\text{s}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$
C.	$\text{Mg}(\text{s}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$
D.	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	$\text{Ag}(\text{s}) \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$

Question 12

Fuel cells are being developed that use fuels other than hydrogen as their energy sources. The table below shows four potential fuels and their reaction in the fuel cell. (Symbols of state have been omitted from these reaction equations for simplicity.)

Fuels		Reaction in fuel cells
methanol	CH ₃ OH	CH ₃ OH + H ₂ O → CO ₂ + 6H ⁺ + 6e ⁻
ethanol	C ₂ H ₅ OH	C ₂ H ₅ OH + 3H ₂ O → 2CO ₂ + 12H ⁺ + 12e ⁻
ethane	C ₂ H ₆	C ₂ H ₆ + 4H ₂ O → 2CO ₂ + 14H ⁺ + 14e ⁻
ethane-1,2-diol	C ₂ H ₄ (OH) ₂	C ₂ H ₄ (OH) ₂ + 2H ₂ O → 2CO ₂ + 10H ⁺ + 10e ⁻

Which one of the fuels would produce the greatest amount of CO₂ per coulomb of electrical charge generated?

- A. methanol
- B. ethanol
- C. ethane
- D. ethane-1,2-diol

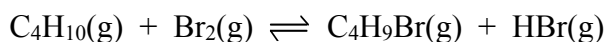
Question 13

What are the products at the respective inert electrodes when 1.0 M KI(aq) is electrolysed?

	Anode	Cathode
A.	O ₂	K
B.	O ₂	H ₂
C.	I ₂	K
D.	I ₂	H ₂

Question 14

Which one or more of the following changes increase the **rate** of the reaction

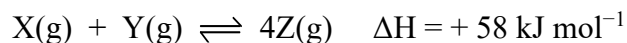


- I increase of pressure
- II increase of temperature
- III removal of HBr(g)

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

Question 15

The equation below describes an equilibrium reaction occurring in a closed system.



Under which set of conditions would the highest equilibrium yield of Z(g) be obtained?

	temperature (°C)	pressure (kPa)
A.	50	100
B.	50	200
C.	300	100
D.	300	200

Question 16

Which of the following statements would apply to compounds that belong to the same homologous series?

- I they have similar physical properties
- II they have similar chemical properties
- III they contain the same functional group
- IV they have the same molecular formula but different structures

- A. III only
- B. IV only
- C. II and III only
- D. I, II, III and IV

Question 17

Which one of the following formulae is that of a secondary halogenated alkane?

- A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$
- B. $\text{CH}_3\text{CBr}(\text{CH}_3)_2$
- C. $(\text{CH}_3)_2\text{CHBr}$
- D. $\text{CH}_3\text{CHOHCH}_2\text{CH}_3$

Question 18

How many 'straight' chain structural isomers of dichlorobutane exist?

- A. 3
- B. 4
- C. 5
- D. 6

Question 19

Which of the following amino acids has five carbon atoms **and** when dissolved in water will most likely result in a pH less than 7?

- A. histidine
- B. aspartic acid
- C. proline
- D. glutamic acid

Question 20

Which one of the following compounds has the lowest boiling point?

- A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- B. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- C. $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- D. $\text{C}(\text{CH}_3)_4$

Question 21

Which of the following fatty acids, represented by their molecular formula, would have the lowest melting temperature?

- A. $\text{C}_{16}\text{H}_{32}\text{O}_2$
- B. $\text{C}_{18}\text{H}_{36}\text{O}_2$
- C. $\text{C}_{18}\text{H}_{34}\text{O}_2$
- D. $\text{C}_{18}\text{H}_{32}\text{O}_2$

Question 22

Which one or more of the following can be carried by a coenzyme?

- I electrons
- II protons
- III particular groups of atoms

- A. I only
- B. I and II only
- C. I and III only
- D. I, II and III

Question 23

A list of organic compounds is shown below

- I $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CHO}$
- II $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
- III $\text{CH}_3\text{COCH}(\text{CH}_3)\text{CHO}$

Which one or more of the organic compounds listed above contains a chiral centre?

- A. I only
- B. I and III only
- C. III only
- D. II and III only

Question 24

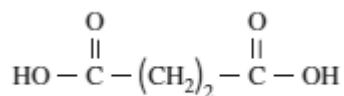
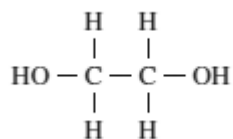
Glycine is one of the amino acids that form proteins. Protein that is not required in the body is broken down in the liver. Unwanted nitrogen is converted into urea, $\text{CO}(\text{NH}_2)_2$ and eliminated in the urine.

The maximum mass, in g, of urea ($M = 60 \text{ g mol}^{-1}$) that could be eliminated as a result of the breakdown of 1.00 g of glycine ($M = 75 \text{ g mol}^{-1}$) is closest to

- A. 0.40
- B. 0.80
- C. 1.2
- D. 1.6

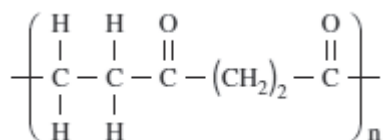
Question 25

Two monomers are shown below.

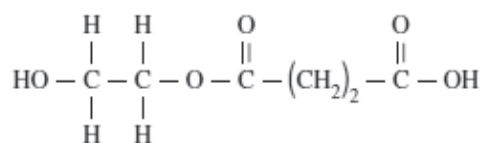


Which of the following shows a condensation polymer formed from the monomers?

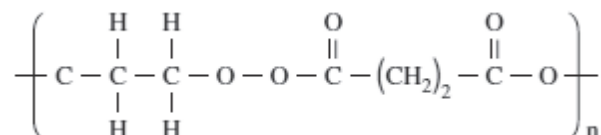
A.



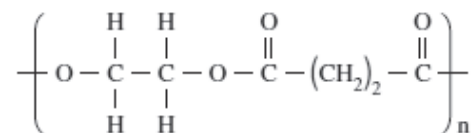
B.



C.



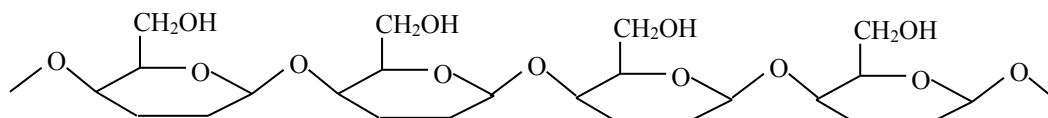
D.

**Question 26**

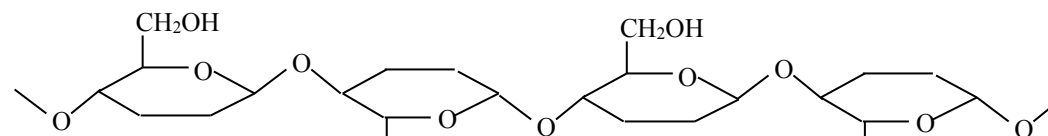
Cellulose is a linear polymer which is a basic structural component of plant cell walls.

Which one of the following is a correct representation of part of a cellulose polymer chain?

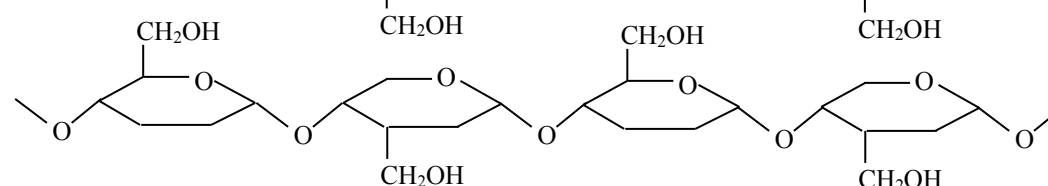
A.



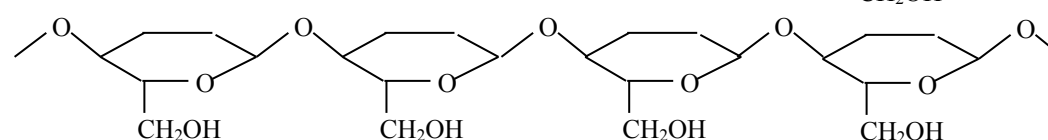
B.



C.



D.



Question 27

The percentage of oxygen by mass in the amino acid proline is 27.8%. The percentage of oxygen by mass in a polypeptide formed solely from proline is

- A. 27.8%
- B. more than 27.8%
- C. less than 27.8%
- D. unable to be determined without further information

Question 28

Correct procedures for a titration include which of the following?

- I Draining a pipette by touching the tip to the side of the conical flask used for the titration.
- II Rinsing the burette with de-ionised water just before filling it with the liquid to be titrated.
- III Swirling the solution in the conical flask frequently during the titration.

- A. I only
- B. I and III only
- C. II and III only
- D. I, II, and III

Question 29

Commercial vinegar was titrated with sodium hydroxide solution to determine the content of ethanoic acid. For a 20.00 mL sample of the vinegar 26.7 mL of 0.600 M NaOH(aq) was required. The concentration, in g L^{-1} , of ethanoic acid in the vinegar if no other acid was present is closest to

- A. 27.0
- B. 36.0
- C. 48.0
- D. 96.0

Question 30

A solution calorimeter was inadvertently calibrated with just 95 mL of water instead of 100 mL and then used to determine the heat of reaction of powdered magnesium in 100 mL of HCl(aq). Compared with the values calculated from this information

- A. the correct calibration factor should be lower and the heat of reaction should be lower.
- B. the correct calibration factor should be higher and the heat of reaction should be higher.
- C. the correct calibration factor should be lower and the heat of reaction should be higher.
- D. the correct calibration factor should be higher and the heat of reaction should be lower.

END OF SECTION A

SECTION B – Short answer questions (90 marks)**Instructions for Section B**

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

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $\text{H}_2(\text{g})$; $\text{NaCl}(\text{s})$

Question 1

- a. Draw structural diagrams of **both** cis and trans 2-chlorobut-2-ene. Label each clearly.

3 marks

- b. Describe how a student could distinguish between the pairs of organic substances in each of the following by describing a suitable test and the expected results.

- i. an alkane and an alkene

2 marks

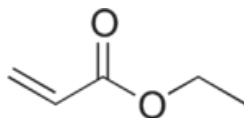
- ii. two alcohols, one a primary alcohol and the other a tertiary alcohol

2 marks

Total 7 marks

Question 2

- a. Determine the molecular formula of the molecule represented by the following skeletal structure.



1 mark

- b.** Could this molecule be polymerised? Give a reason for your answer.

2 marks

Total 3 marks

Question 3

Starting with propane, suggest a **four-step** synthesis of propyl propanoate. Use structural formulae, relevant equations and reagents where possible. States are not required.

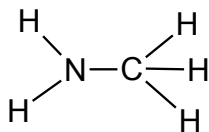
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Total 12 marks

Question 4

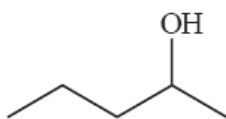
Give the IUPAC names for the following formulae.

a.



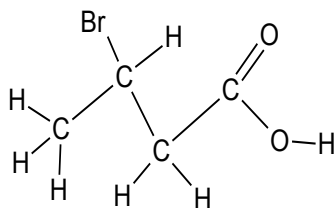
_____ 1 mark

b.



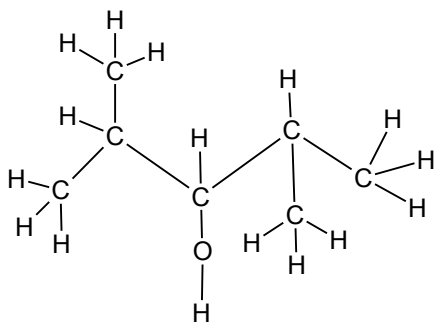
_____ 1 mark

c.



_____ 1 mark

d.



_____ 1 mark

Total 4 marks

Question 5

- a.** Suggest **three** ways in which carbohydrates are used by humans.

3 marks

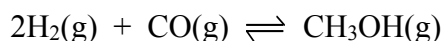
- b.** Amylose and amylopectin are two forms of human starch. Explain why amylose is insoluble in water whereas amylopectin is soluble in water.

4 marks

Total 7 marks

Question 6

At temperatures above 100°C, hydrogen and carbon monoxide react to form methanol gas in the following reversible reaction.



A mixture of hydrogen, carbon monoxide and methanol is placed in a container with a volume that can be changed. The mixture is allowed to reach equilibrium. The initial volume of the container is 1.00 L.

- a. Use Le Chatelier's Principle to account for any changes in the amount and concentration of hydrogen gas when the volume of the container is suddenly increased to 2.00 L.

3 marks

The initial mixture placed in the container had 0.50 mol of hydrogen, 1.00 mol of carbon monoxide and 2.50 mol of methanol. Once the volume of the container had been increased to 2.00 L and equilibrium had been re-established, the number of moles of hydrogen in the mixture had increased by 0.36 mol.

- b. Determine the equilibrium constant, including its unit, for this reaction.

6 marks

Total 9 marks

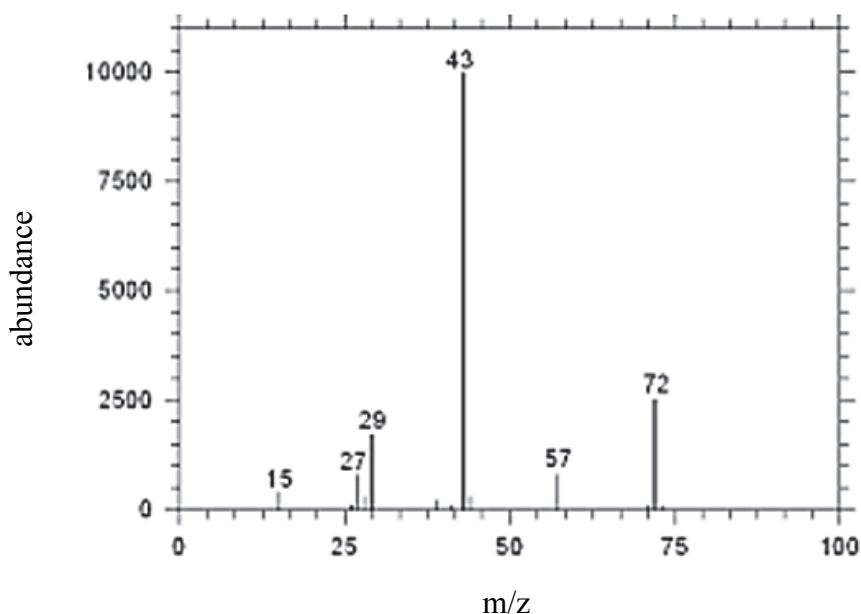
Question 7

An organic substance, compound X, was found by experiment to contain 66.7% carbon, 11.1% hydrogen and 22.2% oxygen by mass.

- a. Determine the empirical formula of compound X.

3 marks

The mass spectrum of compound X is shown below.



- b. From the information on the mass spectrum, write the mass **and** the formula for the

i. base peak: _____

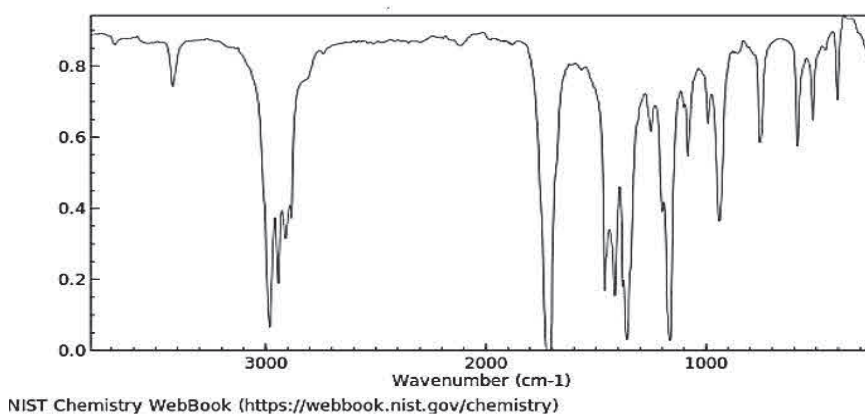
ii. parent molecular ion: _____

2 + 2 = 4 marks

- c. Write the molecular formula of compound X _____

1 mark

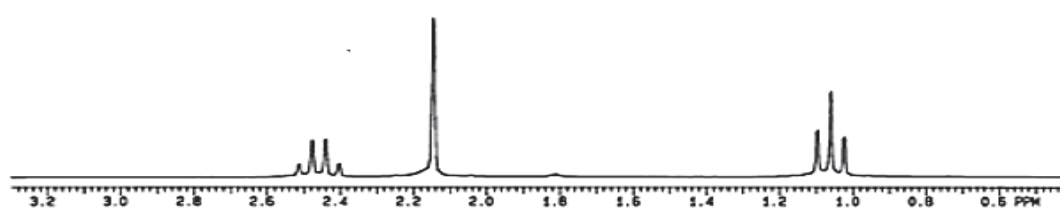
The infrared spectrum of compound X is shown below.



d. List **three** pieces of evidence about the compound that the infrared spectrum provides.

3 marks

The ¹H NMR spectrum of compound X is shown below.



e. Explain what **four** pieces of information can be obtained from this spectrum.

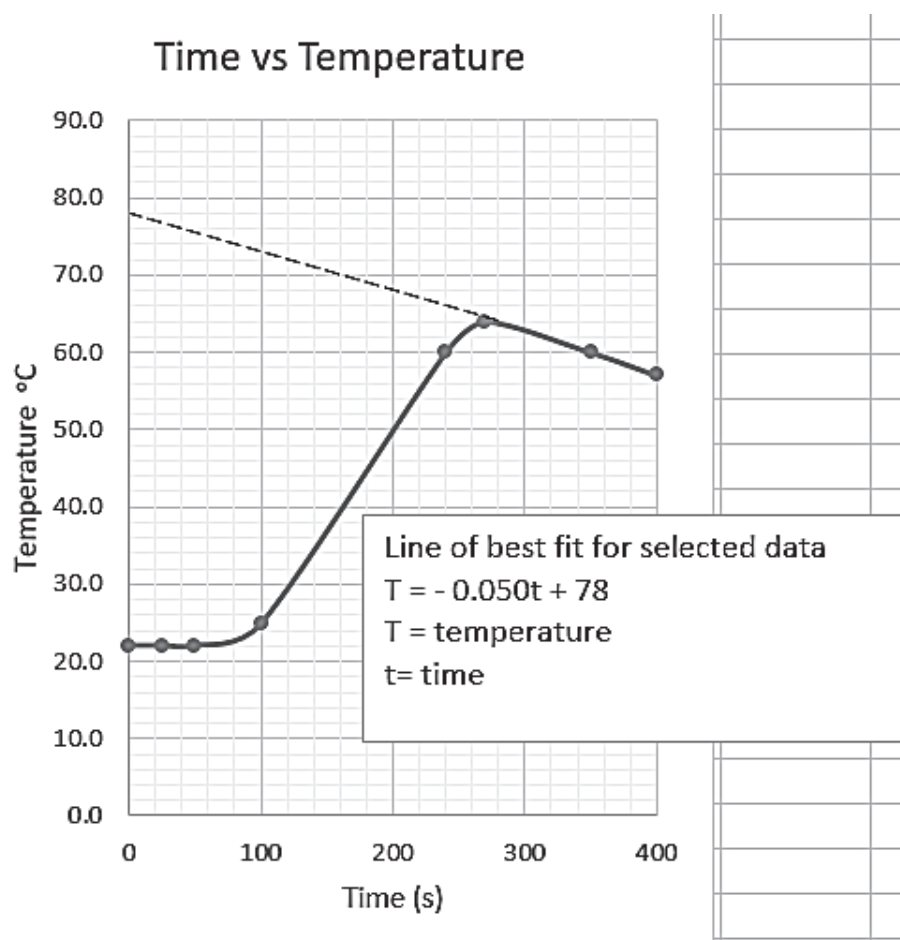
4 marks

f. Draw a possible structure for compound X.

2 marks
Total 17 marks

Question 8

The data below are from an experiment to measure the enthalpy change for the reaction of aqueous copper(II) ions and zinc powder.



50.0 mL of 1.00 M copper(II) sulfate was placed in a polystyrene cup and zinc powder was added **after 60 seconds**. The temperature data was obtained using a data-logger. The graph above shows a plot of the data. A dotted straight line has been drawn through some of the data points. The equation for the line given by the data logging software was $T = -0.050t + 78$

- a. Write the ionic equation, including states, for the reaction.

1 mark

The heat produced by the reaction can be calculated from the temperature change, ΔT , using the expression:

$$\text{heat change} = \text{volume of CuSO}_4(\text{aq}) \times \text{specific heat capacity of H}_2\text{O} \times \Delta T$$

- b. Describe **two** assumptions made in using this expression to calculate heat change.

2 marks

- c. i. Use the data to deduce the temperature change, ΔT , which would have occurred if the reaction had taken place **instantaneously with no heat loss**.

- ii. Calculate the heat, in kJ, produced if the reaction had taken place **instantaneously with no heat loss** using the expression given on the previous page.

1 + 1 = 2 marks

- d. The colour of the solution changed from blue to colourless. Deduce the amount, in mol, of zinc which reacted in the polystyrene cup.

1 mark

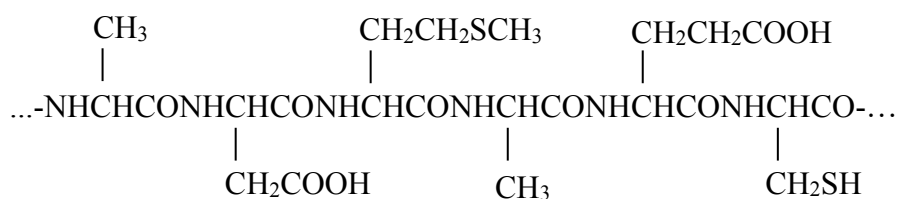
- e. Calculate the enthalpy change, in kJ mol^{-1} , for this reaction.

2 marks

Total 8 marks

Question 9

A segment of a protein chain found in the enzyme serine dehydratase is shown below.



- a. Draw the structure of one peptide link (show all bonds).

1 mark

- b. How many **different** amino acid residues are shown in this segment?

1 mark

- c. Use your data book to name all of the amino acids present in this segment, in order from left to right.

3 marks

Protein chains can be converted into amino acids in acidic solutions.

- d. Draw the structure of the **zwitterion** representing **one** of the amino acids formed from the protein chain shown above that does **not** have an acidic side chain.

1 mark

- e. The structure of amino acids alters at different pH values. Using your answer to d. show the structure of the amino acid in solution **at high pH**.

1 mark

Total 7 marks

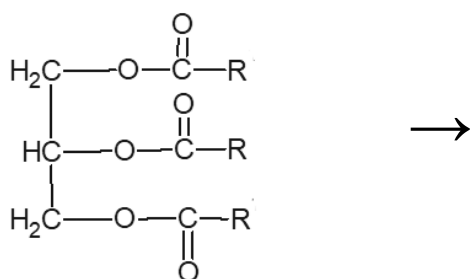
Question 10

Vegetable oils can be converted into diesel fuel by a process known as transesterification.

- a. Explain why vegetable oils themselves are not used as diesel fuels.

2 marks

- b. Complete a two stage process for the conversion of typical vegetable oil into a methyl ester (a typical biodiesel). Structural formulae and semi-structural formulae may be used with any additional reactants above the arrows. However a full structural formula must be shown for the biodiesel.



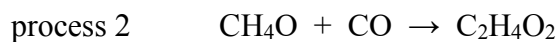
6 marks

- c. Biodiesel can vary in viscosity. Explain why this is so.

2 marks
Total 10 marks

Question 11

A manufacturing company can produce ethanoic acid by two different processes.



- a.** The chemists know that the atom economy of a process is important. Calculate the percentage atom economy for making ethanoic acid by process 1.

1 mark

- b.** The chemists also know that the percentage yield of a process is important. The synthesis uses 5.2 tonnes of methanol in process 2.

- i.** Calculate the mass, in tonnes, of ethanoic acid that can be theoretically produced.

- ii.** 8.5 tonnes of ethanoic acid was actually made. Calculate the percentage yield of the ethanoic acid.

3 + 1 = 4 marks

- c.** Other than cost, what is **one** advantage of a very high atom economy?

1 mark

Total 6 marks

END OF TRIAL EXAMINATION

