Neap:

Trial Examination 2019

VCE Chemistry Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of booklet

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 booklet of 27 pages

Data booklet

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's 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 booklet 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 booklet.

You may keep the data booklet.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2019 VCE Chemistry Units 3&4 Written 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 booklet are **not** drawn to scale.

Question 1

Biodiesel

A. consists only of hydrogen atoms and carbon atoms.
B. produces only carbon monoxide and water when undergoing complete combustion.
C. flows very easily when the outside temperature is low.
D. absorbs moisture from the air that adversely affects fuel quality.

Question 2

Which one of the following statements is true for endothermic reactions but **not** for exothermic reactions?

A. The activation energy of the reaction is always a positive value.
B. There is a change in enthalpy that occurs during the reaction.
C. The energy content of the products is higher than the reactants.
D. The temperature of the surroundings is higher after the reaction.

Use the following information to answer Questions 3 and 4.

Equal volumes of liquid $CH_3CH_2CH_2CH_2COOH$ and liquid $CH_3CH_2CH_2OH$ were mixed and heated in the presence of a small volume of concentrated sulfuric acid.

Question 3

Which one of the following could be a product of the reaction?

A. propyl butanoate
B. butyl propanoate
C. pentyl propanoate
D. propyl pentanoate

Question 4

What is the major role of the sulfuric acid in the reaction?

A. donating protons
B. acting as an oxidant
C. catalysing the reaction
D. being a dehydrating agent

Use the following information to answer Questions 5 and 6.

Under standard conditions, a $Sn^{2+}(aq)/Sn(s)$ half-cell was connected to another half-cell to produce a voltage of 1.52 V in a galvanic cell.

Question 5

The other half-cell in the galvanic cell is most likely to be

A. $Al^{3+}(aq)/Al(s)$

B. $Au^{+}(aq)/Au(s)$

C. $Cl_2(g)/Cl^{-}(aq)$

D. $Mn^{2+}(aq)/Mn(s)$

Question 6

In the galvanic cell, the $Sn^{2+}(aq)/Sn(s)$ half-cell contains the

A. positive electrode, where oxidation occurs.

B. positive electrode, where reduction occurs.

C. negative electrode, where oxidation occurs.

D. negative electrode, where reduction occurs.

Question 7

The range of energy transformations that occur in devices includes the following:

I chemical energy to electrical energy

II electrical energy to chemical energy

III chemical energy to heat energy

Which of these transformations occur in a fuel cell?

A. I and II only

B. II and III only

C. I and III only

D. I, II and III

Question 8

When 0.173 mol of a particular fuel is burnt completely, 225 kJ of energy is produced.

The fuel is likely to be

A. ethane.

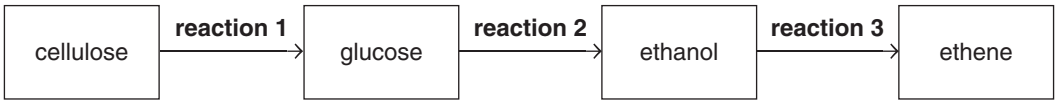
B. ethyne.

C. ethanol.

D. propane.

Use the following information to answer Questions 9 and 10.

The flow chart below shows a pathway for the production of ethene.



Question 9

Which type of bonds are broken in reaction 1?

A. glycosidic
B. ester
C. peptide
D. amide

Question 10

Which one of the following statements about this process is **incorrect**?

A. Reaction 2 involves fermentation and occurs in the absence of oxygen.
B. Ethene produced in this process would be regarded as renewable.
C. Cellulose is the storage material of excess glucose in animals.
D. The ethanol produced would be accurately classed as bioethanol.

Question 11

When comparing vitamin D with vitamin C, it is correct to state that only the vitamin D molecule

A. is soluble in water and insoluble in oil.
B. can be synthesised in the human body.
C. contains many hydroxyl functional groups.
D. is an essential dietary requirement.

Question 12

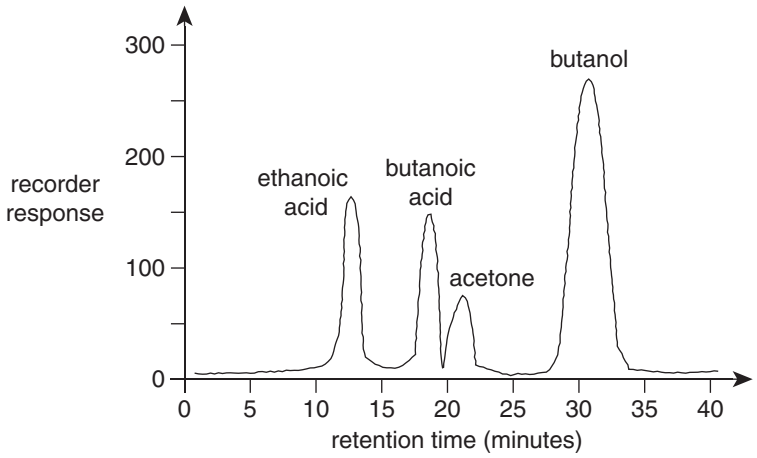
An experiment was conducted to determine the pH that results in the maximum activity of the enzyme amylase. A series of test tubes was used, each containing 20 mL of 0.1 M starch solution at a different pH and at 18°C. A set volume of an amylase solution was added to each test tube.

Which one of the following is correct regarding the experiment described?

	Independent variable	Dependent variable
A.	temperature of the solution	volume of the starch solution
B.	volume of the starch solution	volume of the amylase solution
C.	pH of the starch solution	activity of the enzyme
D.	activity of the enzyme	pH of the starch solution

Use the following information to answer Questions 13 and 14.

A mixture of organic compounds was analysed using high-performance liquid chromatography (HPLC) and produced the result shown in the diagram below.



Question 13

How were the peaks identified?

A. A standard database with retention times of all organic compounds was consulted.
B. The heights of the peaks indicated the molecular structure of the organic compounds.
C. Known compounds were analysed on the same column under identical conditions.
D. The distances between the peaks revealed which organic molecules were present.

Question 14

Which one of the following statements is **incorrect**?

A. Ethanoic acid has the strongest attraction to the mobile phase.
B. Butanol has the weakest attraction to the stationary phase.
C. In the sample analysed, butanol was in the highest concentration.
D. Using a higher pressure would result in all retentions times being shorter.

Question 15

A compound known as FAD is derived from vitamin B_2 and is reduced in the following reaction:

$$FAD + 2H^+ + 2e^- \rightarrow FADH_2$$

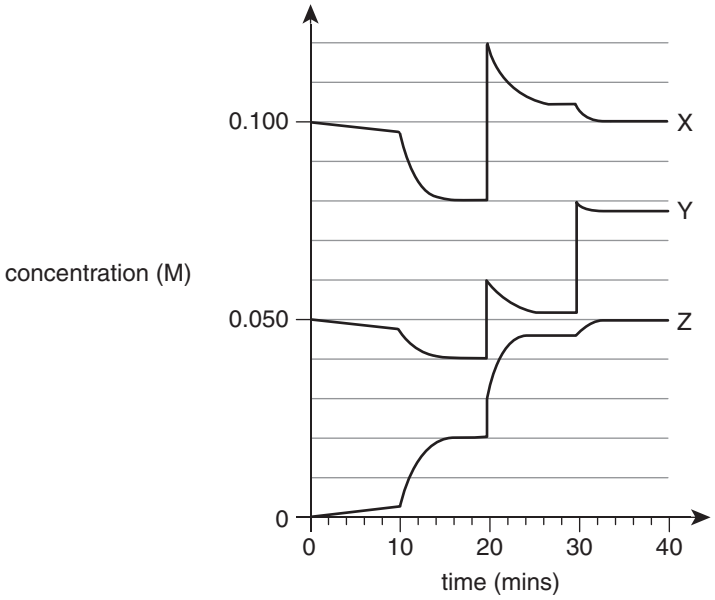
It is known that FAD binds to an active site during catalysis.

FAD is most likely to be a

A. catalyst.
B. polymer.
C. coenzyme.
D. disaccharide.

Use the following information to answer Questions 16–18.

The gases X and Y react to form gas Z in an equilibrium reaction. Initially some X and Y are placed in a sealed vessel. Changes are made to the gaseous mixture at various times and the results are shown in the graph below.



Question 16

What is the equation for the equilibrium reaction?

A. $X(g) + Y(g) \rightleftharpoons 2Z(g)$

B. $X(g) + 2Y(g) \rightleftharpoons Z(g)$

C. $2X(g) + Y(g) \rightleftharpoons 2Z(g)$

D. $2X(g) + 2Y(g) \rightleftharpoons Z(g)$

Question 17

Which one of the following shows the changes made at the specified times?

	Times at which changes were made to the gas mixture		
	10 minutes	**20 minutes**	**30 minutes**
A.	temperature increased	catalyst introduced	total volume increased
B.	catalyst introduced	total volume decreased	more gas Y added
C.	temperature decreased	total volume increased	more gas Z added
D.	pressure of vessel increased	more of all gases introduced	catalyst introduced

Question 18

The equilibrium constants for the equilibrium mixtures at various times are shown in the table below.

Time	18 minutes	28 minutes	38 minutes
Equilibrium constant	K_{c_1}	K_{c_2}	K_{c_3}

Which one of the following shows the correct comparison between the values of the equilibrium constants?

A. $K_{c_1} > K_{c_2}$ and $K_{c_2} < K_{c_3}$

B. $K_{c_1} > K_{c_2} > K_{c_3}$

C. $K_{c_3} > K_{c_2} > K_{c_1}$

D. $K_{c_1} = K_{c_2} = K_{c_3}$

Question 19

Both sucrose and aspartame are used as sweeteners in food.

Which one of the following statements about these compounds is **incorrect**?

A. The structure of aspartame is a methyl ester of a dipeptide.

B. Sucrose and aspartame have about the same energy content per gram.

C. Sucrose and aspartame have the same ratio of C : H : O in their molecules.

D. Less aspartame is needed than sucrose to achieve the same level of sweetness.

Question 20

Eicosapentenoic acid is an omega-3 fatty acid with the molecular formula $C_{20}H_{30}O_2$.

Its structure should contain

A. no more than four C=C double bonds.

B. a double bond on carbon number 17.

C. more than 80% carbon by mass.

D. two C=O groupings of atoms.

Question 21

How many of the carbon atoms in the amino acid threonine are chiral?

A. 1

B. 2

C. 3

D. 4

Question 22

The enzyme that catalyses a reaction of the organic compound glyceraldehyde in the human body has three specific binding sites for the glyceraldehyde substrate on its surface. The enzyme will not catalyse the same reaction of an optical isomer of glyceraldehyde.

The most likely reason for this is that the optical isomer

A. has a different molecular formula compared to the normal substrate.

B. has different functional groups compared to the normal substrate.

C. binds to less than three sites on the surface of the enzyme.

D. binds to more than three sites on the surface of the enzyme.

Use the following information to answer Questions 23 and 24.

A particular food has the following composition by mass.

	Carbohydrates	Fats and oils	Protein	Other
Composition (%)	65	20	12	3

Question 23

How many megajoules of energy would the complete combustion of 150 g of this food in a calorimeter produce?

A. 2.0
B. 2.5
C. 3.0
D. 3.5

Question 24

The amount of energy produced in the human body after consuming 150 g of this food would be less than the energy of combustion in a calorimeter. Possible reasons include the following:

I Compounds in food are digested by condensation reactions that are not 100% efficient.

II Carbohydrates may include cellulose, which is not digested in the human body.

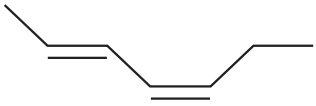
III Not all digestible compounds in the food are broken down in the human body to release all of the stored energy.

Which of these reasons are valid?

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

Question 25

The skeletal structure of 2,4-heptadiene is shown below.

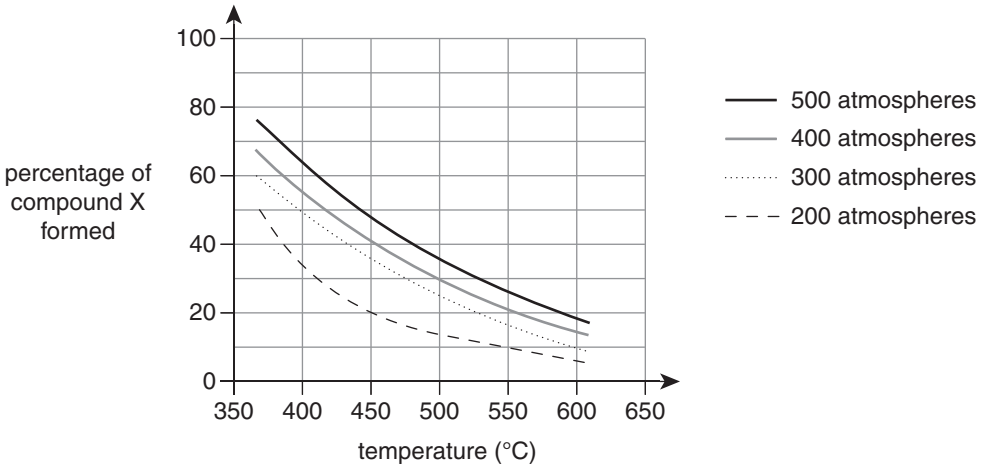


Which one of the following shows the correct configuration of the double bonds?

	C_2–C_3 double bond	C_4–C_5 double bond
A.	trans	trans
B.	trans	cis
C.	cis	cis
D.	cis	trans

Question 26

The percentage of compound X formed in a gaseous equilibrium reaction under different conditions of temperature and pressure is shown in the graphs below.



Which one of the following is correct?

	Side of equation for compound X formation with the higher number of mole of gas	Type of chemical reaction for compound X formation
A.	reactants	endothermic
B.	reactants	exothermic
C.	products	endothermic
D.	products	exothermic

Question 27

Which one of the following factors would have the **least** impact on the amount of chlorine gas produced during the electrolysis of 150.0 mL of an aqueous 2.0 M sodium chloride solution?

A. length of time of electrolysis

B. current flowing

C. temperature of the electrolyte

D. volume of the electrolyte-containing vessel

Question 28

Which one of the following statements concerning the compound C_6H_6 is correct?

A. The compound is known as cyclohexane and is not soluble in water.

B. The compound is known as benzene and is soluble in water.

C. The compound can undergo substitution reactions because there are no carbon–carbon double bonds in the molecule.

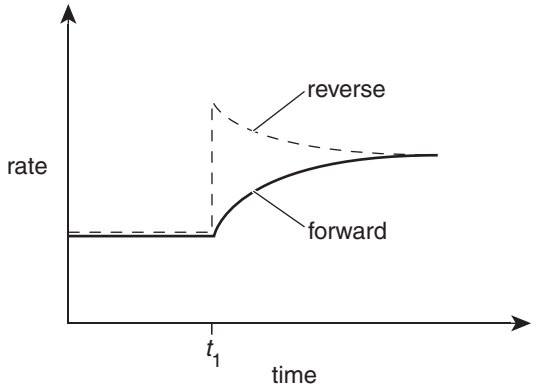
D. The compound can undergo addition reactions because three carbon–carbon double bonds are present in the molecule.

Question 29

The gases dinitrogen tetroxide and nitrogen dioxide exist in an equilibrium reaction represented by the following equation:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H < 0$$

The graph below shows the changes to the rates of forward and reverse reactions that occurred when a change was made to the equilibrium system at time t_1.



Which one of the following changes to the equilibrium mixture would account for the changes shown in the graph?

A. Some N_2O_4 was added to the mixture.

B. A catalyst was added.

C. The volume of the container was increased.

D. The reaction vessel was heated.

Question 30

Consider the following statements in reference to sucrose:

I Sucrose is a disaccharide formed from two glucose monomers.

II An ester linkage forms when sucrose is produced from its monomer compounds.

III Sucrose has the same empirical formula as the monomers used in its formation.

Which of these statements are **incorrect**?

A. I and II only

B. II and III only

C. I and III only

D. I, II and III

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.

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 booklet are **not** drawn to scale.

Question 1 (11 marks)

The triglyceride trilinolein is a component of some vegetable oils and has linoleic acid as the only long-chain fatty acid component.

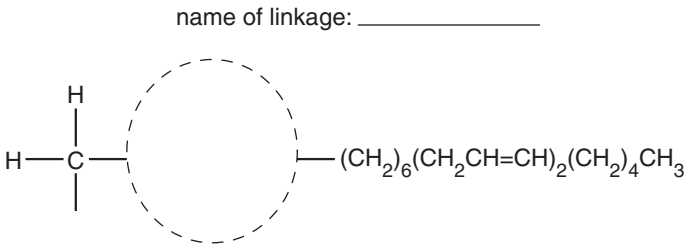
a. i. Why is linoleic acid classed as an **unsaturated** long-chain fatty acid? 1 mark

_____

_____

_____

ii. Complete the drawing and labelling of the structure of trilinolein shown below. 3 marks



iii. Vegetable oil containing trilinolein should be kept in a tightly capped bottle to exclude the air and so prevent oxidative rancidity.

On the diagram in **part a.ii.**, circle and label as X one part of the molecule that is reacted during the process leading to oxidative rancidity. 1 mark

iv. Trilinolein is a liquid at room temperature and does not dissolve in water.
Explain both of these properties, with reference to structure and bonding. 3 marks

_____

_____

_____

_____

_____

_____

b. Volumetric analysis was used to measure the concentration of linoleic acid in a sample of vegetable oil that had been left exposed to the air. The following results were recorded:

Volume of aliquots of vegetable oil used: 20.00 mL

Concentration of KOH solution in burette: 0.0125 M

Average titre required to reach endpoint: 16.35 mL

Calculate the molarity of the acid in the vegetable oil. 3 marks

_____

_____

_____

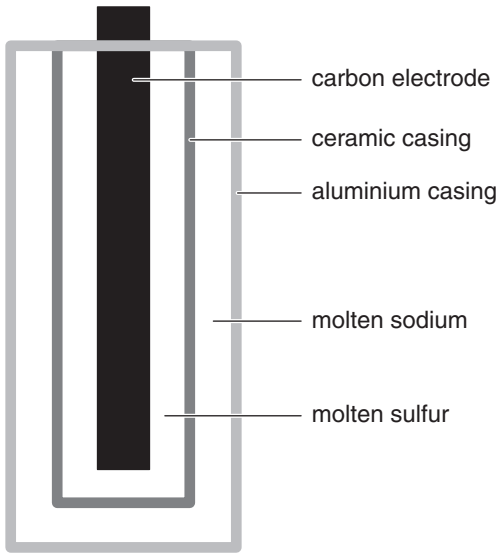
_____

Question 2 (9 marks)

The sodium–sulfur cell is a galvanic cell with the following overall reaction during discharge:

$$2Na(l) + S(l) \rightarrow Na_2S(l)$$

The design of one version of the cell is shown in the simplified diagram below.



The solid ceramic casing is made of a special material that allows only sodium ions to pass through it.

a. **i.** Which component of the cell acts as the anode? 1 mark

_____

ii. Write the half-equation for the reduction reaction that occurs when the cell is discharging. 1 mark

_____

iii. Write the half-equation for the reaction that occurs at the negative electrode when the cell is discharging. 1 mark

_____

b. The cell operates at approximately 300°C but there is no external heat source.

Suggest how the sodium and sulfur are kept molten. 1 mark

_____

_____

_____

c. In a normal galvanic cell, the half-cells are connected by a salt bridge.

i. What is the purpose of the salt bridge? 2 marks

_____

_____

_____

ii. Which component of the sodium–sulfur cell acts as the salt bridge? 1 mark

_____

d. Tick **one** box in the table below to show which electrode of the sodium–sulfur cell should be connected to the positive electrode of the power supply, and the type of reaction which will occur at this electrode in the cell when it is being recharged. 1 mark

	Positive	**Negative**
Oxidation		
Reduction		

e. The sodium–sulfur cell is a secondary cell.

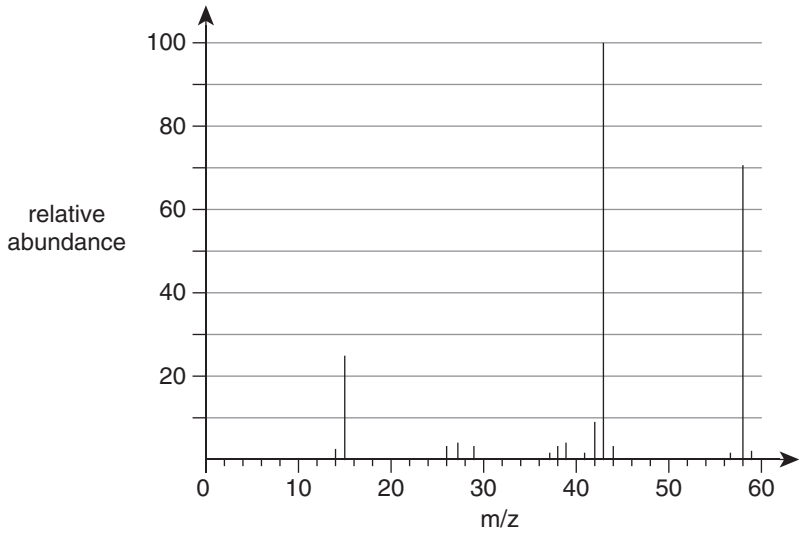
Explain the feature of the sodium–sulfur cell that allows it to be recharged. 1 mark

_____

_____

Question 3 (11 marks)

The empirical formula of a compound is $C_x H_{2x} O_y$. The mass spectrum of the compound is shown below.



a. **i.** Write the molecular formula of the compound. 1 mark

_____

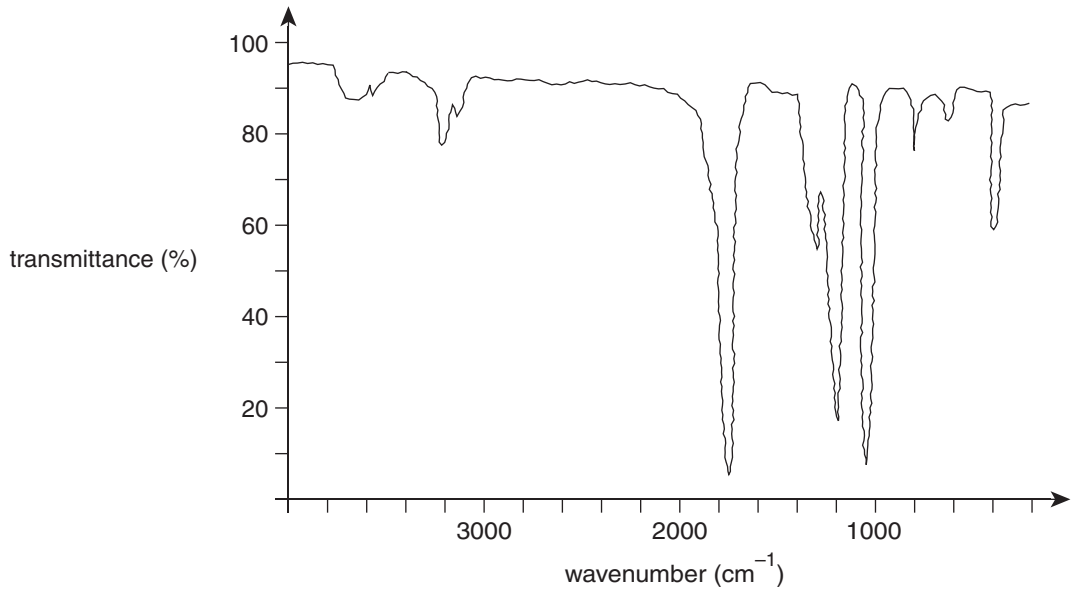
ii. What is the value of m/z of the fragment responsible for the base peak? 1 mark

_____

iii. Write the formula of the fragment responsible for the peak at m/z = 15. 1 mark

_____

b. The infrared (IR) spectrum for the compound is shown below.



i. What evidence from the IR spectrum shows that the compound is **not** an alcohol? 1 mark

_____

_____

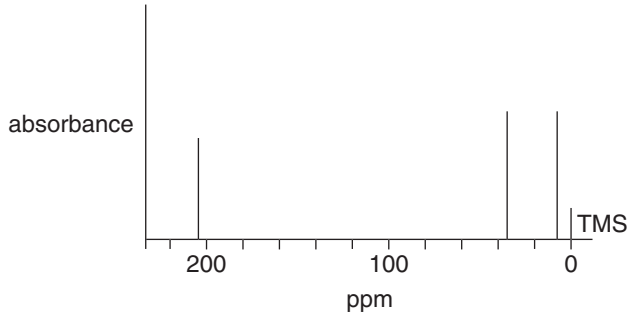
ii. What bond is responsible for the large signal at the wavenumber 1750 cm^{-1}? 1 mark

_____

iii. Draw the structural formula of the compound that is consistent with the data presented. 1 mark

c. An isomer of the compound has no C=C bonds.

i. The ^{13}C NMR spectrum of the isomer is shown below.



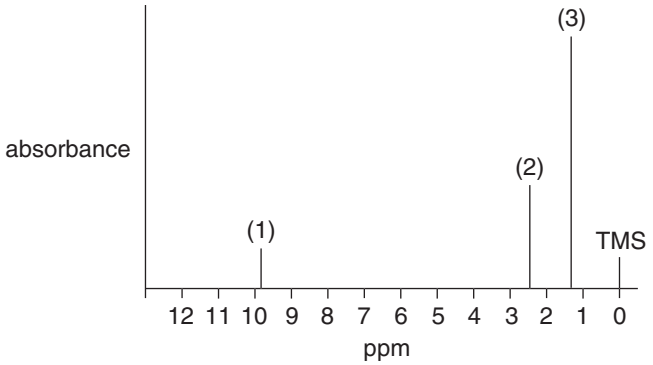
Identify **two** pieces of information about the compound that are revealed by the ^{13}C NMR spectrum. 2 marks

_____

_____

_____

ii. The proton NMR of the isomer is shown below. The relative areas under the peaks are shown in brackets.



In the table below, explain the information that is revealed by each specified feature in the proton NMR. 3 marks

Feature in proton NMR of isomer	Information revealed by this feature about the structure of the isomer
relative areas in the ratio of 1 : 2 : 3	
signal at 1.3 ppm	
signal at 9.8 ppm is a triplet	

Question 4 (11 marks)

The ion of a particular metal is known to have a charge of 3+. An aqueous solution of a compound of this metal was electrolysed and produced the following results:

Current applied throughout the electrolysis:	0.734 A
Duration of electrolysis:	46.5 min
Mass of metal deposited:	0.368 g

a. **i.** Identify the polarity of the electrode (positive or negative) and the type of electrode (anode or cathode) on which the metal was deposited. 1 mark

_____

ii. Given that the metal ion can be represented as M^{3+}, write the half-equation for the deposition of the metal. 1 mark

_____

b. It was decided that electrodes made of graphite would be used.

i. Outline **one** advantage of using electrodes made of graphite. 1 mark

_____

_____

_____

ii. Outline **one** disadvantage of using electrodes made of graphite. 1 mark

_____

_____

_____

c. **i.** Calculate the amount of charge that was transferred during the electrolysis. 1 mark

_____

_____

ii. Calculate the number of mole of electrons used in the electrolysis. 1 mark

_____

_____

iii. Identify the metal deposited. 3 marks

_____

_____

_____

_____

d. In the industrial production of certain metals by electrolysis, aqueous solutions are not used.

Name a metal that is **not** produced by electrolysis of an aqueous solution and explain why. 2 marks

_____

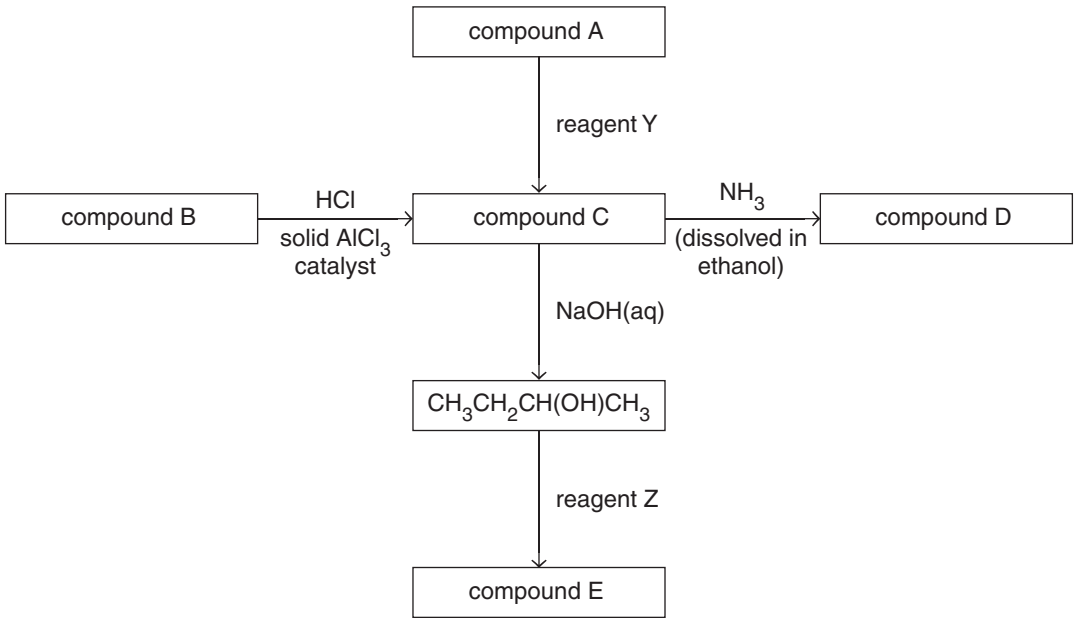
_____

_____

_____

Question 5 (6 marks)

A range of chemical reactions is shown in the flow chart below.



a. Given that compound A is an alkane, write the semistructural formulas of the compounds named in the table below. 2 marks

Compound A	Compound C

b. Give the molecular formula of compound B. 1 mark

_____

c. Identify reagent Y. 1 mark

_____

d. Give the systematic name of compound D. 1 mark

_____

e. Reagent Z is a strong oxidising agent, and molecules of compound E contain four carbon atoms.

To which homologous series does compound E belong? 1 mark

_____

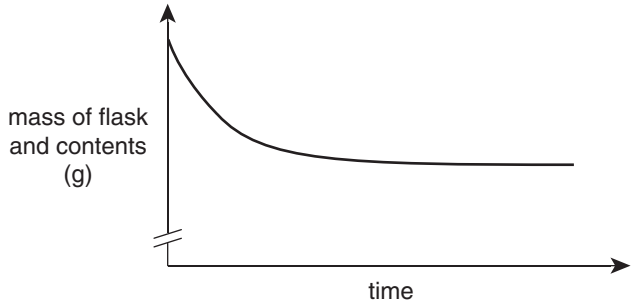
Question 6 (16 marks)

Catalysts are substances that increase the rate of a chemical reaction.

a. Copper(II) oxide catalyses the decomposition of hydrogen peroxide, which occurs according to the following equation:

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$$

In an experiment, 1.0 g of copper(II) oxide was added to 200 mL of hydrogen peroxide solution in an open flask, and the mass of the flask and contents was recorded at regular intervals. The results of the experiment are shown in the graph below.



i. Explain why the mass of the flask and contents decreased over time. 1 mark

_____

_____

ii. State when the rate of reaction was fastest and use collision theory to explain why the reaction rate alters over time. 2 marks

_____

_____

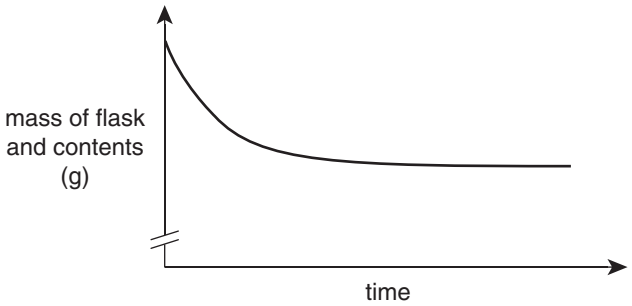
_____

_____

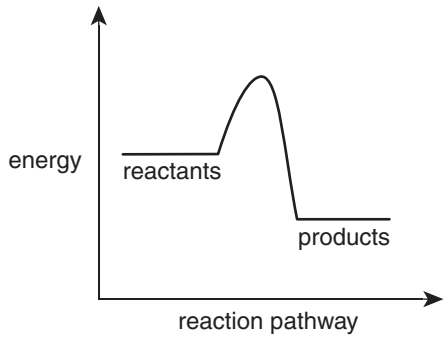
_____

iii. The experiment was repeated under identical conditions, except that 0.50 g of copper(II) oxide was used.

On the graph below, draw in any changes that would be expected in the results for this second experiment. 2 marks



iv. The energy profile for the reaction in the experiment is shown below.



On the profile above, draw in any changes that would occur if the copper(II) oxide had **not** been present during the reaction. 1 mark

b. The enzyme polyphenoxidase is present in apples and catalyses an oxidation reaction that yields brown-coloured products when the flesh of the apple is exposed to air. Various actions can influence the rate of this browning reaction by affecting the activity of the enzyme in different slices of apple.

i. In the table below, tick **one or more** boxes in each row to show the effect, if any, of each treatment of the apple on the different structural levels of the enzyme. 3 marks

Treatment of freshly sliced apple	**Result**	**Level of enzyme structure affected by each treatment**			
		Primary structure	**Secondary structure**	**Tertiary structure**	**No effect on enzyme structure**
1. sliced apple put in refrigerator	very slow browning				
2. lemon juice spread on sliced apple	no browning occurs				
3. sliced apple boiled in water	no browning occurs				

ii. Explain the result observed after treatment 3. 2 marks

_____

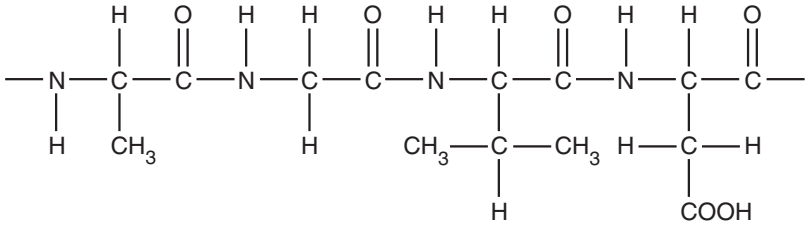
_____

_____

_____

_____

c. Enzymes are proteins. The structure of a section of a polypeptide (a section of a protein) is shown below.



i. This peptide is composed of 2-amino acids.

Draw the structure of an amino acid that is **not** a 2-amino acid. 2 marks

ii. It is possible to break down the polypeptide structure shown above into its constituent amino acids. One method is to boil a solution of the polypeptide under acidic conditions for several hours.

Why are such harsh conditions required? 1 mark

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iii. At a particular pH, an amino acid in solution can exist as a dipolar ion – an ion that has both a positive and negative charge.

For the constituent amino acid (in the polypeptide shown above) with the lowest molar mass, draw its structure in the form of the dipolar ion described, clearly showing all bonds. 2 marks

Question 7 (7 marks)

Methanol is a primary alcohol used to manufacture many other chemicals. One method used in methanol production is shown by the following equation:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H \text{ is positive}$$

a. In one experiment at a particular temperature, the equilibrium constant for the reaction above is 0.417 M^{-2}. An equilibrium mixture in a 5.0 L vessel contained 1.25×10^{-2} mol of CH_3OH and 0.51 mol of CO, as well as hydrogen gas.

i. What does the magnitude of the equilibrium constant indicate about the position of equilibrium in this reaction? 1 mark

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ii. Calculate the number of mol of hydrogen gas in the equilibrium mixture. 3 marks

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b. Another experimental process to manufacture methanol uses the oxidation of methane gas by bacteria, as shown by the following equation:

$$2CH_4(g) + O_2(g) \rightarrow 2CH_3OH(l)$$

In what circumstances would this method of methanol production be considered to be the manufacture of the renewable fuel biomethanol? 1 mark

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c. Methanol is used as a fuel.

Calculate the amount of energy generated for each tonne (10^6 g) of carbon dioxide gas produced in the complete combustion of methanol. 2 marks

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Question 8 (5 marks)

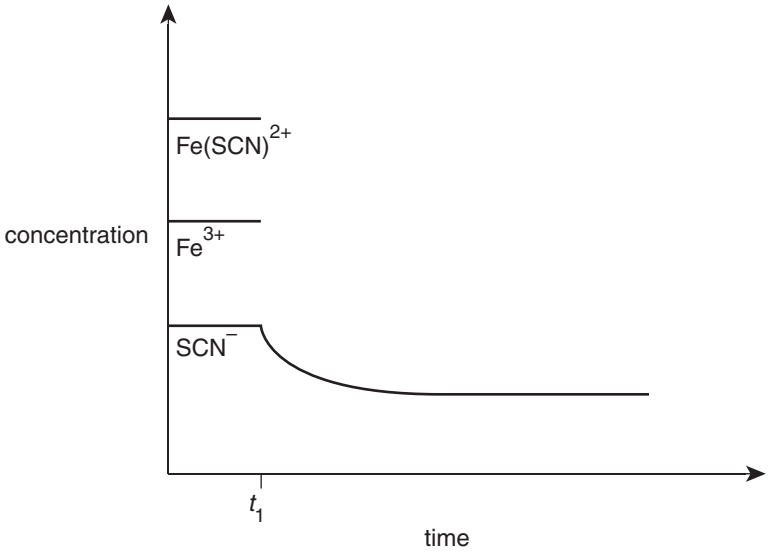
When the colourless ions $Fe^{3+}(aq)$ and $SCN^{-}(aq)$ react together, the complex ion $Fe(SCN)^{2+}(aq)$ forms in an equilibrium reaction. The complex ion is a deep red colour. At room temperature the equilibrium constant favours the product side of the reaction.

a. 50 mL of 1.0 M $Fe^{3+}(aq)$ and 50 mL of 1.0 M $SCN^{-}(aq)$ are mixed in a beaker and allowed to reach equilibrium.

Tick the correct statement/s for the equilibrium system in the table below. 1 mark

The contents of the beaker will be coloured red.	
The concentration of Fe^{3+} ions in the beaker is 1.0 M.	
The formation of the complex ion ceases at equilibrium.	
The $[SCN^{-}]$ remains constant at equilibrium.	

b. Another sample of an equilibrium mixture was cooled at time t_1. The graph below shows the initial concentrations of ions in the mixture and how the concentration of SCN^{-} ions changed after the cooling at time t_1.



i. Complete the graphs by showing the changes in concentrations in Fe^{3+} and $Fe(SCN)^{2+}$ until equilibrium is reached again. 2 marks

ii. Based on the information given, is the formation of $Fe(SCN)^{2+}$ an endothermic or exothermic reaction? Explain your choice. 2 marks

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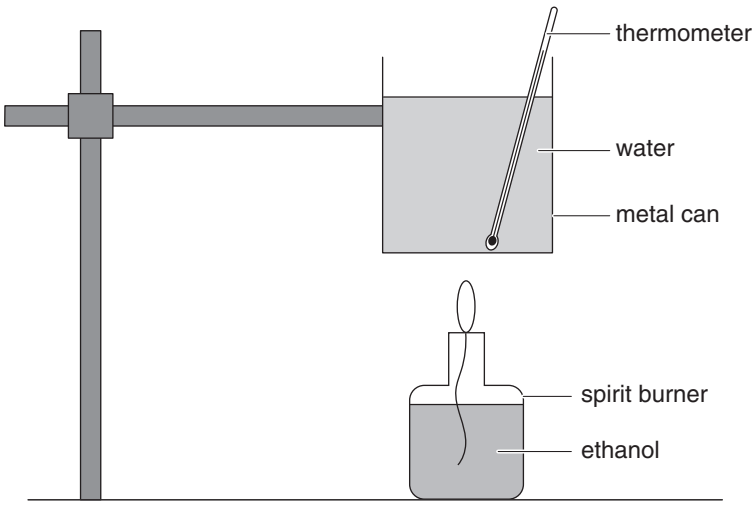
Question 9 (14 marks)

A series of experiments was conducted to determine the heat of combustion of ethanol using the equipment shown in the diagram below.



The results of the experiments are shown in the table below.

	Experiment 1	**Experiment 2**	**Experiment 3**	**Experiment 4**
Mass of water in metal can (g)	75.4	74.8	76.4	78.1
Mass of burner and ethanol before burning (g)	127.34	127.11	123.88	125.94
Mass of burner and ethanol after burning (g)	126.86	126.52	123.37	125.22
Temperature of water before heating (°C)	18.0	18.0	18.0	18.0
Temperature of water after heating (°C)	36.1	36.5	37.4	38.1

a. Suggest **two** reasons why the experiment was conducted four times. 2 marks

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b. Suggest **one** reason why a metal can was used rather than a Pyrex (heat-proof glass) beaker. 1 mark

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c. Using the results for experiment 1, calculate the heat of combustion of ethanol in kJ mol^{-1}. 4 marks

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d. Assess the validity of the experiments, considering that each experiment used a different mass of water and a different mass of ethanol. 2 marks

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e. When the results of the experiment are used to calculate the heat of combustion of ethanol, the calculated value is less than half of the accepted value.

Suggest **two** modifications to the equipment set-up that would improve the accuracy of the calculated value of the heat of combustion. 2 marks

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f. The accepted value of the heat of combustion is determined using a calorimeter, which must be calibrated.

i. Outline the purpose of calibration of a calorimeter. 1 mark

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ii. Suggest how the equipment used for the four experiments could be calibrated using liquid propan-1-ol. 2 marks

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END OF QUESTION AND ANSWER BOOKLET