TSSM
Creating VCE Success

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'2017 Examination Package' -
Trial Examination 8 of 9

STUDENT NUMBER

								Letter

CHEMISTRY

Units 3 & 4 - Written examination

(TSSM's 2015 trial exam updated for the current study design)

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

QUESTION & 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	95
			Total 125

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- One approved scientific calculator is permitted in this examination.

Materials supplied

- Question and answer book of 23 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.

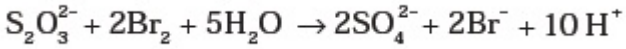
SECTION A – Multiple-choice questions

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

In the presence of both iodine and bromine, thiosulfate reacts as follows:



$$S_2O_3^{2-} + 2Br_2 + 5H_2O \rightarrow 2SO_4^{2-} + 2Br^- + 10\,H^+$$

Which of the following statements justifies this observation?

A. Bromine is a stronger oxidant than iodine
B. Bromine is a weaker oxidant that iodine
C. Thiosulfate undergoes reduction by bromine
D. Bromine undergoes oxidation in preference to iodine

Question 2

For which of the compounds below are cis-trans isomers possible?

$CH_3CH=CH_2$	$CH_3CH=CHCH_2CH_3$	$CH_3CH=CHCH_3$
(1)	(2)	(3)

A. only 2
B. both 1 and 2
C. both 2 and 3
D. all three

Question 3

Consider four $C_3H_5Cl_3$ isomers. Which has two ^{1}H-NMR singlets and three ^{13}C-NMR signals?

A. $CH_3CH_2CCl_3$
B. $CH_2ClCHClCH_2Cl$
C. $CH_3CHClCHCl_2$
D. $CH_3CCl_2CH_2Cl$

Question 4

Four major spectroscopic tools are listed below. Which makes use of the longest wavelength radiation?

A. Infrared
B. Ultraviolet
C. ^{1}H-NMR
D. Visible

SECTION A – continued

Question 5
The standard heat of combustion of ethanol, C_2H_5OH, is 1372 kJ/mol ethanol. How much heat (in kJ) would be liberated by completely burning a 20.0 g sample?
A. 686 kJ
B. 519 kJ
C. 715 kJ
D. 597 kJ

Question 6
Which of the following alcohols forms a ketone when oxidized?
A. 1-propanol
B. methanol
C. 2-methyl-2-propanol
D. 2-propanol

Use the following information to answer Questions 7 and 8
The overall equation for the production of aluminium in a Hall Cell is

$$2Al_2O_3(l) + 3C(s) \rightarrow 4Al(l) + 3CO_2(g)$$

Question 7
When 0.66 mol of aluminium oxide is reacted with 0.72 mol of carbon, the number of mole of aluminium that can be formed is
A. 0.66
B. 0.96
C. 1.02
D. 1.32

Question 8
After a particular reaction, 36 g of carbon has been found to have reacted. The carbon dioxide gas produced was collected and returned to standard laboratory conditions, SLC. The volume will be, in litres,
A. 24.5
B. 49.0
C. 67.2
D. 74.4

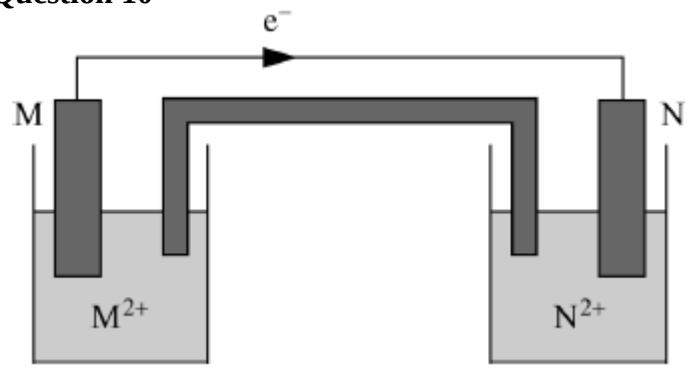
Question 9

$$MnO_4^- + I^- + H^+ \rightarrow Mn^{2+} + IO_3^- + H_2O$$

When the equation shown above is balanced, which of the following is true?
A. The $I^-:IO_3^-$ ratio is 3:1
B. The $MnO_4^-:I^-$ ratio is 6:5
C. The $MnO_4^-:Mn^{2+}$ ratio is 3:1
D. The $H^+:I^-$ ratio is 2:1

SECTION A – continued
TURN OVER

Question 10



Which of the following is true of the cell represented above?

A. Metal M is being oxidised
B. Metal N is the reducing agent
C. N^{2+} ions are being oxidised
D. M^{2+} ions are being reduced

Question 11

Which one of the following statements regarding a catalyst is not correct?

A. An enzyme is a catalyst that only binds certain substrates.
B. An enzyme is a protein that is a highly efficient catalyst for one or more chemical reactions in a living system.
C. Catalysts increase the rate of a reaction by altering the mechanism, thereby increasing the activation energy.
D. Catalysts do not alter the equilibrium constant for a chemical reaction.

Question 12

The reaction A ↔ B has an equilibrium constant of $K = 10^{-4}$. Which one of the following statements is always correct?

A. The reaction will have 50% product B and 50% reactant A at equilibrium.
B. The reaction is very favourable and will have mostly product B at equilibrium.
C. The reaction is unfavourable and will not have very much product B at equilibrium.
D. The equilibrium constant only relates to the speed of a reaction and not to the amount of product formed.

Question 13

A sample of ethyl ethanoate is tested in both proton-NMR and carbon-NMR. The number of different environments it has are

	Carbon environments	Hydrogen environments
A.	1	1
B.	2	2
C.	3	3
D.	4	3

SECTION A – continued

Question 14
The fatty acid with the empirical formula $C_9H_{16}O$, will have how many double carbon to carbon bonds?
A. 0
B. 1
C. 2
D. 3

Use the following information to answer Questions 15 and 16
The reaction between SO_2 and Cl_2 gases is a reversible one;

$$SO_2(g) + Cl_2(g) \rightleftarrows SO_2Cl_2(g)$$

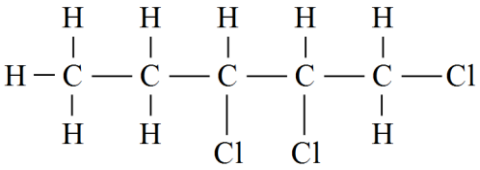
Chlorine gas has a light green colour and it is this colour that can be observed to study changes in the position of equilibrium.

Question 15
A mixture of these gases is at equilibrium. The volume of the container is suddenly halved and the system allowed to re-establish equilibrium. The intensity of the green colour, compared to before the volume was changed, will be
A. unchanged
B. increased
C. reduced
D. predicted from a knowledge of whether the reaction is exothermic or endothermic

Question 16
A mixture of these gases is at equilibrium. The temperature is increased and the green intensity is seen to increase. From this observation, it can be concluded that
A. the reaction is endothermic
B. an alternative reaction must be occurring that is using up some of the chlorine
C. the activation energy for the forward reaction must be decreasing
D. the reaction is exothermic

Question 17
Select an alternative that is correct for propanoic acid.
A. It has two different hydrogen environments.
B. It will be insoluble in water
C. It can be produced from the oxidation of an alkanol
D. It has no structural isomers

Question 18



The systematic name of this molecule is

A. 1,2,3-trichloropentane
B. 3,4,5-trichloropentane
C. trichloropentane
D. 1-chloro-2-chloro-3-chloropentane

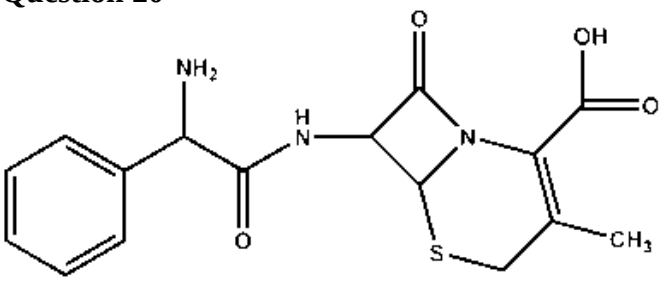
Question 19

Which of the following equilibria would be affected by volume changes at constant temperature?

1. $C_2H_4\,(g) + H_2\,(g) \rightarrow C_2H_6\,(g)$
2. $4NH_3\,(g) + 5O_2\,(g) \rightarrow 4NO\,(g) + 6H_2O\,(l)$
3. $SO_3\,(g) + NO\,(g) \rightarrow NO_2\,(g) + SO_2\,(g)$

A. 3 only
B. 1 and 2 only
C. 1 and 3 only
D. 2 and 3 only

Question 20



The effectiveness of penicillin in humans is dropping. In response, medical researchers are investigating other categories of related chemicals such as the molecule shown above, cephalosporin.

I ester
II hydroxyl
III amide
IV amine
V carboxyl

Of the functional groups listed above, cephalosporin contains

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

SECTION A – continued

Question 21
The equation for the conversion of nitrogen monoxide to nitrogen dioxide is

$2NO(g) + O_2(g) \rightleftarrows 2NO_2(g)$ $\Delta H = -114$ kJ mol^{-1} K = 5.6 M at 80 ^{0}C

The value of ΔH and the magnitude of K for the reverse reaction will be

	ΔH kJ mol^{-1}	K
A.	+114	0.18
B.	+114	-5.6
C.	-0.0088	0.18
D.	-0.0088	-5.6

Question 22
Commercial production of electrical energy from nuclear sources usually involves
A. using neutrons to split the nuclei of large atoms releasing significant thermal energy
B. the release of electrons when the nuclei of large atoms are split
C. using neutrons to fuse the nuclei of small atoms
D. colliding small nuclei at high speeds to produce larger atoms, releasing significant thermal energy

Question 23
The energy released by the complete combustion of 0.460g of ethanol is, in J,
A. 6.26
B. 13.6
C. 6.26×10^3
D. 1.36×10^4

Question 24
A student determines from an experiment that it requires 750 J to raise the temperature of an 80.0g sample of ethanol from 24.5 ^{0}C to 28.4 ^{0}C.
From this data, the specific heat capacity of ethanol, in J g^{-1} ^{0}C^{-1}, is
A. 2.00
B. 2.40
C. 3.90
D. 4.18

Question 25
A galvanic cell is constructed by connecting a $Zn(s)/Zn^{2+}(aq)$ half cell with an $I_2(l)/I^-(aq)$ half cell. A graphite electrode is used in the iodine half cell.
In this cell,
A. zinc metal will be deposited at the positive electrode
B. zinc ions will form at the negative electrode
C. iodide ions will form at the negative electrode
D. iodine solid will be formed at the cathode

SECTION A – continued
TURN OVER

Use the following information to answer Questions 26 and 27

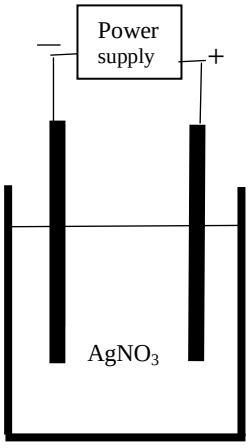
In an experimental methane/oxygen fuel cell, methane gas reacts with oxygen gas in an alkaline environment. The overall equation for this cell will be;

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

Question 26
The reaction at the anode in this cell will be
A. $CH_4(g) + 8OH^-(aq) \rightarrow CO_2(g) + 6H_2O(g) + 8e^-$
B. $CH_4(g) + 4OH^-(aq) \rightarrow CO_2(g) + 4H_2O(g) + 4e^-$
C. $CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$
D. $O_2(g) + 2H_2O(g) + 4e^- \rightarrow 4OH^-(aq)$

Question 27
Methane for this cell could be sourced in a sustainable way by
A. extraction of natural gas
B. the fermentation of glucose
C. conversion of coal to methane
D. biomass from the food industry

Use the following information to answer Questions 28, 29 and 30



Electrolysis is conducted on an aqueous solution of silver nitrate, with inert electrodes.

Question 28
In this cell
A. silver metal will be deposited at the anode
B. hydrogen gas will be produced at the cathode
C. oxygen gas will be produced at the cathode
D. oxygen gas will be produced at the positive electrode

SECTION A – continued

Question 29
In this cell
A. oxygen gas is produced at the negative electrode
B. silver metal will be deposited at the negative electrode which is the anode
C. silver metal will be deposited at the negative electrode which is the cathode
D. silver ions will be produced at the cathode

Question 30
A current of 8.4 amps runs through the circuit for 12 minutes. The mass of silver deposited will be, in g,
A. 0.112
B. 3.38
C. 5.12
D. 6.77

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 (8 marks)

Iron from the Blast Furnace contains carbon. In the steel-making process, oxygen is blown through molten impure iron. At stages during this process samples of iron are taken and analysed to determine the remaining carbon content. One method of analysis involves a redox titration. At one stage a 1.27g sample of this impure iron was reacted with an excess of dilute sulphuric acid. All of the iron in the sample was converted into iron(II) sulfate, and hydrogen was evolved. The solution formed was made up to 250 mL A 25.0 mL sample of this solution reacted completely with exactly 19.6 mL of a 0.0220 mol/L solution of potassium permanganate.

a. Write an equation for the reaction between iron and dilute sulphuric acid.

(1 mark)

_____

b. Write an equation for the reaction of iron (II) ions with permanganate ions in acid solution.

(2 marks)

_____

c. Assuming that carbon is the only impurity, calculate the percentage by mass of carbon in the 1.27g sample.

(5 marks)

_____

_____

_____

_____

_____

SECTION B – continued

Question 2 (5 marks)

In organisms the reactions of sucrose ($C_{12}H_{22}O_{11}$) and oxygen produces carbon dioxide, water and energy.

a. If 5460 kJ of energy is produced per mole of sucrose in this reaction. Write a thermochemical equation for this reaction.

(2 marks)

_____

b. What is the amount of energy available if 1.00 g of sucrose is reacted?

(3 marks)

_____

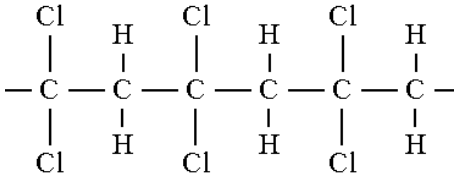
_____

_____

_____

Question 3 (11 marks)

a.

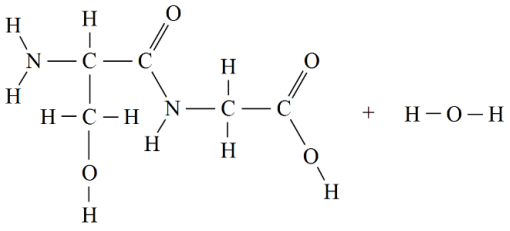
A ⟶ 

A segment of a polymer is shown. The polymer can be formed from monomer A.

i. Draw the structure of monomer A 1 mark

ii. What is the systematic name of this monomer? _____ 1 mark

b.

A + B ⟶ 

The reaction between molecules A and B forms the products shown above.

SECTION B - Question 3 – continued

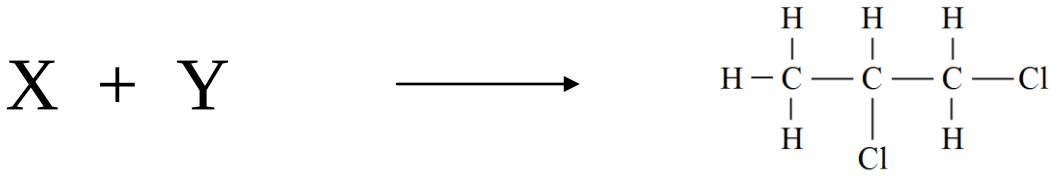
TURN OVER

i. Draw the structures of A and B 2 marks

Molecule A: _____ Molecule B: _____

ii. Use the spaces provided to name both molecules. 2 marks

c.

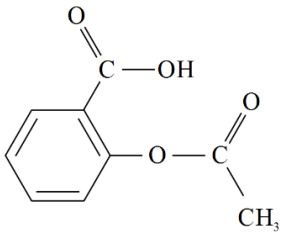


The reaction between X and Y produces the molecule shown as the sole product.

i. Draw the structures of molecules X and Y 2 marks

ii. State the category of reaction occurring. _____ 1 mark

d.



The molecule shown is formed in an esterification reaction. Water is also formed.
Draw the two likely reactants used for this reaction. 2 marks

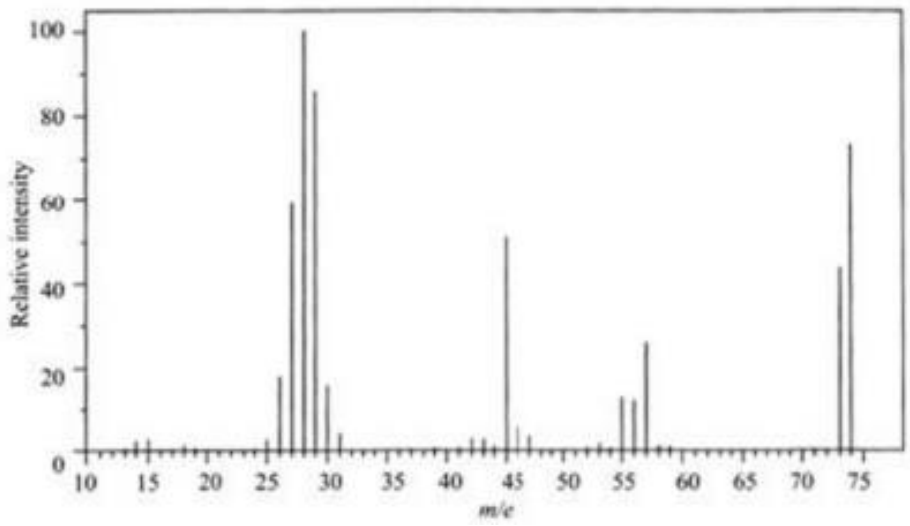
SECTION B – continued
TURN OVER

Question 4 (11 marks)

The instrumental data below has been collected from the testing of a sample of propanoic acid.

a. Draw a structural diagram of propanoic acid. 1 mark

b. The mass spectrum of propanoic acid is shown below.



i. Write an equation for the formation of the parent molecular ion for propanoic acid. 1 mark

_____

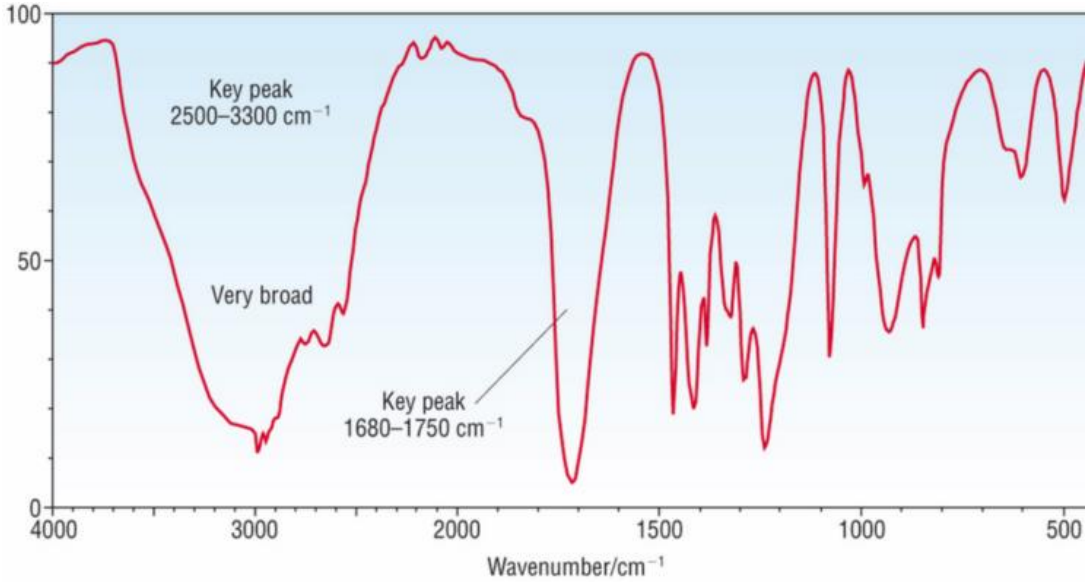
ii. Suggest a fragment that might cause the significant peak at m/e of 45. 1 mark

_____

SECTION B – Question 4 – continued

TURN OVER

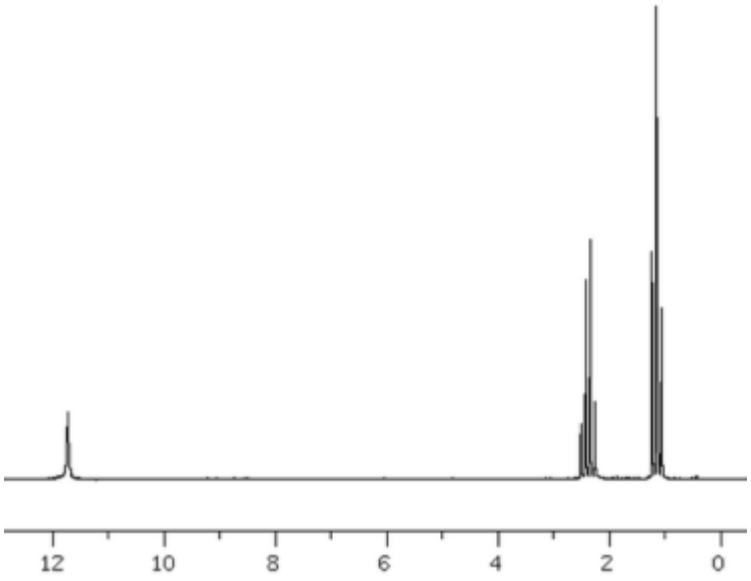
c. The infrared spectrum for propanoic acid is shown below.



There are two key peaks marked on this spectrum. Identify the bonds that have caused these two peaks; 2 marks

- peak at 2500-3300 cm^{-1} _____
- peak at 1680-1750 cm^{-1} _____

d. The proton-NMR spectrum for propanoic acid is shown below.



SECTION B – Question 4 - continued

i. This spectrum contains 3 sets of peaks. Identify the three different hydrogen environments on propanoic acid and identify which peak matches each environment. 3 marks

_____

_____

_____

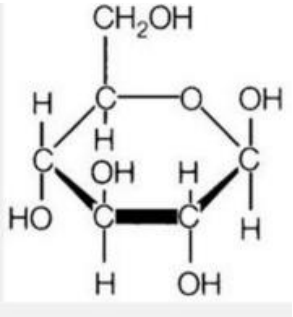
ii. It is not completely clear from the print-out what the splitting pattern is. You should however, be able to predict this from the structure. What is the likely splitting pattern at

- 2.4 ppm _____ 2 marks
- 1.1 ppm? _____

iii. What will be the ratio of the areas under each of these three peaks? _____ 1 mark

Question 5 (9 marks)

a. A molecule of glucose is shown below.



i. Will glucose be soluble in water? Justify your answer. 1 mark

_____

_____

ii. Name the linkage that is formed when one glucose molecule bonds to another. 1 mark

_____

iii. Name one product that can be formed from the polymerisation of glucose. 1 mark

_____

SECTION B – Question 5 – continued

TURN OVER

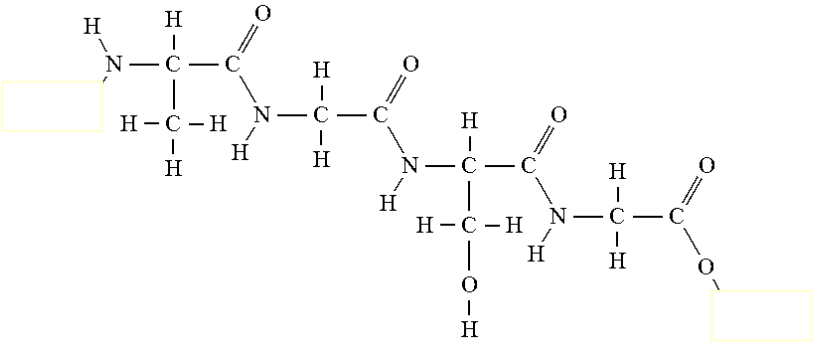
iv. Write a balanced equation for the complete combustion of glucose. 1 mark

_____

v. Write a balanced equation for the fermentation of glucose. 1 mark

_____

b. A section of a protein molecule is shown below



i. Annotate this diagram to explain why proteins have a spiral secondary structure. 2 marks

_____

_____

ii. Proteins are formed from reactions between amino acids. All amino acids have similarities in their structure such as an amine group and a carboxyl group. However the solubility of the different amino acids in water varies significantly. Use the amino acids in the segment of protein shown to explain why the solubility of amino acids in water varies. 2 marks

_____

_____

SECTION B – continued

TURN OVER

Question 6 (10 marks)

The combustion of methane produces significant quantities of carbon dioxide gas, a greenhouse gas. Methane can however, be converted to hydrogen gas. When this hydrogen burns, water is the only product. The production of hydrogen still produces carbon dioxide but it is easier to capture this carbon dioxide and to restrict its environmental impact.

The equation for the reaction to produce hydrogen is

$$CH_4(g) + 2H_2O(g) \rightleftarrows CO_2(g) + 4H_2(g)$$

a. In an experiment, 1.00 mol of methane and 1.40 mol of steam are added to a 1.00 L reaction vessel. The amount of carbon dioxide present at equilibrium is 0.22 mol. A constant temperature was maintained throughout the reaction.

i. Write the expression for the equilibrium constant for this reaction. 1 mark

_____

ii. Determine the equilibrium amounts of methane, steam and hydrogen. 3 marks

_____

_____

iii. Calculate the value of the equilibrium constant 2 marks

_____

_____

_____

SECTION B – Question 6 – continued

TURN OVER

b. Answer True or False to each of the following. 4 marks

Statement	True or False
If 4 mole of methane is added to steam in a reactor and the amount of methane changes to 3 mole over time, the amount of carbon dioxide formed will be 1 mol.	
1 mole of carbon dioxide and 1 mole of hydrogen gas are added to an empty reactor. No reaction will occur as they are both products.	
1 mole of methane is added to 10 mole of steam in an empty reactor. When equilibrium is reached the methane will be all gone as it is very much the scarce reagent.	
If 4 mole of methane and 8 mole of steam are added to an empty reactor, 4 mole of carbon dioxide will form.	

Question 7 (6 marks)

In an experiment to measure the temperature of the flame of a Bunsen burner, a lump of copper of mass 0.12 kg is heated in the flame for several minutes. The copper is then transferred quickly to a beaker, of negligible heat capacity, containing 0.45 kg of water, and the temperature rise of the water measured.

(specific heat capacity of copper = 390 J kg^{-1} K^{-1})

a. If the temperature of the water rises from 15 °C to 35 °C, calculate the thermal energy gained by the water.

(2 marks)

_____

_____

_____

b. i. State the thermal energy lost by the copper, assuming no heat is lost during its transfer.

_____

ii. Calculate the fall in temperature of the copper.

_____

_____

SECTION B – Question 7 – continued

iii. Calculate the temperature reached by the copper while in the flame.

(4 marks)

_____

_____

Question 8 (8 marks)

a. A student runs electrical energy through a poorly insulated calorimeter to determine its calibration factor.
Explain the likely impact of the poor insulation on each of the following;

i. the value of ΔT 1 mark

_____

ii. the value of the calibration factor 1 mark

_____

b. 50 mL of 0.10 M HCl is added to 50 mL of 0.20 M NaOH in a calorimeter and the temperature change is measured.

i. Write a balanced equation for the reaction occurring. 1 mark

_____

ii. Which number of mole should be used when calculating the value of ΔH for this reaction? Explain your answer. 1 mark

_____

_____

c. A calorimeter has been calibrated using 100 mL of water.
An experiment is then conducted where a total volume of 110 mL is unintentionally used.
Explain the impact of this error on each of the following;

i. the value of ΔT 1 mark

_____

ii. the value of ΔH for the reaction 1 mark

_____

SECTION B – Question 8 – continued

TURN OVER

d. The calibration factor of a calorimeter is 684 J $^{0}C^{-1}$. Determine the temperature change when 0.552 g of ethanol undergoes complete combustion in this calorimeter. 2 marks

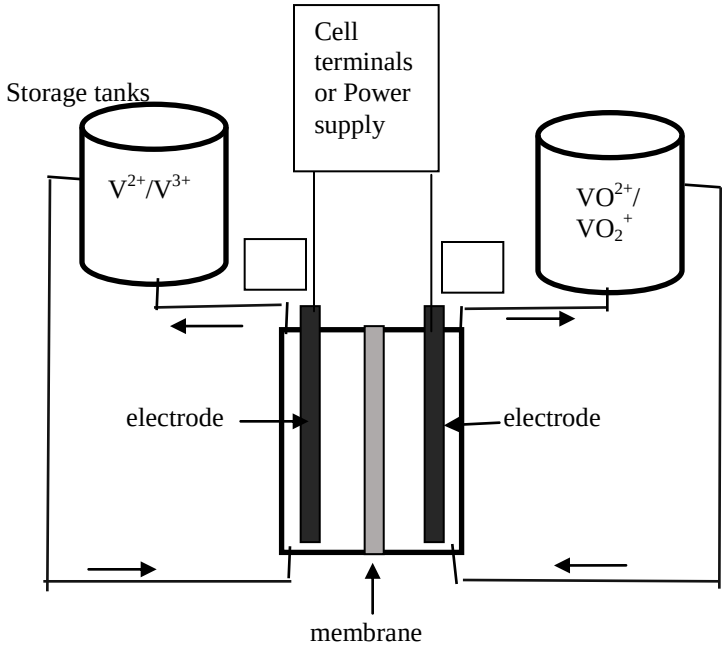
_____

_____

Question 9 (8 marks)

The vanadium redox flow battery was invented at the University of New South Wales in the 1970s. Several versions have been constructed but commercial production has never been viable. It is a secondary cell, where an external voltage is applied to reform the reactants when necessary. Reactants are stored in tanks and are pumped in a cycle around the electrodes and back to storage.

When this battery is **acting as a galvanic cell**, the reactants produce electrical energy, which can power nearby appliances. When the **cell is being recharged**, a power supply is connected to the terminals and the power supply reverses the half equations to restore the reactants.



The left hand storage tank contains V^{3+} ions and V^{2+} ions. The right hand tank contains VO_2^+ ions and VO^{2+} ions.

The relevant half equations needed to analyse this cell are;

$VO_2^+(aq) + 2H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$ 1.00 V

$V^{3+}(aq) + e^- \rightarrow V^{2+}(aq)$ - 0.26 V

SECTION B – Question 9 – continued

a. The element vanadium is present in four different oxidation states in the half equations. List these oxidation states. 2 marks

_____

b. **i**. Write an overall equation for the reaction occurring when the cell is discharging? 1 mark

_____

ii. What potential voltage will this cell produce? _____ 1 mark

iii. Use the spaces provided near the electrodes to identify the anode and the cathode for this cell. 1 mark

c. **i**. Write a balanced equation for the equation occurring when the cell is being recharged. 1 mark

_____

ii. What voltage should be used to recharge this cell? 1 mark

_____

iii. Explain what a secondary cell is. 1 mark

_____

Question 10 (9 marks)
Electrolysis is conducted on a series of cells and the reactions occurring are studied.

a. Cell A: Molten KCl 2 marks
Write a balanced half equation for the reaction occurring at each of

- the cathode

_____

- the anode

_____

SECTION B – Question 10 – continued
TURN OVER

b. Cell B: Dilute KCl solution 2 marks

Write a balanced half equation for the reaction occurring at each of

- the cathode

_____

- the anode

_____

c. Cell C: 4.0 M KCl solution 2 marks

i. Write a balanced half equation for the reaction occurring at each of

- the cathode

_____

- the anode

_____

ii. What volume of gas is produced at the negative electrode if a current of 3.4 amps runs for 25 minutes? The temperature is 24 ^{0}C and the pressure 105 kPa. 3 marks

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SECTION B – continued

Question 11 (10 marks)

25.0 mL of potassium dichromate solution were acidified and treated with excess KI (aq). The liberated iodine was titrated with 24.4 mL of 0.102 mol/L $Na_2S_2O_3$(aq).

a. Write the overall reaction that occurred when potassium dichromate reacted with potassium iodide. Ignore the spectator potassium ions and the products formed were the chromium (III) ion and iodine (I_2).

3 marks

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_____

_____

b. Write the overall reaction that occurred when iodine was reacted with sodium thiosulfate. Products were the $S_4O_6^{2-}$ ion and the iodide ion.

3 marks

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_____

c. Calculate the concentration of the $K_2Cr_2O_7$ (aq)

4 marks

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END OF QUESTION AND ANSWER BOOK