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2020 Trial Examination

STUDENT NUMBER | | | | | | | | | Letter |

CHEMISTRY

Units 3 & 4 – Written examination

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	10	10	90
			Total 120

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer book of 26 pages.
Data Book
Answer sheet for multiple choice questions

Instructions

Print your name and student number in the space provided on the top of this page.
All written response 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 in pencil on the answer sheet provided for multiple – choice 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.
Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Question 1
Biodiesel has a higher viscosity than petrodiesel. This is largely due to:

A. The kinks in the biodiesel molecules making it harder for the chains to move relative to each other
B. the larger biodiesel molecules having stronger dispersion forces between molecules
C. the presence of dipole-dipole bonds between biodiesel molecules
D. the presence of hydrogen bonds between biodiesel molecules

Question 2
The heating of an enzyme can cause denaturation to occur. This disrupts the:

A. primary structure only
B. secondary, tertiary and quaternary structures
C. tertiary and quaternary structures
D. the primary, secondary, tertiary and quaternary structures

Question 3
Vitamin C;

A. is non polar so needs to be consumed regularly
B. can act as an enzyme
C. can act as an antioxidant where it interrupts the propagation of free radicals
D. can be produced by the body using sunlight

SECTION A – continued

The following information refers to the next two questions

The production of hydrogen fluoride from hydrogen gas and fluorine gas is exothermic. The equation is;

$$H_{2(g)} + F_{2(g)} \rightleftharpoons 2HF_{(g)} \quad \Delta H = -536 \text{ kJmol}^{-1}$$

The value of K for this reaction is 7.8×10^{14}

Question 4

The yield and rate of production could be increased by

A. increasing the pressure
B. adding a catalyst
C. heating the mixture
D. adding extra hydrogen gas

Question 5

For the reaction $2HF_{(g)} \rightleftharpoons F_{2(g)} + H_{2(g)}$, the ΔH value and equilibrium constant are;

A. $+536 \text{ kJmol}^{-1}$ and 1.28×10^{-15}
B. $1.87 \times 10^{-3} \text{ kJmol}^{-1}$ and 1.28×10^{-15}
C. $+536 \text{ kJmol}^{-1}$ and -7.8×10^{14}
D. $1.87 \times 10^{-3} \text{ kJmol}^{-1}$ and -7.8×10^{14}

Question 6

The energy produced when 100.0 g of nonane (C_9H_{20}) is burnt is 4.861 MJ. The Heat of Combustion of nonane in kJ mol^{-1} is;

A. 6 222
B. 3 860
C. 3 860
D. 48.61

Question 7
Hydrogen undergoes combustion readily. The activation energy for the reverse reaction was found to be +362 kJ mol^{-1} and the ΔH for the reverse reaction was +282 kJ mol^{-1}. The activation energy for the forward reaction in kJ mol^{-1} is;

A. 80
B. -80
C. 644
D. -644

Question 8
When 1M $CuSO_4$ is electrolysed using a copper anode and platinum cathode the products at the anode and cathode are;

A. O_2, H^+, H_2, OH^-
B. O_2, H^+, Cu
C. Cu^{2+}, Cu
D. Cu^{2+}, H_2, OH^-

Question 9
A series of galvanic cells were constructed using four metals (A, B, C, D) and four 1M solutions (A^{2+}, B^{2+}, C^{2+}, D^{2+}) It was found that;

- When the half-cell A/A^{2+} was connected to a B/B^{2+} half-cell, electrons flowed from metal A to metal B.
- When metal C was added to a solution of D^{2+}, a coating of metal D appeared on metal C.
- When the half cell A/A^{2+} was connected to a D/D^{2+} half cell, the mass of metal D decreased.

The ranking of metals from weakest reductant to strongest reductant would be;

A. B, A, D, C
B. A, B, C, D
C. C, D, A, B
D. B, D, A, C

SECTION A – continued

Question 10
An electric current is passed through a solution of 1M NaI solution. The pH in the container would;

A. increase at the anode and decrease at the cathode
B. increase overall
C. decrease overall
D. increase at the cathode and decrease at the anode

Question 11
The series of equations below shows how increasing CO_2 levels increase the acidity of seawater.

$$CO_{2(g)} \rightleftharpoons CO_{2(aq)}$$
$$CO_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$$
$$H_2CO_{3(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$$
$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons CO_3^{2-}{}_{(aq)} + H_3O^+{}_{(aq)}$$

A possible solution to this might be to add calcium ions to seawater as calcium ions would react with CO_3^{2-} to form a $CaCO_3$ precipitate. The equation for this is;

$$Ca^{2+}{}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightleftharpoons CaCO_{3(s)}$$

The conversion of CO_2 to $CaCO_3$ would be virtually 100% complete as;

A. K for all reactions is large
B. $CaCO_3$ forms a solid so is removed from the equilibrium mixture
C. the level of carbon dioxide is increasing so it is easy to shift the equilibrium of all reactions to the right
D. CO_2 is a volatile gas

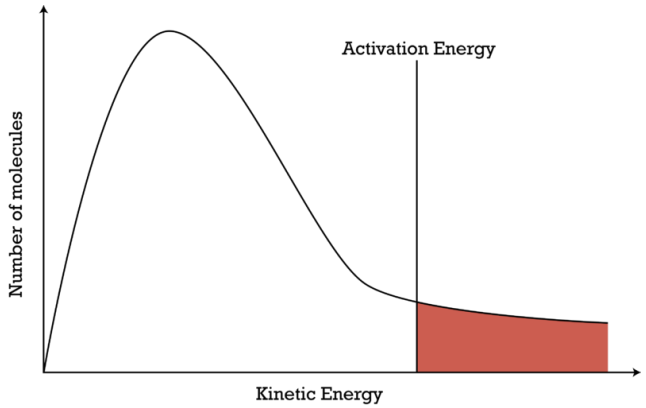
Question 12
The products formed from the reaction of propanoic acid with methanol are;

A. methylpropanoate
B. propylmethanoate
C. methylpropanoate and water
D. propylmethanoate and water

Question 13
To synthesise 2-methylpropan-2-amine the chemicals used could be;

A. propene and ammonia
B. propene and methylamine
C. 2-methylpropene and ammonia
D. 2-methylpropene and methylamine

Question 14
The kinetic energy of the particles involved in a reaction can be represented by the diagram below:



When the reaction mixture is heated;

A. the whole curve will shift to the right meaning that more molecules will have enough energy to react
B. the activation energy shifts to the left meaning that more molecules will have enough energy to react
C. the activation energy shifts to the right meaning that more molecules will have enough energy to react
D. the molecules will all have a greater energy so more molecules will have enough energy to react

Question 15
A chemical is analysed using a mass spectrometer. Major peaks were found at m/e values of 27, 29, 41 (the tallest peak), 78 and 80. The chemical is known to contain chlorine. The peak at 41 is known as the _____ and is most likely formed by the loss of _____ from the species that forms the peak at a m/e value of 80

A. base peak; $C_3H_5^+$
B. molecular ion; $H_2{}^{37}Cl^+$
C. base peak; $H_4{}^{35}Cl^+$
D. base peak; $H_2{}^{37}Cl$

SECTION A – continued

Question 16
For the equation;
_ $NO_3^-{}_{(aq)}$ + _ $H^+{}_{(aq)}$ + _ $Cu_{(s)}$ → _ $NO_{(g)}$ + _ $H_2O_{(l)}$ + _ $Cu^{2+}{}_{(aq)}$, the coefficients in the equation, in order are;

A. 1:4:1:1:2:1
B. 2:6:4:2:6:4
C. 2:4:3:2:2:3
D. 2:8:3:2:4:3

Question 17
The oxidation number of sulfur in each chemical increases in list:

A. S_8, H_2S, H_2SO_3, H_2SO_4, $Na_2S_2O_3$
B. S_8, H_2S, $Na_2S_2O_3$, H_2SO_3, H_2SO_4
C. H_2S, S_8, H_2SO_3, H_2SO_4, $Na_2S_2O_3$
D. H_2S, S_8, $Na_2S_2O_3$, H_2SO_3, H_2SO_4

Question 18
An experimental fuel cell uses methanol as an energy source. An acidic electrolyte is used. The reaction occurring at the negative electrode would be;

A. $CH_4O_{(g)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 6H^+{}_{(aq)} + 6e^-$
B. $CH_4O_{(g)} + 2H_2O_{(l)} \rightarrow CO_{2(g)} + 8H^+{}_{(aq)} + 8e^-$
C. $O_{2(g)} + 4H^+{}_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$
D. $O_{2(g)} + 2H^+{}_{(aq)} + 2e^- \rightarrow H_2O_{(l)}$

Question 19
Catalytic converters in cars convert harmful gases like NO and CO to less harmful gases such as NO_2 and CO_2. The catalytic converter is a mixture of solids with a porous structure. The catalyst;

A. needs to be replaced at regular intervals as it is slowly consumed by the reactions occurring
B. is known as a homogeneous catalyst as it is in a different state to the reactants.
C. adsorbs the reactants allowing bonds between atoms to break more easily and new bonds to form
D. absorbs the reactants which concentrates them and therefore increases the rate of reaction

The following information refers to the next two questions

A student decides to test what factors affect the rate of reaction. They grind some calcium carbonate pieces into a fine powder and then react 1.0g of pieces and 1.0g of powder with 1M hydrochloric acid which has been heated to 40°C. They then record the time taken for the powder to completely react. However they find that while the powder reacts more quickly, the reaction stops just before the calcium carbonate has all reacted.

Question 20

In this experiment;

A. the time taken is the dependent variable and there is an excess of calcium carbonate
B. the time taken is the independent variable and there is an excess of calcium carbonate
C. the time taken is the dependent variable and there is an excess of hydrochloric acid
D. the time taken is the independent variable and there is an excess of hydrochloric acid

Question 21

The experiment could be improved by;

A. collecting and measuring the volume of carbon dioxide gas produced in a syringe
B. placing the reaction container on a balance and recording the mass lost over time
C. increasing the amount of calcium carbonate so that a complete reaction occurs
D. heating the mixture to 60°C to increase the rate of reaction

Question 22

Chromium metal is produced from chromium ions (Cr^{3+}). If 1.0×10^{-2}mol of chromium metal is produced from passing an electric current through a 1.0M solution of Cr^{3+} which has been adjusted to pH of zero, the mass of oxygen produced at the anode, in grams, would be;

A. 0.16
B. 0.24
C. 0.32
D. 0.96

Question 23
To produce magnesium metal and chlorine gas from magnesium chloride, a molten electrolyte needs to be used. This is because;

A. water is a stronger reductant than chloride ions
B. water is a stronger oxidant than magnesium ions
C. less energy is used when electrolysing a molten electrolyte as water does not react
D. the products produced from an aqueous solution can react together spontaneously

Question 24
At a pH of 12, a solution of aspartic acid would have an overall charge of;

A. -2
B. -1
C. 0
D. +1

Question 25
The secondary structure of a protein is held together by;

A. covalent bonds
B. ionic bonds
C. hydrogen bonds
D. covalent, ionic and hydrogen bonds.

Question 26
Carbohydrates that can be digested most quickly have a;

A. low glycaemic index
B. high proportion of the monosaccharide, fructose
C. high proportion of amylose present
D. highly branched structure

Question 27
An essential amino acid;

A. is essential for good health and can be made by the body
B. needs to be consumed as part of a healthy diet
C. cannot be metabolised by the body
D. can act as a co-enzyme

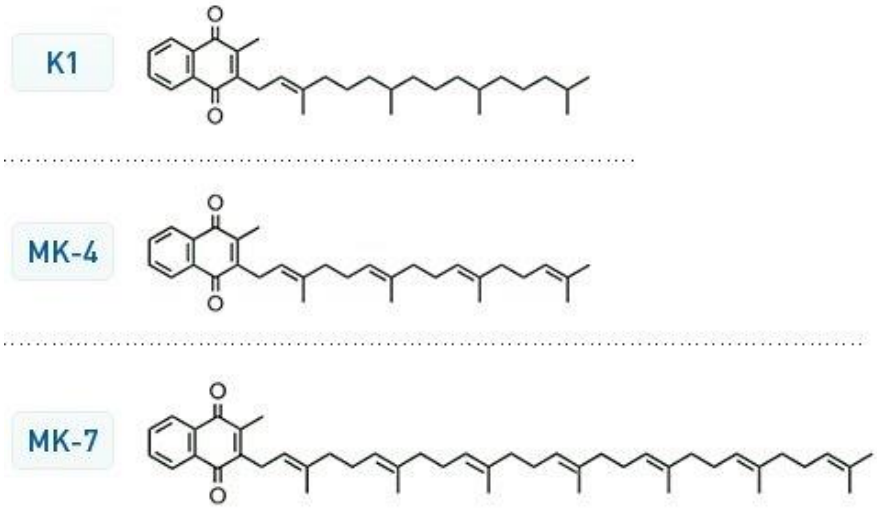
Question 28
Aspartame;

A. has no chiral centres
B. contains an ester and carboxylic acid functional group
C. is almost as sweet as glucose
D. contains a primary amide group

Question 29
The induced fit model of enzyme action means that;

A. a co-enzyme is required to change the shape of the enzyme
B. The substrate can change its shape to fit into an enzyme
C. The enzyme can act over a greater range of temperatures and pH
D. The substrate does not need to perfectly fit into the active site of an enzyme

Question 30
There are a range of structures of vitamin K as shown below;



It is reasonable to conclude that;

A. vitamin K is water soluble
B. MK-7 would have a higher viscosity than MK-4
C. that these vitamins could be produced by the human body
D. there is a trans arrangement of bonds in MK-7

END OF SECTION A

SECTION B - Short-answer questions

Instructions for Section B

Questions must be answered in the spaces provided in this book.
Write using blue or black pen.

- 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)

Unless otherwise indicated, diagrams in this book are not drawn to scale.

Question 1 (14 marks)

The use of biofuels have been proposed as a way of reducing greenhouse gases.

a. What is a biofuel?

_____

_____

1 mark

b. Write a chemical equation to show the production of ethanol from;

i. glucose

_____

ii. ethene

_____

2 x 1 = 2 marks

c. Why might the production of ethanol from biological sources such as sugar cane **NOT** be regarded as carbon neutral?

_____

_____

_____

2 marks

SECTION B - Question 1- continued

TURN OVER

d. 2.30 tonne of sugar cane is converted to 3.00×10^2 kg of sucrose. If the sucrose is hydrolysed to glucose and fructose (assuming a 100% conversion rate), what mass of glucose could be obtained from 3.00×10^2kg of sucrose?

_____

_____

_____

3 marks

e. **i.** In Brazil, cars run on E25 fuel which contains 25.0% ethanol and 75.0% octane. How much energy would be released by a full tank of 60.0 litres containing E25 fuel? (The density of octane is $0.703 gmL^{-1}$. The density of ethanol is $0.789 gmL^{-1}$.)

_____

_____

_____

_____

_____

ii. What volume of carbon dioxide at SLC would be released by the ethanol component of this fuel?

_____

_____

_____

_____

3 + 3 = 6 marks

SECTION B- continued

Question 2 (8 marks)

Consider the following reaction;

$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)} \quad \Delta H = -124\ kJmol^{-1}$

2.5 mol of PCl_5 is added to a previously evacuated 3.0 L container. At equilibrium 1.5 mol of PCl_5 is left.

a. Determine the equilibrium constant, for the equation shown above, assuming the temperature remains constant throughout the reaction.

_____

_____

_____

_____

3 marks

b. Determine the effect on the position of equilibrium and the rate of reaction when each of the changes takes place.

Condition	Direction of equilibrium shift	Effect on rate of reaction
Increase temperature		
Decrease pressure		
Addition of a catalyst		

3 marks

c. Some chlorine gas is removed from the mixture. Explain by referring to LeChatelier's Principle, which way the equilibrium will shift.

_____

_____

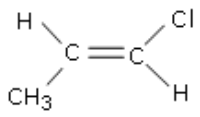
_____

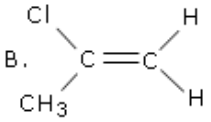
2 marks

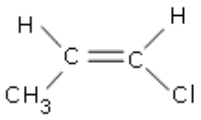
SECTION B - continued
TURN OVER

Question 3 (9 marks)

Consider the 6 organic molecules below;

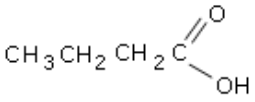
A. 

B. 

C. 

D. $CH_3CH(OH)CH_3$

E. $CH_3CH_2CH_2OH$

F. 

a. Write the systematic names for B, C and F

B: _____

C: _____

F: _____

3 marks

b. Which one or more compounds (A → F)

i. Has the empirical formula of C_2H_4O? _____

ii. is/are highly soluble in, or miscible with, water? _____

iii. are geometric isomers of each other? _____

iv. can undergo addition polymerisation? _____

v. will form 1-chloropropane when reacted with H_2? _____

vi. can react with each other in the presence of concentrated H_2SO_4 to form an ester?

_____

6 x 1 = 6 marks

SECTION B - continued

Question 4 (5 marks)

A storage battery used in hybrid cars contains a series of nickel metal hydride cells. MH represents a metal hydride alloy that is used as one electrode. The other electrode is composed of nickel oxide hydroxide (NiOOH)

The half equations during discharging are;

$$NiOOH_{(s)} + H_2O_{(l)} + e^- \rightarrow Ni(OH)_{2(s)} + OH^-_{(aq)}$$
$$MH_{(s)} + OH^-_{(aq)} \rightarrow M_{(s)} + H_2O_{(l)} + e^-$$

a. Give the formula of the reductant during discharging.

_____

1 mark

b. Suggest a suitable electrolyte for the battery.

_____

1 mark

c. Write the half equation occurring at the anode during recharging

_____

1 mark

d. Write a total equation for the battery when it is recharging

_____

1 mark

e. Would this cell be described as a primary, secondary or fuel cell? Why?

_____

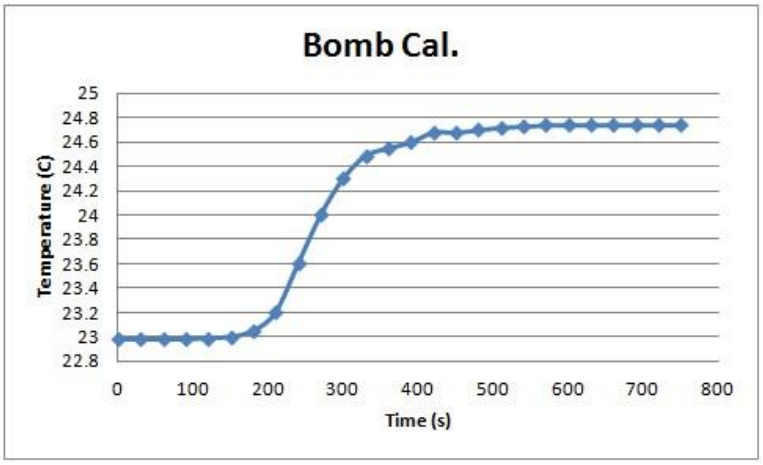
1 mark

SECTION B - continued
TURN OVER

Question 5 (9 marks)

The energy content of a potato chip can be determined using a bomb calorimeter. The calorimeter is calibrated by the complete combustion of 1.476 g of benzoic acid. The temperature of the water in the calorimeter rose from 15.2°C to 18.2°C during the calibration. ($M(C_6H_5COOH)$ = 122.0 g/mol and ΔH = -3227 kJ mol^{-1}).

The water inside the calorimeter was then replaced with the same volume of water at a temperature of 10°C. 1.06 g of potato chip was then completely burnt in the calorimeter and the student recorded the temperature change in the graph below.



a. Determine the calibration factor of the calorimeter.

3 marks

b. Determine the energy content of the potato chip in kJg^{-1}.

3 marks

SECTION B - Question 5- continued

c. A major food nutrient in potato is starch. They also contain up to 10% cellulose. By referring to their chemical structures, what is the main difference between the monomers that form starch and cellulose?

_____

_____

_____

2 marks

d. The bomb calorimeter has oxygen pumped into it at a high pressure. Why is the high pressure of oxygen required in the bomb part of the calorimeter?

_____

1 mark

SECTION B - continued
TURN OVER

Question 6 (8 marks)

A student has a mixture of 3 amino acids; alanine, aspartic acid and leucine. The mixture is analysed using HPLC. The mobile phase has a high polarity and the stationary phase has a low polarity. The retention time and peak areas obtained are shown below;

Component	Peak area (units)	Retention time (seconds)
A	10	135
B	15	240
C	15	325

a. Write down the name of each component and give a reason for your choices;

i. A _____

ii. B _____

iii. C _____

Reason_____

_____

_____

3 marks

b. Indicate the effect of each of the following on the retention time and give a reason by referring to particle movement if applicable;

i. Increasing the length of the column.

_____

_____

ii. Increasing the pressure in the column

_____

_____

SECTION B - Question 6- continued

iii. Increasing the temperature of the column

_____

_____

3 x 1 = 3 marks

c. Describe how you could determine the concentration of component B.

_____

_____

_____

2 marks

SECTION B - continued
TURN OVER

Question 7 (10 marks)

A student decides to investigate the "Paleo Diet". His research shows that this diet is high in fats and protein and relatively low in carbohydrates.

a. Write an equation to show how energy could be obtained from the metabolism of oleic acid.

_____

1 mark

b. i. Draw the structure of the triglyceride that oleic acid would form.

ii. Name the linkage formed.

_____

iii. Would you expect this triglyceride to be a solid or liquid at room temperature? Explain your reasoning by referring to the bonding in the carbon – carbon chains

_____

_____

_____

1 + 1 + 2 = 4 marks

c. What might be a problem with this diet for someone who undertakes high intensity sports training?

_____

_____

1 mark

SECTION B - Question 7- continued

d. The digestion of protein takes place mainly in the stomach where the pH is about 1. The dipeptide ala-gly is broken down into its amino acids there.

i. Draw the structure of ala-gly.

ii. Describe how the structure of ala-gly might change as it enters the stomach but before digestion takes place.

_____

_____

iii. The digestion of substances such as ala-gly requires the presence of enzymes. What types of bonds might form between atoms on ala-gly and an enzyme to allow the digestion to take place in the stomach.

_____

_____

_____

1+1+2 = 4 marks

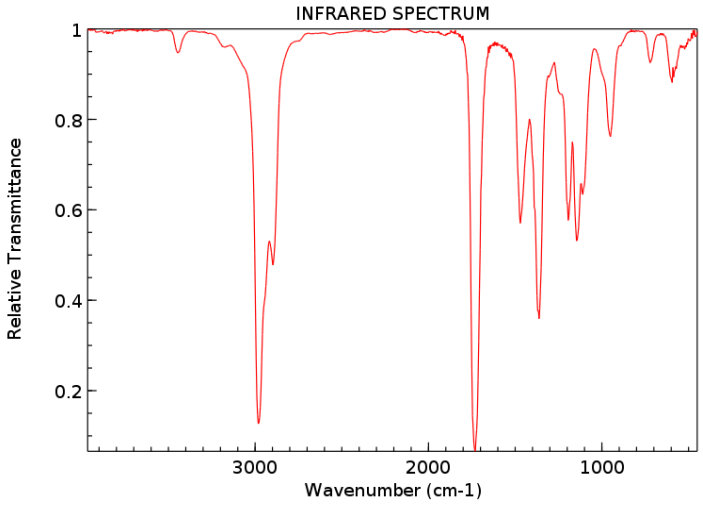
SECTION B - continued
TURN OVER

Question 8 (7 marks)

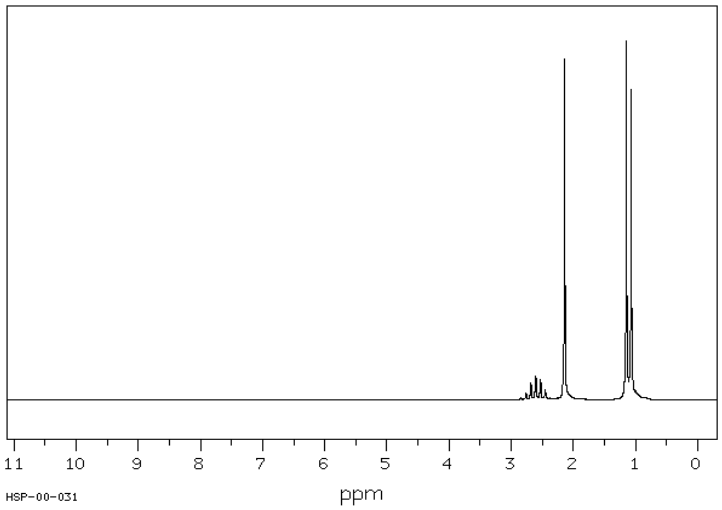
A student oxidizes an alcohol using an acidified solution of potassium permanganate. To identify the compound produced, they then examine the infra-red, carbon NMR and hydrogen NMR spectra of the compound.

The ^{13}C-NMR consists of four peaks.

The IR and ^{1}H-NMR spectra are shown below



^{1}H-NMR SPECTRUM



Shift (ppm)	Relative Peak Area	Splitting
2.6	1	7
2.0	3	1
1.2	6	2

a. Apart from the C-H group, name the functional group present in the molecule.

_____

1 mark

b. Examine the ^{1}H-NMR spectrum,

i. There is a set of peaks that show a 7 way split. Suggest what might be the cause of this splitting pattern.

_____

_____

ii. The peak at a shift of 2.0 ppm does not show a splitting pattern. What does this suggest about the location of this group of hydrogen atoms?

_____

_____

1+1=2 marks

c. How many carbon atoms are in the molecule? _____

1 mark

d. **i.** Draw the structure of the compound.

ii. Are there any chiral carbons in this compound? If so, circle any chiral carbon atoms.

_____

1+ 1 = 2 marks

e. Give the name of the organic compound that would have been oxidised to form this compound.

_____

1 mark

SECTION B - continued

TURN OVER

Question 9 (8 marks)

The concentration of vitamin C ($C_6H_8O_6$) in orange juice was determined using a titration. A solution of iodine (I_2) was made up by dissolving 0.258 g of iodine in a 250 mL volumetric flask and adding water to the mark. A 20.00 mL aliquot of iodine was titrated against vitamin C and titres of 18.98mL, 19.01mL, 18.21mL and 18.95mL were obtained.

The equation for the reaction is;

$C_6H_8O_{6(aq)} + I_{2(aq)} \rightarrow C_6H_6O_{6(aq)} + 2H^+_{(aq)} + 2I^-_{(aq)}$

a. Write a half equation for the oxidation of vitamin C.

_____

1 mark

b. Calculate the average titre that should be used in the calculation of vitamin C.

_____

1 mark

c. Calculate the concentration of vitamin C in grams per litre.

_____

_____

_____

_____

_____

_____

5 marks

d. A student performing this experiment washes the burette with only water before using it. What effect will this have on the calculated concentration?

_____

_____

1 mark

SECTION B - continued

Question 10 (12 marks)

If humans ever create a lunar base, one of the biggest challenges will be figuring out how to breathe. Transporting oxygen to the moon is extremely expensive, so for the past several years NASA has been looking into other possibilities. One idea is extracting oxygen from oxide ions (O^{2-}) contained in moon rock. Based on experiments with a simulated lunar rock developed by NASA, the researchers calculate that three one-meter-tall reactors could generate one tonne of oxygen per year on the Moon.

a. Each tonne of oxygen would require three tonnes of rock to produce and the temperature on the moon can fall to as low as -200 °C during the night.

i. What volume would 1.00 tonne of oxygen gas occupy at 50.0 kPa and -200 °C?

_____

_____

_____

ii. What current would the solar cells need to provide to produce 1.00 tonne of oxygen in a year?

_____

_____

_____

_____

_____

_____

2+4 = 6 marks

b. Given the high cost of transporting materials to the moon, suggest how energy from solar cells might be used to extract oxygen gas from the moon rock.

_____

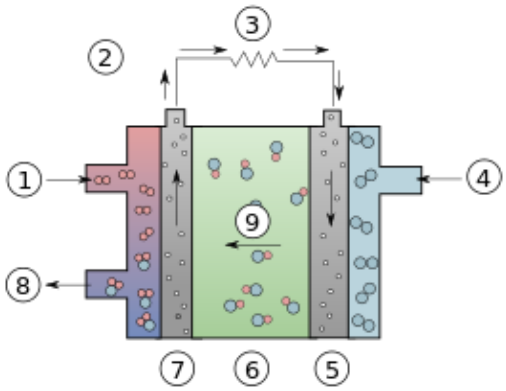
_____

_____

_____

3 marks

c. Lunar nights can last up to 334 days in some places. A regenerative fuel cell can use hydrogen and oxygen gas to produce water during the night and then the water can be converted back to hydrogen and oxygen gas during the day. The system is totally sealed so there is no loss of chemicals. A diagram of the cell discharging is shown below; An electrolyte of 1M KOH is used.



i. What chemical is indicated at the inlet marked 4?

_____

ii. Write a half equation for the reaction occurring at the electrode marked 7

_____

iii. What marked 9 is moving between the electrodes?

_____

3x1=3 marks

END OF QUESTION AND ANSWER BOOK