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2015 Trial Examination

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

CHEMISTRY

Written examination

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	94
			Total 124

- 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 24 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

An equation that can be used to calculate the mass of gas present in a sample is

A. $\frac{P \times V \times M}{R \times T}$

B. $\frac{P \times V}{M \times R \times T}$

C. $\frac{R \times T}{M \times P \times V}$

D. $\frac{M \times R \times T}{P \times V}$

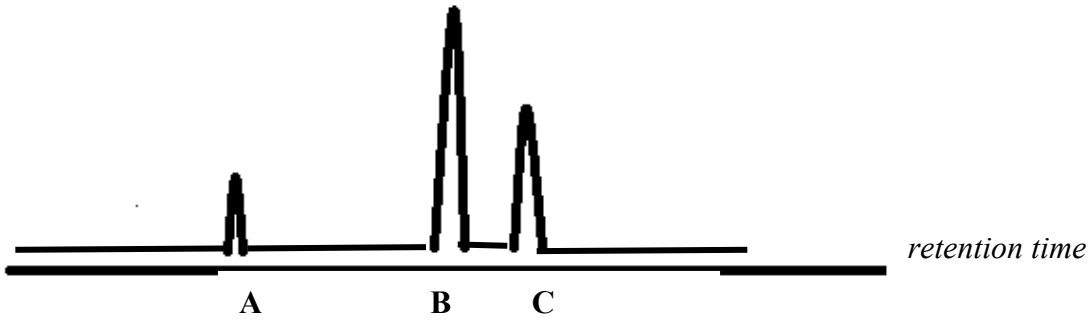
Question 2

Select the alternative that represents the greatest amount of hydrochloric acid.

A. 44.8 g of HCl gas
B. 1200 mL of 1.0 M HCl
C. 500 mL of 2.0 M HCl
D. 44.8 L of HCl gas at STP

Use the following information to answer Questions 3 and 4

A non-polar solvent is used in a HPLC column to separate three components in a mixture. The components are labelled on the chromatogram as A, B and C and component A has the shortest retention time.

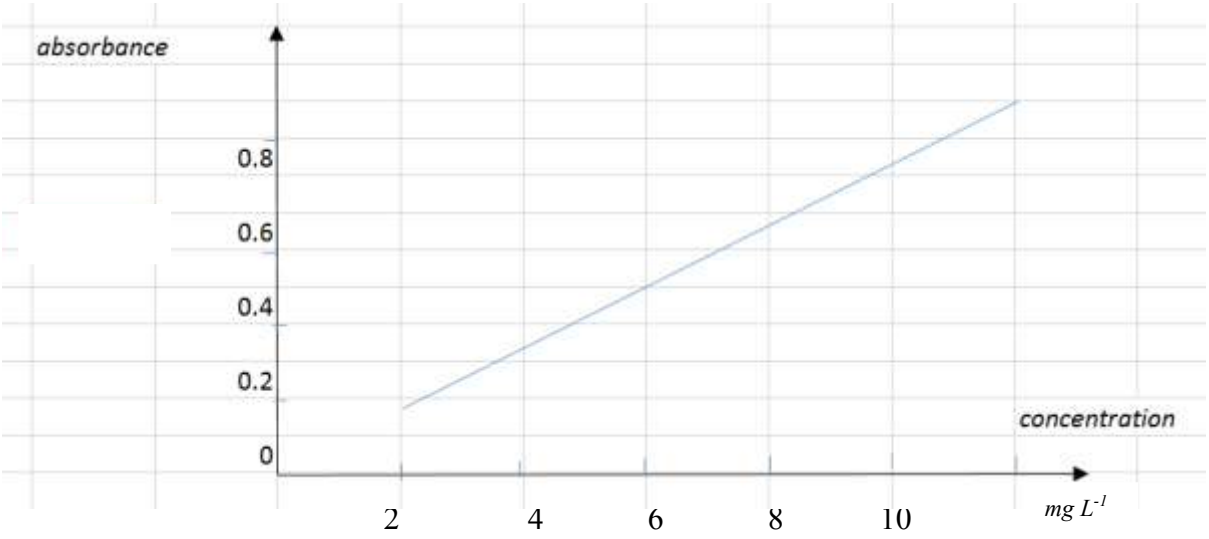


SECTION A – continued

Question 3
From the chromatogram we can conclude that
A. a faster flow rate of solvent is needed to better separate components B and C
B. component C is likely to be the least polar of the three components
C. component A is likely to be the least polar of the three components
D. component A adsorbs strongly on the stationary phase

Question 4
If the same mixture is now spotted on to a TLC plate and the same solvent used, it is likely that
A. component A will have the lowest R_f value
B. the R_f values will be in the same order as the retention time values
C. component A will have the highest R_f value
D. the order of R_f values will not be related to the retention time values

Use the following information to answer Questions 5 and 6
Arsenic levels in the soil in many regions of Victoria are relatively high, especially in some areas that were once goldfields. Atomic absorption spectroscopy can be used to determine arsenic levels. The graph below is a calibration curve prepared from arsenic standards.
A 10 g soil sample is mixed with acid and then added to a 100 mL volumetric flask. The flask is made up to the mark with distilled water and the solution is tested in the spectrometer. The absorbance is found to be 0.51



Question 5
The mass of arsenic in the sample, in g, is closest to
A. 6.0×10^{-4}
B. 6.0×10^{-3}
C. 0.6
D. 6.0

SECTION A – continued
TURN OVER

Question 6
Arsenic solutions are absorbing radiation
A. due to electrons moving from an excited state back to the ground state
B. as it requires energy to promote electrons to outer levels
C. as the bonds in the solution are stretched and rotated
D. when light of a complementary colour is directed at the solution

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. 73.5

Question 9
20 mL of 0.1 M NaOH is added to three separate flasks. A few drops of phenolphthalein indicator is added to each flask. Each flask is titrated with a different 0.1 M acid, the three acids used being phosphoric acid (H_3PO_4), hydrochloric acid and ethanoic acid. The expected titres, in mL, will be

	Phosphoric acid	Hydrochloric acid	Ethanoic acid
A.	6.66	20	20
B.	10	20	20
C.	40	20	30
D.	60	20	20

SECTION A – continued

Question 10
A 1.0 tonne sample of brown coal is estimated to be 24 % carbon by mass. The mass of carbon dioxide that will be produced from the complete combustion of the brown coal will be, in g,
A. 0.88
B. 8.8×10^2
C. 4.4×10^5
D. 8.8×10^5

Question 11
10 mL of 0.1 M NaOH is added to 10 mL of 0.3 M HCl. The pH of the resultant solution will be
A. 0.7
B. 1
C. 1.3
D. 7

Question 12
Which of the following alternatives is not a balanced half equation?
A. $Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$
B. $SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow SO_2(g) + 2H_2O(l)$
C. $CH_3CH_2OH(aq) + H_2(g) \rightarrow CH_3COOH(aq) + 4H^+(aq) + 2e^-$
D. $NO_2(g) + H_2O(l) \rightarrow NO_3^-(aq) + 2H^+(aq) + e^-$

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

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

SECTION A – continued
TURN OVER

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

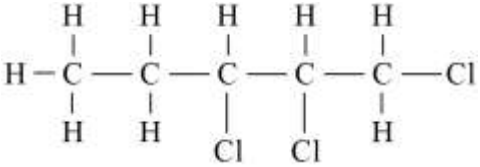
A. the reaction is endothermic
B. an alternative reaction must be occurring that is using up some of the chlorine
C. the activation energy for the forward reaction must be decreasing
D. the reaction is exothermic

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

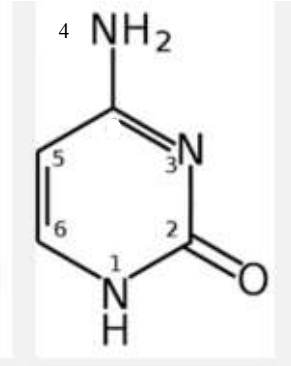


The systematic name of this molecule is

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

SECTION A – continued

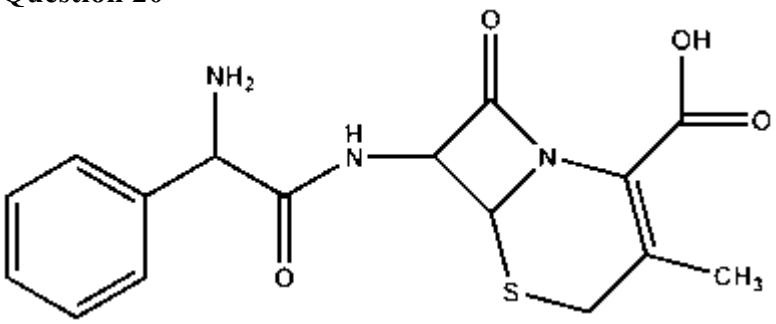
Question 19



The base molecule shown joins to a sugar molecule at the nitrogen atom marked with a 1. At which of the points 2 to 5, will this base form hydrogen bonds?

A. 2 and 4
B. 2, 3 and 4
C. 4, 5 and 6
D. 3, 4 and 5

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
TURN OVER

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

SECTION A – continued

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

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;

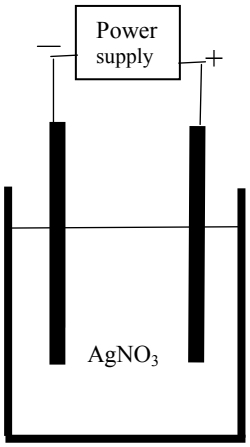
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

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

SECTION A – continued
TURN OVER

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

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

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 (9 marks)

Tartaric acid, $C_4H_6O_6$, is a weak diprotic acid found naturally in grapes and vinegar. The concentration of tartaric acid in a sample of grapes can be tested by back titration.

A 2.60 g sample of grapes is crushed and added to a 40.0 mL sample of 0.100 M NaOH.

The remaining NaOH is neutralised with 0.120 M sulfuric acid, H_2SO_4. The titre required is 14.6 mL.

a. **i**. Give one reason for the grapes being crushed. 1 mark

_____

ii. State one assumption made in this analysis. 1 mark

_____

b. **i**. If tartaric acid is represented as H_2Ta, write a balanced equation for the reaction between tartaric acid and NaOH. 1 mark

_____

ii. Write a balanced equation for the reaction between NaOH and H_2SO_4. 1 mark

_____

c. **i**. Calculate the amount of H_2SO_4 that reacted with excess NaOH. 1 mark

_____

SECTION B – Question 1 – continued
TURN OVER

ii. Determine the number of mole of NaOH added at the start. 1 mark

_____

iii. Calculate the mass of tartaric acid in the grapes. 2 marks

_____

_____

_____

iv. Calculate the percentage mass of tartaric acid in grapes. 1 mark

_____

_____

Question 2 (4 marks)

Nitrate ions can be converted to ammonium ions by bacteria.

a. What is the oxidation number of nitrogen in; 2 marks

- NO_3^- _____
- NH_4^+? _____

b. Write a balanced half equation for this conversion, assuming acidic conditions. 1 mark

_____

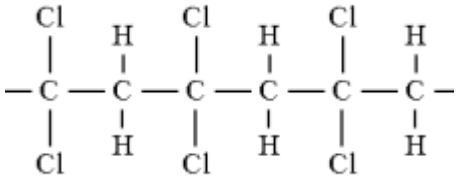
c. Write a balanced equation for the reaction of ammonium ions in water. 1 mark

_____

Question 3 (11 marks)

a.

A ⟶



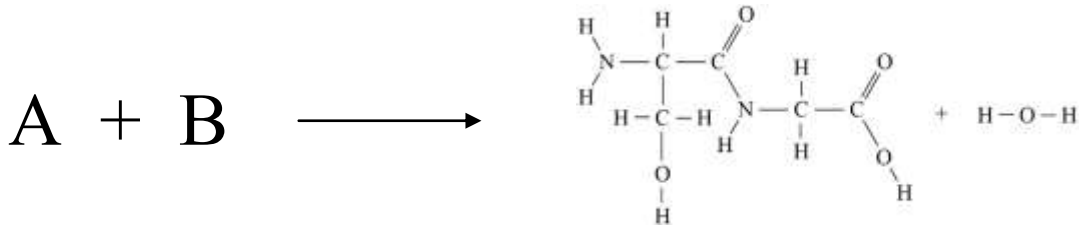
A segment of a polymer is shown. The polymer can be formed from monomer A.

i. Draw the structure of monomer A 1 mark

SECTION B - Question 3 – continued

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

b.



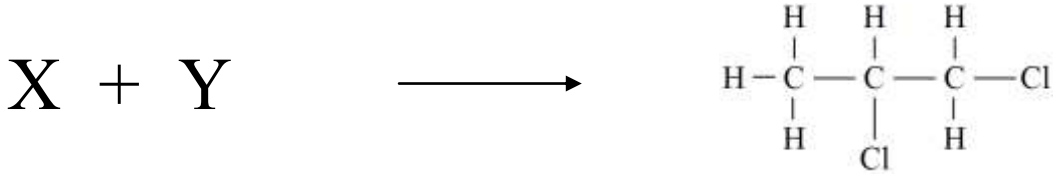
The reaction between molecules A and B forms the products shown above.

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.

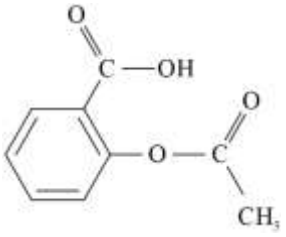


The reaction between X and Y produces the molecule shown as the sole product.

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

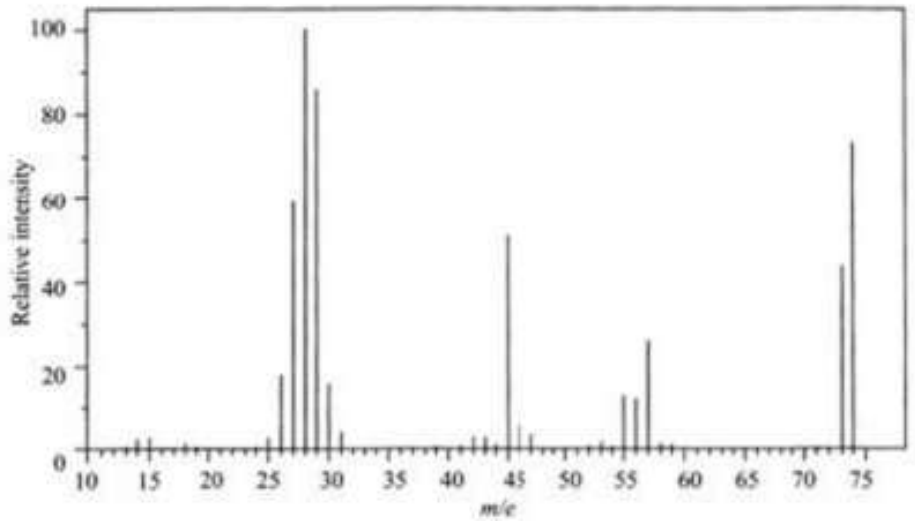
SECTION B – continued
TURN OVER

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

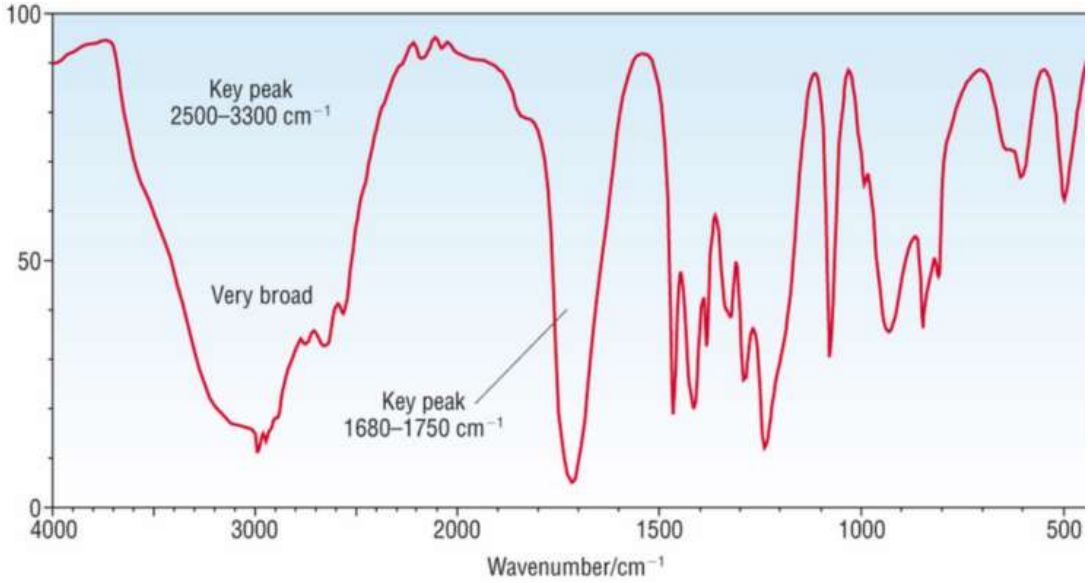
_____

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

_____

SECTION B – Question 4 - continued

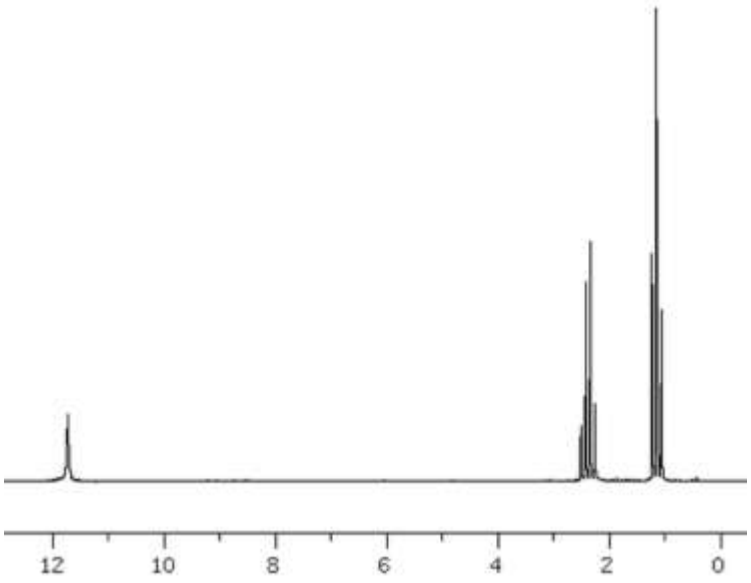
c. The infrared spectrum for propanoic acid is shown below.



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
TURN OVER

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

_____

_____

_____

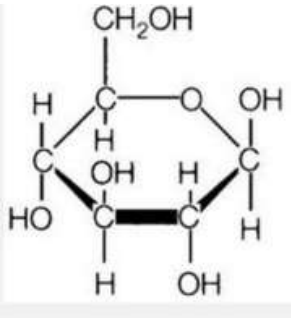
ii. It is not completely clear from the print-out what the splitting pattern is. You should however, be able to predict this from the structure. What is the likely splitting pattern at

- 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

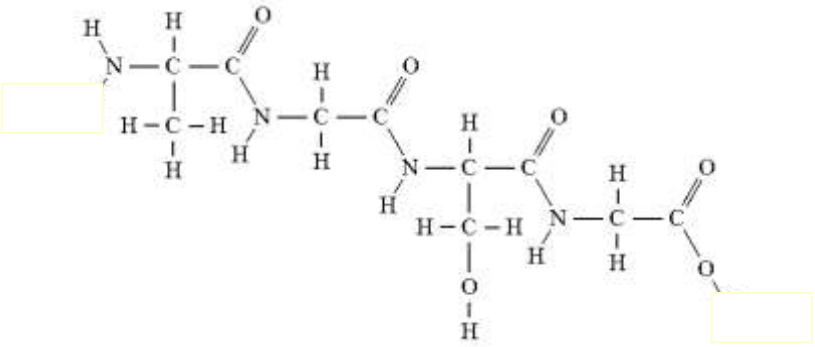
iv. Write a balanced equation for the complete combustion of glucose. 1 mark

_____

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

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 (11 marks)

a. A number of weak acids are listed in your Data Book. The highest K_a value provided is that of hydrofluoric acid while the lowest value provided is that of ammonium ion.

Calculate the pH of a 0.10 M solution of each of the following;

i. HCl _____ 1 mark

ii. HF 3 marks

_____

_____

_____

iii. NH_4^+ 3 marks

_____

_____

_____

SECTION B – Question 7 - continued

TURN OVER

b. The pH of a sample of pure water is found to be 6.8

i. What is the $[H_3O^+]$ in the water sample? 1 mark

_____

ii. What is the value of K_w? 1 mark

_____

iii. Write an equation for the self-ionisation of water. 1 mark

_____

iv. If the water sample is at 45 ^{0}C, what conclusion can you draw about whether the self-ionisation is exothermic or endothermic? Justify your answer. 1 mark

_____

_____

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

_____

_____

SECTION B – Question 8 - continued

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

_____

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

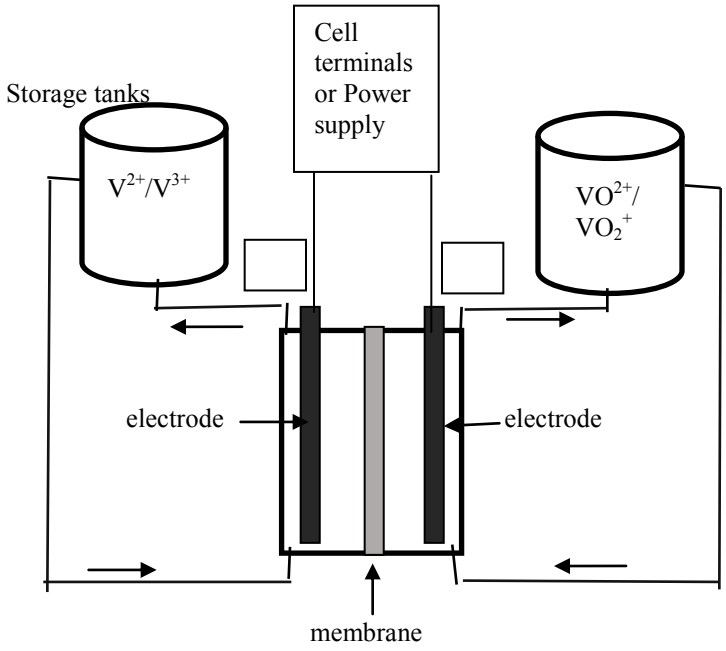
_____

_____

SECTION B – continued
TURN OVER

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

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

_____

SECTION B – Question 9 – continued

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

_____

b. Cell B: Dilute KCl solution 2 marks
Write a balanced half equation for the reaction occurring at each of

- the cathode

_____

SECTION B – Question 10 - continued
TURN OVER

- 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

_____

_____

_____

Question 11 (4 marks)

Iron forms several different compounds with sulfur. To find the empirical formula of a particular compound, a 4.000 g sample is burnt in excess oxygen. All the sulfur present is converted to sulfur dioxide, SO_2, and the mass of sulfur dioxide formed is 3.700 g.

Determine the empirical formula of the compound.

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_____

_____

_____

END OF QUESTION AND ANSWER BOOK