UNIT 4 CHEMISTRY 2005

WRITTEN EXAMINATION 2

TRIAL EXAMINATION PAPER

Reading Time: 15 minutes
Writing Time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of Book

Section	*Number of Questions*	*Number of Questions to be Answered*	*Number of Marks*	*Suggested Times (minutes)*
A	20	20	20	25
B	9	9	62	65
			Total 82	**Total 90**

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MULTIPLE CHOICE QUESTIONS - ANSWER SHEET

Please note that the format and requirements of this answer sheet are different to the answer sheet that will be issued in the VCAA examination. Copies of the actual examination answer sheet may be obtained at: **www.vcaa.vic.edu.au**

Choose the correct response or the response which best answers the question by shading the square corresponding to your response in the table below.

Question 1	A	B	C	D
Question 2	A	B	C	D
Question 3	A	B	C	D
Question 4	A	B	C	D
Question 5	A	B	C	D
Question 6	A	B	C	D
Question 7	A	B	C	D
Question 8	A	B	C	D
Question 9	A	B	C	D
Question 10	A	B	C	D
Question 11	A	B	C	D
Question 12	A	B	C	D
Question 13	A	B	C	D
Question 14	A	B	C	D
Question 15	A	B	C	D
Question 16	A	B	C	D
Question 17	A	B	C	D
Question 18	A	B	C	D
Question 19	A	B	C	D
Question 20	A	B	C	D

SECTION A – MULTIPLE CHOICE QUESTIONS

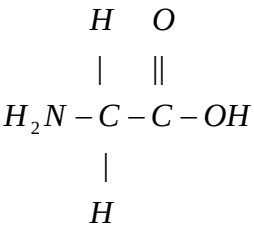
Instructions For Section A

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

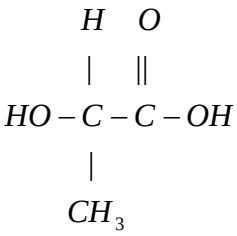
QUESTION 1
The species that acts as the strongest oxidant is

A Mn^{2+}
B MnO_2
C MnO_4^-
D K_2MnO_4

QUESTION 2
Glycine and lactic acid can react to form two different compounds. Which of the following best describes the type of functional group formed when these molecules react?



Glycine



Lactic acid

	Glycine + Lactic acid	Lactic acid + Glycine
A	Peptide	Peptide
B	Ether	Peptide
C	Carboxyl	Peptide
D	Ester	Peptide

QUESTION 3
Which of the following statements is **incorrect**?

A The oxidation state of manganese in MnO_4^{2-} is $+6$ as each manganese atom has lost 6 electrons during bond formation.
B Transition metal atoms lose electrons from the $4s$ subshell first.
C Changes in the oxidation state of a transition metal atom in compounds are frequently accompanied by changes in colour.
D Different coloured compounds may be observed in different compounds containing transition metal atoms with identical oxidation numbers.

QUESTION 4
Which of the following statements is **correct**?

A The core charge of a Group II ion is +2.
B The core charge of a Group II ion is +8.
C The core charge is equal to the nuclear charge in atoms and ions.
D The effect of the nuclear charge on the valence electrons in an atom is diminished by electrons in completely filled shells.

QUESTION 5
$(NH_4)_3VF_6$ is an example of a complex ion. The ligand(s) in this complex are

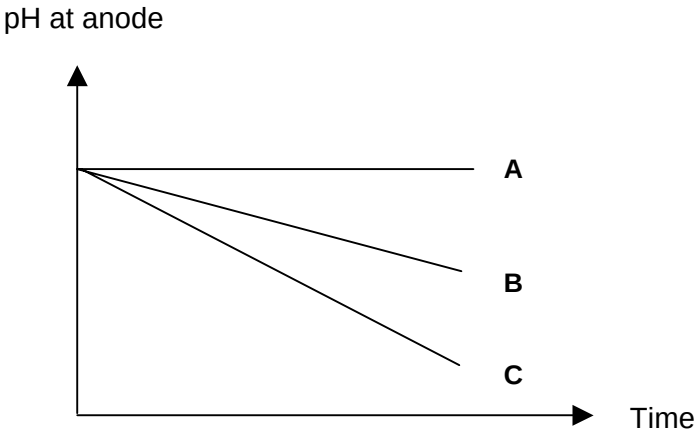
A V^{3+}
B F^- and NH_4^+
C F^-
D NH_4^+

QUESTION 6
The electron configuration of an atom changed from $1s^2 2s^2 2p^6 3p^2$ to $1s^2 2s^2 2p^6 3s^1 3p^1$. During the course of this change

A Every electron returned to its ground state and energy was released.
B Every electron returned to its ground state and energy was absorbed.
C The atom remains in its excited state and energy was released.
D The atom remains in its excited state and energy was absorbed.

QUESTION 7
An electrolytic cell was constructed using different concentrations of sodium chloride using platinum electrodes.

The changes in pH that occur at the anode may be represented by curves A, B and C.



Which option below correctly represents the changes in pH that occur at the anode at the different concentrations of $NaCl$?

	$1.0\,M\ \ NaCl$	$2.5\,M\ \ NaCl$	$10.0\,M\ \ NaCl$
A	Curve A	Curve B	Curve C
B	Curve C	Curve B	Curve A
C	Curve A	Curve C	Curve B
D	Curve C	Curve A	Curve B

QUESTION 8
Which of the following statements is **incorrect**?

A The two isotopes of nitrogen $^{14}_{7}N$ and $^{15}_{7}N$ will produce identical atomic absorption spectrums.

B The $^{14}_{7}N$ atom and its ion will produce identical atomic absorption spectrums.

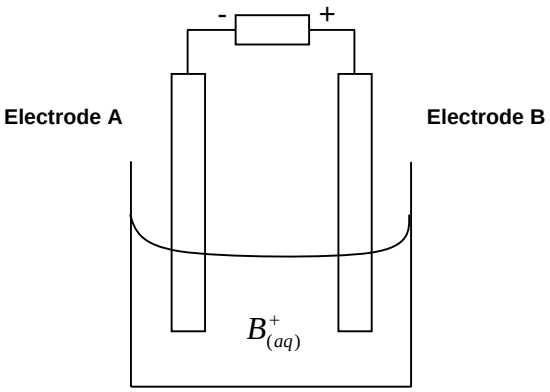
C The two isotopes of nitrogen $^{14}_{7}N$ and $^{15}_{7}N$ will produce different mass spectrums.

D The $^{14}_{7}N$ atom and its ion will produce different atomic absorption spectrums.

QUESTION 9
The fatty acid containing three double C to C bonds is

A $C_{18}H_{30}O_2$
B $C_{26}H_{52}O_2$
C $C_2H_4O_2$
D $C_{20}H_{32}O_2$

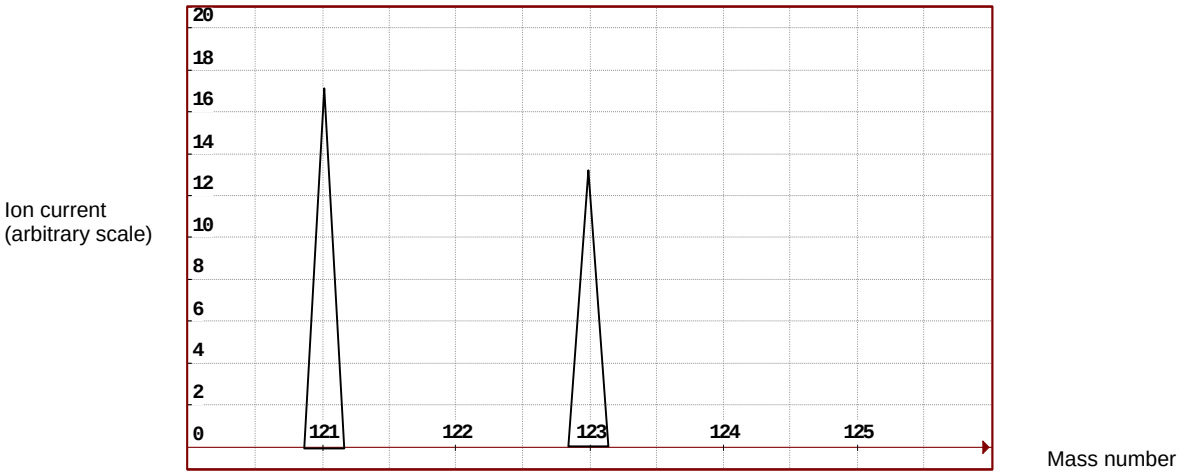
QUESTION 10
Consider the following electrolytic cell.



Which of the following statements is correct?

A Electrode A represents the anode.
B Metal B would be deposited at electrode A.
C Electrons flow through the electrolyte from A to B.
D $[B^+_{(aq)}]$ will decrease during the electrolytic process.

QUESTION 11
The graph below shows the relative abundances of two isotopes of a particular element.



The element's relative atomic mass lies across the interval

A 121 – 121.5
B 121.5 – 122
C 122 – 122.5
D 122.5 - 123

QUESTION 12
Which property shows a general increase across a period in the periodic table?

A Atomic radius
B Metallic nature
C Electronegativity
D Reducing strength

QUESTION 13
In which section of the periodic table is the species with the greatest oxidising strength located?

A Bottom left hand side
B Bottom right hand side
C Top left hand side
D Top right hand side

Questions 14 and 15 refer to the following information.

A bomb calorimeter is calibrated using pure methanol, which has a heat of combustion of $727\,kJ$ for each mole of methanol.

QUESTION 14

$1.50\,g$ of pure methanol is placed in a bomb calorimeter at $20.50^{o}C$ and reacted with excess oxygen at high pressure. If the calibration factor of the calorimeter is $5.41 kJ / K$ the final temperature of the calorimeter is closest to:

A $6.30^{o}C$
B $12.60^{o}C$
C $14.20^{o}C$
D $26.80^{o}C$

QUESTION 15

The ΔH for the reaction describing the complete combustion of methanol, and which is written using coefficients in the simplest whole number ratio is

A $727\,kJ\,/\,mol$
B $-727\,kJ\,/\,mol$
C $1454\,kJ\,/\,mol$
D $-1454\,kJ\,/\,mol$

QUESTION 16

The equation of an important biological reaction is given below.

$$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)} \quad \Delta H = -2803\ kJ\,/\,mol$$

If the heat of vaporisation of water is $44\,kJ$ for each mole of $H_2O_{(l)}$, the ΔH for the reaction below is closest to

$$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)} \quad \Delta H = ?$$

A $-2539\,kJ\,/\,mol$
B $-2759\,kJ\,/\,mol$
C $-2803\,kJ\,/\,mol$
D $-2847\,kJ\,/\,mol$

QUESTION 17
When amino acids are broken down, excess nitrogen is removed from the body as a component of

A NH_3
B NH_4^+
C NO_3^-
D $CO(NH_2)_2$

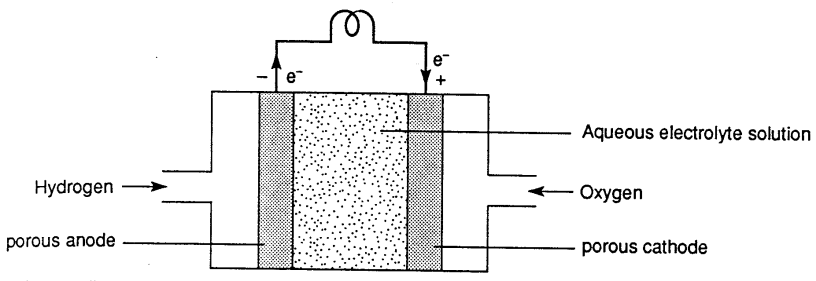
QUESTION 18
A molecule of lactose is comprised of

A Sucrose and glucose
B Galactose and fructose
C Galactose and glucose
D Glucose and glucose

QUESTION 19
Which molecule represents the formula of a carbohydrate?

A $C_2H_4O_2$
B $C_{18}H_{32}O_{16}$
C $C_{18}H_{34}O_2$
D $C_3H_7O_2N$

QUESTION 20
Fuel cells are electrochemical cells that convert chemical energy into electrical energy. The hydrogen-oxygen fuel cell is an example of a common fuel cell.



The reaction that takes place at the cathode in an **acid** hydrogen-oxygen fuel cell is

A $H_{2(g)} + 2OH^-_{(aq)} \rightarrow 2H_2O_{(l)} + 2e^-$
B $H_{2(g)} \rightarrow 2H^+_{(aq)} + 2e^-$
C $O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$
D $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$

SECTION B – SHORT ANSWER QUESTIONS

Instructions For Section B

This section consists of 9 short answer questions. Section B is worth approximately 76% of the marks available. You should spend approximately 65 minutes on this section.

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 to all numerical questions; unsimplified answers will not be give 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, $H_{2(g)}$; $NaCl_{(s)}$.

QUESTION 1

Nuclear fusion and fission reactions can be associated with the release of large quantities of energy. It is hoped that the energy released during these processes can be used to produce electricity, and replace coal as a primary future energy source.

To date, scientists have not yet been able to sustain controlled fusion reactions and harness the energy released from this process.

a. (i) Give a reason why controlled fusion reactions cannot be currently sustained.

_____

_____

_____

_____

_____

1 mark

(ii) Identify the equation below that represents a fusion reaction that is exothermic in nature. Circle the correct response.

A $^{56}_{26}Fe \rightarrow 13\ ^{4}_{2}He + 4\ ^{1}_{0}n$

B $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{9}F + ^{1}_{0}n$

C $^{238}_{92}U + ^{12}_{6}C \rightarrow ^{246}_{98}Cf + 4^{1}_{0}n$

D $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{145}_{57}La + ^{88}_{35}Br + 3^{1}_{0}n$

(iii) Give a reason as to why the formation of elements that are larger than iron in stars can only be produced during a supernova.

_____

_____

_____

1 mark

b. Fission reactions may occur spontaneously or induced by bombarding heavy nuclei with neutrons. In the process, a variety of products may be formed.

(i) Seaborgium ($^{263}_{106}Sg$) decays by emission of an alpha particle (the nucleus of a helium atom). Write an equation to represent the decay process of Sg.

_____

(ii) The carbon isotope ^{14}C decays by emission of an electron (beta particle). Write an equation to represent the decay process of ^{14}C.

_____

(iii) An isotope of fluorine $^{18}_{9}F$ decays by emission of a positron (positive electron). Write an equation to represent the decay process of $^{18}_{9}F$.

_____

1 + 1 + 1 marks

Total 6 marks

QUESTION 2

Transition metals occupy the d block in the periodic table, and consist of three horizontal series in Periods 4, 5 and 6. Each series contains ten elements, and involve the filling of the d subshell. Chemically, the transition elements share a general similarity in properties across each series.

a. Explain why there are no special trends evident as one moves across a transition metal series, whereas strong patterns are present across other periods in the periodic table.

_____

_____

_____

_____

_____

_____

_____

_____

2 marks

b. Many transition metals display a variety of unique properties, including:

- The ability to form coloured complexes.
- The ability to adopt multiple oxidation states in ions and compounds.

Although part of the transition metal series, zinc does not display the typical unique properties displayed by other transition metals.

(i) State why zinc does not display the ability to form coloured compounds like other transition metals.

_____

_____

_____

(ii) State why zinc is not able to form ions with multiple oxidation states.

_____

_____

_____

1+1 marks

Complex ion formation is one of the more dramatic (and colourful) aspects of transition metal chemistry. Few main group metals, in contrast, are able to form complex ions, and those that do exist are colourless.

c. Sketch the complex ion produced when Fe^{3+} reacts with six chloride ions.

Name the bonding that arises between Fe^{3+} and chloride: _____

1+1 mark

d. Write the formula of the complex formed between Fe^{3+} and $C_2O_4^{2-}$, and whose coordination number is 6.

_____

1 mark

e. Write the formula for the compound formed when $Fe(CN)_6^{4-}$ reacts with Al^{3+}.

_____

1 mark

Total 8 marks

QUESTION 3
There are many trends evident across the periods and groups of the Periodic Table such as those observed in ionisation energy requirements.

a. Which section of the periodic table would you find elements with the smallest ionisation energies?

_____

1 mark

b. Consider the successive removal of the electrons from a sodium atom and the corresponding ionisation energy requirements:

Number of electrons removed	Ionisation Energy (kJ / mol)
1	510
2	4560
3	6940
4	9540
5	13,400
6	16,600
7	20,100
8	25,500
9	28,900
10	141,000
11	158,700

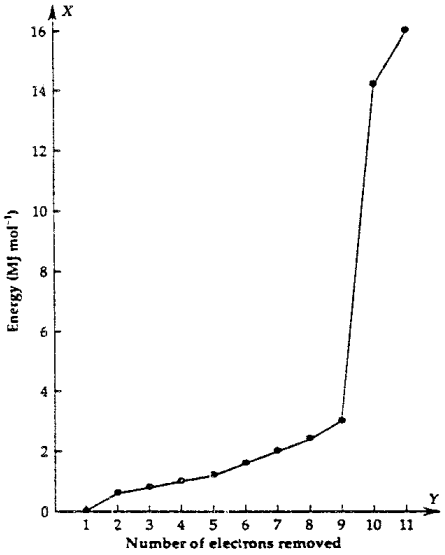


Diagram (Chemistry Two – Heinemann)

(i) Explain why successive electrons require more energy for their removal.

_____

_____

_____

_____

1 mark

(ii) Use the graph to explain how successive ionisation energies are used to support the existence of energy levels within atoms.

2 marks

c. Consider the ionisation energies (in megajoules per mole) for the successive removal of the first eight electrons of the elements A and B:

A	1.1	1.7	3.1	5.9	8.3	10.0	12.8	93.0
B	0.5	0.8	1.3	1.9	2.7	3.9	18.1	21.3

Suggest the most likely formula for the compound formed between A and B.

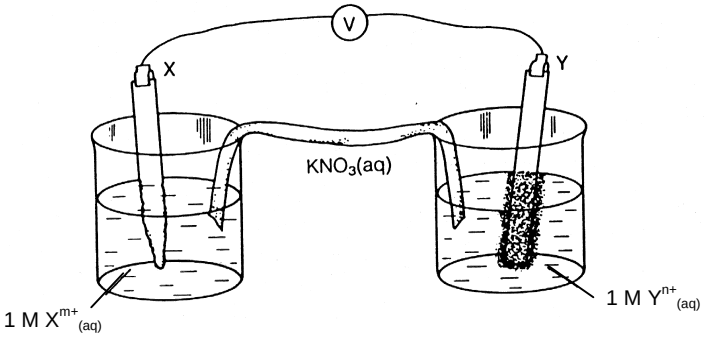
1 mark

Total 5 marks

QUESTION 4
An extract from the electrochemical series is given below.

	E^o in Volt
$Ba^{2+}_{(aq)} + 2e^- \rightarrow Ba_{(s)}$	-2.90
$Cd^{2+}_{(aq)} + 2e^- \rightarrow Cd_{(s)}$	-0.403
$Co^{2+}_{(aq)} + 2e^- \rightarrow Co_{(s)}$	-0.28
$Cr^{2+}_{(aq)} + 2e^- \rightarrow Cr_{(s)}$	-0.905
$Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$	-0.23
$Ag^{+}_{(aq)} + e^- \rightarrow Ag_{(s)}$	$+0.80$

An experimental galvanic cell was constructed where X and Y represent two different metals from the above electrochemical series. The cell was constructed so that an EMF of approximately $1.2\,V$ was generated.



a. (i) Identify electrode X: _____

(ii) Identify electrode Y: _____

2 marks

b. (i) State the main energy transformation that occurs in the above cell and indicate whether this process is exothermic or endothermic.

_____

(ii) Explain why a voltage would not be observed if the reactions were carried out in a single cell.

_____

_____

1 + 1 marks

c. $8640\,C$ of charge was passed through the second experimental cell across a 2.00 hour period.

(i) Calculate the current generated in the cell.

1 mark

(ii) Calculate the mass loss that occurs at the anode across the 2.00 hour period.

2 marks

(iii) If the actual mass loss at the anode was in fact $4.25\,g$, calculate the % current efficiency of the cell.

1 mark

Total 8 marks

QUESTION 5

An electrolytic cell contains $500.00\,ml$ of a mixture of Cu^{2+}, Sn^{2+}, Co^{2+}, Fe^{2+} and Al^{3+}, each at $1.00\,M$ concentration.

Two graphite rods are placed in the solution and an electric current generating $1.6V$ is passed through the cell.

After some time, it was noticed that the mass of the cathode was no longer changing. The electrolytic procedure was stopped, and the cathode was removed for analysis.

a. Which metal(s) were deposited at the cathode during the electrolytic procedure?

_____

1 mark

b. Would the first layer of metal deposited be pure? Explain.

_____

_____

_____

2 marks

c. How many coulombs of charge would be required to deposit the metals?

_____

_____

_____

2 marks

Total 5 marks

QUESTION 6
Many important chemical species are produced via electrolytic procedures. Examples of such chemicals include sodium, chlorine, sodium hydroxide and aluminium.

a. Aluminium is extracted from aluminium oxide (alumina Al_2O_3) by electrolysis in the Hall-Heroult Cell.

Alumina can be dissolved in strong acids and bases to give aqueous solutions of aluminum ions, however, such solutions cannot be electrolysed to produce aluminium metal.

(i) Give an equation that shows alumina acting as an acidic oxide.

_____

_____

(ii) Give an equation that shows alumina acting as a basic oxide.

_____

_____

(iii) Explain why such solutions cannot be electrolysed to produce aluminium metal.

_____

_____

_____

(iv) Write the equation that describes the overall reaction that occurs in the Hall-Heroult Cell.

_____

1 + 1 + 1 + 1 marks

b. Sodium is produced in the Down's Cell using a molten mixture of $NaCl$ and $CaCl_2$.

(i) Why is calcium chloride added to the cell?

_____

_____

_____

(ii) Explain why the addition of calcium chloride to the reaction chamber has no effect on the purity of sodium formed.

_____

_____

_____

(iii) Why is an iron mesh screen incorporated into the design of the Down's Cell?

_____

_____

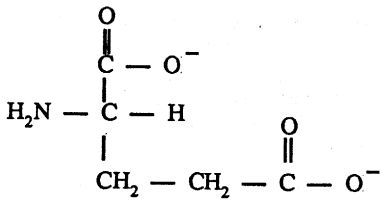
_____

1 + 1 + 1 marks

Total 7 marks

QUESTION 7

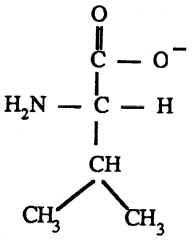
Monosodium glutamate (M.S.G.) is a food additive that enhances taste. It is made from glutamic acid, which has a structural formula of



a. (i) At what pH would glutamic acid exist in its illustrated form?

_____

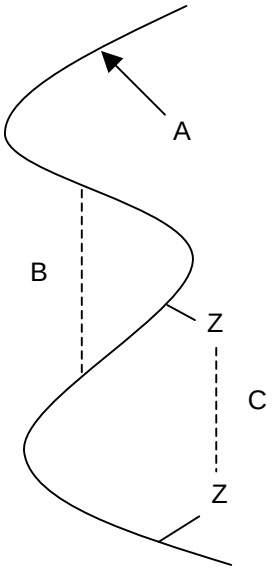
(ii) The structural formula valine at the same pH is given below.



Draw the structural formula of the product formed when glutamic acid reacts with valine at the pH for which the structures above are shown.

1 + 1 marks

b. A portion of a protein acid chain is illustrated below.



(i) Name the bonding responsible for maintaining the protein structure at A.

_____

(ii) Name the bonding responsible for maintaining the protein structure at B.

_____

(iii) Which bond is **least likely** to be affected when the protein chain is heated to $60^{o}C$? Circle the correct response.

Bonding at A Bonding at B Bonding at C

(iv) Which bonding plays the **greatest** role in determining the overall 3 dimensional shape of an enzyme? Circle the correct response.

Bonding at A Bonding at B Bonding at C

2 marks

Enzymes are an important group of proteins that act as catalysts in biochemical reactions.

An experiment to investigate the hydrolysis of maltose was conducted as follows:

- Maltose solution was placed in six test-tubes with a suitable indicator to show the presence of glucose.
- The test-tubes were agitated in water baths at different temperatures.
- A suitable enzyme was added to each test-tube, and the time taken for the formation of glucose, as shown by a colour change in the indicator, was recorded.

  The results are shown in the table below:

Test-tube	**Temperature (^{0}C)**	**Time (s) for colour change to occur**
1	10	60
2	20	40
3	30	20
4	40	10
5	60	50
6	80	No reaction by 180 s

c. Explain why the catalytic function of an enzyme molecule is dependent on the way the molecule is folded.

_____

_____

_____

_____

_____

_____

2 marks

d. (i) Briefly explain why the time taken for a colour change to occur decreases between $10^{o}C$ and $40^{o}C$.

1 mark

(ii) Explain why the time taken for a colour change to occur increases between $40^{o}C$ and $60^{o}C$.

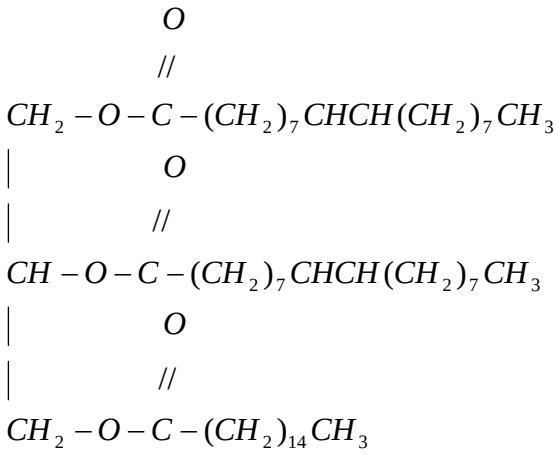
1 mark

(iii) Identify *two* quantities that should be held at the same value in all test-tubes in this experiment.

1 mark

Total 9 marks

QUESTION 8
Fats and oils in foods are made up of complex mixtures of saturated and unsaturated fatty acids. One such example is olive oil and is illustrated below.



a. Antioxidants are frequently added to fatty foods and oils to protect them from turning rancid.

Circle a region in the above molecule that would be protected by an antioxidant and explain how an antioxidant protects fats and oils from turning rancid.

_____

_____

_____

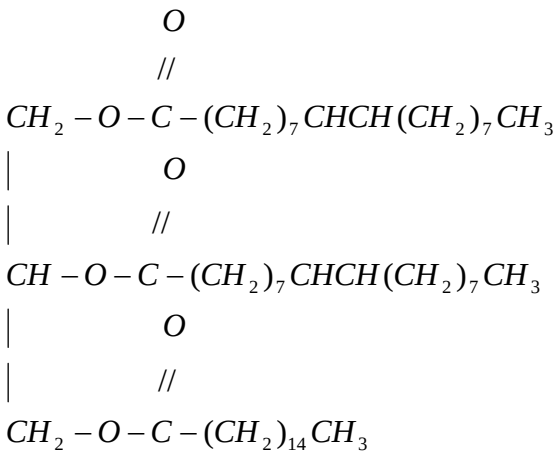
_____

_____

_____

2 marks

b. (i) Write an equation to represent the reaction that occurs in the presence of the enzyme lipase.



2 marks

(ii) What is the common name for this type of reaction?

_____

1 mark

c. A sample of olive oil was reacted as described below:

$$\text{oil} + \text{A} \xrightarrow{\text{B}} \text{fat}$$

(i) Identify:

Reagent A: _____

Substance B: _____

1 mark

(ii) What is the common name for this class of reaction?

_____

1 mark

(iii) State the change in the chemical structure of the oil when it is converted into fat.

_____

_____

1 mark

(iv) Which statement below **incorrectly** describes a change in the physical property of the oil when it is converted into fat? Circle the incorrect response.

A Product becomes less susceptible to rancidity.
B Product becomes more solid.
C The melting point of the product decreases.
D Product becomes less easy to spread.
E The density of the product increases.

1 mark

Total 9 marks

QUESTION 9

a. Give the equation for the reaction that occurs when oxygen is bubbled through an acidified solution of iron (II) chloride, $FeCl_{2(aq)}$.

_____

_____

_____

_____

_____

2 marks

b. (i) What is nitrogen fixation?

_____

_____

_____

1 mark

(ii) Why is nitrogen fixation essential to life?

_____

_____

_____

1 mark

(iii) Give an equation that illustrates the process of nitrogen fixation.

_____

_____

1 mark

Total 5 marks

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