Trial Exam 2024

Unit 3/4 VCE

Chemistry

Student name _____

Question and answer book

Reading time 15 minutes

Writing time: 2 hours and 30 minutes

Structure of book

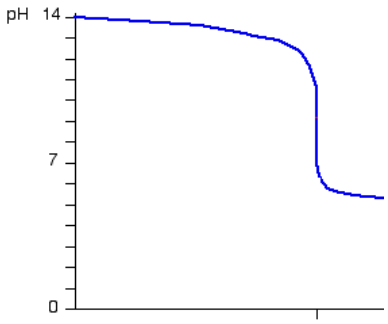
Section	Number of questions	Number of marks
A	25	30
B	11	158

ANSWER SHEET PART A: **NAME**_____

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

Circle the correct response to each question on the answer sheet.

1) A solution was analysed by titration. The pH curve is shown on the right. Which one of the following comments is most likely correct?
   a) A solution of strong base is titrated against a weak acid.
   b) A concentrated solution of hydrochloric acid is titrated against a weak base.
   c) A solution of NaOH is titrated against a 4.5M HCl solution.
   d) A concentrated solution of NaOH is titrated against a dilute solution of NaOH.



2) Which indicator should be used for this titration?
   a) Phenol red.
   b) Bromophenol blue
   c) Methyl orange
   d) Phenolphthalein

3) 1.50 grams of thymine ($C_5H_6N_2O_2$) would contain:
   a) 0.333 grams of nitrogen
   b) 0.33 grams of nitrogen
   c) 0.300 grams of oxygen
   d) 0.3 grams of oxygen

4) Serotonin is a compound that conducts nerve impulses in the brain and muscles. Each molecule has 12 hydrogen atoms and contains 6.82% hydrogen by mass. Its formula mass is:
   a) 176;
   b) 233;
   c) 156;
   d) Cannot be calculated from the information given.

5) Consider the following chemical equation that illustrates a transformation of a carbohydrate:

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

   Which of the following statements best aligns with the principles of green chemistry and sustainability in relation to this reaction?
   a) The reaction is unsustainable because it produces carbon dioxide, a known greenhouse gas.
   b) This reaction promotes sustainability by utilizing renewable resources and generating a biofuel.
   c) The reaction does not adhere to green chemistry principles due to its low percent atom economy, which is below 30%.
   d) The reaction is considered sustainable as it produces only a small amount of carbon dioxide

6) Ethene burns in oxygen according to the equation below.

$2C_2H_4(g) + 6O_2(g) \Rightarrow 4CO_2(g) + 4H_2O(l)$ $\Delta H = -2822$ kJ

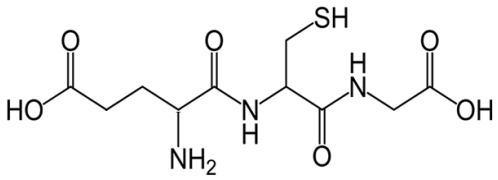
If a 30.0 litre sample of ethene is mixed with 70.0 litres of oxygen gas and ignited at SLC, which comment below is true?

a) 10 L of ethene remain unreacted and 200 kJ of energy is released.
b) 6.9 L of ethene remain unreacted and 1.3×10^3 kJ of energy is released.
c) 6.9 L of ethene remain unreacted and 130 kJ of energy is released.
d) 0.24 mol of oxygen remain unreacted and 2220 kJ of energy is released.

7) A small peptide is shown on the right.

What amino acids formed it?

a) Alanine, threonine, cysteine, glycine.
b) Glutamic acid, cysteine, glycine.
c) Alanine, glutamic acid, cysteine, glycine.
d) Alanine, threonine, cysteine.

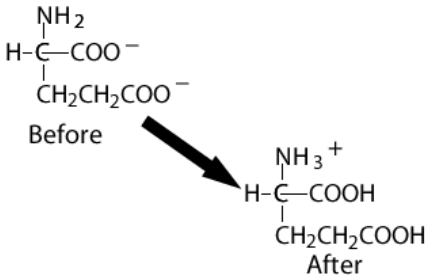


8) What option best describes the process by which proteins are digested in the digestive system?

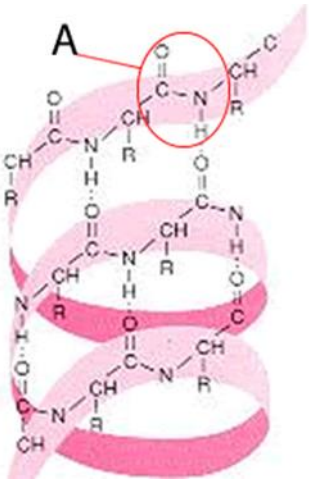
a) Hydrolysis
b) Esterification polymerisation
c) Oxidation
d) Condensation polymerisation

9) Glutamic acid exists as a zwitterion at a pH of 3.2. It is placed in a solution of unknown pH. The pH of the solution is then changed and the structure of glutamic acid determined by analysis. The structure of glutamic acid before the change in pH and after is shown on the right. The original solution of glutamic acid is most likely:

a) at a pH of 10 and changes to a pH of 7.
b) at a pH of 10 and changes to a pH of 14.
c) at a pH of 4 and changes to a pH of 7.
d) at a pH of 6 and changes to a pH of 3.



Questions 10 and 11 refer to the structure shown on below.



10) The image represents:
    a) the secondary structure of a polypeptide brought about by hydrogen bonding;
    b) the primary structure of a protein chain brought about by covalent bonding and dispersion forces;
    c) the tertiary structure of a protein chain brought about by disulphide links;
    d) the tertiary structure of a polypeptide brought about by ionic, covalent and hydrogen bonding.

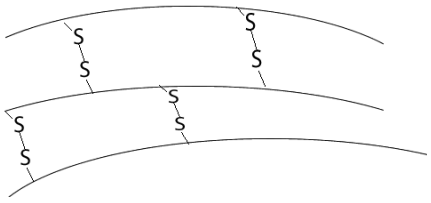
11) The functional group labelled “A” is known as:
    a) an ether link produced by a carboxyl and an amine functional group;
    b) an ester link produced by a hydroxyl and a carboxyl functional group;
    c) an amide link produced by an amino and carboxyl functional groups;
    d) an ether link produced by a two hydroxyl functional groups.

12) An enzyme operates optimally at 37°C, facilitating the breakdown of a specific fat. However, when heated to 50°C, the enzyme loses its functionality. What is the most likely reason for this loss of activity?

    a) The ionic and covalent bonds maintaining the helical and sheet structures of the enzyme have been disrupted.
    b) Covalent bonds have been disrupted, damaging the secondary structure of the enzyme.
    c) Covalent bonds have been disrupted, affecting the primary structure of the enzyme.
    d) The relatively weak forces of attraction stabilizing the secondary and tertiary structures of the enzyme have been disrupted.

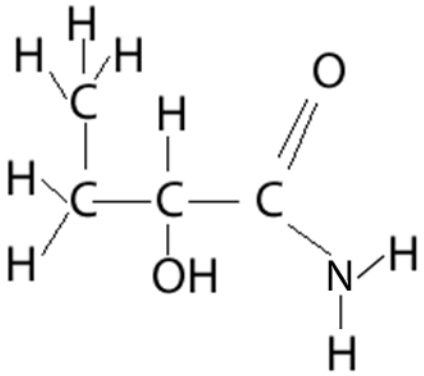
13) An enzyme in the body is made up of 100 amino acids and its structure is shown below. How many (CONH) functional groups are present in the enzyme?

a) 100
b) 97
c) 99
d) 50



14) What is the correct systematic name of the compound shown below.

a) 3-methyl-2-hydroxypropanamide
b) 1-amino-2- hydroxybutanal
c) 1-amido-2-methylpropan-2-ol
d) 2-hydroxybutanamide



15) Which one of the following analytical techniques can be used to isolate, identify and determine the concentration of an organic molecule?

a) High pressure liquid chromatography.
b) IR spectroscopy
c) ^{1}H NMR
d) Mass spectroscopy

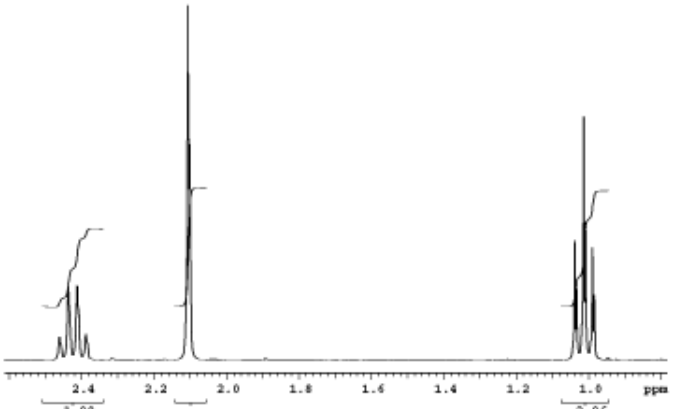
16) Which one of the following is least useful in investigating the molecular structure of a complex organic molecule?

a) HPLC
b) Mass spectroscopy
c) ^{1}H NMR
d) ^{13}C NMR

17) For analysis, a hydrocarbon is placed in a strong magnetic field and irradiated with electromagnetic radiation in the radio wave frequency. This is most likely to:

a) cause ionisation and fragmentation of the parent molecule;
b) cause electrons to become excited and jump to higher energy levels;
c) increase the bond vibration of the molecule;
d) cause a change in the energy state of nucleons.

18) The ^{1}H NMR spectrum of an organic molecule is shown below.



Which one fo the following options represents the semistructural formula of the molecule?

a) $CH_3CHOHCH_3$
b) $CH_3COCH_2CH_3$
c) $CH_3COOCHCH_2$
d) $(CH_3)_2CH_2$

19) Which of the following techniques can be used to obtain the ratio of U^{235} and U^{238} isotopes in a sample of uranium ore?

a) ^{1}H NMR
b) IR spectroscopy
c) Mass spectrometry
d) HPLC

The following information is to be used to answer question 20-21

Hydrogen gas is formed via steam reformation according to the reaction shown below.

$$CH_4(g) + H_2O(g) \rightarrow 3H_2(g) + CO(g)$$

A mass of 3.20 grams of methane gas completely reacted with steam to produce 0.85 grams of hydrogen gas.

20) What is the percent yield of the reaction?

a) Exactly 50%
b) Closer to 32%
c) Exactly 65%
d) Closer to 71%

21) The percent atom economy for the reaction is

a) 34%
b) 6 %
c) 18%
d) 83%

22) A student was given colourless liquids that were labelled A, B, C and D. They were known to be ethanol, ethanoic acid, pentane and hexene, but the exact identity of each liquid was unknown.

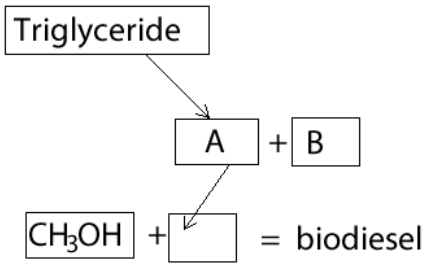
The student tested the properties of three of the liquids and obtained the results shown below. Identify each of the liquids.

	A	B	C
Solubility in water	insoluble	soluble	soluble
Addition of brown Br_2 solution	Br_2 solution turns clear	No reaction	No reaction
Reaction with Na_2CO_3 powder.	No reaction	Gas evolved	No reaction
Reaction with orange acidified $Cr_2O_7^{2-}(aq)$	No reaction	No reaction	Turns the orange solution green.

a) A is hexene, B is ethanoic acid and C is ethanol
b) A is hexene, B is ethanol and C is ethanoic acid
c) A is ethanoic acid, B is pentane and C is ethanol
d) A is ethanoic acid, B is ethanol and C is pentane

23) The formation of biodiesel is summarised in the diagram below. Which comment is true?

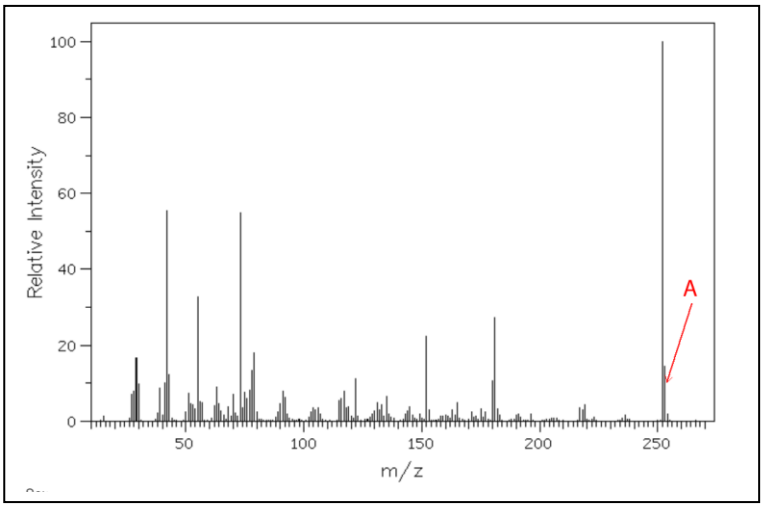
a) A is most likely glycerol.
b) B is most likely an ester.
c) The reaction to form A and B from a triglyceride is known as a hydrolysis reaction.
d) The reaction that produces biodiesel is an oxidation reaction.



24) An ether link is most likely found in:

a) carbohydrates and is formed between two carboxyl functional groups.
b) proteins and is formed in an esterification reaction .
c) carbohydrates and is formed in a condensation reaction.
d) proteins and is formed in an oxidation reaction.

The following information is to be used to answer questions 25- 26
A compound was analysed and was found to contain the following composition by mass. Carbon 47.62%, hydrogen 4.76%, nitrogen 22.22% and oxygen 25.40%. The mass spectrum of this compound is shown below.



25) This compound has the molecular formula:

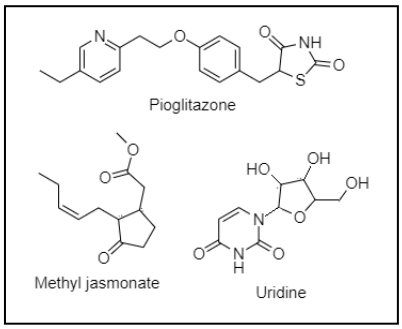
a) $C_{10}H_{12}N_4O_4$;
b) $C_5H_6N_2O_2$;
c) $C_{10}H_{20}N_4O_2$;
d) $C_{10}H_{10}N_4O_6$.

26) Peak A, pointed to by the arrow in the MS, is due to the:

a) ^{14}N isotope;
b) ^{18}O isotope;
c) ^{13}C isotope;
d) ^{1}H isotope.

27) Consider the molecular structures of the three molecules shown on the right. Which one statement is correct?

a) Uridine has two optical isomers.
b) Pioglitazone has no optical isomers.
c) Uridine has 1 chiral centre.
d) Methyl jasmonate has 4 optical isomers.



28) At a given temperature, the **reaction quotient** (**Q**) for the equilibrium shown below has a value of 4.9 M^2.

$$Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6H_2O(l)$$

Given no temperature change which of the following options is most likely correct?

a) The equilibrium constant (K_c) for the equilibrium below is closest to 0.042 M^{-2}

$$2CoCl_4^{2-}(aq) + 12\,H_2O(l) \rightleftharpoons 2\,Co(H_2O)_6^{2+}(aq) + 8Cl^-(aq)$$

b) The reaction quotient for the equilibrium below is closest to 0.2 M^2

$$CoCl_4^{2-}(aq) + 6\,H_2O(l) \rightleftharpoons Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq)$$

c) The addition of NaCl(aq) to the equilibrium mixture will give a value for K_c (equilibrium constant) greater than 4.9 M^{-2}

d) Dilution of the equilibrium mixture by the addition of water would immediately increase the value of Q but will eventually return to an equilibrium position with the same K_c value.

The following information is to be used to answer questions 29-30.

Cobalt (II) chloride, when dissolved in water, forms an equilibrium between a hydrated form and dehydrated form.

$$Co(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6H_2O(l) \quad \Delta H>0$$

$Co(H_2O)_6^{2+}(aq)$ is pink whilst $CoCl_4^{2-}(aq)$ is blue.

29) Which one of the following options will drive the equilibrium system to the left and make the solution turn from a blue to a pink colour?

a) Addition of NaCl(s) to the equilibrium mixture.
b) Addition of $AgNO_3$ (s) to the equilibrium mixture.
c) Heating the solution over a Bunsen flame.
d) Adding KNO_3 (s) to the equilibrium mixture.

30) $Co(NO_3)_2$ is added and the system is allowed to reach equilibrium once more. Once at equilibrium the:

a) $[Cl^-]$ will be lower than before $Co(NO_3)_2$ was added;
b) $[Co(H_2O)_6^{2+}]$ will be lower than before $Co(NO_3)_2$ was added;
c) $[Cl^-]$ will be higher than $[Co(H_2O)_6^{2+}]$;
d) $[Cl^-]$ will be higher than $[CoCl^{2-}]$.

SECTION B –Short answer questions

Question 1

The amount of vitamin C (176.14 g/mol) in a brand of orange juice can be determined by titration with a standard iodine solution. Iodine reacts with vitamin C according to the equation below.

$$C_6H_8O_6\ (aq) + I_2(aq) \Rightarrow C_6H_6O_6\ (aq) + 2H^+(aq) + 2I^-(aq)$$

A 25.00 mL sample of juice is placed in a 250 mL volumetric flask and made to the mark with distilled water. Four 20.00 mL aliquots are each placed in four 100mL conical flasks and titrated against a standard 1.45 X 10^{-3} mol/L I_2 solution. Four trials are carried out and the results recorded in the table below.

	1	2	3	4
Titre (mL)	10.95	11.00	18.99	17.01

a) Write a balanced half equation for the oxidation of vitamin C, states included..

_____2 marks

b) Calculate the average titre?

1 mark

c) Calculate the amount, in mol, of vitamin C present in the 20.00 mL aliquot.

2 marks

d) Calculate the amount, in mol, of vitamin C in the original orange 25.00 mL sample.

2 marks

e) Calculate the concentration, in % w/v, of vitamin C in the original juice, to the right number of significant figures.

2 marks

f) A student carried out the titration rinsing the burette with distilled water before performing the titration. All four trials were carried out without refilling the burette.

i. How would this impact the average titre achieved? Explain your reasoning.

_____
_____
_____
_____
_____
_____
_____
_____2 marks

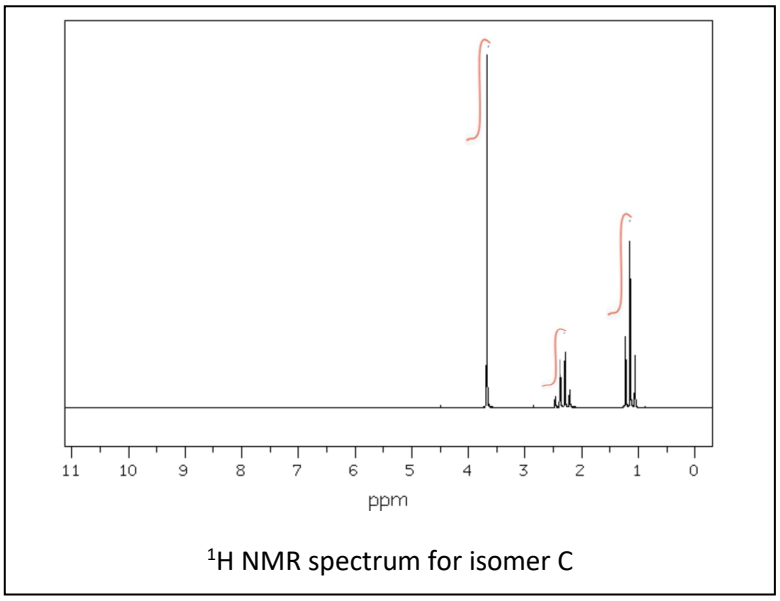
ii. Would this introduce a **systematic error,** a **random error** or no error, in the titration? Justify your reasoning.

_____
_____
_____
_____
_____
_____
_____
_____2 marks

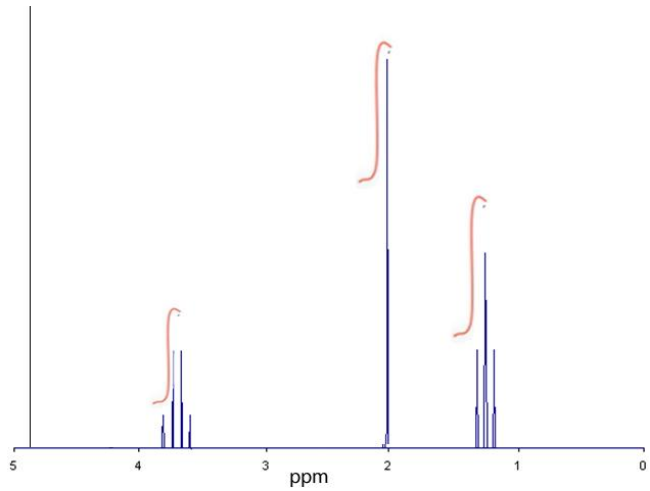
Question 2

Three different isomers A, B and C with the formula $C_4H_8O_2$ are analysed using different techniques.

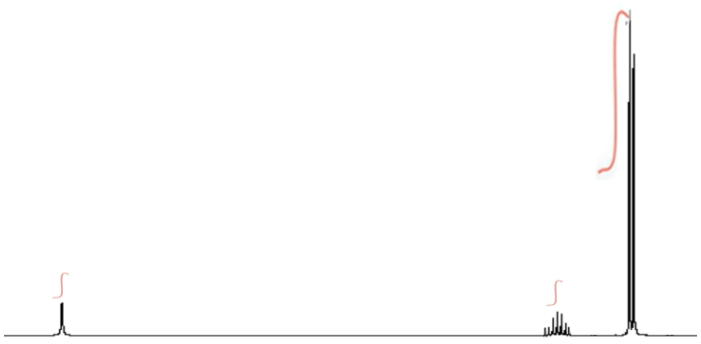
^{1}H NMR spectra of selected isomers are shown below.



^{1}H NMR spectrum for isomer C



^{1}H NMR spectrum for isomer B



^{1}H NMR spectrum of isomer A.
Consists of a doublet, septet and a singlet

a) Given that isomer "A" reacts with Na_2CO_3 to produce carbon dioxide while isomers "B" and "C" are products of a reaction between a primary alcohol and a carboxylic acid, draw a possible structural formula for each of the three isomers.

Isomer A	Isomer B	Isomer C

2+2+2= 6 marks

a) Consider the ^1H NMR spectrum of A.

i) What number of chemically equivalent hydrogens is represented by the septet?

_____1 mark

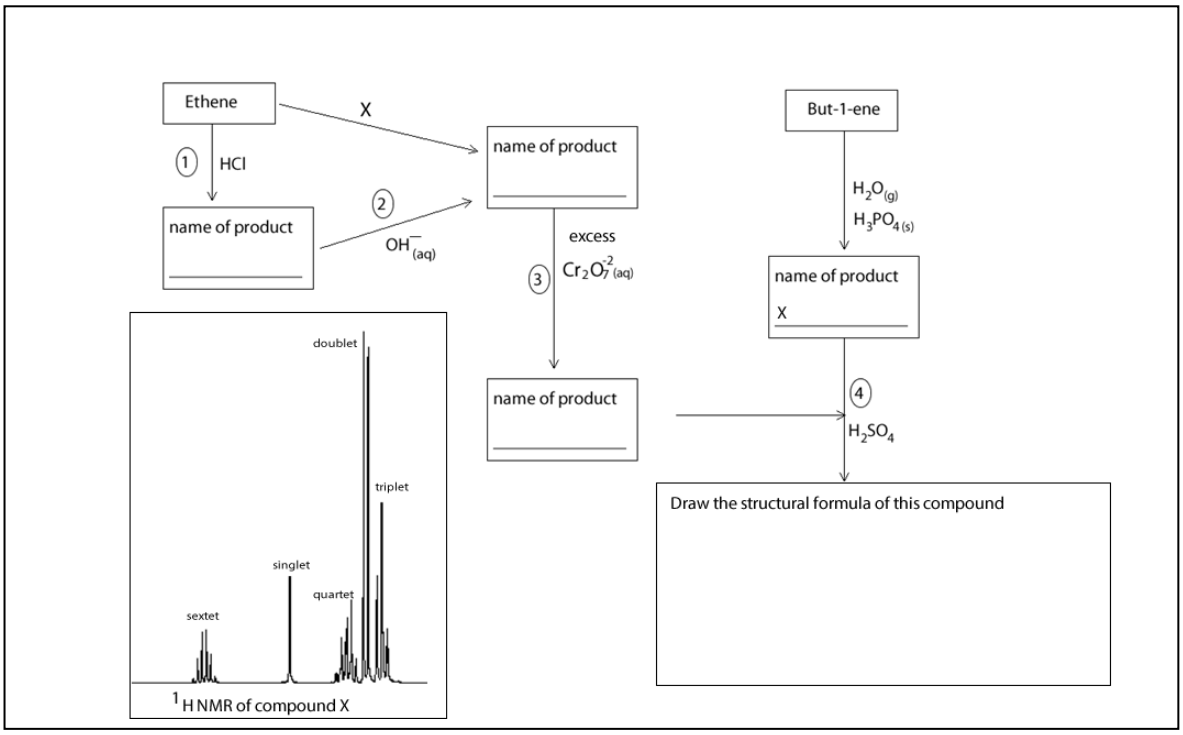
ii) Explain how the signal was split into a septet.

_____
_____
_____
_____2 marks

b) Define *chemical shift* and *nuclear shielding* and use these terms to discuss why the splitting patterns in the ^1H NMR spectrum of isomers B and C are identical but arranged in a different unique order relative to the TMS signal at 0 ppm. You may redraw the structural formulae of each isomer in order to add clarity to your explanation.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____4 marks

Question 3



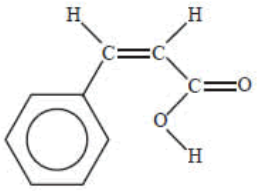
a) Fill in the boxes on the diagram above. 5 marks

b) Identify the type of reaction represented by

1) _____
2) _____
3) _____
4) _____ 4 marks

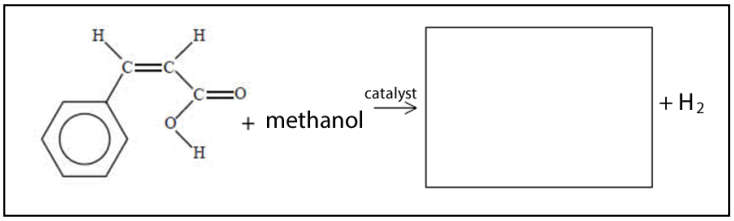
c) Identify the reagents and conditions represented by X
_____ 1 mark

d) Cinnamic acid is an organic acid that contributes to the flavour of cinnamon. Its structure is shown on the right. Draw structural formulae of the product molecule formed in the following reactions.

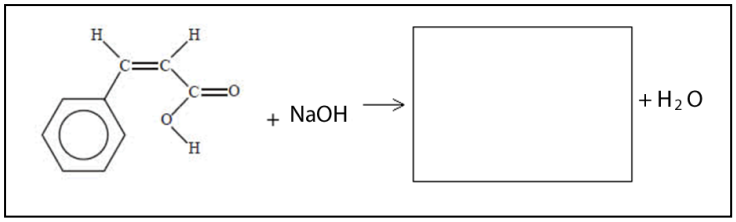


Cinnamic acid

i)



ii)



2+2=4 marks

e) The degree of unsaturation is a measure of the number of ring structures and multiple bonds (double or triple) in a molecule. Each degree of unsaturation represents the loss of two hydrogen atoms from the fully saturated formula of a compound. This includes:

- Carbon–carbon double bonds (e.g. in alkenes loss of 2 hydrogens per bond)
- Carbon–carbon triple bonds (e.g. in alkynes loss of 4 hydrogens per bond)
- Carbon ring structure (eg. Cyclohexane, benzene loss of 2 hydrogens per ring)
- Carbonyl groups (C=O) (eg. Ketone loss of 2 hydrogens per carbonyl group)

i) A molecule with the formula C_6H_{10} has a ring structure and _____ 1 mark

ii) What is the degree of unsaturation for cinnamic acid? _____ 1 mark

iii) Two unbranched hydrocarbons with six carbons each are analysed. Hydrocarbon A is saturated, and Hydrocarbon B has a degree of unsaturation of 3 and no ring structure. Compare their melting temperatures and justify your answer with reference to structure and bonding.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____3 marks

Question 4

Palm tree oil is used to manufacture biodiesel.

a) What is meant by the term renewable?

_____
_____
_____ 1 mark

b) What is meant by the term sustainable practices?

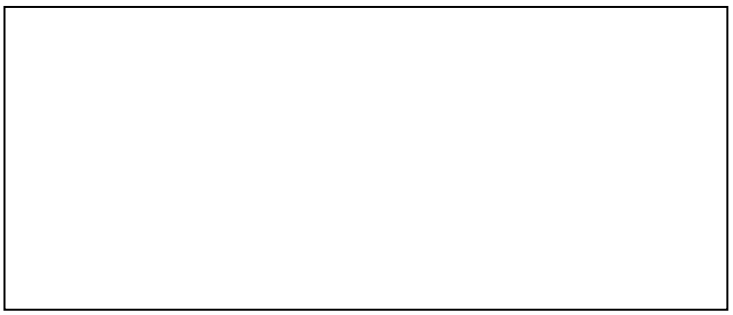
_____
_____
_____ 1 mark

c) Give an example of how biodiesel can be renewable but not sustainable. Provide a clear and concise explanation to justify your answer.

_____
_____
_____
_____
_____
_____2 marks

d) The triglyceride **tricaproin** consists of three fatty acid chains derived from **caproic acid** ($C_6H_{12}O_2$, 116 g/mol), a straight-chain fatty acid.

i. Draw the skeletal structure of tricaproin in the space provided below



3 marks

ii. Give the IUPAC name for caproic acid

_____ 1 mark

e) Tricaproin is used to form biodiesel. A simplified pathway is show in fig. 1 below.

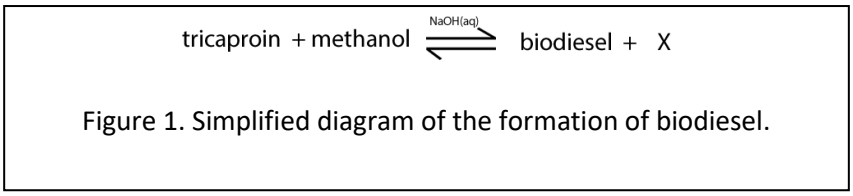


Figure 1. Simplified diagram of the formation of biodiesel.

i. Give the name of the molecule that forms the major component of the biodiesel.

_____ 1 mark

ii. Give the IUPAC name of compound X

_____ 1 mark

iii. Give the balanced chemical equation for the complete combustion, at SLC, of the biodiesel, given as the answer to question i. above. Use chemical formulas and states.

_____ 3 marks

iv. Given that the molar heat of combustion of the biodiesel, mentioned above, is 3997 kJ/mol, calculate the useful heat energy, in kJ, obtained from burning 11.6 grams of the diesel, assume no energy is lost to the environment.

3 marks

f) Given that the biodiesel molecule contains the following bonds 5 X C-C, 14 X C-H, 1 X C=O and 2 X C-O

i. Calculate the activation energy in kJ/mol. Show all working out in the space provided.

2 marks

ii. Complete the energy profile shown below,

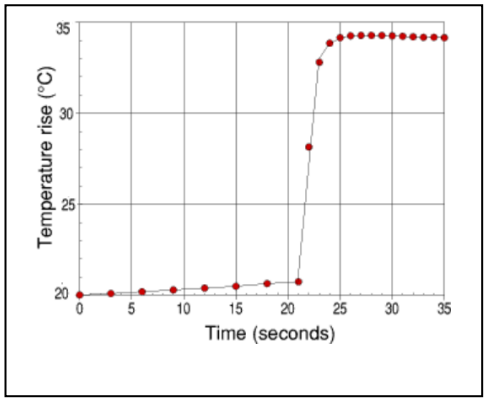
On the set of axes, shown above, clearly draw the energy profile of the reaction, showing the position and value of the following:

- Activation energy for the forward reaction
- ΔH
- Activation energy for the reverse reaction

4 marks

Question 5

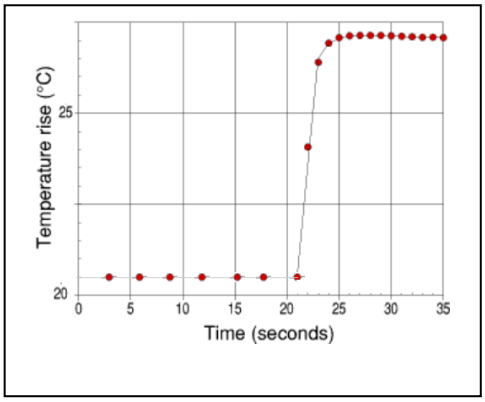
A bomb calorimeter, containing 50.0 mL of water at 20.6 °C was calibrated by passing a current of 6.11 A at 2.76 V for 2.50 minutes through the heating coil. The temperature was recorded periodically and the data recorded on a temperature vs time graph shown on the right.



a) Calculate the calibration factor (C_f) for the calorimeter.

3 marks

b) 0.0280 grams of liquid butane was placed in the bomb calorimeter with excess oxygen and ignited. The temperature was recorded and shown on the graph below.



i. Calculate the molar heat of combustion for butane using the information above and your answer to question a).

3 marks

ii. Write a balanced thermochemical equation for the complete combustion of butane at SLC using your answer to question i. above.

_____ *3 marks*

c) Consider the information used to determine the calibration factor (C_f) for this calorimeter.

i. Will the molar heat of combustion calculated in question b part i. provide an

underestimation, accurate estimation, or overestimation?

Circle the correct response.

ii. Justify your choice.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____ 2 marks

d) When conducting the experiment, the analyst placed 100 mL of water in the calorimeter instead of 50 mL. Assuming that the specific heat capacity of water (4.18 J/g°C) does not change, the analyst concluded that using a different volume would not affect the calculated molar heat of combustion. Is this assumption accurate? Justify your answer.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____ 2 marks

Question 6

Potassium permanganate ($KMnO_4$) is a strong oxidant. In a certain reaction 5.78 grams of chromium(II) sulphate reacted exactly with 37.60 mL of 0.265 M $KMnO_4$. During this reaction the Cr^{2+} ions were oxidised to Cr^{3+}.

a) What oxidation state was Mn in $KMnO_4$ reduced to?

3 marks

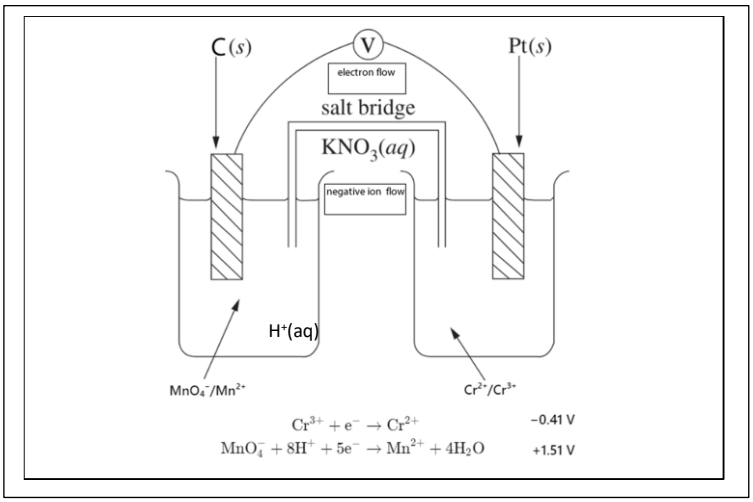
b) MnO_4^- is used as an oxidant to convert propan-1-ol to propanoic acid and in the process forming Mn^{2+} ions.

i) Give the oxidation half-equation for this reaction. States not required.

ii) Give the reduction half-equation for this reaction. States not required.

2+2=4 marks

c) The galvanic cell, shown below, was set up and operated at standard conditions.



i. Identify the:
Reductant _____

Oxidant _____

2+2=4 marks

ii. Give the overall equation taking place in the cell. States required.
_____ 2 marks

iii. Indicate the direction of electron flow and negative ion flow by placing an arrow in the respective boxes provided. 2 marks

iv. Give the cell EMF. _____ 1 mark

v. Describe two changes that would occur in a galvanic cell if the carbon electrode is replaced with a zinc metal electrode: one chemical change and one energy transformation. Provide a concise explanation for why each change takes place.

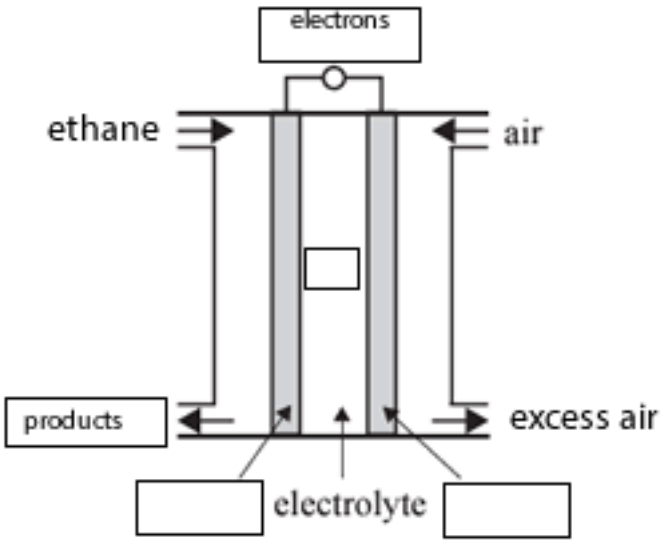
Chemical change
_____
_____
_____
_____
_____ 2 marks

Energy transformation change
_____
_____
_____
_____
_____ 2 marks

Question 7

A solid oxide fuel cell (SOFC) is shown below. Ethane undergoes partial oxidation when reacted with atmospheric oxygen to produce carbon dioxide and hydrogen gas according to the equation below.

$$C_2H_6(g) + 2O_{2(g)} \rightarrow 2CO_2(g) + 3H_2(g)$$



Combustion of ethane in a solid oxide fuel cell

a) In the diagram above, label the following:
   i. Direction of electron flow.
   ii. Anode and cathode and its polarity.
   iii. Direction of ion flow through the electrolyte. 3 marks

b) The electrolyte allows for the flow of ions from one electrode to the other.
   i. Identify the ions that flow through the solid electrolyte.

   _____1 mark

   ii. Indicate, by placing an arrow in the box provided in the diagram above, the direction of ion flow through the electrolyte 1 mark

c) Give the balanced half equations, states not included, that take place at the:
   i. Anode _____ 2 marks

   ii. Cathode _____ 2 marks

d) The fuel cell consumes 0.496 L of ethane per hour, at SLC, what is the current produced if the cell runs at 60.0% efficiency.

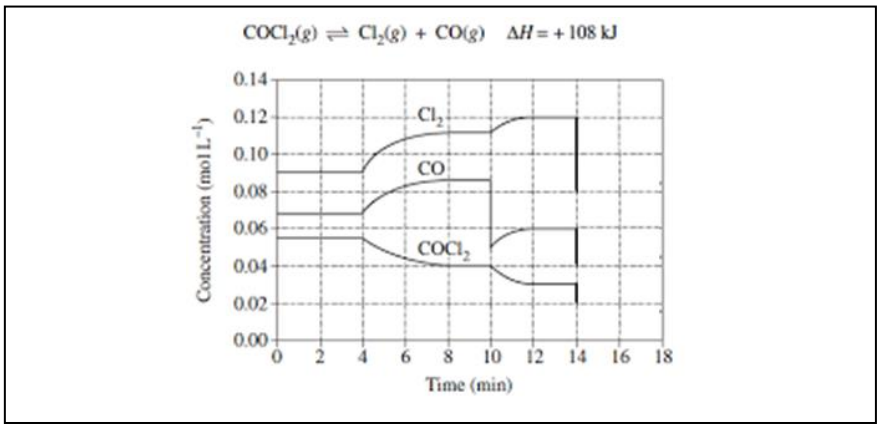
4 marks

e) Is a solid oxide fuel cell running on ethane an example of a circular or linear economy? Explain your reasoning

_____
_____
_____
_____
_____
_____
_____
_____
_____2 marks

Question 8

One mol of phosgene gas ($COCl_2$) is placed in a sealed 1.0 L reaction vessel and allowed to decompose to form Cl_2 and CO gases. Equilibrium is quickly achieved in under one minute. The concentration of the different species over time is shown below.



a) At the one minute mark 0.085 mol of Cl_2 was present. Calculate the value, with appropriate units, of the equilibrium constant (K_c) at the 2 minute mark.

3 marks

b) How has the value of K_c and the rates of both the forward and backward reactions changed at t_8 as compared to the K_c and the rates at t_2? Circle the appropriate responses from the options below.

K_c	increases	decreases	unchanged
Rates	increase	decrease	unchanged

c) Justify your response to question b) above.

_____
_____
_____
_____2 marks

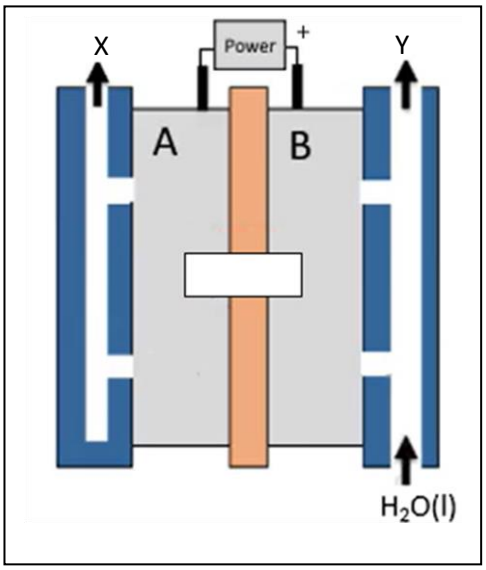
d) Suggest a likely stress imposed on the system at t_{14} and comment on how the K_c value at t_{14} differs from the K_c value at t_{12}. Justify your suggestion.

_____
_____
_____
_____
_____3 marks

e) Complete the graph, above, indicating how the system responds to the stress at t_{14}. 2 marks

Question 9

Consider the proton exchange membrane electrolyser shown below.



a) Which electrode is the anode?

_____ 1 mark

b) Give the balanced chemical equation for the reaction taking place at each electrode. States not required

A _____ 1 mark

B _____ 1 mark

c) Clearly identify the ions travelling through the electrolyte and their direction of travel in the box provided.

d) Identify the following species

Y _____ 1 mark

X _____ 1 mark

e) Suggest one requirement, when operating this electrolyser, that is necessary for the production of Green hydrogen. Justify your suggestion.

_____

_____

_____

_____

_____

_____

_____

_____2 marks

Question 10

A rechargeable nickel-cadmium battery has the following overall reaction taking place when discharging.

$$Cd(s)+2NiO(OH)(s)+2H_2O(l)\rightarrow Cd(OH)_2(s)+2Ni(OH)_2(s)$$

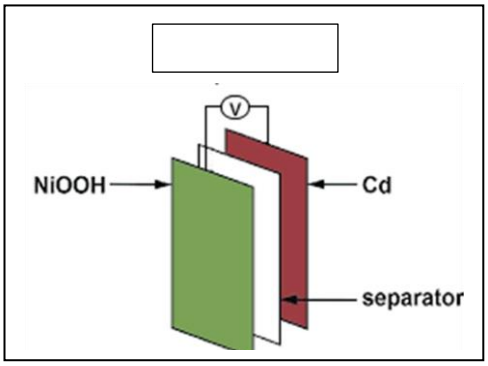
a) Write the half reaction taking place at the negative electrode during **discharge**. States included.

_____ 2 marks

b) Write the half reaction taking place at the positive electrode during **recharge**. States included.

_____ 2 marks

c) A simple schematic of the battery is shown below.



i. What is the polarity of the Cd electrode during discharge?

_____ 1 mark

ii. How does the polarity of the Cd electrode change during recharge?

_____

_____1 mark

d) Based on the half reactions taking place at each electrode, explain why the battery is rechargeable.

_____

_____

_____

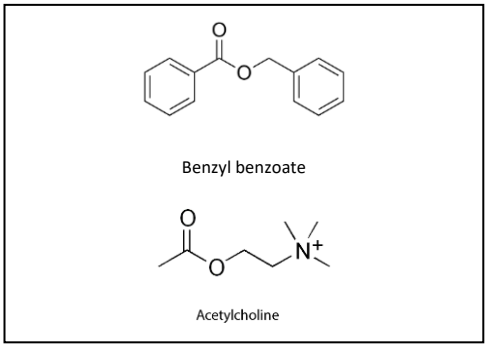
_____

_____ 2 marks

e) Place an arrow in the box provided in the diagram above to show the direction of electron flow. 1 mark

Question 11

Acetylcholine is a neurotransmitter that transmits signals from nerves to muscles and other organs. The enzyme acetylcholinesterase is responsible for breaking down acetylcholine after it has been released to terminate the signal. Benzyl benzoate acts as a competitive inhibitor of acetylcholinesterase, competing with acetylcholine for binding to the enzyme's active site and thereby prolonging the effects of acetylcholine at the synapse.



a) Given the chemical structures of benzyl benzoate and acetylcholine, shown above:

i. What functional group do both of these molecules share.

_____1 mark

ii. What type of reaction does the enzyme facilitate in order to break down this functional group and hence degrade acetyl choline?

_____ 1 mark

b) A mixture of benzyl benzoate and acetylcholine is to be separated into its pure components using HPLC. The HPLC column is filled with beads coated with methyl groups (CH_3).

i. The operator dissolves the mixture in a polar solvent before injecting it into the column. She expects benzyl benzoate to elute from the column first, ahead of acetylcholine. Do you agree? Provide a clear explanation based on your chemical knowledge.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____3 marks

ii. Give a clear explanation of how HPLC can be used to identify the presence of both acetylcholine, and benzyl benzoate and to discount the possibility of potential contamination with an unknown organic substance.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____ 4 marks

c) Describe a way that a pure sample of benzyl benzoate and acetylcholine can be obtained from the mixture using a more simple technique, such as solvent extraction with water as the solvent. Provide a brief summary of the procedure detailing how each component will be separated from the mixture given the density of benzyl benzoate is 1.118 g/mL.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____4 marks

d) The buildup of lactic acid during intense exercise contributes to muscle cramps through its effects on muscle pH, which can impair the function of acetylcholinesterase. This impairment can lead to prolonged acetylcholine activity, causing excessive muscle contraction known as cramps. Explain in terms of protein structure and bonding how lactic acid build up in muscle tissue impacts on the ability of acetylcholinesterase to degrade acetylcholine. You may use a diagram to enhance your explanation.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____4 marks

Question 12

Below is an investigation conducted by a chemist in a scientific laboratory.

Practical Investigation: Determining the Concentration of Vitamin C in Orange Juice

Aim:

To determine the concentration of vitamin C (ascorbic acid) in different varieties of orange juice using an iodine titration method.

Materials:

A mass of 0.5 kg of different varieties of oranges (e.g., Navel, Valencia, Blood Orange)
100 mL freshly squeezed orange juice from each variety
0.005 M iodine solution
1% starch indicator solution
1 X 50 mL burette
3 X Pipette (10 mL)
4 X Conical flask (100 mL)
Distilled water
Standard vitamin C solutions 5mg/100mL, 20 mg/100mL, 40 mg/100mL, 60 mg/100mL for calibration
White tile (for colour contrast during titration)

Method:

1. Squeeze the juice from each variety of orange and filter to remove pulp.
2. Using new, clean, 10mL pipette deliver a 10 mL of aliquot of orange juice into each of the three conical flasks.
3. Add 2 mL of starch indicator solution.
4. Titrate the juice with the iodine solution, carefully adding iodine from the burette until the solution remains a blue-black colour for 30 seconds. Record the volume of iodine used.
5. Repeat steps 1 -4 three more times.
6. Repeat steps 1 – 5 for each orange juice sample.
7. Perform titration with the standard vitamin C solutions.
8. Plot the graph of iodine volume vs vitamin C concentration to create a calibration curve.
9. Use the calibration curve to determine the concentration of vitamin C in each of the three orange juice samples.

Results:

Orange Variety	**Volume of Iodine Used (mL)**	**Average Volume (mL)**	**Vitamin C Concentration (mg/100 mL)**
Navel Orange	15.20, 15.27, 15.30, 15.25	15.23	45.0
Valencia Orange	14.80, 14.95, 14.74, 15.15	14.77	43.5
Blood Orange	12.00, 12.15, 12.30, 12.30	12.15	36.5

a) Give the variables in this investigation

i. Independent variable _____ 1 mark

ii. Dependent variable _____ 1 mark

iii. Two controlled variables

_____

_____2 marks

b) The results from which type of orange were most repeatable? Justify your choice.

_____

_____

_____

_____

_____2 marks

c) The results from which type of orange were impacted by random errors? Justify your choice.

_____

_____

_____

_____

_____2 marks

d) Aside from vitamin C, orange juice contains a variety of antioxidants, such as flavonoids and phenolic compounds, which may also react with iodine.

i. Given this information and the results derived from the Navel orange trials, discuss if the results are valid and reproduceable.

_____

_____

_____

_____

_____

_____2 marks

ii. What type of error does the presence of other antioxidants in orange juice pose for this investigation? Explain.

_____

_____

_____

_____

_____

_____2 marks

iii. In a well-equipped laboratory, a chemist wants to determine the exact concentration of vitamin C in different brands of orange juice. Due to the presence of other antioxidants like flavonoids and phenolic compounds, she resorts to using HPLC. Suggest how this method would specifically measure vitamin C concentration.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____3 marks

iv. Discuss how the used of HPLC would improve the validity of the investigation compared to an iodine titration, and how it may or may not improve, the accuracy of the results.

_____
_____
_____
_____
_____
_____
_____2 marks

e) Write a relevant conclusion for this investigation.

_____
_____
_____
_____
_____
_____2 marks