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'2017 Examination Package' -
Trial Examination 3 of 9

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Units 3 & 4 - Written examination

*(*TSSM's 2010 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	98
			Total 128

- 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 26 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.

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

Which of the following is a non-renewable energy resource?

A. Wind
B. Methane
C. Geothermal
D. Coal

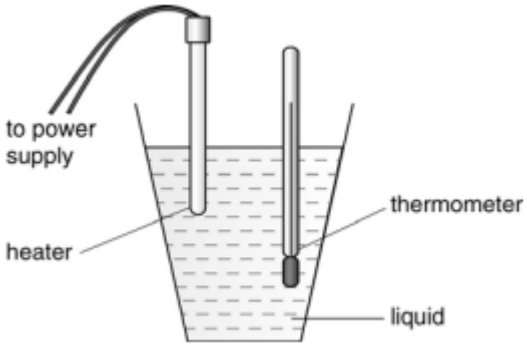
Question 2

Which of the following is an endothermic process?

A. Water freezing
B. Ice melting
C. Water vapour condensing
D. Decreasing the temperature of a beaker of water

Question 3

The apparatus shown below is used to measure the specific heat capacity of a liquid. Which of the following can be done to improve the accuracy of the experiment?



(1) Take the final temperature of the liquid immediately after the power supply is switched off.
(2) Cover the cup with a lid.
(3) Totally immerse the heating element of the heater into the liquid.

A. (1) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

SECTION A - continued

Question 4
Calculate the weight of $CuCO_3$ that would be required to produce 29.5 L of carbon dioxide measured at SLC.

$$CuCO_3\ (s) \rightarrow CuO\ (s) + CO_2\ (g)$$

A. 163 g
B. 110 g
C. 149 g
D. 124 g

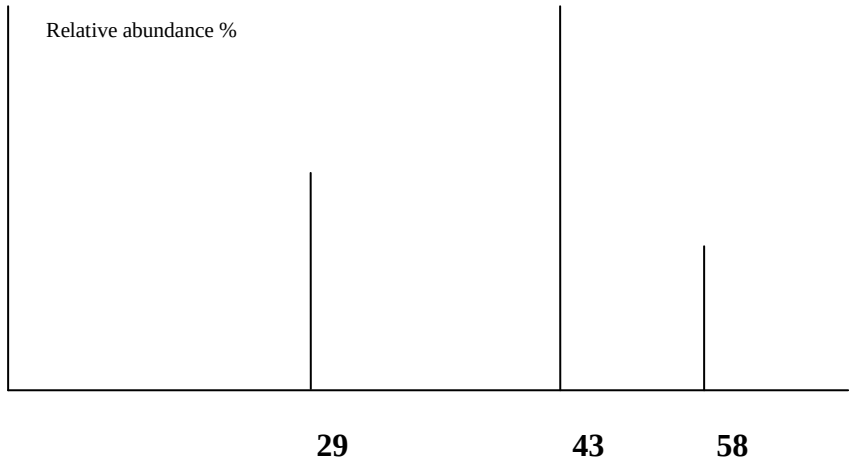
Question 5
Some standard electrode potentials (E^0) of four redox pairs are provided below. On the basis of these values choose the correct option.
Br_2/Br^- = + 1.09 V
Cu^{2+}/Cu = + 0.34 V
Ag^+/Ag = + 0.80 V
I_2/I^- = + 0.54 V

A. Br^- is the strongest oxidant
B. Ag will reduce Br_2
C. Cu^{2+} will oxidise I^-
D. Cu is the strongest oxidant

Question 6
Which of the following statements about vitamins is incorrect?
A. Vitamins are classified as either fat-soluble or water-soluble
B. Vitamins are vital to the normal functioning of animals
C. Vitamins do not have a common structure
D. All vitamins are considered essential

Questions 7 and 8 refer to the following information

A simplified mass spectrum for butane is shown below.



Question 7

The mass spectrum for butane shows three peaks. The three peaks correspond to

A. CH_3, CH_3CH_2 and C_4H_{10}

B. $CH_3CH_2^{\cdot}$, $CH_3CH_2CH_2^{\cdot}$ and $C_4H_{10}^{\cdot}$

C. CH_4, CH_3CH_3 and C_4H_{10}

D. $CH_3CH_2^{+}$, $CH_3CH_2CH_2^{+}$ and $C_4H_{10}^{+}$

Question 8

The fragment(s) that must have been lost from the molecular ion to form this spectrum would be: (Note: electrons are not considered a molecule fragment)

A. CH_3^{+}

B. CH_3^{+}, $CH_3CH_2^{+}$

C. $CH_3^{\cdot}$, $CH_3CH_2^{\cdot}$

D. CH_3^{+},CH_3^{+}

Question 9

HPLC can be classified as:

A. Quantitative only

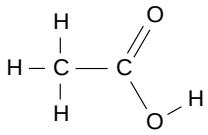
B. Qualitative only

C. Both qualitative and quantitative

D. Neither qualitative or quantitative

Question 10

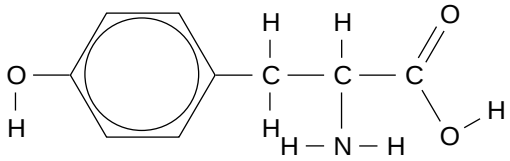
The ethanoic acid molecule shown will have:



	^{1}H NMR high resolution	Infrared spectrum cm^{-1}	Mass spectrum
A.	1 peak	2 peaks	3 peaks
B.	2 peaks with no splits	includes a peak at 3000 but no peak at 1700	a base peak at 60
C.	2 peaks with no splits	includes a peak at 3000 and a peak at 1700	includes a peak at 15 and at 45
D.	2 peaks, one a quartet and the other not split	includes a peak at 3000 and a peak at 1700	includes a peak at 15 and at 29

Questions 11 and 12 refer to the following information

Adrenaline is a hormone. The body releases adrenaline when it is subjected to shock or fright. Adrenaline can be prepared synthetically, using tyrosine as a starting point. The structure of tyrosine is drawn below:



Question 11

The functional groups present in this molecule are:

A. hydroxyl, amine and carboxyl
B. hydroxyl, amide and acid
C. carboxyl, amine and ester
D. ester and amine

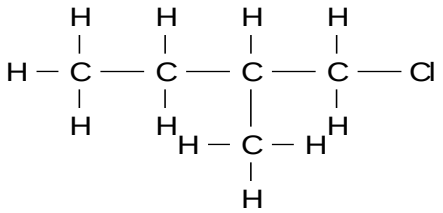
Question 12

The molecular formula of tyrosine is:

A. $C_3H_7O_3N$
B. $C_7H_7O_3N$
C. $C_7H_{11}O_3N$
D. $C_9H_{11}O_3N$

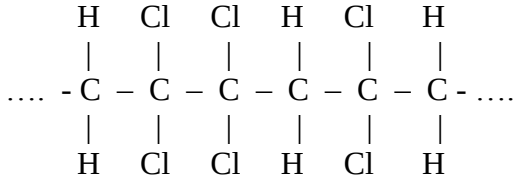
SECTION A – continued
TURN OVER

Question 13
The systematic name for the compound drawn is:



A. 4-chloro-3-methylbutane
B. 3-methyl-4-chlorobutane
C. 1-chloro-2-methylbutane
D. 1-chloro-3-methylpentane

Question 14
The monomer used to make the polymer below is:

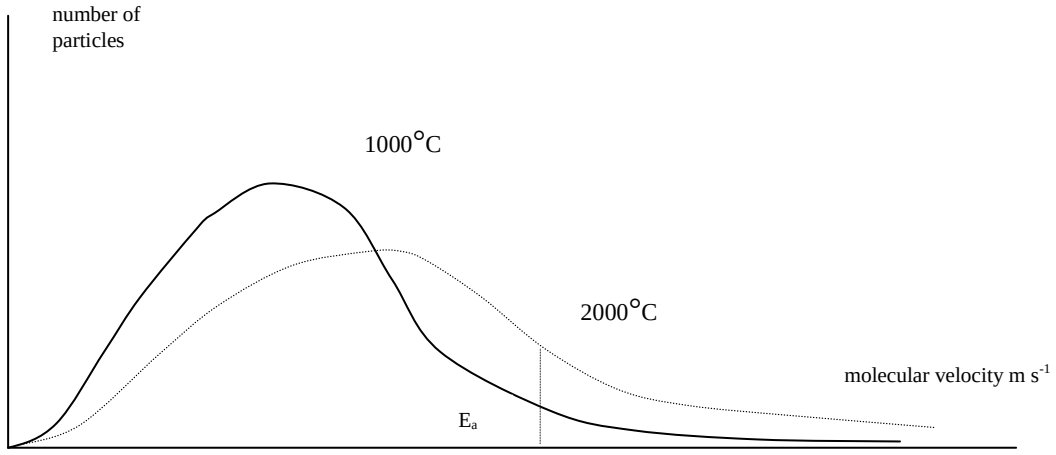


A. 1,1-dichloroethane
B. 1,1-dichloroethene
C. 1,2-dichloroethane
D. hexachloroethane

Question 15
Maltose is a disaccharide formed from the reaction between two glucose molecules.
In maltose, the number of hydroxyl and ether functional groups is:

	hydroxyl	**ether**
A.	0	1
B.	2	1
C.	8	1
D.	8	3

Questions 16 and 17 refer to the following information



Maxwell-Boltzmann distribution curves like the ones above are often used to explain reaction rate changes. The activation energy (E_a) required for a particular reaction is shown on the graph.

Question 16
For a sample of the gases at 2000 °C,
A. all molecules have the same kinetic energy and the same velocity
B. all molecules have the same kinetic energy but their velocities vary significantly
C. the molecules have a range of kinetic energies and a range of velocities
D. the velocities of the particles increase as the kinetic energies decrease

Question 17
In comparing a gaseous mixture at 1000 °C with a mixture at 2000 °C,
A. some molecules will react at 2000 °C but none at 1000 °C will react
B. twice as many molecules will react at 2000 °C because it is twice the temperature
C. an equal number of molecules will react at either temperature
D. a greater percentage of molecules will react at 2000°C than at 1000 °C

Question 18
Enzymes are _____ catalysts, they _____ the rate of reaction by providing an alternative pathway with a _____ activation energy. Enzymes _____ the equilibrium of the reaction.

A. Biological/increase/lower/do not change
B. Biological/decrease/higher/do not change
C. Organic/increase/lower/increase
D. Organic/increase/higher/increase

SECTION A – continued
TURN OVER

Question 19
Nitrogen reacts with oxygen in internal combustion reactions. The equation is:

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

At 500 °C, the value of K is 4.6×10^{-4}

A mixture of nitrogen and oxygen gas is added to a reactor at 500 °C. When equilibrium has been reached, the:

A. number of mole of NO will be less than that of N_2
B. number of mole of NO will be double that of N_2
C. number of mole of NO will be double that of O_2
D. number of mole of NO will be equal to the number of mole of N_2 added to O_2

Question 20
Steam and methane can react to produce carbon monoxide and hydrogen:

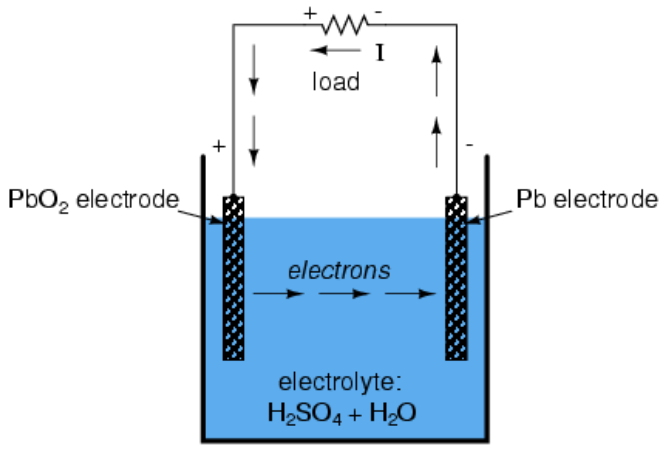
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

0.60 mole of methane and 0.40 mole of steam are added to an empty reactor and a reaction occurs. Which alternative below lists possible equilibrium amounts of each gas?

	CH_4	**H_2O**	**CO**	**H_2**
A.	0.40	0.20	0.20	0.20
B.	0.20	0.20	0.20	0.60
C.	0.50	0.30	0.10	0.30
D.	0.20	0.0	0.40	1.20

SECTION A – continued

Question 21
The diagram below shows a simple version of a lead-acid battery during discharge:



At (+) electrode: $Pb(IV)O_2 + 3H^+ + HSO_4^- + 2e^- \longrightarrow Pb(II)SO_4 + 2H_2O$
At (-) electrode: $Pb + HSO_4^- \longrightarrow Pb(II)SO_4 + H^+ + 2e^-$

In which of the following situations would the pH of the electrolyte increase in the lead acid battery:
A. During discharge
B. During recharge
C. During both discharge and recharge
D. During neither

Question 22
The reaction between carbon monoxide and nitrogen dioxide is a reversible one:

$CO\,(g) + NO_2\,(g) \rightleftharpoons CO_2\,(g) + NO\,(g) \qquad \Delta H = -210\ kJ\ mol^{-1}$

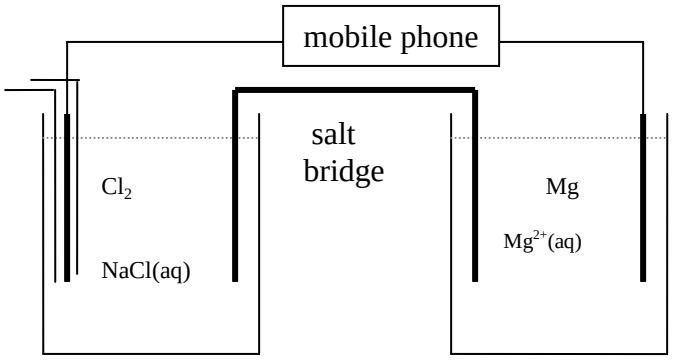
A mixture of the above gases is at equilibrium. The temperature is then doubled. The impact of the temperature change will lead to:
A. a decrease in K, an increase in the amount of CO and a decrease in the amount of NO
B. a decrease in K, a decrease in the amount of CO and a decrease in the amount of NO
C. an increase in K, a decrease in the amount of CO and a decrease in the amount of NO
D. an increase in K, an increase in the amount of CO and a decrease in the amount of NO

Question 23
Which list below contains only metals that can be extracted by electrolysis of aqueous solutions?
A. lithium, aluminium, magnesium and sodium
B. lead, nickel, potassium and cobalt
C. silver, lead, copper and nickel
D. silver, cobalt, magnesium and lithium

SECTION A – continued
TURN OVER

Question 24
A sample of distilled water is placed in a calorimeter. The water is at 18.0 °C.
0.10 g of methanol is burnt in the calorimeter and the temperature rises to 28.0 °C.
The calibration factor for the calorimeter is, in kJ $°C^{-1}$
A. 113
B. 0.227
C. 454
D. -454

Question 25
A standard galvanic cell is established to power a mobile phone, as shown below



In this cell,
A. the magnesium will be negative and its mass will decrease
B. the magnesium will be positive and its mass will increase
C. the chlorine half cell will be positive and it will be the anode
D. the chlorine half cell will be negative and it will be the cathode

Question 26
One of the first lithium batteries was the lithium – iodine cell, designed for use in pacemakers. Although it is now superseded, over one million of these batteries were implanted to power pacemakers.
The reaction in this cell is between lithium metal and iodine liquid using a conductive organic liquid as an electrolyte. Using your data book, the overall equation for this cell should be
A. $2Li\ (s) + I_2\ (l) \rightarrow 2LiI\ (l)$
B. $Li\ (s) \rightarrow Li^+\ (l) + e^-$
C. $2Li\ (s) + 2I^-\ (l) \rightarrow 2LiI\ (l)$
D. $2LiI\ (l) \rightarrow 2Li\ (s) + I_2\ (l)$

Questions 27 and 28 refer to the following information

Question 27

A galvanic cell is constructed from the following half cells, at 25°C

	electrode	**solution**
half cell	silver	clear solution of $AgNO_3$
half cell	nickel	green solution of $NiSO_4$

Which one of the following is likely to occur when the cell is operating?

A. The silver electrode will increase in mass and the green intensity will increase
B. The nickel electrode will increase in mass and the green intensity will increase
C. The silver electrode will increase in mass and the green intensity will decrease
D. Nothing, until a power supply is added

Question 28

When the current is flowing, the

A. electrons will flow from the silver to the nickel
B. silver electrode will be the cathode and it will be positive
C. electrons will flow through the salt bridge from the nickel to the silver
D. mass of both electrodes will increase

Questions 29 and 30 refer to the following information

An electric current is passed through a molten solution containing tin ions. The current of 2.1 amps is run for 5.0 minutes. The mass of tin produced in the cell was 0.388 g. The other product formed is chlorine gas.

Question 29

The charge on the tin ions must have been

A. -2
B. +1
C. +2
D. +4

Question 30

While the current was running, the volume of chlorine gas produced at SLC was, in litres

A. 0.0021
B. 0.081
C. 0.146
D. 0.292

END OF SECTION A
TURN OVER

SECTION B – Short answer questions

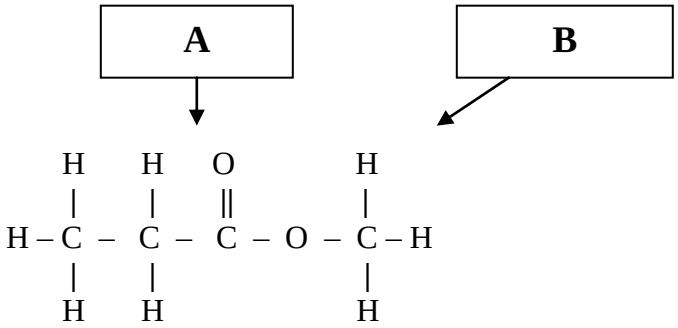
Instructions for Section B

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 (12 marks)



a. Give a systematic name for the molecule shown. _____

1 mark

b. The molecule drawn above can be produced from two smaller molecules, shown as A and B.

i. Draw molecule A, showing all bonds. Name it. 2 marks

Name: _____

ii. Draw molecule B, showing all bonds. Name it. 2 marks

Name: _____

c. The molecule in **part a** is subjected to ^1H NMR. It has three peaks, caused by each of the segments shown in the table below.

i. Use the first row of the table to give the ratio of the areas of each peak. 1 mark

ii. Use the second row to state the number of hydrogen atoms on neighbouring atoms.

1 mark

SECTION B – Question 1 - continued

iii. Use the third row to give the number of splits each peak would have in high resolution NMR. 1 mark

Segment	H | H – C – | H	H | – C – | H	H | – C – H | H
Area			
Number of hydrogen atoms on neighbouring atoms			
Number of splits			

d. The ester in **part a** is one of the esters usually present in red wine. It is the presence of these esters that wine connoisseurs are able to detect when they are wine tasting.

i. Describe how the identities of a mixture of esters can be determined using chromatography. 2 marks

_____

_____

_____

ii. Describe how the concentration of one particular ester could be determined quantitatively using chromatography. 2 marks

_____

_____

SECTION B – continued
TURN OVER

Question 2 (7 marks)

An α-amino acid has the molecular formula $C_3H_7NO_3$.

a. **i**. Draw the amino acid, showing all bonds: 1 mark

ii. Name the amino acid: _____ 1 mark

iii. Name all functional groups in the amino acid. 1 mark

_____

At a particular pH, the amino acid can exist as its zwitterion.

b. Draw the structure of the zwitterion. 2 marks

The amino acid above can react with the amino acid alanine.

c. **i**. Draw the structure of one of the dipeptides that can form from this reaction. 1 mark

ii. Circle the peptide link in the dipeptide you have drawn in **part i** above. 1 mark

Question 3 (11 marks)

Bioethanol is made by the fermentation of glucose with yeast enzymes.

a. Write the equation for the formation of bioethanol via fermentation.

_____

2 marks

b. The combustion of bioethanol produces carbon dioxide and water and is considered to be carbon neutral.

i. What is meant by the term carbon-neutral?

_____

_____

_____

1 mark

ii. Write the equation for the combustion of bioethanol.

_____

2 marks

c. Another name for combustion is oxidation, write the two half equations involved in the combustion reaction.

_____

_____

2 marks

d. If 3000 kJ of energy is produce from the combustion of bioethanol. What mass of glucose is required to produce this amount of energy?

_____

_____

_____

3 marks

SECTION B – Question 3 - continued
TURN OVER

e. What is one of the main disadvantages of biofuels?

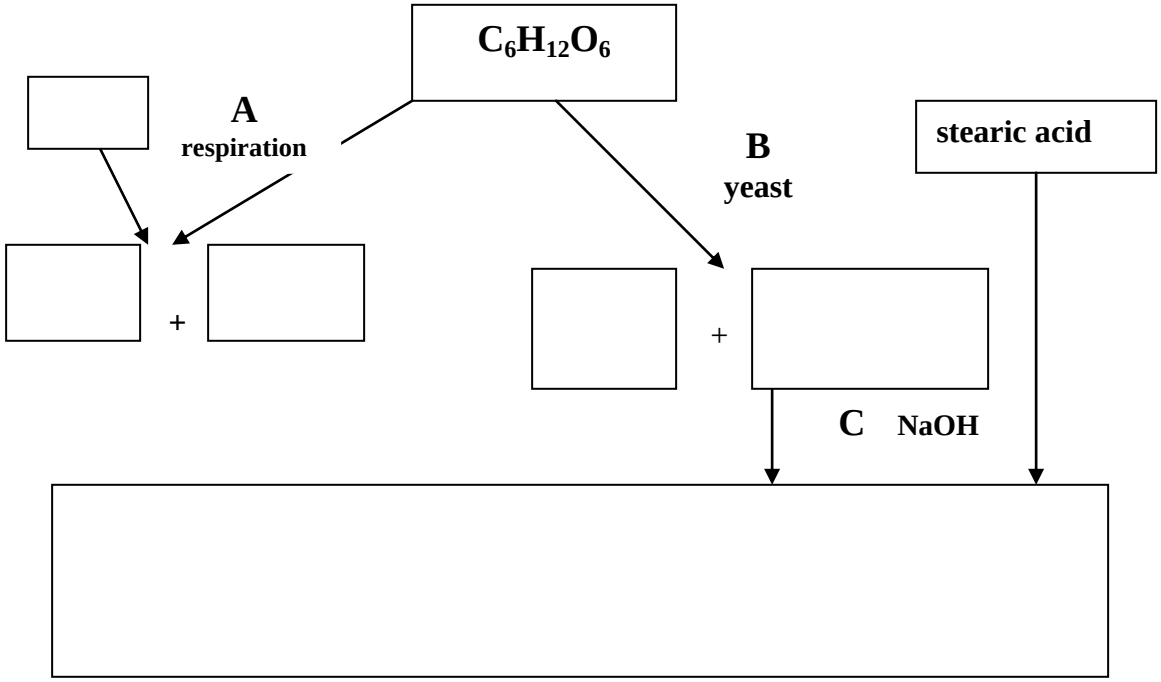
_____

_____

1 mark

Question 4 (12 marks)

Glucose has a molecular formula $C_6H_{12}O_6$. The flowchart below refers to reactions of glucose.



a. Process A is respiration.

i. Write the chemical formulas of the molecules produced by respiration in the boxes on the flowcharts. 2 marks

ii. Use the box provided to name the other reactant required for respiration. 1 mark

b. Process B is the reaction of glucose and yeast in the absence of air.

i. Write a balanced chemical reaction for process B. 1 mark

_____

ii. Draw the molecules produced by process B in the two boxes provided. Show all bonds. 2 marks

SECTION B – Question 4 - continued

iii. What is the role of yeast in this reaction? 1 mark

_____

iv. If the reacting mixture in process B is heated over 60 °C, the reaction stops. Why do you think this might happen? 1 mark

_____

c. **i**. One of the products of process B can react with stearic acid to form a biodiesel molecule. This is shown on the diagram as reaction C.
Use the large box provided in the diagram on the previous page to draw this large biodiesel molecule. Show all bonds. 1 mark

ii. What does the term biochemical fuel mean? 1 mark

_____

iii. What mass of biodiesel could be formed from 100 kg of stearic acid? 2 marks

_____

_____

_____

_____

SECTION B – continued
TURN OVER

Question 5 (10 marks)

A chemistry student is performing a calorimetry experiment using a constructed coffee cup calorimeter.

a. If the coffee cup calorimeter contains 30.0 mL of pure water at 18.0 °C and the student adds 70.0 mL of hot water at 65.0 °C, the final temperature of the calorimeter is 48.6 °C. What is the calibration factor for the calorimeter?

_____

_____

_____

_____

3 marks

b. The same coffee cup calorimeter was then emptied and 20 mL of 0.0240 M sodium carbonate is mixed with 80 mL of 8.65 x 10^{-3} M ethanoic acid. The temperature of the calorimeter goes from 20.4 °C initially to 15.3 °C.

i. Write the equation for the reaction occurring in the calorimeter.

_____

1 mark

ii. How much energy is absorbed by the calorimeter?

_____

_____

1 mark

iii. Calculate the ΔH for the reaction.

_____

_____

_____

3 marks

SECTION B – Question 5 - continued

c. Reflecting on the experiment the student realises that they placed 25 mL of the sodium carbonate solution. What effect will this have on the final ΔH result?

_____

_____

_____

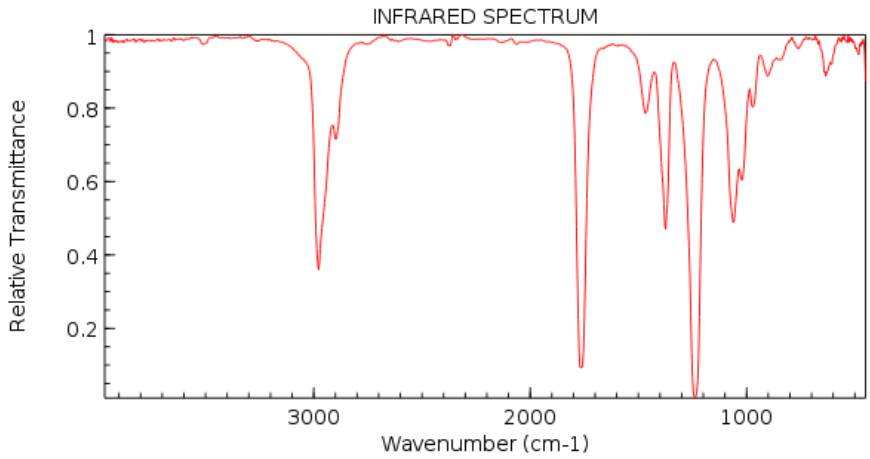
2 marks

SECTION B – continued
TURN OVER

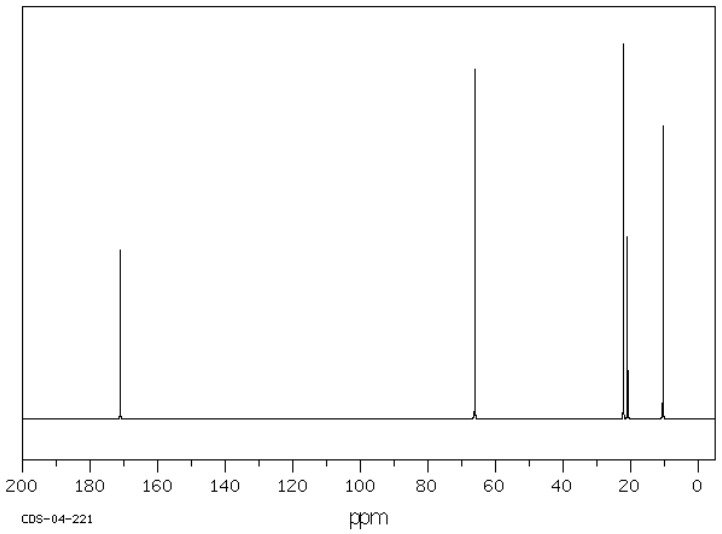
Question 6 (4 marks)

Suggest a reasonable structure for the compound with the formula $C_5H_{10}O_2$ that has the following IR, ^{1}H-NMR and ^{13}C-NMR spectra. Provide one reason from each spectra provided.

4 marks

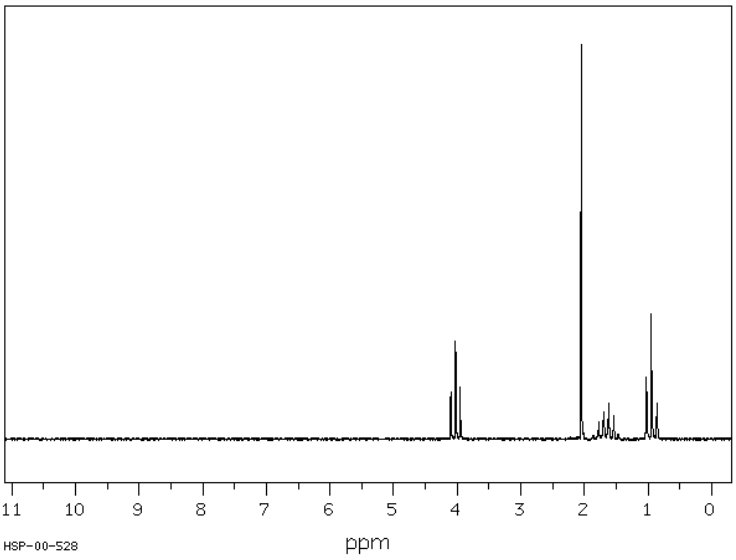


^{13}C-NMR



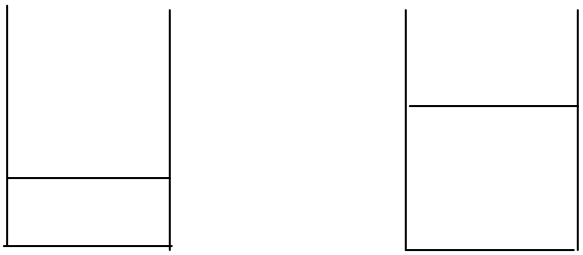
SECTION B – Question 6 - continued

^{1}H-NMR



SECTION B – continued
TURN OVER

Question 7 (12 marks)



Beaker A	Beaker B
V = 30mL	V = 50mL
T = 18°C	T = 22°C
m = 0.20g	m= 0.40 g

0.20 g of ethanol is used to heat a sample of water in a Beaker A. 0.40 g of methanol is used to heat the water in Beaker B.

a. Use the spaces below to write a balanced equation for the combustion of each fuel. Write in also the value of ΔH for each fuel. 4 marks

	Equation	ΔH
Ethanol	_____	_____
Methanol	_____	_____

b. i. Calculate the amount of energy, in **J** released when the ethanol is burnt. 2 marks

_____

ii. Calculate the amount of energy, in **J** released when the methanol is burnt. 2 marks

_____

Assume that 60% of the heat energy from each fuel is transferred to the water

c. i. Calculate the final temperature of the water in Beaker A. 2 marks

_____

_____

ii. Calculate the final temperature of the water in Beaker B. 2 marks

_____

_____

SECTION B – continued

Question 8 (8 marks)

Methanol can be produced in a reversible reaction between carbon monoxide and hydrogen gas.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H < 0$

a. Comment on the accuracy of the following statements.

i. 10 mol of carbon monoxide is introduced into a reactor containing excess hydrogen gas. After equilibrium is reached, 20 mol of hydrogen gas will have reacted. 1 mark

_____

_____

ii. Carbon monoxide and hydrogen are added to an empty reactor. After equilibrium is reached, 2.44 mol of methanol has formed. This means that 1.22 mol of carbon monoxide must have reacted with 1.22 mol of hydrogen. 1 mark

_____

_____

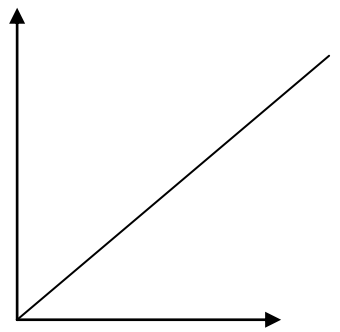
iii. A mixture of the above gases is at equilibrium. The volume of the reactor is suddenly halved. The temperature of the reactor will increase in response to the pressure change. 2 marks

_____

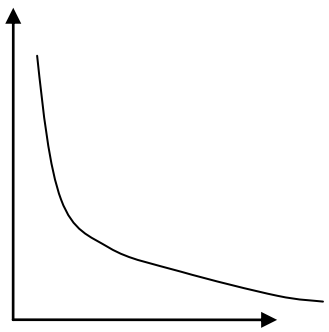
_____

b. Which graph below, A, B or C, could represent the value of the equilibrium constant, K, plotted against temperature? 1 mark

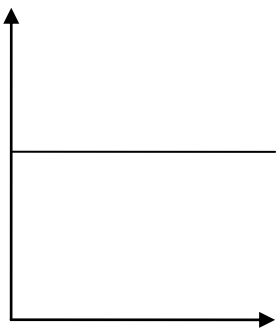
_____



A



B



C

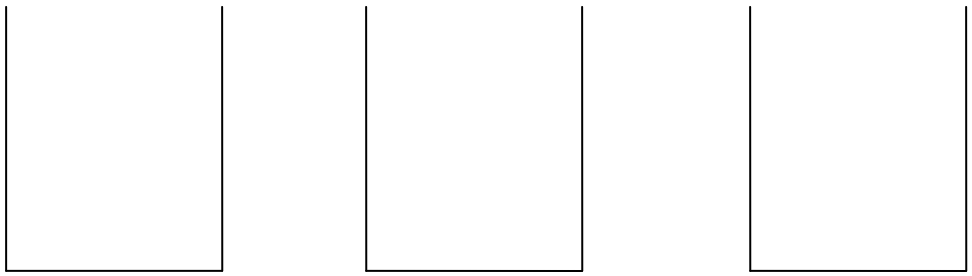
SECTION B – Question 8 – continued
TURN OVER

c. The K value for the above reaction is 1.0 at 152°C. Methanol is added to an empty reactor at 152°C and a reaction occurs. At equilibrium, the concentration of methanol is 0.10 M. Calculate the concentration of hydrogen gas. 3 marks

_____

_____

Question 9 (8 marks)
Three beakers are drawn below to be set up as half cells.



A **B** **C**

a. Choose appropriate electrodes and solutions to make the following half cells;

i. Beaker A: sketch the half cell required for the reaction $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$ 1 mark

ii. Beaker B: sketch the half cell required for the reaction $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ 1 mark

iii. Beaker C: sketch the half cell required for the reaction $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$ 1 mark

iv. Name the strongest oxidant present in any of the three beakers _____ 1 mark

v. Which combination of beakers could be used to produce the highest voltage? 1 mark

_____

b. Draw a salt bridge to connect Beaker B and Beaker C to make a galvanic cell. An electrical lead is used to connect both electrodes.
This is a $Fe^{3+}(aq),Fe^{2+}(aq) \parallel Ni^{2+}(aq),Ni(s)$ cell

In this cell, the

i. positive electrode will be _____ 1 mark

ii. the oxidant will be _____ 1 mark

iii. electrons will flow from the beaker ____ to beaker _____ 1 mark

SECTION B – continued

Question 10 (7 marks)

The world's energy woes have triggered massive research into battery technology. Many of the significant innovations revolve around the use of lithium. Lithium is now used in the batteries used in mobile phones and computers. The lithium cells belong to one of two categories – lithium or lithium-ion.

Lithium-ion cells combine lithium with transition metals like cobalt. The half equations for a typical lithium-ion cell are;

	Polarity	
$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	☐	anode / cathode
$LiC_6 \rightarrow C_6 + Li^+ + e^-$	☐	anode / cathode

(phases are not shown as organic solvents are used)

a. **i**. Use the boxes provided to indicate the polarity of each half equation. 1 mark

ii. Circle anode or cathode to indicate which electrode is the anode and which is the cathode. 1 mark

iii. Write a balanced overall equation for the cell. 1 mark

_____

iv. What is the oxidation number of the cobalt atoms before and after reaction? 1 mark

Before _____ After_____

The cell operates with a voltage of 4.6 volts.

b. How much energy is released if it operates for 5.0 minutes with a current of 1.1 amps? 1 mark

_____

c. This cell can be recharged successfully many times.

i. Write a balanced equation for the recharge of this cell. 1 mark

_____

ii. Which electrode will be the positive terminal during recharge? 1 mark

_____

SECTION B – continued
TURN OVER

Question 11 (7 marks)

Hydrochloric acid, HCl, reacts readily with chalk, $CaCO_3$, releasing an inflammable gas.

a. Write a balanced equation for the reaction occurring between calcium carbonate and hydrochloric acid. 1 mark

_____

b. **i**. How will the pH of a reaction mixture change as the reaction proceeds? 1 mark

_____

ii. Will the final pH at 25°C be 7? Explain your answer. 2 marks

_____

_____

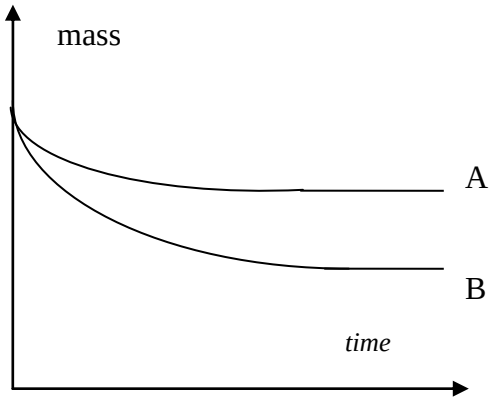
40 mL of hydrochloric acid is added to two separate flasks, labelled as A and B. Both flasks are placed on separate balances. 5.0 g of $CaCO_3$ is then added to each flask. The mass change in each flask is shown on the graph below.

c. Suggest a reason for the difference observed between the two graphs. 1 mark

_____

_____

_____



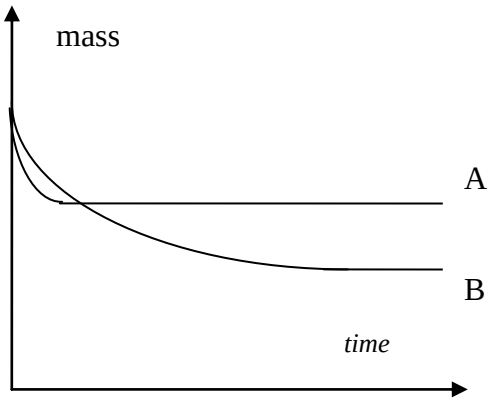
In a second experiment, 40 mL of hydrochloric acid is added to two separate flasks. Both flasks are placed on separate balances. 5.0 g of $CaCO_3$ is then added to each flask. The mass changes are shown on the graph below.

d. Suggest an explanation that is consistent with the shape of these graphs. 2 marks

_____

_____

_____



END OF QUESTION AND ANSWER BOOK