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'2017 Examination Package' -
Trial Examination 5 of 9

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Units 3 & 4 - Written examination

(TSSM's 2012 trial exam updated for the current study design)

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

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	11	11	87
			Total 117

- 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 white out liquid/tape.
- VCAA data book is permitted in this examination.

Materials supplied

- Question and answer book of 27 pages.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses must be in English.

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

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SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions.
Choose the response that is **correct** or **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
No mark will be given if more than one answer is completed for any question.
Marks will **not** be deducted for incorrect answers.

Question 1

A 0.580 g sample of a compound containing only carbon and hydrogen contains 0.480 g of carbon and 0.100 g of hydrogen. At STP, 33.6 mL of the gas has a mass of 0.087 g. What is the molecular formula for the compound?

A. CH_3
B. C_2H_6
C. C_2H_5
D. C_4H_{10}

Question 2

1.95 kJ of heat is required to raise the temperature of 500 g of lead from 15°C to its final temperature. Taking the specific heat capacity of lead to be 130 J/(kg °C), the final temperature is:

A. 45°C
B. 37.5°C
C. 30°C
D. 22.5°C

Question 3

To determine the amount of iodine (I_2) in a redox titration, a suitable reagent is:

A. $AgNO_3$
B. $Fe(NO_3)_2$
C. KBr
D. $Sn(NO_3)_2$

Question 4

It is known that a particular reaction releases energy and has an activation energy of 75 kJ/mol, which of the following statements are correct?

I. The reverse reaction has an activation energy also equal to 75 kJ/mol.
II. The reverse reaction has an activation energy less than 75 kJ/mol.
III. The reverse reaction has an activation energy greater than 75 kJ/mol.
IV. The change in enthalpy is less than zero.
V. The change in enthalpy is greater than zero.

A. I and IV
B. II and IV
C. III and IV
D. III and V

SECTION A - continued

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Question 5
Which of the following sets of changes would occur during the electrolysis of silver nitrate solution using graphite electrodes?

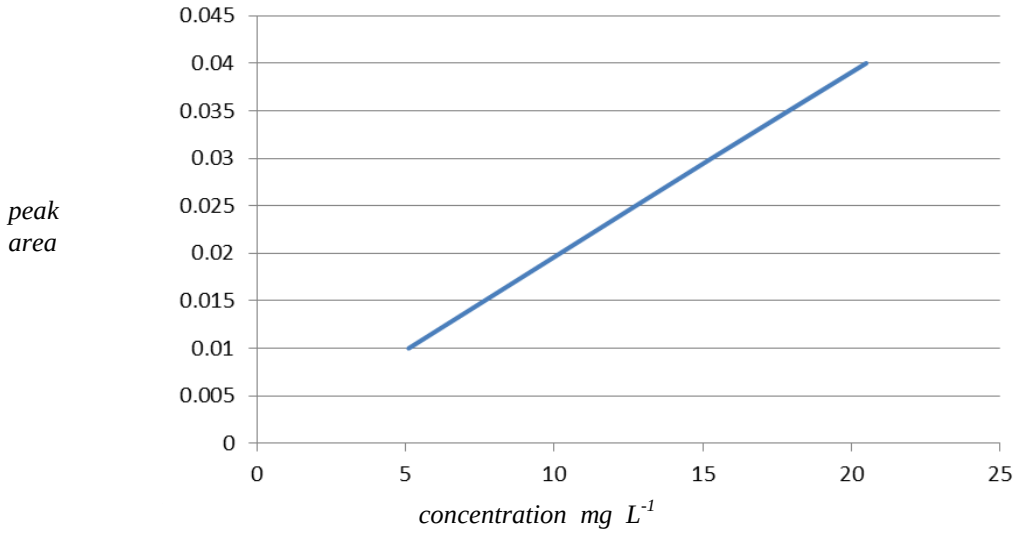
	Number of moles of Ag^+ (aq)	**Number of moles of NO_3^- (aq)**	**pH of the solution**
A.	Decreases	Decreases	Remains unchanged
B.	Decreases	Remains unchanged	Decreases
C.	Remains unchanged	Remains unchanged	Decreases
D.	Remains unchanged	Decreases	Remains unchanged

Question 6
A solution of an organic molecule is to be analysed and the following information is obtained.

Infrared spectrometry: absorptions included 1700 cm and 3100 cm
Proton NMR: two singlets only
Titration: its concentration can be determined by titration against sodium carbonate

Given this information the molecule could be
A. ethanol
B. ethanoic acid
C. ethanamine
D. propanoic acid

Question 7
A graph is obtained from one of the instruments you have studied this year



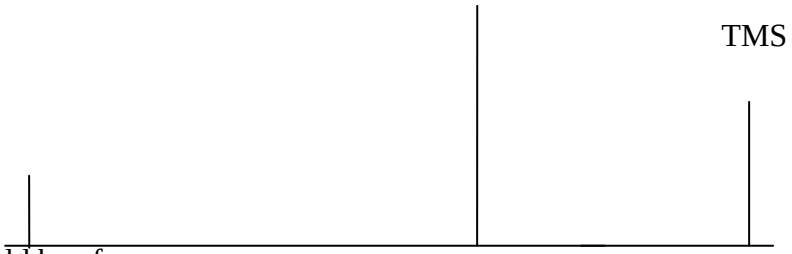
This analysis is most likely to be
A. a calibration curve obtained from HPLC chromatograms of standard ethanol solutions
B. a calibration curve obtained from atomic absorption of standard ethanol solutions
C. a calibration curve obtained from the infrared testing of standard ethanol solutions
D. a wavelength scan of ethanol solutions under ultra violet spectroscopy

SECTION A – continued
TURN OVER

Question 8
The mass spectrum of a molecule produces peaks with *m/e* values of 15, 29 and 31. The possible ions causing these respective peaks could be
A. CH_3^+, $C_2H_3^+$, CH_2OH^-
B. CH_3, C_2H_5, CH_2OH
C. CH_3^+, $C_2H_5^+$, CH_2OH^+
D. CH_3^+, CO^+, $CHOH^+$

Question 9
Each enzyme can speed up only one particular reaction. This specificity is due to the:
A. shape of both the enzyme and the substrate
B. lowering of the energy of activation
C. pH of the surrounding medium
D. temperature of the surrounding medium

Question 10
A high resolution ^1H NMR spectrum is drawn below.



This NMR co[illegible] of
A. ethane
B. ethanol
C. ethanoic acid
D. 1-propanol

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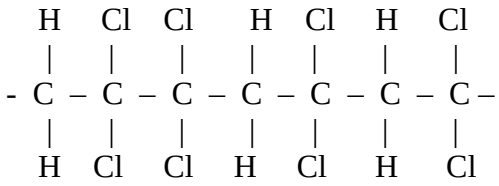
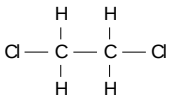
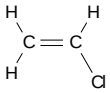
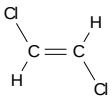
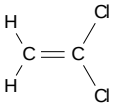
Question 11
The monomer used to produce the polymer segment shown is



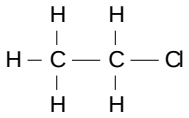
A. 

B 

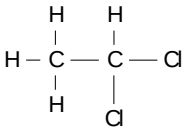
C. 

D. 

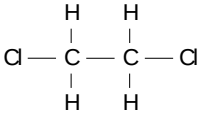
Question 12
Consider the following structures



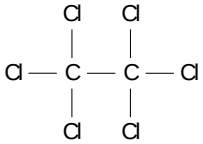
I



II



III



IV

When a substitution reaction occurs between ethane and excess chlorine gas in the presence of uv light, the possible product(s) formed are

A. **I** only
B. **I** and **III** only
C. **III** only
D. all of the above

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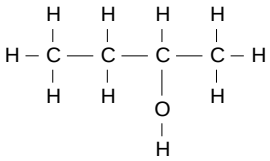
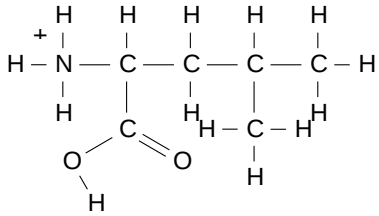
Question 13
How many isomers will the molecule shown have (including this one)?



A. 2
B. 3
C. 4
D. 5

Question 14
An organic molecule is drawn below.



The molecule is
A. leucine in acid solution
B. the zwitterion of valine
C. the zwitterion of leucine
D. the product of the reaction between ethanoic acid and 1-aminobutane

Question 15
A farmer grows a crop of sugar cane and a crop of canola. The sugar cane is crushed and allowed to ferment. The mixture is then distilled to obtain product A.
The canola seeds are also crushed and the oil is filtered to obtain product B.
Product A and product B are then mixed together and concentrated sodium hydroxide solution is added.

The final product of this process is
A. glycerol
B. starch
C. biodiesel
D. an ester that can be used as an artificial flavouring

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Question 16
During recharge in a secondary cell, the cathode is negative and the anode is positive, therefore during discharge:
A. The cathode is negative and the anode is positive and electrons flow from anode to cathode.
B. The cathode is positive and the anode is negative and electrons flow from cathode to anode.
C. The cathode is positive and the anode is negative and electrons flow from anode to cathode.
D. The cathode is negative and the anode is positive and electrons flow from cathode to anode.

Question 17
Hydrogen iodide can decompose to form hydrogen gas and iodine gas. The equation is

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

When 0.034 mole of hydrogen iodide is added to an empty reactor, the amount of hydrogen gas at equilibrium is found to be 0.0080 mole. The numerical value of K will be
A. 0.0019
B. 0.198
C. 0.240
D. 280

Question 18
A calorimeter with a calibration factor of 93.0 J/°C was initially at 15.0° C. When 80.0 g of an alloy at 100° C is dropped into the calorimeter, the resulting temperature is 20.4° C. What is the specific heat of the alloy?
A. 0.08 J/(g°C)
B. 0.079 J/(g°C)
C. 0.0789 J/(g°C)
D. 0.07886 J/(g°C)

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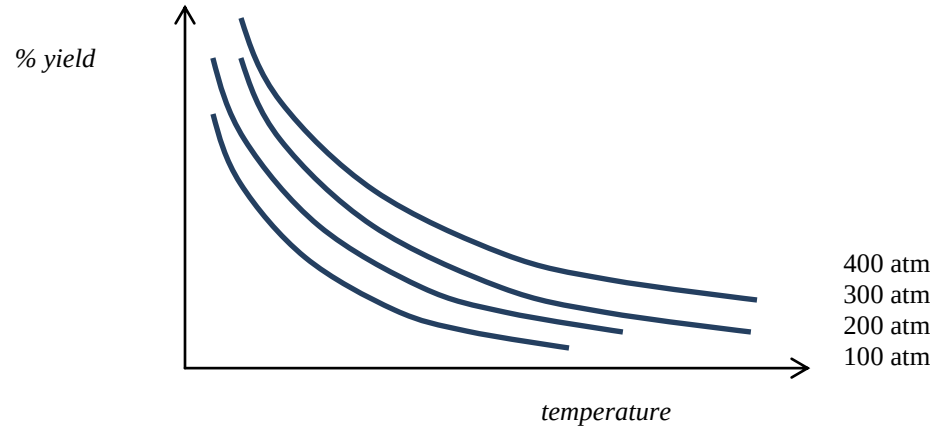
Question 19

The yield of a particular reversible reaction varies with changes to the temperature and pressure. The graph shows the trends in yield at a range of different conditions.



From the graph it can be concluded that the reaction is a reversible one that is

A. exothermic with more product molecules than reactant molecules
B. endothermic with less product molecules than reactant molecules
C. exothermic with less product molecules than reactant molecules
D. endothermic with more product molecules than reactant molecules

Question 20

Which of the following processes will NOT produce a gas at anode?

A. Electrolysis of silver nitrate solution using carbon electrodes
B. Electrolysis of dilute lead (II) nitrate using platinum electrodes
C. Electrolysis of very concentrated sodium chloride solution using carbon electrodes
D. Electrolysis of dilute copper (II) chloride solution using a carbon cathode and a copper anode.

Question 21

LPG gas is a mixture of propane and butane gases. The proportion varies with the source of the LPG. The mass of propane, in g, that releases the same amount of energy as 1.00 g of butane is close to

A. 0.90
B. 0.98
C. 1.00
D. 1.02

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Question 22

Sulfur can be converted to sulfur trioxide, SO_3 in a two-step process. The overall equation for this process is

$$2S\,(g) + 3O_2\,(g) \rightarrow 2SO_3\,(g)$$

The ΔH value for this reaction given the following information will be, in kJ mol^{-1},

$$S\,(g) + O_2\,(g) \rightarrow SO_2\,(g) \qquad \Delta H = -297 \text{ kJ mol}^{-1}$$
$$2SO_3\,(g) \rightarrow 2SO_2\,(g) + O_2\,(g) \qquad \Delta H = +198 \text{ kJ mol}^{-1}$$

A. + 396
B. + 99
C. - 396
D. - 792

Question 23

Four common sources of energy used in society are:

brown coal	galvanic cell	nuclear fission	photovoltaic cell
I	**II**	**III**	**IV**

The order of efficiency of these energy sources, from most efficient to least, is
A. **I, II, III** and **IV**
B. **II, III, I** and **IV**
C. **III, II, I** and **IV**
D. **IV, II, III** and **I**

Question 24

Methane gas is used as a fuel in an acidic fuel cell. The half equation occurring at the anode is
A. $O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(g)$
B. $CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$
C. $CH_4(g) + 4H^+(g) \rightarrow CO_2(g) + 4H_2O(l) + 4e^-$
D. $CO_2(g) + 8H^+(aq) + 8e^- \rightarrow CH_4(g) + 2H_2O(g)$

Question 25

In an electrolysis experiment, measurements reveal that 0.88 mole of material is formed at the anode and 1.76 mole of material is formed at the cathode. The electrolyte could be
A. 0.1 M $CuBr_2$
B. molten $MgCl_2$
C. 0.1 M NaCl
D. 5.0 M NaCl

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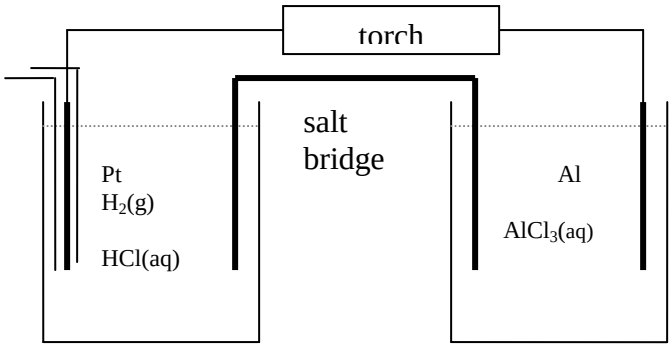
Questions 26 and 27 refer to the following information

A galvanic cell is established to power a torch, as shown below



Question 26

For this cell, the

A. electrons will flow from the aluminium to the hydrogen half cell
B. aluminium electrode will be the positive anode
C. concentration of aluminium ions in solution will be falling
D. hydrogen half-cell will be the negative cathode

Question 27

For this cell, the overall equation will be

A. $2Al(s) + 3H_2(g) \rightarrow 2Al^{3+}(aq) + 6H^+(aq)$
B. $3Cl^-(aq) + Al(s) \rightarrow AlCl_3(aq)$
C. $2Al^{3+}(aq) + 3H_2(g) \rightarrow 2Al(s) + 6H^+(aq)$
D. $2Al(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2(g)$

Questions 28 and 29 refer to the following information

Alkaline cells get their name from the fact that the electrolyte they use is a strong alkaline solution like potassium hydroxide. The high conductivity of the solution and the powdered zinc electrodes give the alkaline cell performance advantages over the standard zinc-carbon cells. The alkaline cells have a higher energy density, longer shelf life and lower internal resistance.

A typical alkaline cell utilises the following half-reactions.

$2MnO_2(aq) + H_2O(l) + 2e^- \rightarrow Mn_2O_3(s) + 2OH^-(aq)$ +0.76 V

$ZnO(s) + H_2O(l) + 2e^- \rightarrow Zn(s) + 2OH^-(aq)$ -0.71 V

Question 28

The overall equation occurring in this cell during discharge will be

A. $2MnO_2(aq) + Zn(s) \rightarrow Mn_2O_3(s) + ZnO(s)$
B. $2MnO_2(aq) + H_2O(l) + Zn(s) \rightarrow Mn_2O_3(s) + ZnO(s) + 2OH^-(aq)$
C. $2MnO_2(aq) + ZnO(s) \rightarrow Mn_2O_3(s) + Zn(s)$
D. $Mn_2O_3(s) + ZnO(s) \rightarrow 2MnO_2(aq) + Zn(s)$

SECTION A – continued

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Question 29

When this cell is discharging, the pH will

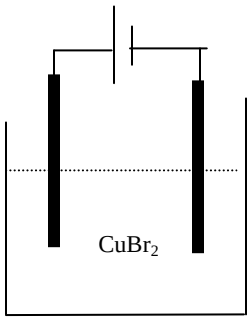
A. not be changing because all products and reactants are neutral
B. not be changing as the alkaline level is not changing
C. be increasing because OH^- ions are being consumed
D. be decreasing because OH- ions are being consumed

Question 30

Electrodes are placed in an aqueous solution of copper bromide and the power supply switched on. A current of 2.0 amp flows for 48250secs.

The number of mole of copper that will be deposited at the anode in this cell will be

A. 0
B. 0.5
C. 1.0
D. 2.0



END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B

Questions must be answered in the spaces provided in this book.
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 given full marks.
- Show all workings 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 (4 marks)
The reaction between ethanoic acid and dichromate ions is a redox reaction conducted in acid conditions.

a. **i**. The incomplete half equation for the reaction of ethanol to ethanoic acid is shown below. Complete and balance this equation. 1 mark

$$C_2H_5OH(aq) \rightarrow CH_3COOH(aq) + H^+(aq)$$

ii. The incomplete half equation for the reaction of orange dichromate ions to green chromium ions is shown below. Complete and balance this equation. 1 mark

$$Cr_2O_7^{2-}(aq) + H^+(aq) \rightarrow Cr^{3+}(aq)$$

b. The concentration of ethanol solutions can be determined by titration of the ethanol solution with potassium dichromate solution.

i. Explain how will you know when the titration endpoint has been reached? 1 mark

_____

_____

ii. If the titre of dichromate solution required contains 0.346 moles of dichromate ions, how many moles of ethanol must have been present? 1 mark

_____

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Question 2 (11 marks)

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

For the reaction above, the value of the equilibrium constant at 200 °C is 44 M^{-1}

a. Write the expression for the equilibrium constant of this reaction.

_____

1 mark

To start this reaction 1.45 mol of nitrogen gas and 2.64 mol of hydrogen gas were placed in a 5.0 L container at a temperature of 200 °C and allowed to react.

b. At a certain point the amount of each substance present was measured as follows:

N_2 = 0.54 mol; H_2 = 1.24 mol; NH_3 = 0.68 mol

i. Calculate the value of the concentration fraction at this time.

_____

_____

2 marks

ii. Is the reaction at equilibrium? If not, which direction does the reaction need to proceed in order to reach equilibrium?

_____

_____

2 marks

c. The researchers experimented with the effect of temperature on this reaction. They increased the temperature to 400 °C and introduced the same amounts of nitrogen gas (1.45 mol) and hydrogen gas (2.64 mol) into another 5.0 L container. When the reaction reached equilibrium it was found that 0.31 mol of nitrogen gas used.

i. Calculate the amounts of hydrogen and ammonia at equilibrium.

_____

_____

_____

2 marks

SECTION B - Question 2 – continued
TURN OVER

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ii. Calculate the equilibrium constant at this equilibrium.

_____

_____

2 marks

iii. Is this reaction endothermic or exothermic? Explain your answer.

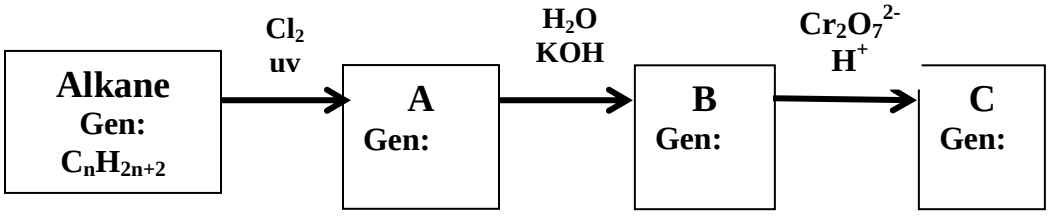
_____

_____

_____

2 marks

Question 3 (8 marks)
The flowchart below shows a generalised chemical pathway for the production of a carboxylic acid from an alkane molecule



a. The general formula for an alkane is shown in the first box. Use the boxes provided to write the general formula for each of the molecules formed in Box A, Box B and Box C. 3 marks

b. If the compound formed in C is butanoic acid, draw the structural formulas for molecules A and B. 2 marks

A B

c. If the molar mass of compound C is found to be 74 g. What would be the molecular formula of compound A? 1 mark

_____

SECTION B - Question 3 – continued

d. The molecule formed in Box B belongs to a homologous series.

i. What is the name of this homologous series? 1 mark

_____

ii. How much does the molar mass of each member of this homologous series differ from the molar mass of the previous member of the same series? 1 mark

_____

SECTION B - continued
TURN OVER

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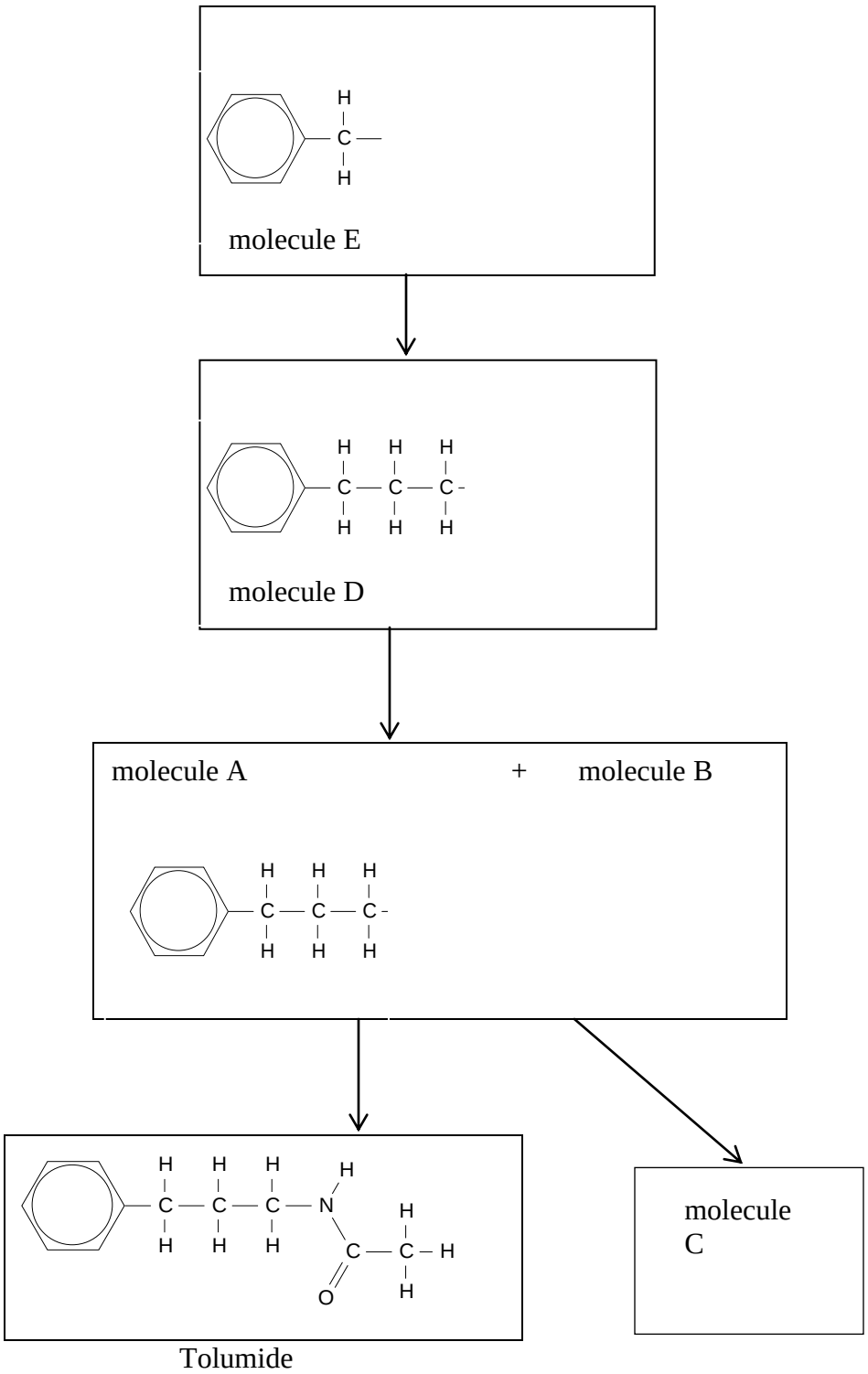
Question 4 (5 marks)

The molecule at the bottom of the flowchart below is Tolumide. It is a new drug being trialled as an anaesthetic. The last few stages in the synthesis of Tolumide are shown in the flowchart.



SECTION B - Question 4 – continued

a. The final step sees Tolumide formed from a condensation reaction between a carboxylic acid, molecule B, and molecule A.

i. Use the box provided to complete the structure of molecule A. 1 mark

ii. Draw a structural diagram of molecule B in the box provided. 1 mark

iii. Another molecule, molecule C, is formed in the condensation reaction. Draw the structure of molecule C in the box provided. 1 mark

b. Molecule A is formed in a substitution reaction between molecule D and ammonia gas. The other product is hydrochloric acid gas.
Use the box provided to complete the structure of molecule D. 1 mark

c. Molecule D in turn, is formed at the top of the flowchart from the addition reaction between an alkene, molecule E, and HCl gas. Use the box provided at the top of the flowchart to complete the structure of molecule E. 1 mark

Question 5 (8 marks)
A 2.840 g sample of an organic molecule is found to contain 60.0 % carbon by mass and 26.7 % oxygen. The remaining element present is hydrogen.

a. **i**. Determine the empirical formula of the compound. 2 marks

_____

_____

_____

ii. The mass spectrum shows the parent molecular ion has a *m/e* ratio of 60. What is the molecular formula of the molecule? 1 mark

_____

SECTION B - Question 5 – continued
TURN OVER

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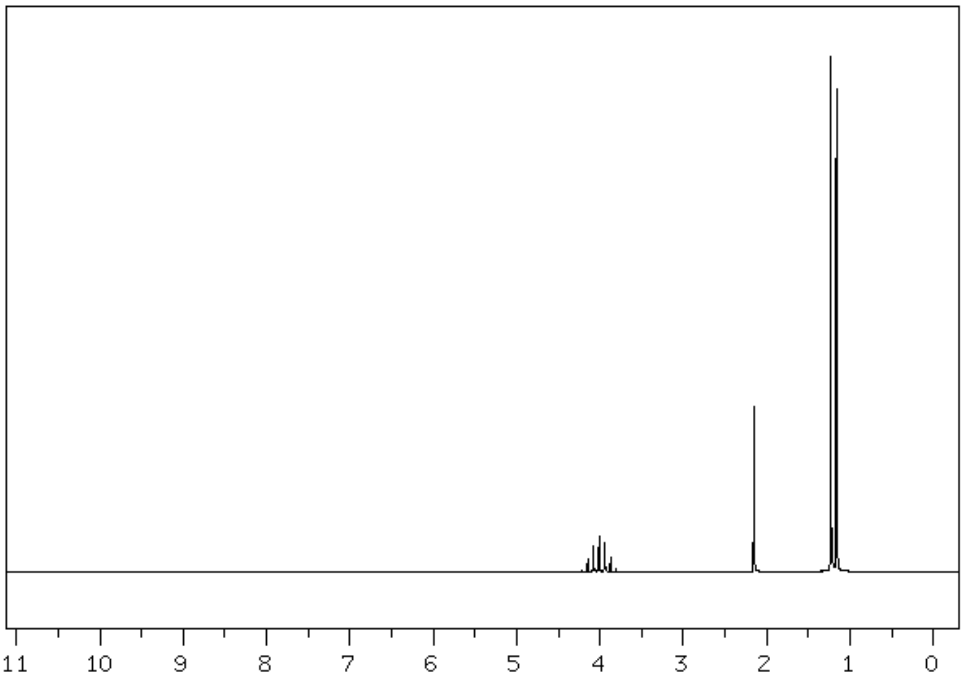
b. Draw two possible isomers of this alkanol. Name both isomers. 2 marks

Isomer 1 Isomer 2

Name: _____ Name: _____

The high resolution proton NMR of the molecule is shown below

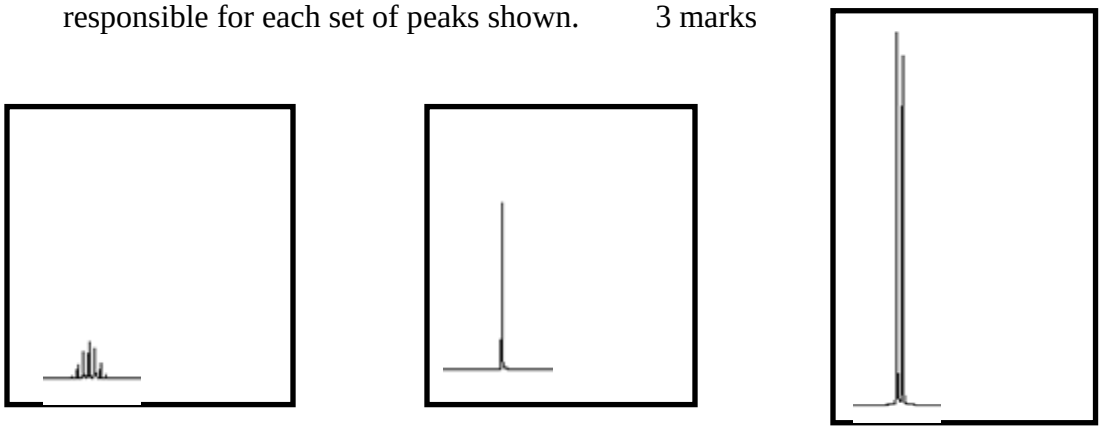


c. **i**. How many different hydrogen environments does this molecule have? _____ 1 mark

ii. Which isomer is the mystery molecule? _____ 1 mark

SECTION B - Question 5 – continued

iii. Use the boxes provided to draw in the section of the molecule that is responsible for each set of peaks shown. 3 marks

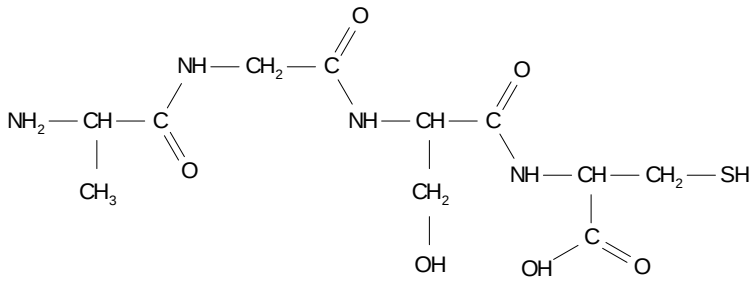


iv. The number of splits in the peak with a shift of 4 ppm is not easy to tell from the spectrum shown. Knowing the structure of the molecule, how many splits would you expect? 1 mark

_____

_____

Question 6 (6 marks)
The structure of a polypeptide is shown below.



a. How many amino acids are there in this molecule? _____ 1 mark

b. Name each of the amino acids. 2 marks

_____

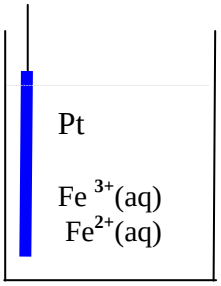
c. How many water molecules were formed when the amino acids combined to form this molecule? 1 mark

_____

SECTION B - Question 6 – continued
TURN OVER

d. Circle and name four different functional groups present in this molecule. 2 marks

Question 7 (8 marks)



a. The half-cell drawn above represents one of the half reactions shown on the electrochemical series.

i. Select the equation that this half cell is representing and write it out exactly as shown on the electrochemical series. 1 mark

_____

ii. Which species is the reductant? _____ 1 mark

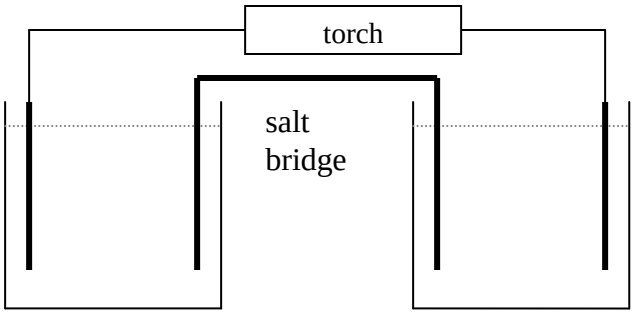
iii. You are asked to set this half cell up in a 250 mL beaker at standard conditions for an experiment. List all materials that you would use. 2 marks

_____

_____

SECTION B - Question 7 – continued

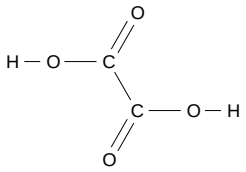
b. The half cell above is connected to a silver, silver ion half cell to power a torch
Use the outline below to show each of the following 4 marks
-the polarity of each electrode
-direction of electron flow
- half equations and overall equation



Half equation: _____ Half equation: _____

Overall equation: _____

Question 8 (6 marks)
Rhubarb is a plant grown in some parts of Victoria that has a stem like celery. The stem is edible and can be made into a pie, often mixed with apple. It has a very tart taste due to the presence of oxalic acid.
A molecule of oxalic acid is shown in the diagram.



When rhubarb is added to purple coloured potassium permanganate solution, $KMnO_4$, the solution slowly goes clear. This is a redox reaction between the oxalic acid and the MnO_4^- ions.

oxalic acid + MnO_4^- → colourless solution
purple

a. What is the molecular formula of the oxalic acid? _____ 1 mark

b. When the oxalic acid reacts, it is oxidised to carbon dioxide.
i. Write a balanced half equation for the oxidation of the oxalic acid. 1 mark

_____

ii. If a galvanic cell is formed between the oxalic acid and the MnO_4^-, what will the polarity of the oxalic acid electrode be? 1 mark

_____

SECTION B - Question 8 – continued
TURN OVER

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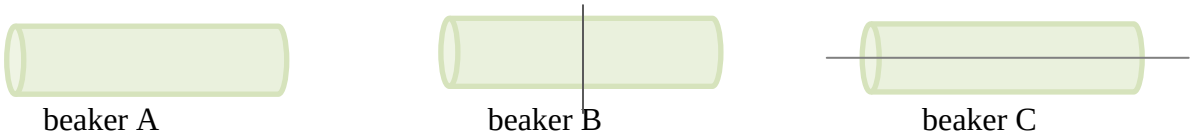
c. Three beakers are prepared that contain equal volumes of 0.10 M $KMnO_4$ solution. Three equal sized pieces of rhubarb are to be added to each beaker and the time it takes for the solution to become colourless is recorded.



beaker A
rhubarb added as one piece

beaker B
rhubarb sliced across middle

beaker C
rhubarb sliced as shown

i. List, in order of shortest time to longest, the times taken for each beaker to go colourless. 1 mark

_____

ii. List, in order of slowest to fastest, the reaction rates of each beaker. 1 mark

_____

iii. Suggest a reason for the different reaction rates obtained between beaker B and beaker C. 1 mark

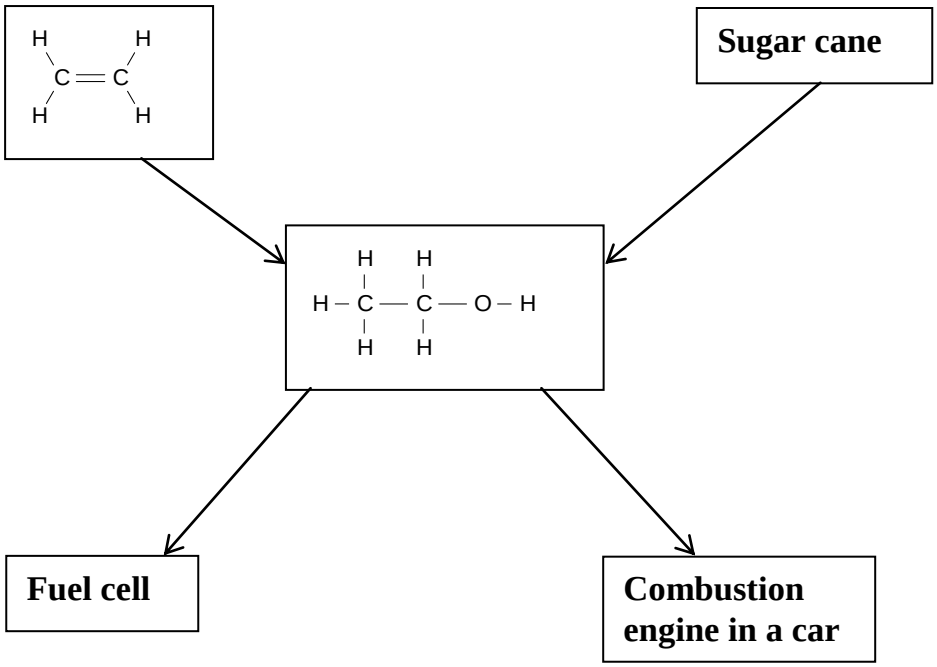
_____

_____

SECTION B - Question 8 – continued

Question 9 (9 marks)

Ethanol, C_2H_5OH, can be used as a fuel. Two sources of ethanol are shown in the flowchart below. Once the ethanol is produced it can be used in many ways. Two examples are in a fuel cell or blended with petrol in a conventional car engine.



a. **i.** Which process for the manufacture of ethanol is considered to be the more sustainable? Explain your answer. 1 mark

_____

_____

ii. List one disadvantage or limitation of the production of ethanol from sugar cane. 1 mark

_____

SECTION B - Question 9 – continued
TURN OVER

b. i. Write a balanced overall equation for the combustion of ethanol in a car engine. 1 mark

_____

ii. Calculate the amount of energy released from the combustion of 10 litres of ethanol. The density of ethanol is 0.78 g mL^{-1} at the temperature used. 3 marks

_____

_____

_____

_____

c. Give the half equation for the reactions occurring at each electrode in an ethanol fuel cell if acid conditions are used. 2 marks

anode: _____

cathode: _____

d. Several energy conversions are required in the process of ethanol fuel causing a car to move. Outline what these energy conversions are in a conventional combustion engine car. 1 mark

_____

SECTION B –- continued

Question 10 (10 marks)

Freon-12 is a CFC, a chlorofluorocarbon with a formula CCl_2F_2. Its use is now limited as a refrigerant because of links between it and the damage to the Earth's ozone layer. Freon-12 is manufactured in a reversible reaction between carbon tetrachloride and hydrogen fluoride;

$$CCl_4(g) + 2HF(g) \rightleftharpoons CCl_2F_2(g) + 2HCl(g)$$

a. As the temperature of this reaction is increased, the yield of Freon-12 increases.

i. What conclusion can you draw from this information? 1 mark

_____

ii. Even though high temperatures increase the yield, the reaction is conducted at a relatively low temperature of 250^{o}C. Give two possible reasons for the temperature being limited to 250^{o}C. 2 marks

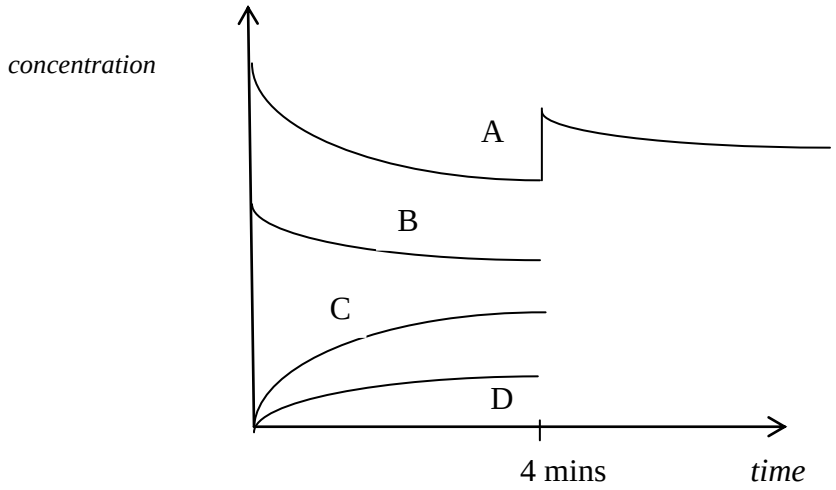
_____

_____

b. High pressures are not used in this reaction. Explain why. 1 mark

_____

c. Reactants for this reaction are added to an empty reactor at 250^{0}C. The concentrations of each substance present are shown on the graph below.



i. Identify which graph represents each substance. 2 marks

A _____ B _____

C _____ D _____

SECTION B - Question 10 – continued

TURN OVER

ii. What change was made to the system at the 4 minute mark? 1 mark

_____

iii. The system will respond to partially oppose the change made at the 4 minute mark. Draw on the graph provided the concentrations of the other three substances present. 2 marks

iv. How will the value of the equilibrium constant, K, compare after equilibrium is re-established? Explain your answer. 1 mark

_____

_____

Question 11 (12 marks)
400 mL of 0.10 M $CuSO_4$ solution is added to a beaker. Inert electrodes are placed in the solution and a current of 0.23 amps is run through the circuit for 6.0 minutes.

a. **i.** List the possible species present that might react. 1 mark

_____

ii. List, in order of voltage, the half equations of each species present. 3 marks

_____

_____

_____

iii. Write a balanced overall equation for the reaction that occurs. 1 mark

_____

b. Calculate the expected mass change at the negative electrode. 3 marks

_____

_____

_____

SECTION B - Question 11 – continued

c. A gas is collected at the positive electrode. Calculate the volume of gas obtained if the gas is at SLC. 2 marks

_____

_____

d. Calculate the concentration of the copper ions in the solution after the 6 minutes has elapsed. 2 marks

_____

_____

END OF QUESTION AND ANSWER BOOK

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