THE SCHOOL FOR EXCELLENCE (TSFX)

UNITS 3 & 4 CHEMISTRY 2015

WRITTEN EXAMINATION

Reading Time: 15 minutes
Writing Time: 2 hours 30 minutes

QUESTION AND ANSWER BOOK

Student Name:

Structure of Booklet

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 white out liquid/tape.

Materials Supplied

- Question and answer book of 35 pages.

Instructions

- Write your **name** in the space provided above on this page.
- All written responses must be in English.

Students are **NOT** permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

QUESTION 1

If $10.0\ g$ of $Na_2CO_3.10H_2O$ is heated to remove all water, the mass loss would be

A $0.50\,g$
B $0.63\,g$
C $3.70\,g$
D $6.29\,g$

QUESTION 2

Carbon monoxide reacts with oxygen as follows: $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$

If $100\ cm^3$ of CO and $100\ cm^3$ of O_2 are mixed at STP, the final volume of gas in the mixture will be

A $50\ cm^3$
B $100\ cm^3$
C $150\ cm^3$
D $200\ cm^3$

QUESTION 3

$5.00\ g$ of $AgNO_3$ and $10.00\ g$ of $MgCl_2$ were dissolved in $200.00\ ml$ of water. Assuming that complete ionisation occurs, the number of ions in solution is

A 1.11×10^{23}
B 1.63×10^{23}
C 1.89×10^{23}
D 2.27×10^{23}

QUESTION 4
Lead is a very toxic metal and there is no concentration of lead in the blood that is considered to be safe. Lead poisoning, however, is defined as a concentration of $10\mu gL^{-1}$. Which of the following is not equivalent to this concentration?

A $4.8\times10^{-8}M$
B $1\times10^{-6}\ \%\ w/v$
C $0.010\ mgL^{-1}$
D $0.10\ ppm$

QUESTION 5
Which of the following statements is **incorrect**?

A The oxidation number of Cl in $Ba(ClO_3)_2$ is $+5$.
B The oxidation number of N in NH_3 is $-\frac{1}{3}$.
C The oxidation number of O in OF_2 is -2.
D The oxidation number of H in $LiAlH_4$ is $+1$.

QUESTION 6
Gas chromatography could **not** be used to

A Determine the purity of a sample of perfume.
B Separate low molecular weight alcohols.
C Compare the components of two petrol samples.
D Determine the concentration of aspirin in an analgesic tablet.

QUESTION 7
A certain amino acid contained 40.4% carbon, 7.9% hydrogen and 15.7% nitrogen.
If the balance of the molecule is oxygen, the amino acid is most likely to be

A Alanine
B Cysteine
C Glycine
D Valine

QUESTION 8

A VCE chemistry student analysed the sulfuric acid content (H_2SO_4) of car battery acid using the procedure shown below.

1. Extraction of a $10\ ml$ sample of battery acid using a graduated pipette.
2. Sample placed into a $250\ ml$ conical flask and $50\ ml$ distilled water added.
3. Excess $BaCl_2$ solution added to flask to ensure all the sulfate present in the acid precipitated as $BaSO_4$.
4. Precipitate collected by filtration, dried and weighed to constant mass.
5. Mass of precipitate obtained = $9.3\ g$.

From this information, the approximate concentration of H_2SO_4 in battery acid is

A $0.7\ mol\ L^{-1}$
B $1\ mol\ L^{-1}$
C $2\ mol\ L^{-1}$
D $4\ mol\ L^{-1}$

QUESTION 9

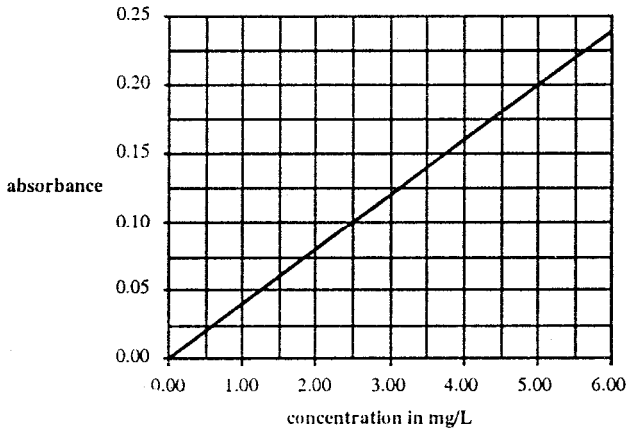
The amount of salt in a packet of potato chips was determined using gravimetric analysis. $5.75\ g$ of the chips were ground up and then $50.0\ ml$ of water was added. The mixture was filtered and then excess silver nitrate was added. The precipitate was collected, dried and weighed to constant mass. The percentage of sodium chloride in the chips was then determined.

Which experimental error/mistake could cause the percentage of sodium chloride to be higher than the actual value?

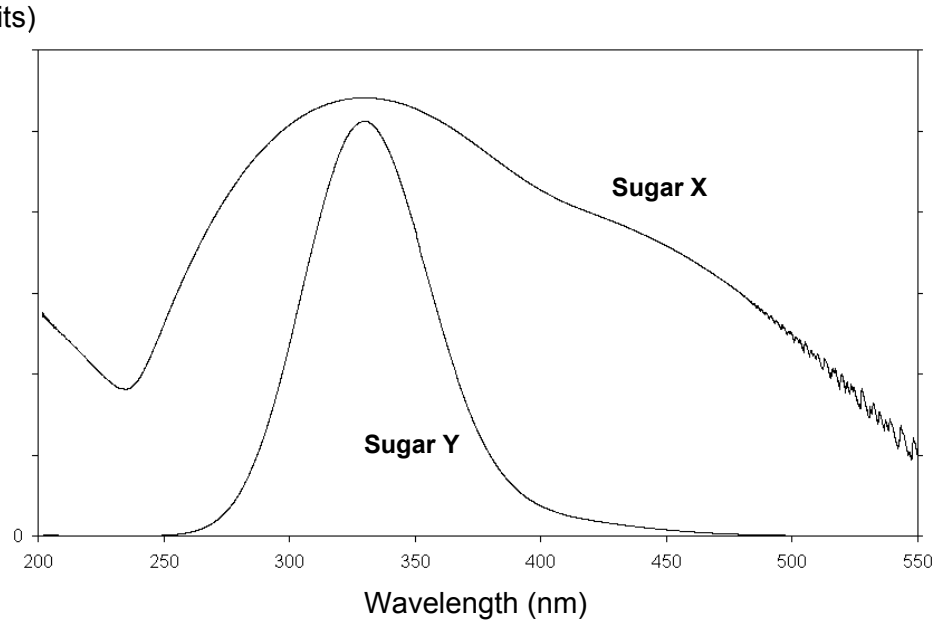
A Incomplete transfer of the precipitate to the filter paper.
B The amount of silver nitrate added to the mixture was not in excess.
C The mass of the sample was recorded as $5.57\ g$ rather than the actual mass of $5.75\ g$.
D Some of the sodium ions remained in solution.

QUESTION 10
The calibration graph below shows the absorbance of a series of standard solutions containing magnesium, when analysed using an atomic absorption spectrometer.
The $2.00\ ml$ sample was diluted to $10.00\ ml$ and a small aliquot produced an absorbance reading of 0.10 units. The concentration of magnesium in the undiluted sample is

A $2.5\ ppm$
B $12.5\ ppm$
C $25\ ppm$
D $125\ ppm$



QUESTION 11
The ultraviolet spectrum of two different sugars is given below.



Which wavelength would you select to measure the concentration of Sugar X without interference from Sugar Y ?

A $200\ nm$
B $240\ nm$
C $335\ nm$
D $550\ nm$

QUESTION 12
Which of the following statements is incorrect?

A The ^{12}C nucleus will undergo a measurable change in spin energy levels when exposed to radiation from the radio wave region of the electromagnetic spectrum.

B There is insufficient energy in radio wave radiation to cause bending and stretching in covalent bonds.

C Energies corresponding to the visible spectrum are able to cause excitation of valence electrons in atoms and molecules.

D Different functional groups in organic molecules absorb radiation of different frequencies from the infra-red region of the electromagnetic spectrum.

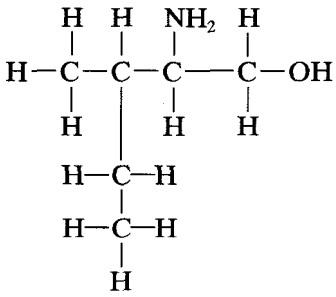
QUESTION 13
An analytical technique that **could not** be used to obtain information that could assist in the determination of the structure of an amino acid is

A Atomic Absorption Spectroscopy
B Nuclear Magnetic Resonance Spectroscopy
C Infrared spectroscopy
D Thin Layer Chromatography

QUESTION 14
The organic compound in with the lowest solubility in water is

A Methanoic acid
B Ethanoic acid
C Propanoic acid
D Butanoic acid

QUESTION 15
The systematic name for the given compound is



A 2-amino-3-methylpentan-1-ol
B 4-amino-3-methylpentan-1-ol
C 3-amino-2-ethylbutan-2-ol
D 2-ethyl-3-aminobutan-4-ol

QUESTION 16
2-methyl-2-butanol is an isomer of

A 2-butanol
B pentanoic acid
C 1-pentanol
D 2,3-dimethyl-2-butanol

QUESTION 17
Which statement regarding the reaction of ethanol and ethanoic acid is incorrect?

A The reaction can be described as a condensation and an esterification reaction.

B The reaction requires the presence of concentrated sulphuric acid in order to proceed.

C The % C in the product will be less than the total % C in the ethanol and ethanoic acid.

D The product created has the formula $CH_3CH_2OCOCH_3$.

QUESTION 18
Saran is a copolymer made by polymerising a mixture of two monomers. A section of Saran has the following structure:

$$-CH_2-CCl_2-CH_2-CHCl-CH_2-CCl_2-CH_2-CHCl-CH_2-CCl_2-CH_2-CHCl-$$

The monomers used to form this polymer include

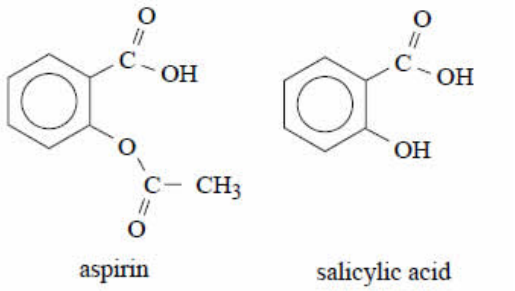
A CH_2CCl_2 and CH_2CHCl

B CH_2CH_2 and CCl_2CCl_2

C CH_3CHCl_2 and CH_3CH_2Cl

D CH_2CH_2 and Cl_2

QUESTION 19
The structure of salicylic acid and aspirin are given below.



The synthesis of aspirin from salicylic acid

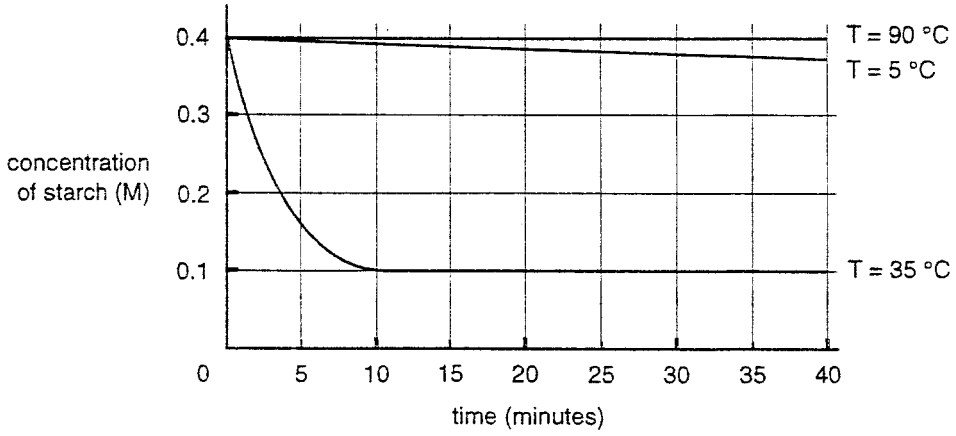
A Is classified as an addition reaction.

B Involves the reaction between a carboxylic acid group and acetic anhydride.

C Results in the formation of an ether link and a molecule of ethanoic acid.

D Involves the transformation of a hydroxyl group into an ester link via a condensation reaction.

QUESTION 20
The following graph shows the concentration of starch in a mixture containing amylase at different temperatures. Which of the following statements is incorrect?



A The reaction rate at 5^oC is small as the greater majority of the amylase has been denatured at this temperature.

B As the temperature decreases, the reaction rates decrease.

C The enzyme is denatured at 90^oC.

D The reaction occurring at 35^oC is a hydrolysis reaction.

QUESTION 21
A ranger out on a three day hike at 10^oC and $1.5\ atm$ carries a $4.0\ L$ canister of butane gas to boil water for his evening meals. The butane gas needs to supply enough energy to raise the temperature of the water from 10^oC to boiling. How much water can the ranger boil on each of the two evenings?

A $682\ mL$
B $986\ mL$
C $1364\ mL$
D $1970\ mL$

QUESTION 22
Consider the following equations:

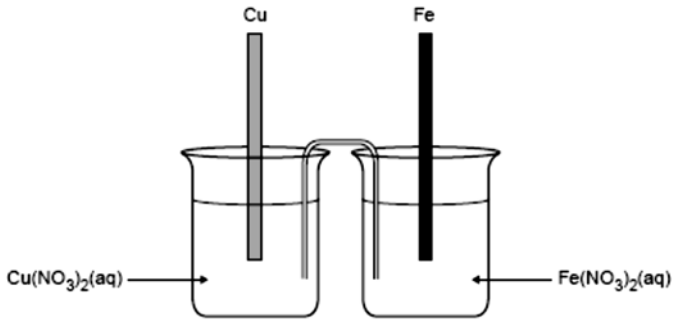
$$Na_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(s)} + \frac{1}{2}H_{2(g)} \qquad \Delta H = -146\ kJ$$

$$Na_2SO_{4(s)} + H_2O_{(l)} \rightarrow 2NaOH_{(s)} + SO_{3(g)} \qquad \Delta H = +418\ kJ$$

The enthalpy change for the reaction $Na_2SO_{4(s)} + H_{2(g)} \rightarrow 2Na_{(s)} + H_2O_{(l)} + SO_{3(g)}$ is

A $-126\ kJ$
B $+408\ kJ$
C $+564\ kJ$
D $+710\ kJ$

QUESTION 23
A student sets up a galvanic cell using two standard half cells as illustrated below.



The solutions are connected to each other with a salt bridge consisting of an inverted U-tube containing an appropriate electrolyte.

Which species below could be used as the electrolyte for the salt bridge in the illustrated cell?

A CH_3OH
B $NH_4(NO_3)$
C $AgNO_3$
D KOH

QUESTION 24

When metal X is placed in a solution of Y^{2+} ions, Y and X^{2+} are formed. When both metals are placed in an acidified solution, no reaction occurs. The order in which the species X^{2+}, Y^{2+} and H^+ decrease in oxidising strength is

A $Y^{2+} > X^{2+} > H^+$
B $X^{2+} > Y^{2+} > H^+$
C $H^+ > Y^{2+} > X^{2+}$
D $X^{2+} > H^+ > Y^{2+}$

QUESTION 25

The most common secondary cell is the lead-acid accumulator, which is used as a car battery. The overall equation representing the discharge reaction in this cell is:

$$Pb_{(s)} + PbO_{2(s)} + 2SO^{2-}_{4(aq)} + 4H^+_{(aq)} \rightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$$

In the recharging process

A $Pb_{(s)}$ is produced at the negatively charged anode.
B $Pb_{(s)}$ is produced at the negatively charged cathode.
C $PbO_{2(s)}$ is produced at the negatively charged anode.
D $PbO_{2(s)}$ is produced at the negatively charged cathode.

QUESTION 26

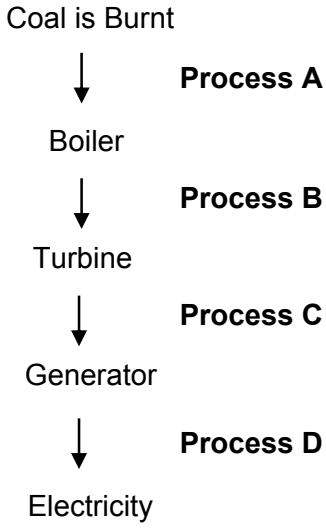
Fuel cells do not store energy; they convert energy directly and continuously to electrical energy. A fuel cell may be constructed using methanol and oxygen contained in an alkaline electrolyte. The overall reaction for the methanol/oxygen fuel cell is:

$$2CH_3OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 4H_2O_{(l)}$$

If the reaction at the cathode is $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$ then the reaction at the anode would be

A $CH_3OH_{(l)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 6H^+_{(aq)} + 6e^-$
B $CH_3OH_{(l)} + 6OH^-_{(aq)} \rightarrow 2CO_{2(g)} + 5H_2O_{(l)} + 6e^-$
C $CH_3OH_{(l)} + 3O_{2(g)} \rightarrow CO_{2(g)} + 3H_2O_{(l)}$
D $CH_3OH_{(l)} \rightarrow CO_{(g)} + 4H^+_{(aq)} + 4e^-$

QUESTION 27
Most of Australia's electrical energy is obtained from the combustion of coal. A diagram of the processes involved in the production of electricity in a coal fired power station is given below.



Which of the following best describes the energy transformation that occurs in Process C?

	Reactants		**Products**
A	Chemical potential energy	is converted to	Kinetic energy
B	Chemical potential energy	is converted to	Chemical potential energy
C	Kinetic energy	is converted to	Chemical potential energy
D	Kinetic energy	is converted to	Kinetic energy

QUESTION 28
$1.50\,g$ of pure methanol is placed in a bomb calorimeter at $20.50^{o}C$ and reacted with excess oxygen at high pressure. If the calibration factor of the calorimeter is $5.41 kJ/K$, the final temperature of the calorimeter is closest to

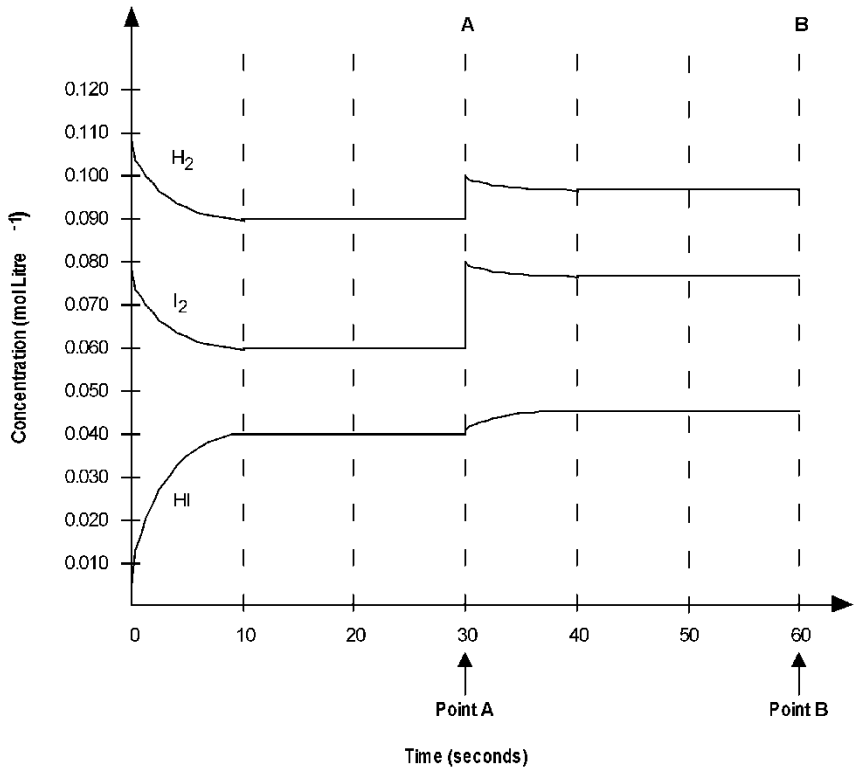
A $6.30^{o}C$
B $12.60^{o}C$
C $14.20^{o}C$
D $26.80^{o}C$

QUESTION 29

The reaction between $H_{2(g)}$ and $I_{2(g)}$ in a $1.0\,L$ container was observed to be:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)} \quad \Delta H = -ve$$

During the reaction the temperature was kept at $200^{o}C$. The concentration versus time graph for this reaction was determined and is shown below.



What change occurred at Point B?

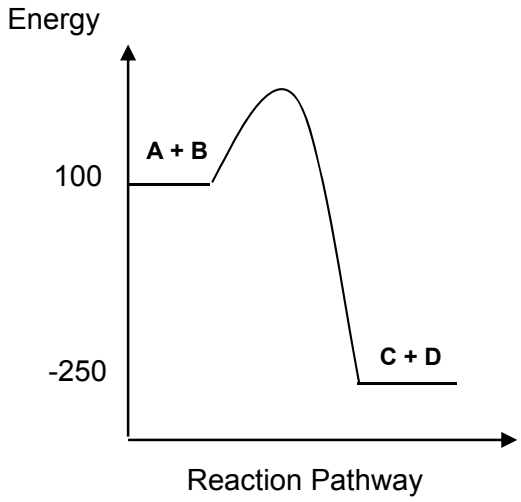
A The volume of the vessel was decreased, changing the value of K.

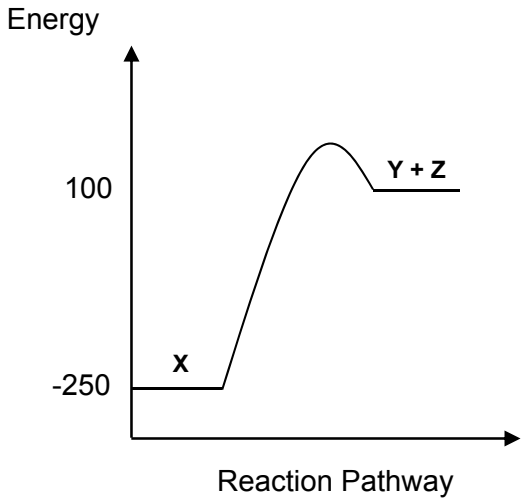
B The volume of the vessel was decreased, without a change in the value of K.

C $H_{2(g)}$ and $I_{2(g)}$ were added, changing the value of K.

D $H_{2(g)}$ and $I_{2(g)}$ were added, without a change in the value of K.

QUESTION 30
The energy profiles of two reactions are shown below.





The reaction with the lowest activation energy is

A $A + B \rightarrow C + D$
B $X \rightarrow Y + Z$
C $C + D \rightarrow A + B$
D $Z + Y \rightarrow X$

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using black or blue pen.

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 working in your answers to numerical questions; no marks 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, $H_{2(g)}$, $NaCl_{(s)}$.

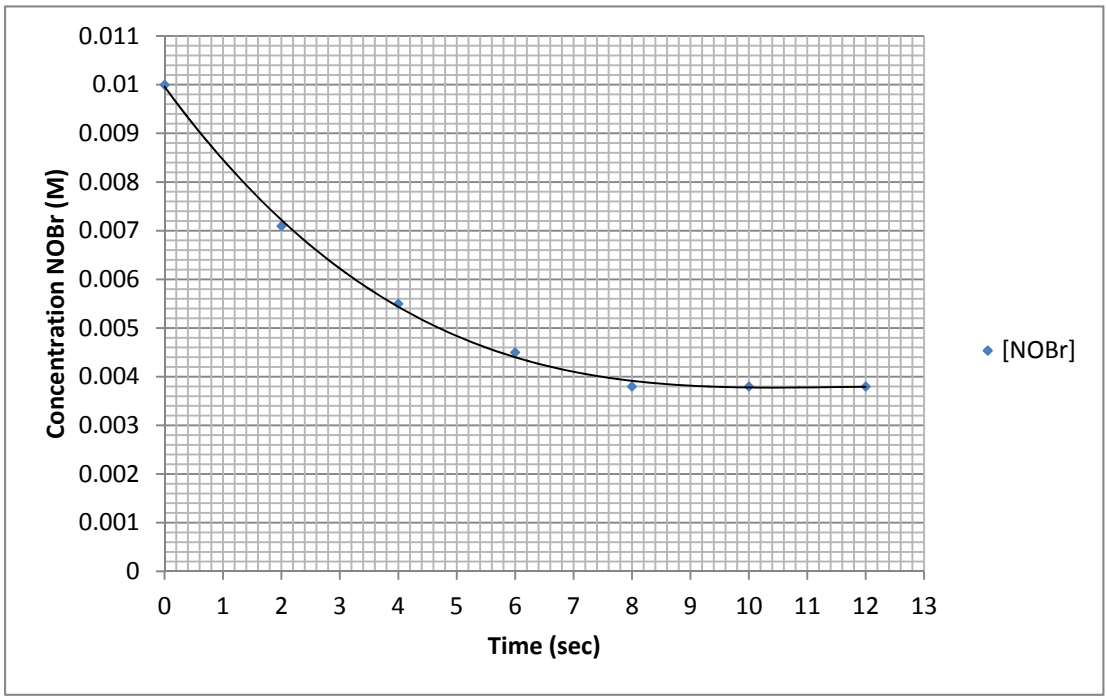
QUESTION 1 (7 marks)
Nitrosyl bromide decomposes according to the following equation:

$$2NOBr_{(g)} \rightarrow 2NO_{(g)} + Br_{2(g)}$$

A student placed some nitrosyl bromide in a container and used a manometer (an instrument for comparing pressures) to collect the below data.

Time (sec)	Concentration $NOBr\,(M)$
0	0.0100
2	0.0071
4	0.0055
6	0.0045
8	0.0038
10	0.0038
12	0.0038

The data collected was used to plot the following graph:



a. Determine:

i. The initial rate of reaction in terms of [$NOBr$].

_____

_____

_____

_____

1 mark

ii. The average rate of reaction across the first 8 seconds. State your answer in terms of [$NOBr$].

_____

_____

_____

_____

1 mark

b. The initial rate of reaction is greater than the average rate over the first 8 seconds. Give a reason for this observation.

_____

_____

_____

_____

1 mark

c. On the given graph, show how the concentration of Br_2 would change over the 10 second period.

2 marks

d. The student repeats the experiment using a higher pressure, which was accomplished by decreasing the volume of the container at constant temperature. Explain the effect of this change on the back reaction rate.

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2 marks

QUESTION 2 (12 marks)
John has always been interested in cooking and so decides to mix his hobby with his studies to determine the accuracy of a claim on the packet of bicarbonate soda that he had been using.

The label on this packet states: **"Ingredients: Bicarbonate soda"** implying that the product is 100% bicarbonate soda. He knew that bicarbonate soda was the old common name still in use for the compound known by chemists as sodium hydrogen carbonate, $NaHCO_3$.

John collected a bottle containing $0.100\,M\ HCl$ from the school laboratory, as well as a $250\,mL$ volumetric flask, a $20\,ml$ pipette, a $20\,ml$ burette and a $50\,ml$ burette. He carefully weighed out $2.06\,g$ of baking soda, transferred it to the $250\,mL$ volumetric flask and added water to the mark. After careful mixing, $20.00\,ml$ was transferred to a conical flask.

a. **i.** Write an equation to represent the reaction that would occur during the titration.

_____

_____

1 mark

ii. Explain why a $20\,ml$ burette will not be adequate for this titration. Provide relevant calculations to support your answer.

_____

_____

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_____

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_____

2 marks

John fills a $50.00\,mL$ burette with the $0.100\,M\ HCl$ solution and adds a few drops of phenolphthalein indicator into the flask containing $NaHCO_3$.

b. Is phenolphthalein an appropriate indicator for this reaction? Give a reason to support your answer.

_____

_____

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_____

2 marks

John performs 4 titrations and the following titres were obtained:

$24.36\ mL$ $22.64\ mL$ $22.58\ mL$ $22.56\ mL$

He calculates a mean titre of $24.04\ mL$ and uses this value for his calculations.

c. **i.** Comment on John's calculation of the mean titre.

_____

_____

_____

1 mark

ii. Using John's calculated mean titre, find the % purity of the bicarbonate soda.

_____

_____

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_____

3 marks

iii. Give **two** reasons why John's calculated percentage purity markedly overestimates the true value. In your answer, provide a clear explanation as to how **one** of your stated reasons results in a higher calculated percentage.

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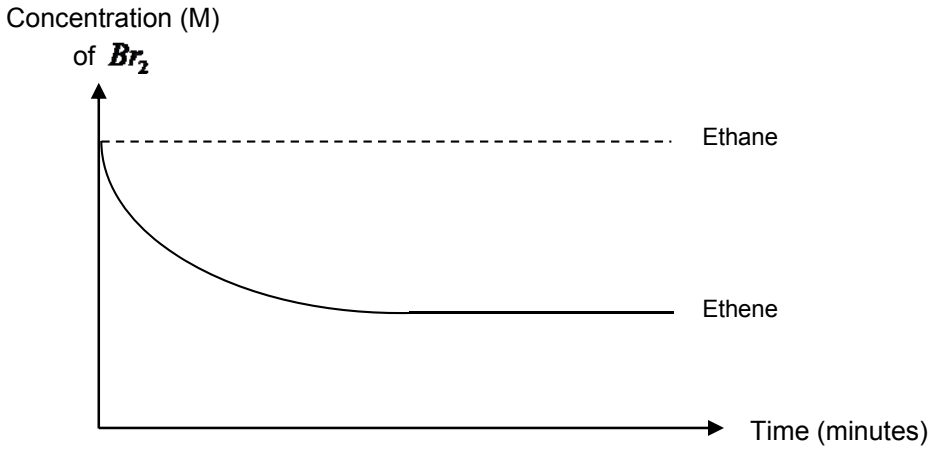
3 marks

QUESTION 3 (11 marks)

Br_2 is added to a sample of ethene, and separately, to a sample of ethane. The variation in $Br_{2(aq)}$ concentration was monitored using colorimetry, and the following graph was obtained.



a. **i.** Explain why the concentration of bromine decreases when it reacts with ethene. In your answer, give an equation to describe the reaction occurring.

_____

_____

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2 marks

ii. What needs to be introduced to the mixture containing ethane before the concentration of bromine is observed to decrease?

_____

_____

1 mark

b. Explain why alkanes and their corresponding alkenes have similar physical properties, but very different chemical properties.

_____

_____

_____

_____

2 marks

c. **i.** Write equations using structural formulae to illustrate the production of propanoic acid from propene. In your answer, give the name of any catalysts used in the process.

3 marks

ii. Ethene reacts in the presence of acidified $MnO^-_{4(aq)}$ to produce $C_2H_4(OH)_{2(l)}$ and $Mn^{2+}_{(aq)}$. Write the equation describing this reaction.

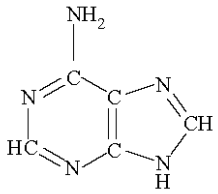
3 marks

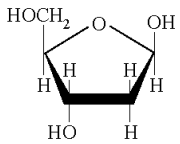
Total 11 marks

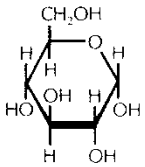
QUESTION 4 (8 marks)
The following structures represent some biologically important molecules.

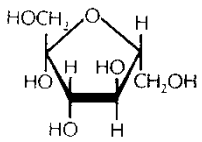
A H_2NCHCH_3COOH

B $CH_3(CH_2)_{14}COOH$

C 

D 

E 

F 

G $NH_2CH_2CH_2COOH$

H $C_{12}H_{22}O_{11}$

I H_2O

a. Circle the response(s) that best answer the questions below.

i. Which molecule(s) could be used to form proteins in the human body?

A B C D E F G H I

ii. Which structure(s) represent the product(s) of the hydrolysis of carbohydrates?

A B C D E F G H I

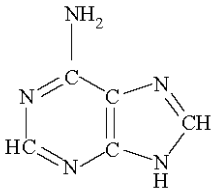
iii. Which structure(s) represent the product(s) of the complete oxidation of fats?

A B C D E F G H I

1 + 1 + 1 = 3 marks

b. Molecule C forms a component of human DNA. This molecule forms specific bonds with another nitrogen containing compound on a complementary strand of DNA.

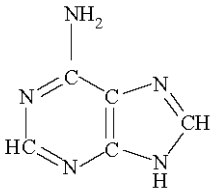
Molecule C

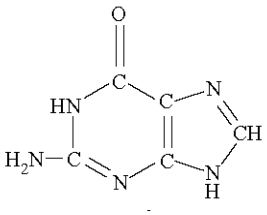


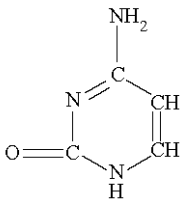
i. Circle the components directly involved in maintaining the secondary structure of DNA.

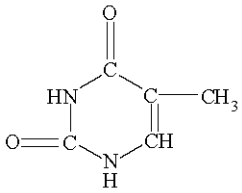
1 mark

ii. Identify the base which is complementary to Molecule C and circle the components of this molecule that are directly involved in maintaining the secondary structure of DNA with molecule C.







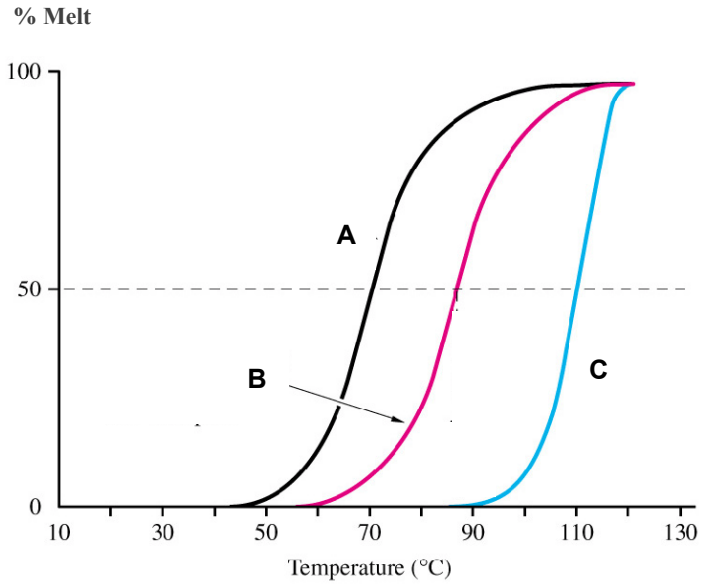


2 marks

c. When double stranded DNA samples are heated, the strands separate in a process known as “melting”.

DNA melting is often used to detect sequence differences between different strands of DNA, as well as to obtain an indication of the relative amounts of each base in a DNA strand.

The % Melt for 3 different DNA strands at varying temperatures is given below. Assuming that the strands contain the same number of nucleotides, identify the curve (A, B or C below) that most likely represents the melt properties of a strand of DNA containing large amounts of Molecule C. Give a reason for your answer.



_____

_____

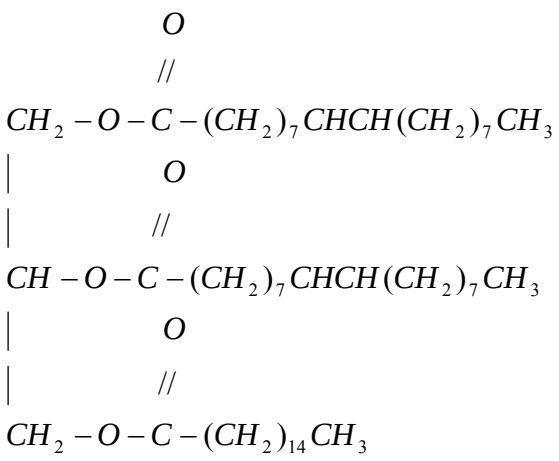
_____

_____

_____

2 marks

QUESTION 5 (7 marks)
Fats and oils in foods are made up of complex mixtures of saturated and unsaturated fatty acids. One such example is olive oil, which is illustrated below.



a. In the space above, write an equation to show the hydrolysis of this oil, clearly showing the products of the reaction.

2 marks

b. Some of the products of the hydrolysis of fats and oils can be used to form biodiesel.

i. Write **an** equation to represent the production of a biodiesel fuel from olive oil.

_____

_____

_____

_____

1 mark

ii. Write **an** equation to show the incomplete combustion of your biodiesel fuel.

_____

_____

_____

_____

1 mark

c. A sample of olive oil was reacted as follows: $Oil + A \xrightarrow{B} Fat$

i. Identify:

Reagent A: _____

Substance B: _____

1 + 1 = 2 marks

ii. Which statement below **incorrectly** describes a change in the physical property of the oil when it is converted into a fat? Circle the incorrect response.

A Product becomes more solid.

B The melting point of the product decreases.

C Product becomes harder to spread.

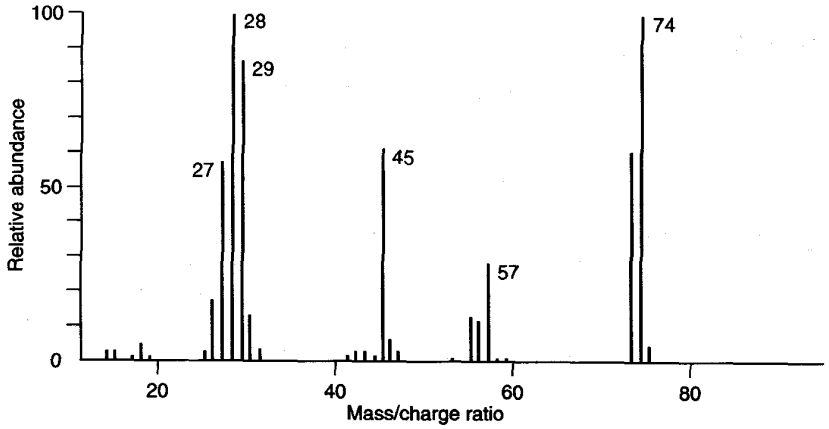
D The density of the product increases.

1 mark

QUESTION 6 (9 marks)

Compound X is an organic molecule with empirical formula $C_3H_6O_2$. The infrared spectrum, mass spectrum and proton NMR spectrum for this compound are given below.

Mass Spectrum for Compound X



a. **i.** Give the formula of the component that produced the peak at mass/charge ratio 74.

_____

1 mark

ii. Account for the structural differences for the components that produced the peaks at mass/charge ratio 74 and 75.

_____

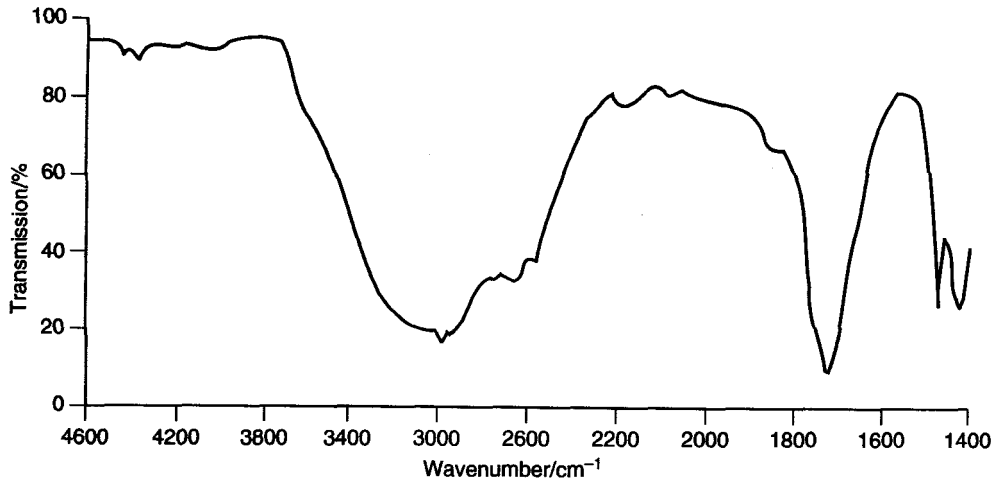
_____

_____

_____

1 mark

Infra-Red Spectrum for Compound X



b. **i.** To which family of organic compounds does $C_3H_6O_2$ belong?

_____

_____

1 mark

ii. Would the same infra-red spectrum be obtained if Compound X was analysed in its gaseous state rather than as a liquid? Give a reason for your answer.

_____

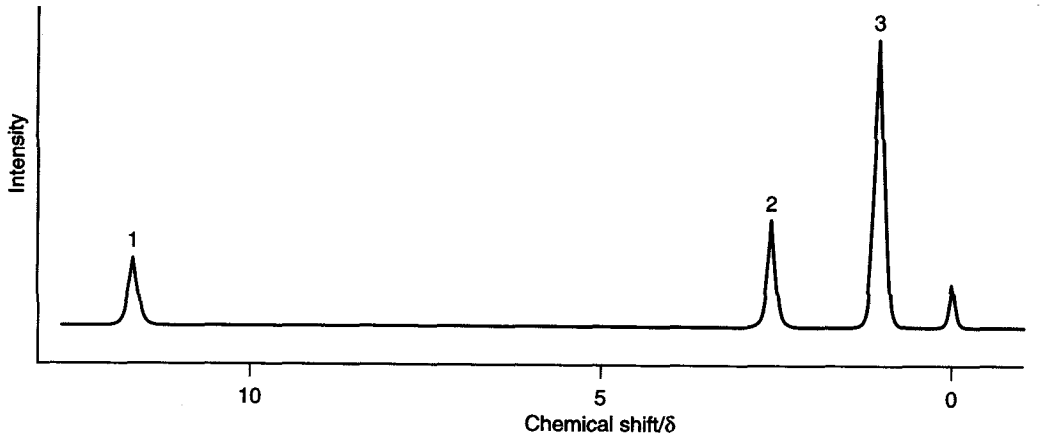
_____

_____

_____

2 marks

Proton NMR Spectrum for Compound X



c. **i.** Use the above spectrum in conjunction with the spectra from parts **a.** and **b.** to draw the structural formula for Compound X.

2 marks

ii. Would an isomer of Compound X produce the same proton NMR spectrum to that given above? Give a reason for your answer.

_____

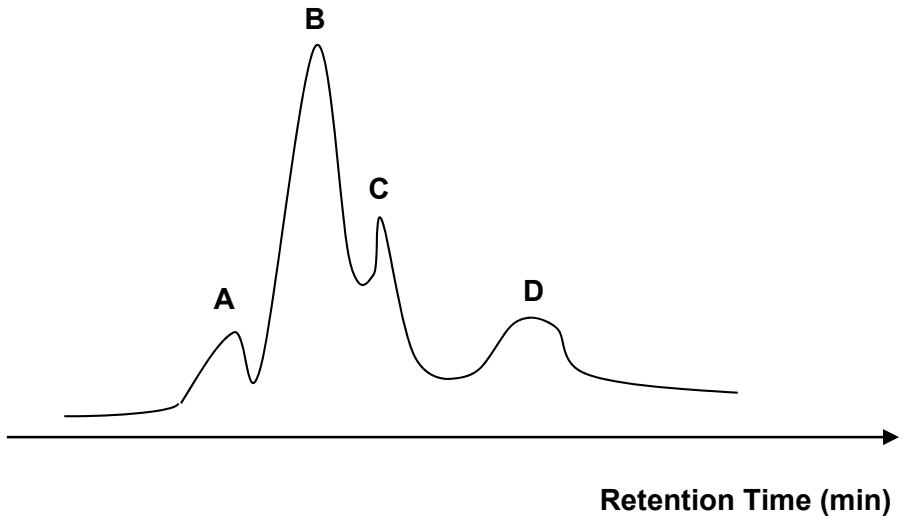
_____

_____

_____

2 marks

QUESTION 7 (7 marks)
A mixture containing low molecular weight alcohols and carboxylic acids were separated using chromatography on a polar stationary phase. The chromatogram obtained is illustrated below.



A sample containing a mixture of ethanol, ethanoic acid, propanol and propanoic acid was injected into the top of the column and vapourised.

a. **i.** Why it is important to vapourise the sample upon entry into the column?

_____

_____

_____

1 mark

ii. Give an example of an appropriate mobile phase for this column.

_____

1 mark

Peaks A and B represent the alcohols whereas peaks C and D represent the carboxylic acids in the mixture.

b. **i.** Explain, in terms of bonding and structure, why the carboxylic acids display longer retention times as compared to the given alcohols.

_____

_____

_____

2 marks

ii. Identify the alcohol at peak B.

_____

1 mark

iii. Which species, A, B, C or D is present in the lowest concentration?

_____

1 mark

iv. State two changes that could be applied to produce a better separation of peaks.

_____

_____

1 mark

QUESTION 8 (8 marks)

H_2SO_4 is one of the most important chemicals produced in industry, as there are very few consumer goods that do not require the acid at some stage in their production.

As an example, the production of peroxymonosulfuric acid (H_2SO_5) is formed by mixing concentrated hydrogen peroxide and concentrated sulfuric acid.

$$H_2O_{2(l)} + H_2SO_{4(l)} \rightleftharpoons H_2SO_{5(l)} + H_2O_{(l)}$$

a. Write an expression for the equilibrium constant for this reaction.

_____

_____

1 mark

b. During the production of peroxymonosulfuric acid, the initial amounts, in mole, of $H_2SO_4 : H_2O_2 : H_2O$ used is $2.5 : 1.0 : 1.8$. When 2.50 mole of H_2SO_4 is used, 0.70 mole of H_2SO_5 is present at equilibrium. If the volume of the mixture is $1.0\ dm^3$, calculate the equilibrium constant for the formation of peroxymonosulfuric acid.

_____

_____

_____

_____

_____

_____

_____

_____

3 marks

c. One equilibrium has been established, H_2SO_5 is removed from the reaction mixture keeping temperature and volume constant. Choose the correct answer for each of the statements below (✓).

i. Equilibrium is re-established via:

- ☐ A net forward reaction
- ☐ A net back reaction.

ii. While equilibrium is being re-established, the rate of the forward reaction:

- ☐ Increases
- ☐ Decreases
- ☐ Remains constant

iii. Once equilibrium has been re-established, the amount of H_2SO_5 will be:

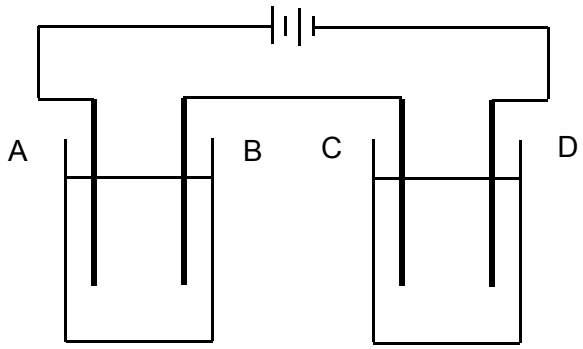
- ☐ Higher
- ☐ Lower
- ☐ The same as the previous equilibrium amount of H_2SO_5.

iv. Once equilibrium has been re-established, the forward and back reaction rates will be:

- ☐ Higher
- ☐ Lower
- ☐ The same as the previous equilibrium reaction rates.

1 + 1 + 1 + 1 = 4 marks

QUESTION 9 (14 marks)
Two electrolytic cells were connected in series using platinum electrodes, as shown below.



Cell 1 $FeCl_{3(aq)}$ $(50\ mL,\ 1.00\ M)$ **Cell 2** $ZnBr_{2(aq)}$ $(50\ mL,\ 1.00\ M)$

a. **i.** Predict the reactions occurring at:

Electrode A:_____

1 mark

Electrode D: _____

1 mark

ii. Write an overall equation for Cell 1.

_____

_____

_____

_____

1 mark

iii. Determine the voltage that would be required for the electrolysis of the two solutions. Using equations if appropriate, describe the effect, if any, that this voltage will have on the predicted reactions occurring at electrodes A to D.

_____

_____

_____

_____

_____

_____

3 marks

b. When a current of $2.50\ A$ was applied, $1.02\ g$ of Zn was produced in Cell 2.

i. Determine the amount, in mole, of electrons that passed through the cell.

1 mark

ii. What would be the concentration of $Fe^{3+}_{(aq)}$ in Cell 1 at this time?

3 marks

iii. How long would it have taken for these changes to take place?

2 marks

c. If $50.0\ mL$ of $1.00\ M\ \ PbI_{2(aq)}$ was used instead of $ZnBr_{2(aq)}$ under the same conditions, what would be the effect on the concentration of $Fe^{3+}_{(aq)}$?

_____

_____

_____

1 mark

d. How would the operation of the two cells be affected if:

i. The size of the electrodes was increased?

_____

_____

_____

1 mark

ii. The distance between the electrodes in each cell was decreased?

_____

_____

_____

1 mark

QUESTION 10 (7 marks)

Boric acid, H_3BO_3 was used in the old days as eyewash to treat infections. The K_a value for boric acid at 37^oC is 7.30×10^{-10}.

a. Comment on the K_a value of boric acid in terms of its strength and why it was safe to use as eyewash.

1 mark

b. **i.** Calculate the pH of a $0.50\ M$ solution of boric acid.

3 marks

ii. In the calculations above, an approximation was used. Explain why it was appropriate to use this approximation in this case.

1 mark

iii. What percentage of the boric acid hydrolyses at 37^oC?

2 marks

END OF QUESTION AND ANSWER BOOKLET