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'2017 Examination Package' -
Trial Examination 2 of 9

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Units 3 & 4 - Written examination

*(*TSSM's 2009 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	110
			Total 140

- 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 22 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

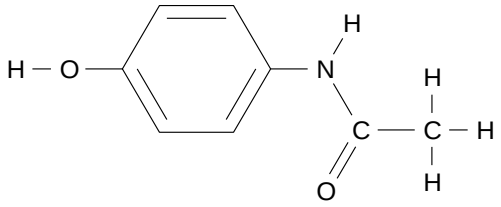
Answer **all** questions.
Choose the response that is **correct** or **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
No mark will be given if more than one answer is completed for any question.
Marks will **not** be deducted for incorrect answers.

Question 1

What is the molecular weight of a pure gaseous compound having a density of 4.95 g/L at -35°C and 1020 mmHg?

A. 72 g/mol
B. 15 g/mol
C. 10 g/mol
D. 36 g/mol

Question 2



The molecule above is paracetamol. It is a common analgesic or painkiller.
A molecule of paracetamol contains

A. a carboxylic acid functional group and an alkanol functional group
B. an alkene functional group and an ester functional group
C. an ester functional group and an alkanol functional group
D. an amide functional group and an alkanol functional group

Question 3

How many chiral centres are there in paracetamol?

A. 0
B. 1
C. 2
D. 3

Question 4

A 2.00 kg metal object requires 5.02×10^3 J of heat to raise its temperature from 20.0 °C to 40.0 °C. What is the specific heat capacity of the metal?

A. 63.0 kJ/(g °C)
B. 7.97×10^3 kJ/(g °C)
C. 1.26×10^{-4} kJ/(g °C)
D. 126 kJ/(g °C)

SECTION A – continued

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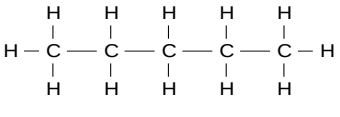
Question 5
Which of the following is the strongest oxidizing agent?
A. Pb
B. Ag
C. I_2
D. Cu^{2+}

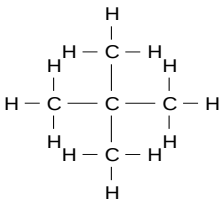
Question 6
Which of the following is the definition of chirality?
A. The non-superposability of an object on its mirror image
B. The superposability of an object on its mirror image
C. A molecule that has a carbon atom with four different substituents
D. A molecule with a mirror image

Questions 7 and 8 refer to the following information

The molecules below are structural isomers. They are difficult to distinguish as their properties are similar



molecule A



molecule B

Question 7
If both molecules are subjected to low resolution NMR, the results will show the following number of peaks:

	molecule A		molecule B	
	^{1}H NMR	^{13}C NMR	^{1}H NMR	^{13}C NMR
A.	1	1	1	1
B.	2	2	2	1
C.	3	3	1	2
D.	5	3	3	3

Question 8
Both molecules are passed though a mass spectrometer. Molecule A
A. will have peaks at 14 and 29 that molecule B will not have
B. will have a peak at 57 that molecule B does not have
C. will have less peaks than molecule B
D. will have a different parent molecular ion mass to that of molecule B

SECTION A – continued
TURN OVER

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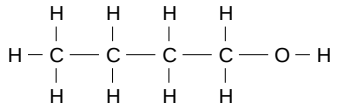
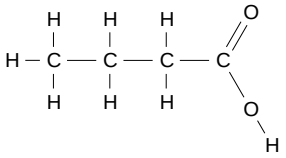
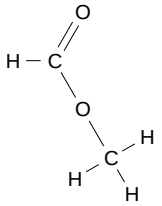
Question 9







The systematic names for the molecules drawn above are, respectively:

A. butanol, butanoic acid, ethyl methanoate
B. 1–butanol, 1-butanoic acid, methyl methanoate
C. 1-butanol, butanoic acid, methyl methanoate
D. 4-butanol, 1-butanoic acid, methyl methanoate

Question 10

A compound extracted from wheat has a molecular formula of $C_{685}H_{1068}N_{196}O_{211}S_5$

A. No natural compound could have a molecule such as this.
B. The molecule is a carbohydrate. Its role is energy storage.
C. The molecule is an enzyme found in the cells of wheat.
D. The molecule is an essential amino acid that can form disulfide links to neighbouring molecules.

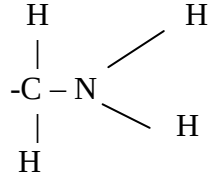
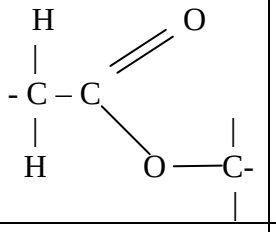
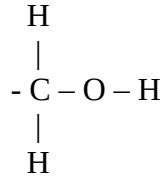
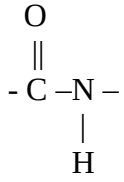
Question 11

Apricot flavouring can be isolated as pentyl propanoate. The artificial synthesis of this compound would require

A. sulfuric acid, 1-pentanol, 1-propanol and dichromate ions
B. sulfuric acid, 2-propanol, 1-pentanol and dichromate ions
C. sulfuric acid, pentanoic acid and 1-propanol
D. sulfuric acid, 1-pentanol and pentanoic acid

Question 12

Pick the alternative that names the functional groups correctly.

				
A.	amine	ester	alkanol	amide
B.	amide	ester	alcohol	amine
C.	amine	carboxylic acid	alkanol	amide
D.	amine	carboxylic acid	alkanol	nylon

SECTION A – continued

Question 13
What is the x-axis of a mass spectrum?
A. mass
B. mass/energy
C. mass/charge
D. charge

Question 14
Linolenic acid is a fatty acid with the molecular formula $C_{18}H_{32}O_2$
Linolenic acid will have
A. one carbon to carbon double bond, a non polar segment and a polar segment
B. two carbon to carbon double bonds and no significant dipoles
C. all single bonds between carbon atoms and a double bond to an oxygen atom.
D. two carbon to carbon double bonds, one carbon to oxygen double bond and a long non polar segment

Question 15
Inulin is a polysaccharide molecules used in plants for energy storage. The monomer in inulin is fructose. Fructose has 6 carbon atoms and an empirical formula of CH_2O. A typical inulin molecule contains around 2200 monomers. The mass of this typical molecule would be, in *amu*,
A. 32000
B. 66000
C. 396419
D. 356418

Questions 16 and 17 refer to the following information

The rate of the reaction between bromine and methanoic acid is easy to study. The Br_2 has a deep red-brown colour, while most other reactants and products are colourless or lightly coloured.

$$Br_2(aq) + HCOOH(aq) \rightarrow 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$

Question 16
The following measurements are made during a series of experiments between these two reactants

I the mass of the container
II the volume of gas evolved
III the pH of the solution

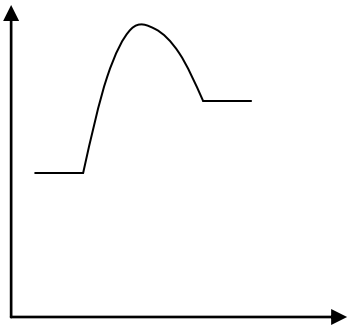
The rate of this reaction could be studied through the use of
A. I only
B. I or II only
C. II or III only
D. any of the above

SECTION A – continued
TURN OVER

Question 17
A cross is placed on a piece of cardboard and each reacting flask is placed over this cross. The rate of reaction
A. cannot be monitored in this way
B. is evident from the time it takes for the cross to be obscured
C. is evident from the time it takes for the cross to become visible
D. is obviously faster if the cross is obscured in a shorter time

Questions 18, 19 and 20 refer to the following information

The energy profile diagram for the reaction $N_2O_4(g) \Leftrightarrow 2NO_2(g)$ is



At 100°C, the value of K is 0.80 M

Question 18
The yield of this reaction will be increased through the use of
A. high temperature and low pressure
B. low temperature and high pressure
C. low temperature and low pressure
D. a catalyst and high pressure

Question 19
A mixture of the two gases is at equilibrium. The pressure is increased. The temperature of the reactor will
A. not change
B. decrease because the reverse reaction is exothermic
C. increase because the reverse reaction is exothermic
D. increase because the forward reaction is exothermic

Question 20
Four flasks containing mixtures of the two gases are heated to 200°C. The concentrations of the N_2O_4 and NO_2 are given below. Which flask might be at equilibrium?

Flask	**$[N_2O_4]$**	**$[NO_2]$**
A.	0.77	1.30
B.	0.50	0.63
C.	1.30	0.77
D.	1.00	0.80

SECTION A- continued

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Question 21
Which of the following processes takes place upon absorption of infrared radiation?
A. bond vibration
B. electron excitation
C. nuclear spin flip
D. electron spin flip

Question 22
For the decomposition of NOCl, the reversible reaction is

$2NOCl(g) \Leftrightarrow 2NO(g) + Cl_2(g) \qquad K = 1.2 \times 10^{-5}$ M at 30ºC

At 30ºC in an equilibrium mixture
A. the [NOCl] will equal [NO]
B. the $[Cl_2]$ will be half the [NOCl]
C. the $[Cl_2]$ will be double [NOCl]
D. the [NOCl] will be many times greater than $[Cl_2]$

Question 23
Photovoltaic cells differ from most other sources of electrical energy because
A. they do not require a turbine turning in a magnetic field
B. the source of the energy is very expensive, making the process very expensive
C. they require more energy conversions hence they have low efficiency
D. the sun's energy is responsible for the turning of a turbine in a magnetic field

Question 24
0.16 g of methane is burnt in a bomb calorimeter. The temperature changes from 12.8^oC to 24.5^oC. The calibration factor of the calorimeter is, in J^oC^{-1},
A. 0.76
B. 380
C. 760
D. 1520

Question 25
The fuel that produces the greatest amount of energy per gram during combustion is
A. ethanol
B. propane
C. octane
D. hydrogen

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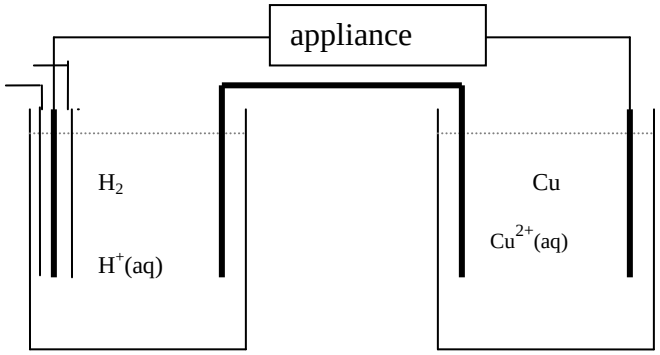
Questions 26 and 27 refer to the following information

An appliance is connected to a galvanic cell constructed from the materials shown in the diagram



Question 26
In this cell,

	Oxidant	**Reductant**	**Positive electrode**	**Negative electrode**
A.	H_2	Cu^{2+}	Cu	H_2
B.	Cu^{2+}	H_2	Cu	H_2
C.	H_2	Cu^{2+}	H_2	Cu
D.	Cu	H^+	Cu	H_2

Question 27
In this cell, the
A. reaction will stop when the copper electrode has been consumed in the reaction
B. electrons travel through the salt bridge to complete the circuit
C. electrons travel from the hydrogen electrode to the copper
D. electrons flow when the appliance is switched off

Question 28
When comparing the electrolysis of molten CuI_2 with that of a 1.0 M aqueous solution of CuI_2, which one of the following statements is correct?
A. The products at the anode and the cathode are the same in both cases.
B. The product at the cathode is the same in both cells but the products at the anode are different.
C. The product at the anode is the same in both cells but the products at the cathode are different.
D. The products at the cathodes of both cells are different as are the products at the anodes.

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Question 29
A charge of 8042 coulomb is passed through a molten ionic solution. The product at the cathode could be

A. 0.166 mol of hydrogen gas
B. 0.0833 mol of magnesium metal
C. 0.0417 mol of sodium metal
D. 0.0278 mol of aluminium metal

Question 30
The overall equation for the methane – oxygen fuel cell, operating in acid conditions, is

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

The half equation for the reaction occurring at the anode will be

A. $CH_4(g) + 2H_2O(l) + 8e^- \rightarrow CO_2(g) + 8H^+(aq)$
B. $CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g)$
C. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$
D. $CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$

END OF SECTION A
TURN OVER

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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)
The table below lists six different analysis tasks to be performed.
Below the table, six different techniques are listed.

Select an appropriate analysis technique from the list provided for each required task. Use the spaces provided in the table to write in the technique you have chosen and the justification for your choice.
Each technique can only be used once.

Task	Method chosen	Justification
Identification of amino acids present in a health bar		
Concentration of a solution of lithium hydroxide		
Distinguish between two isomers of butane		
Concentration of lead ions in waste water		
Chloride ion concentration in mineral water		
Empirical formula of a hydrocarbon molecule		

Techniques available

Acid/base titration	TLC	Mass spectrometry
NMR	Precipitation	Atomic absorption spectrometry

SECTION B – continued

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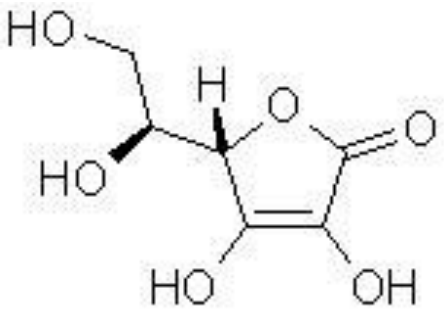
Question 2 (10 marks)

Vitamin C is better known to scientists as ascorbic acid. Its concentration in a food item or fruit juice can be determined by several different methods. One of the methods is a redox titration, using iodine as an oxidant.



The half equation for the reaction of ascorbic acid is

$C_6H_4O_2(OH)_4(aq) \rightarrow C_6H_4O_2(OH)_2(aq) + 2H^+(aq) + 2e^-$

a. Write the half equation for the reaction of iodine. 1 mark

_____

b. Write a balanced overall equation for this titration. 1 mark

_____

The endpoint of the titration can be determined using starch as an indicator. Starch will be blue in the presence of iodine.

c. **i.** If you are performing this titration, explain how you would know when to stop adding from the burette. 2 marks

_____

_____

ii. Why is starch not listed in your chemistry data book amongst the indicators? 1 mark

_____

20.00 mL samples of 0.104 M iodine solution are added to flasks and titrated against an ascorbic acid solution. The average titre is 18.56 mL.

d. Calculate the concentration of the ascorbic acid solution. 2 marks

_____

_____

e. Iodine solution is not suitable as a primary standard. What does this mean? 1 mark

_____

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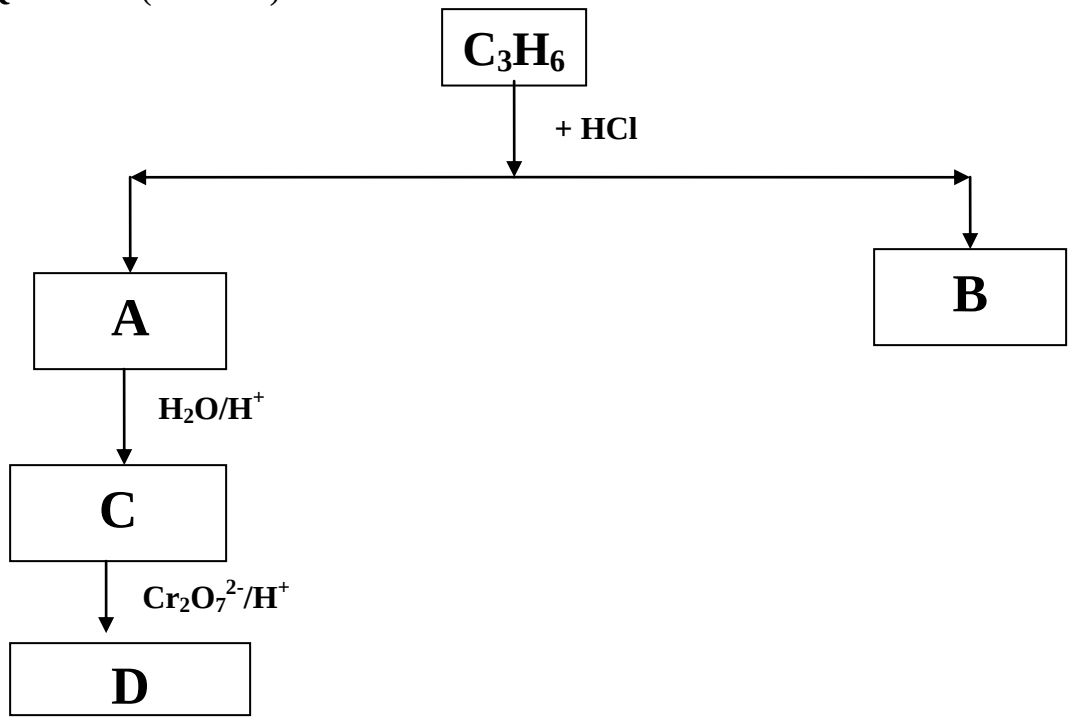
f. Name two functional groups present in ascorbic acid and give the infrared frequency these functional groups would absorb at. 2 marks

functional group	frequency
_____	_____
_____	_____

Question 3 (13 marks)



The molecule C_3H_6 can form two isomers when it reacts with hydrochloric acid.

a. Draw structural diagrams, and name, each of the molecules A to D. Use the spaces provided. 4 marks

A _____ B _____

C _____ D _____

SECTION B – Question 3 – continued

b. Name the type of reaction that is responsible for: 3 marks

$C_3H_6 \rightarrow A$ _____

$A \rightarrow C$ _____

$C \rightarrow D$ _____

c. **i**. Name an instrument other than mass spectrometry that could be used to distinguish molecule B from A. 1 mark

_____

ii. For the instrument you have chosen, explain how the print-out will differ for each molecule. 2 marks

_____

_____

d. Molecule C is passed through a mass spectrometer.

i. What is the mass of the parent molecular ion? 1 mark

_____

ii. Suggest two peaks that this molecule might have and explain what fragmentation has led to their formation. 2 marks

_____ _____

_____ _____

SECTION B – continued
TURN OVER

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Question 4 (9 marks)
An organic molecule contains the elements carbon, hydrogen and oxygen. A 4.111 g sample of the molecule contains 2.667 g of carbon and 0.555 g of hydrogen.

a. Determine the empirical formula of this molecule. 3 marks

_____

_____

_____

b. The mass spectrum of this molecule shows the parent molecular ion has a mass of 74.
What is the molecular formula? 1 mark

_____

c. Draw two possible structures for this molecule. 2 marks

d. An infrared spectrum of this molecule shows a very broad absorbance band at 3400 cm^{-1} and no band at 1700 cm^{-1}. What conclusion might you draw from this information? 1 mark

_____

e. The ^{1}H NMR spectrum of this molecule is shown on the following page. Note the area under the right peak.
Draw and name the molecule under investigation. 2 marks

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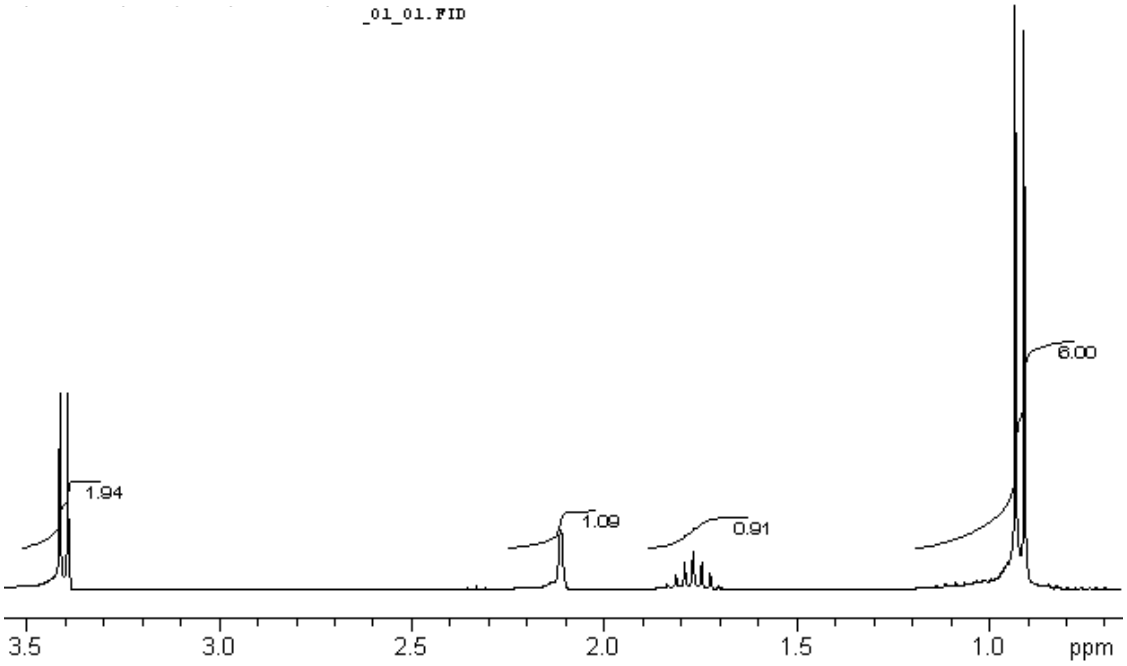
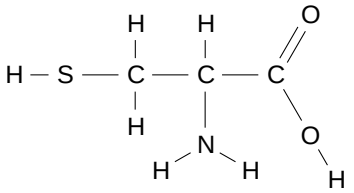


Question 5 (9 marks)



a. Circle two functional groups on the molecule shown. Write the names of the two functional groups that you have circled next to the circles you made. 2 marks

b. Name this molecule _____ 1 mark

c. Draw the structure of this molecule if it is in a solution of pH 3. 1 mark

d. Draw the products formed when this molecule bonds to itself. 2 marks

SECTION B – Question 5 – continued
TURN OVER

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e. **i**. When this molecule is spotted onto a TLC plate, with isobutanol as a solvent, its R_f value is known to be 0.43. On one such plate, the molecule moves 3.8 cm. How far should the solvent have moved? 1 mark

_____

ii. For this particular chromatogram, name the stationary phase and the mobile phase. 2 marks

stationary phase: _____ mobile phase: _____

Question 6 (13 marks)

The standard enthalpies of combustion of the petro–diesel and the biodiesel are very similar:
Petro-diesel (Hexadecane, $C_{16}H_{34}$): ΔH = -10699.1 kJ/mol
Biodiesel (Linoleic acid methyl ester, $C_{19}H_{34}O_2$): ΔH = -11690.1 kJ/mol

a. Write the thermochemical equation for the combustion of hexadecane (major constituent of petro-diesel).

2 marks

_____

b. Although biofuels are attractive replacements for fossil fuels, their acceptance has several disadvantages. Provide one example of an advantage and a disadvantage of biofuels.

2 marks

_____

_____

_____

_____

c. If a particular source of Petro-diesel has a hexadecane content of 0.832 kg/L, how much energy can be produced from a 60.0 L petrol tank?

4 marks

_____

_____

_____

_____

_____

SECTION B – Question 6 – continued

d. If the density of the biofuel is 0.875 g/mL, what volume of biofuel is required to produce an equivalent amount of energy?

3 marks

e. If it takes 1 hectare of land to produce 600 litres of the biofuel, what area of land is required to produce this amount of biofuel?

2 marks

Question 7 (8 marks)
Comment on the accuracy of each of the following statements.

a. In the reversible reaction;

$$A(g) + 2B(g) \rightleftharpoons C(g)$$

i. the concentration of B will always be twice that of A 1 mark

ii reactant A will run out before B 1 mark

iii. a reaction will still occur if C is added to an empty reactor 1 mark

b. 4.0 mole of electrons is passed through a series of molten ionic cells.

i. The same number of mole of any metal would be obtained at the cathode 1 mark

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ii. The same number of mole of electrons passes through the anode as through the cathode. 1 mark

_____

iii. 4.0 mol of chlorine gas would be obtained from NaCl molten solution. 1 mark

_____

_____

c. A fuel cell involving oxygen gas is operating.

i. The reaction at the anode will be $O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l)$ 1 mark

_____

ii. Carbon dioxide gas will be one of the products of the cell. 1 mark

_____

Question 8 (8 marks)

Hydrogen peroxide is a clear liquid with a formula H_2O_2.

It is unstable and best stored in dark plastic containers in a refrigerator. Under such conditions, it has a shelf life of about two years.

a. **i**. Use half equations from the electrochemical series to derive the overall equation for the decomposition of H_2O_2 3 marks

oxidation half equation _____

reduction half equation _____

overall equation _____

ii. The electrochemical series indicates that this is a spontaneous reaction. Why is it that the shelf life is over two years? 1 mark

_____

SECTION B – Question 8 – continued

iii. Explain clearly, in terms of particle movement, why refrigeration in a dark container enhances shelf life. 1 mark

_____

b. When manganese dioxide, MnO_2 is added to the hydrogen peroxide, the reaction occurs more rapidly. If the products are filtered at the end of the reaction, the MnO_2 can be recovered and reused.

i. Explain the role of the MnO_2 1 mark

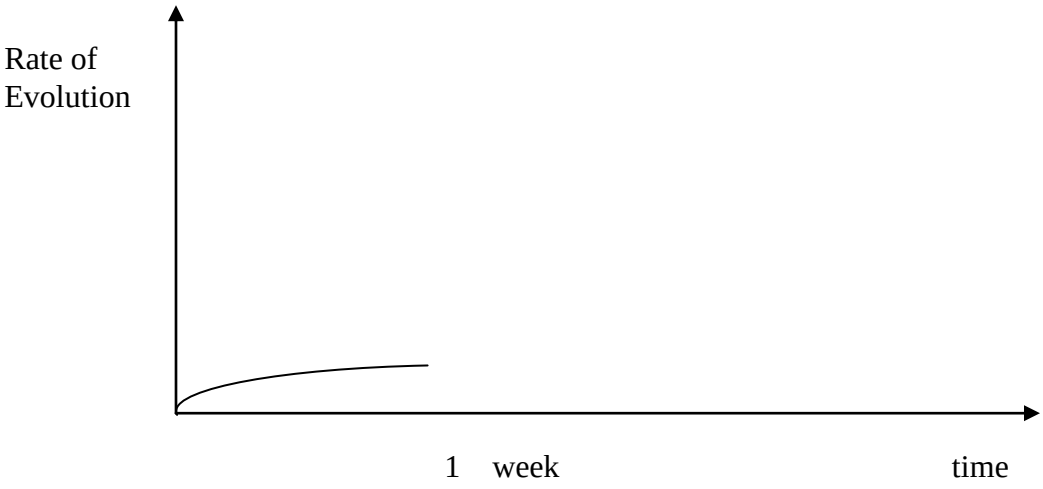
_____

_____

ii. What compound do you think the MnO_2 has formed during the reaction? 1 mark

_____

c. The graph below shows the rate of gas evolution from a container of hydrogen peroxide. At the one week mark, a spatula of MnO_2 is added to the hydrogen peroxide. Sketch, on the graph, the impact on the rate of evolution of gas of the addition of the MnO_2. 1 mark



SECTION B – continued
TURN OVER

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Question 9 (9 marks)
One of the reactions occurring in the catalytic converter of a car is

$$2NO(g) + 2CO(g) \rightleftharpoons N_2(g) + 2CO_2(g) \qquad \Delta H = +ve$$

The nitrogen monoxide and carbon monoxide are both converted to less harmful gases. This reaction can also be used in the laboratory as a source of nitrogen gas.

a. The closer the catalytic converter is to the engine, the higher the temperature it runs at. From an equilibrium point of view, is it desirable for the converter to be close to the engine or as far as possible from the engine? Explain your answer. 2 marks

_____

_____

b. Should the converter be run at high pressure? Explain your answer. 1 mark

_____

_____

c. A hole in the exhaust of a particular car is allowing air to enter the exhaust before the fumes reach the catalytic converter. What is the likely impact of air on this reaction? 2 marks

_____

_____

d. Write an expression for K for the reaction above. 1 mark

e. 0.30 mol of NO reacts with 0.44 mol of CO. At equilibrium, 0.12 mol of CO_2 has formed. What is the concentration of the other three gases in 1L?
3 marks

NO _____ CO _____ N_2 _____

SECTION B– continued

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Question 10 (11 marks)

Lithium is the key element to many new cells. One such example is the Lithium-Iron cell. It is of interest because the voltage produced is 1.5 volts, making it compatible with the conventional cells used in many common appliances. The Lithium-Iron cell can produce 2.5 times the capacity of an alkaline cell.

The overall equation for this cell is;

$$FeS_2 + 4Li \rightarrow Fe + 2Li_2S$$

Phases are not shown in this equation because an organic solvent is used.

a. Write half equations in the spaces provided and indicate the polarity of each electrode. (You should be able to use the likely oxidation state of lithium to deduce the oxidation states of the other elements) 4 marks

	Half equation	Polarity
anode	_____	_____
cathode	_____	_____

b. Why do you think an organic solvent is used in these cells? 1 mark

_____

c. Why might a voltage of 1.5 volts be considered advantageous? 1 mark

_____

d. Like all cells, this one eventually goes 'flat'. In terms of the chemicals involved, why does this battery go flat? 1 mark

_____

e. The operating voltage of the cell is 1.40 volts.

i. How much energy is produced by this cell if it runs for 8.0 hours with a current of 3.50 amps? 2 marks

_____

_____

ii. What mass of lithium would react in this time? 2 marks

_____

_____

SECTION B – continued
TURN OVER

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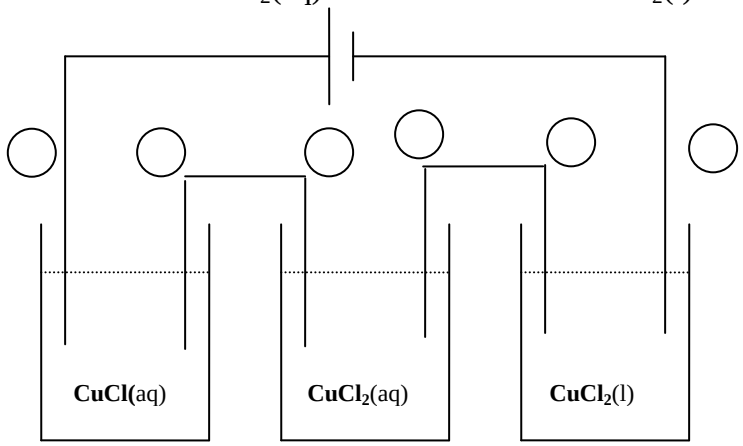
Question 11 (8 marks)
Three cells are connected in series to each other and to a power supply. The solutions in each are, respectively
CuCl(aq), $CuCl_2$(aq) and $CuCl_2$(l)



a. Use the circles provided to indicate the polarity of each electrode. 3 marks

4.0 mol of electrons passes through the power supply.

b. **i**. How many mol of electrons passes through each cell? 1 mark
$CuCl$(aq) _____
$CuCl_2$(aq) _____
$CuCl_2$(l) _____

ii. How many mol of chlorine gas is produced in each cell? 3 marks
$CuCl$(aq) _____
$CuCl_2$(aq) _____
$CuCl_2$(l) _____

iii. How many mol of metal is produced in each cell? 1 mark
$CuCl$(aq) _____
$CuCl_2$(aq) _____
$CuCl_2$(l) _____

END OF QUESTION AND ANSWER BOOK