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2014 Trial Examination

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Units 3 & 4 - Written examination

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

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	11	11	93
			Total 123

- 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.
- A scientific calculator is permitted in this examination.

Materials supplied

- Question and answer book of 25 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

The number of mole of electrons required to obtain 0.12 mole of aluminium from a molten electrolytic cell will be

A. 0.04
B. 0.12
C. 0.24
D. 0.36

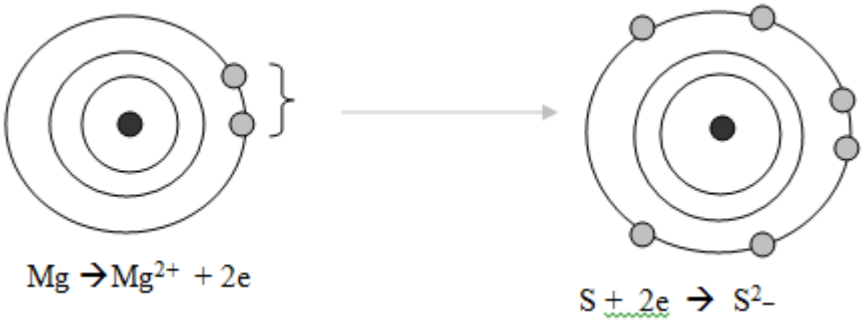
Question 2

In electrolysis,

A. oxidation occurs at the anode and the anode is negative
B. oxidation occurs at the anode and the anode is positive
C. the weakest oxidant reacts with the weakest reductant
D. reduction occurs at the cathode and the cathode is positive

Question 3

The diagram below shows the outer shell electron movement in a reaction.



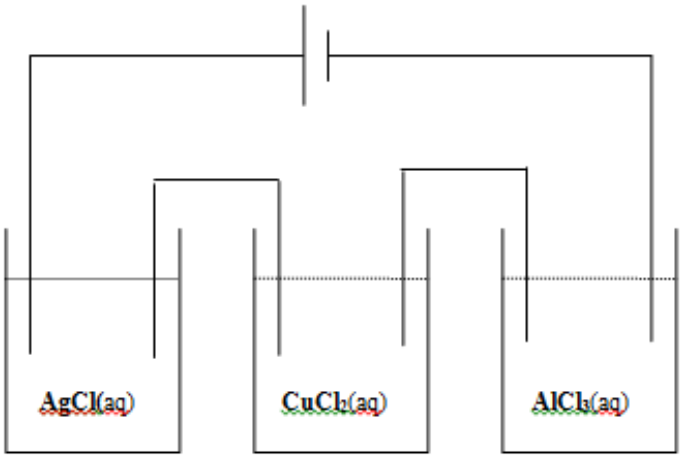
The electron transfer shown could be the

A. electrolysis of a molten solution of magnesium sulfide
B. precipitation of magnesium sulfide from an aqueous solution
C. reaction occurring in a galvanic cell between magnesium and sulfur
D. reduction of magnesium metal by sulfur

SECTION A - continued

Question 4

Aqueous solutions of AgCl, $CuCl_2$ and $AlCl_3$ are connected in series to a power supply.



After 0.60 mole of electrons has passed through this circuit the amounts of metal deposited will be, in mole,

A. 0.20 Ag, 0.20 Cu, 0.20 Al

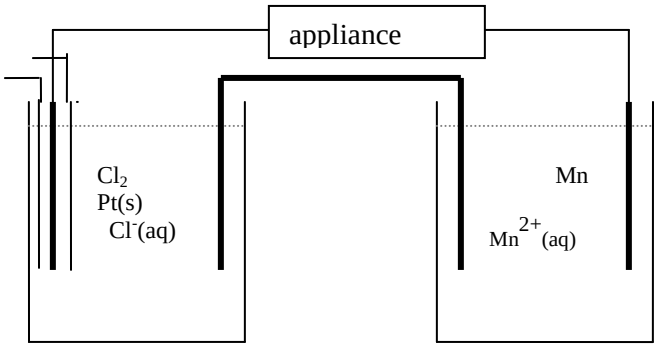
B. 0.60 Ag, 0.30 Cu, 0.20 Al

C. 0.60 Ag, 0.30 Cu, 0 Al

D. 0.60 Ag, 1.20 Cu, 1.80 Al

Question 5

A galvanic cell is constructed from a chlorine half cell connected to a manganese half-cell.



In this cell

	oxidant	reductant	anode	cathode
A.	Mn^{2+}	Cl^-	Pt	Mn
B.	Mn	Cl_2	Mn	Pt
C.	Cl_2	Mn	Mn	Pt
D.	Cl^-	Mn^{2+}	Mn	Pt

SECTION A – continued

TURN OVER

Use the following information to answer Questions 6 and 7

A cell that is popular in military uses is the cell formed from the reaction of lithium and sulfur dioxide. The cell is expensive but is capable of producing a voltage of almost 3 volts. The overall equation for this cell is

$2Li + 2SO_2 \rightarrow Li_2S_2O_4$

Question 6

The half equation for the reaction at the cathode in this cell will be

A. $Li \rightarrow Li^+ + e$

B. $2SO_2 + 2e \rightarrow S_2O_4^{2-}$

C. $SO_2 + 2OH^- + 2e \rightarrow S_2O_4^{2-}$

D. $SO_2 + O_2^- + 2e \rightarrow S_2O_4^{2-}$

Question 7

In this reaction, the oxidation number of sulfur

A. remains unchanged

B. changes from +2 to +4

C. changes from +4 to +6

D. changes from +4 to +3

Question 8

Which one of the following fuels is the most sustainable?

A. bioethanol

B. diesel

C. natural gas

D. uranium

Question 9

Which 0.05 M solution of the following acids has the highest pH?

A. hydrochloric acid

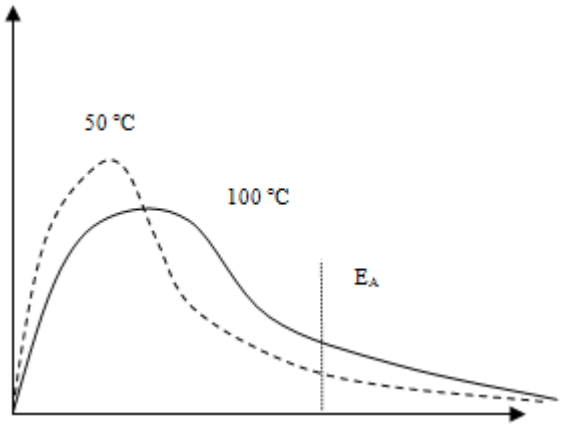
B. ethanoic acid

C. hypobromous acid

D. propanoic acid

Question 10

The diagram below represents the distributions of kinetic energy of reactant particles at two different temperatures, 50 ^{o}C and 100 ^{o}C.



From this diagram it can be concluded that,

A. more reactants particles have sufficient energy to react at 100 ^{o}C than 50 ^{o}C

B. all reactant particles at 100 ^{o}C have more kinetic energy than those at 50 ^{o}C

C. the activation energy for the reaction is higher at 100 ^{o}C

D. the reaction in question is an exothermic one

Question 11

Enthalpy changes for the phase changes of water are provided below;

$H_2O(s) \rightarrow H_2O(l) \qquad \Delta H = +6.0 \text{ kJ mol}^{-1}$

$H_2O(g) \rightarrow H_2O(l) \qquad \Delta H = -44.0 \text{ kJ mol}^{-1}$

The enthalpy change for the reaction $H_2O(g) \rightarrow H_2O(s)$ will be, in kJ mol^{-1},

A. + 50.0

B. + 38.0

C. – 38.0

D. – 50.0

Question 12

The numerical value of K at 30 ^{0}C for the reaction below is 24.2.

$NO_2(g) \rightleftharpoons \frac{1}{2}N_2O_4$ K = 24.2 at 30 ^{0}C

The numerical value of the equilibrium constant at 30 ^{0}C of the reaction

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ will be

A. 1.71×10^{-3}

B. 0.0413

C. 0.203

D. 586

Question 13

The hydroxide ion concentration in a sample of pure water is found to be $10^{-6.8}$. The pH of the water will be

A. $10^{-7.2}$

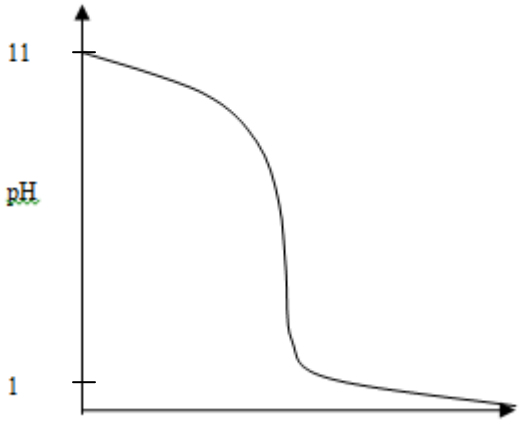
B. 7.2

C. 6.8

D. $10^{-6.8}$

Question 14

A pH probe is placed in a flask under a burette to monitor the pH change during a titration.



The pH curve shown could be from the reaction between

A. nitric acid and sodium carbonate

B. hydrochloric acid and sodium hydroxide

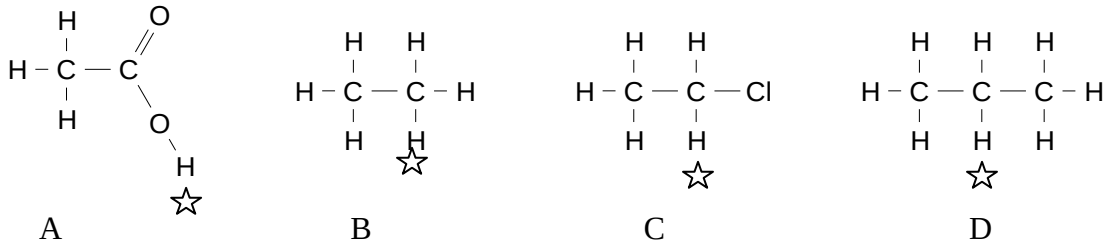
C. ethanoic acid and sodium hydroxide

D. ethanoic acid and sodium carbonate

SECTION A – continued

Question 15

Four different carbon compounds are drawn below and labelled from A to D. A hydrogen atom has been marked in each compound.



A B C D

The ranking of the shift of the marked hydrogen atom in proton-NMR will be (from lowest to highest)

A. A, C, D, B

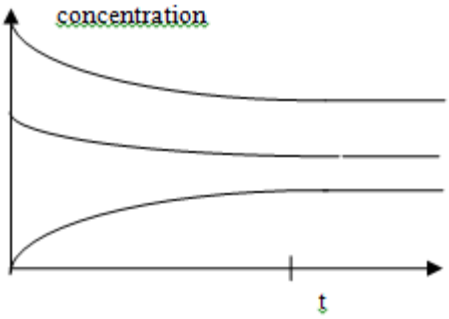
B. B, D, A, C

C. D, B, C, A

D. B, D, C, A

Question 16

The concentrations of the components of a reversible reaction are graphed below.



The equilibrium system in the graph could be

A. $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

B. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

C. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

D. $COBr_2(g) \rightleftharpoons CO(g) + Br_2(g)$

Question 17

In a 0.1 M solution of benzoic acid, the species present in the highest concentration is

A. $C_6H_5COO^-$

B. H_3O^+

C. C_6H_5COOH

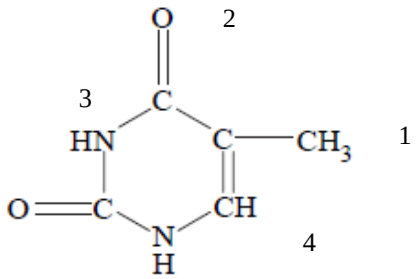
D. H_2O

SECTION A – continued

TURN OVER

Question 18

The molecule pictured is one of the base molecules present in DNA.



Hydrogen bonding to neighbouring base molecules will occur at sites

A. 1 and 2 only

B. 2 and 3 only

C. 2 and 4 only

D. 2, 3 and 4

Question 19

The empirical formula of a molecule is CH_2O.

Consider the following molecules.

I glycerol

II glucose

III fructose

IV ethanoic acid

The molecule could be

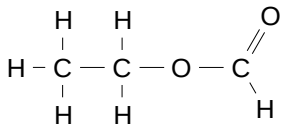
A. II only

B. II and III only

C. I and II only

D. II, III or IV

Question 20



The systematic IUPAC name for the molecule shown above is

A. ethyl propanoate

B. methyl propanoate

C. propanoic acid

D. ethyl methanoate

SECTION A – continued

Question 21

An organic compound reacts with both dilute hydrochloric acid and dilute sodium hydroxide. The molecule could be

A. propanoic acid

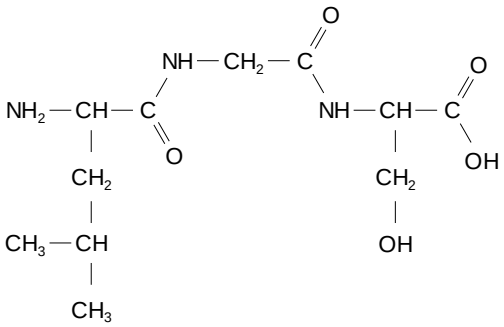
B. glucose

C. glycine

D. glycerol

Question 22

A tripeptide is drawn below



The amino acids in this molecule are, from left to right,

A. leucine, glycine and serine

B. leucine, alanine and threonine

C. valine, alanine and cysteine

D. valine, glycine and serine

Question 23

Which one of the following reactions is **not** a redox reaction?

A. $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

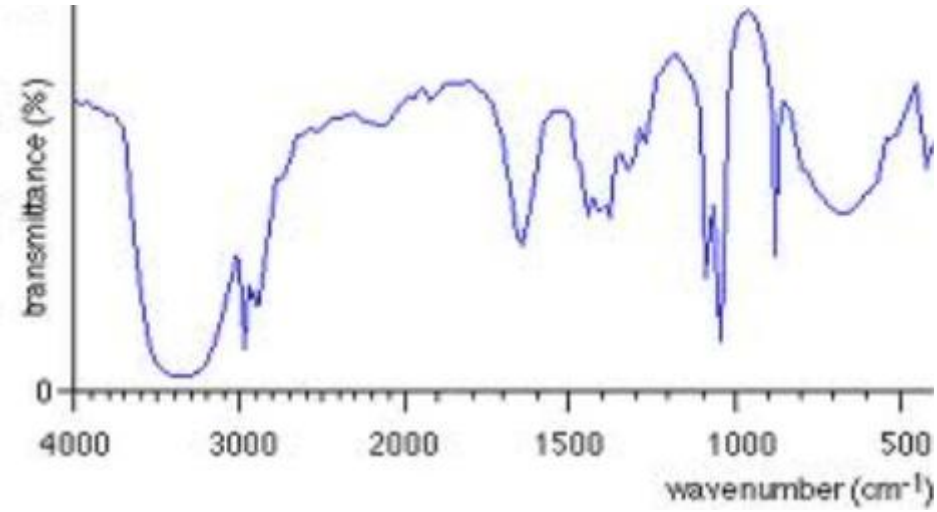
B. $2FeCl_2(aq) + Cl_2(g) \rightarrow 2FeCl_3(aq)$

C. $CH_3OH(l) + HCOOH(l) \rightarrow HCOOCH_3(l) + H_2O(l)$

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

Question 24

The infrared spectrum shown is likely to be that of



A. ethanoic acid

B. ethanol

C. 1-chloropropane

D. ethane

Question 25

100 mL of 1.0 M NaOH is added to 200 mL of 1.0 M HCl. The pH of the resulting solution will be

A. 0

B. 0.30

C. 0.48

D. 1.0

Question 26

A few drops of thymol blue are added to 20 mL of 0.01 M benzoic acid. The solution will be

A. acidic and yellow in colour

B. acidic and red in colour

C. basic and blue in colour

D. basic and yellow in colour

Question 27

Which of the following molecules represents a monounsaturated fatty acid?

A. linolenic acid

B. $C_{17}H_{34}O_2$

C. stearic acid

D. $C_{18}H_{34}O_2$

Question 28

The number of different hydrogen environments in a glycerol molecule will be

A. 3

B. 4

C. 5

D. 8

Question 29

A 400 mL sample of hydrochloric acid is found to react exactly with 8.0 g of calcium. The concentration of the hydrochloric acid is, in M,

A. 0.40

B. 0.50

C. 1.0

D. 2.0

Question 30

A sample of butane is found to contain 2.00 g of carbon. The mass of hydrogen in the sample will be, in gram,

A. 0.16

B. 0.42

C. 2.0

D. 5.0

END OF SECTION A
TURN OVER

SECTION B

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 (10 marks)
Living things are capable of converting monosaccharides to disaccharides and to polysaccharides.

Example: _____ _____ _____

Molecular formula: _____ _____

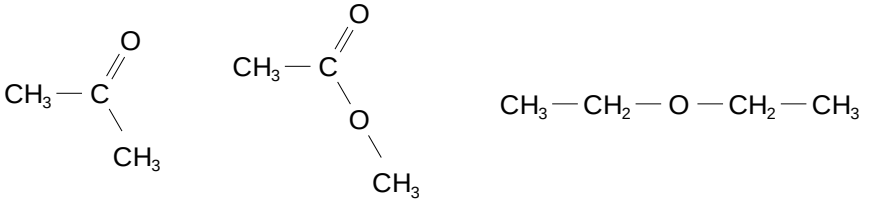
Structural isomer : _____

a. **i**. Use the spaces provided to give an example of each type of carbohydrate 1 mark

ii. Use the spaces provided to write the molecular formula of the monosaccharide and the disaccharide you chose. 2 marks

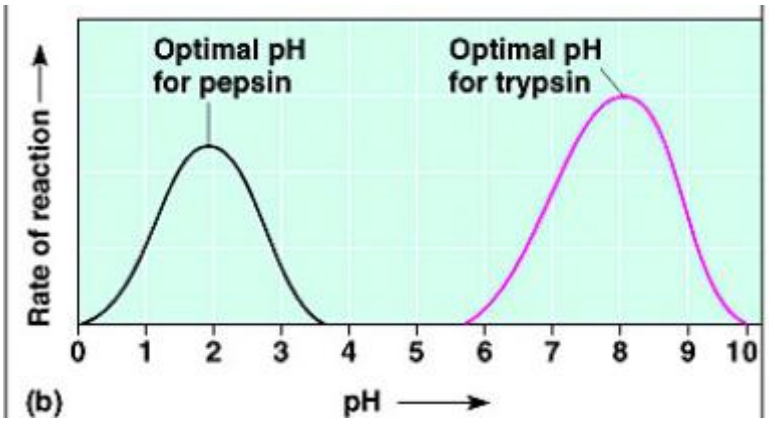
iii. Use the space provided to name a structural isomer of the monosaccharide you chose 1 mark

b. Circle the molecule drawn that has the same functional group as the linkage in a disaccharide. 1 mark



SECTION B – Question 1- continued

c. Enzymes are proteins that catalyse specific reactions. Pepsin and trypsin both serve to hydrolyse proteins back to the amino acids they were formed from. They act, however, in different parts of the body. The graph below compares the performance of both catalysts at different pH values.



i. The pH in an typical human stomach is around 1.8. Comment on the performance of both enzymes at this pH.

2 marks

_____

_____

ii. If pepsin passes into the small intestine where the pH is around 8, it is permanently destroyed as a catalyst. Explain how the bonding in pepsin changes at this pH.

1 mark

_____

_____

iii. If a protein containing 20000 amino acids is completely hydrolysed back to amino acids, how will the mass of the amino acids formed compare to the mass of the original protein? Explain your answer. 2 marks

_____

_____

SECTION B- continued
TURN OVER

Question 2 (10 marks)
Sulfur dioxide (SO_2) is used as a preservative in wine. The level used is monitored carefully as many people are sensitive to its presence.
Sodium hydroxide and sulfuric acid are added in turn to a sample of wine to ensure that all sulfur is present as SO_2.

The SO_2 level in a 20.0 mL sample of wine is determined by titration against a 0.00620 M standardised iodine solution using starch as an indicator.

The reaction occurring is;

$SO_2(g) + 2H_2O(l) + I_2(aq) \rightarrow 4H^+(aq) + 2I^-(aq) + SO_4^{2-}(aq)$

The titre obtained was 13.2 mL.

a. The reaction between I_2 and SO_2 is a redox reaction. Write a balanced half equation for the
i. oxidation reaction occurring 1 mark

_____

ii. reduction reaction occurring 1 mark

_____

b. What oxidation state change occurs in sulfur atoms in this reaction?
1 mark

_____

c. **i**. Use the titre obtained to determine the SO_2 concentration in the wine sample in M.
2 marks

_____

_____

_____

ii. What is the SO_2 level in mg L^{-1}? 1 mark

_____

_____

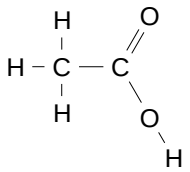
c. SO_2 prevents the oxidation of ethanol to ethanoic acid. 1 mark
Write a balanced half equation for the oxidation of ethanol to ethanoic acid.

_____

SECTION B – Question 2- continued

d. In a molecule of ethanoic acid, 1 mark

i. how many different hydrogen environments are there?



_____

ii. high resolution proton-NMR will not show any peak splitting. Explain why. 1 mark

_____

_____

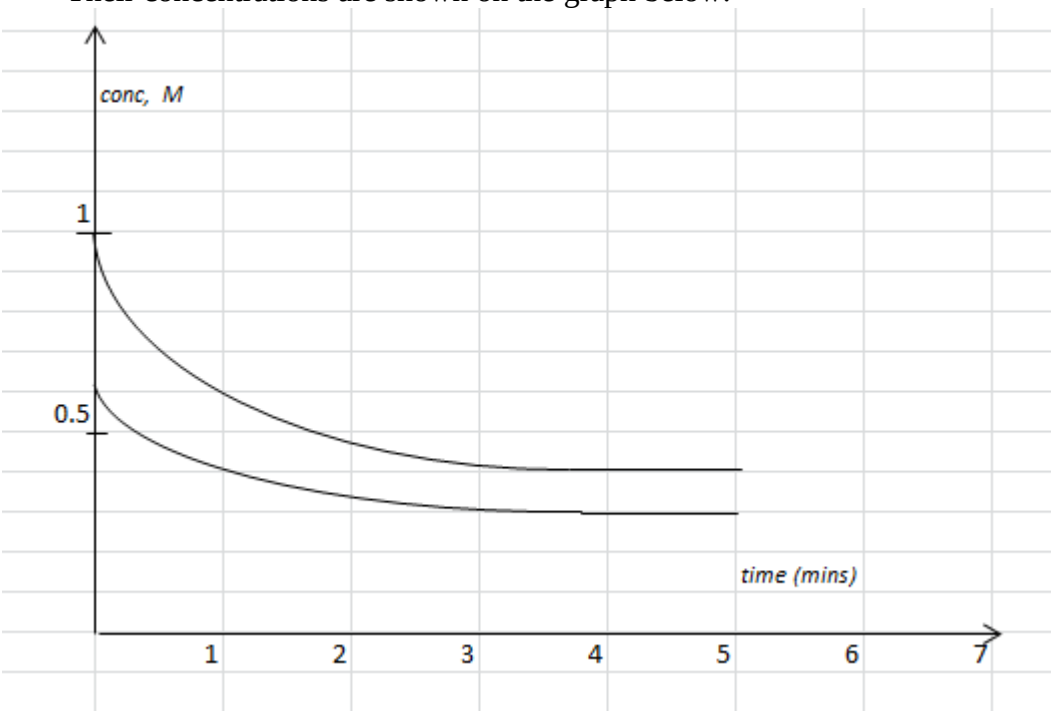
iii. what is the likely shift value of the hydrogen atom that is part of the carboxyl group? 1 mark

SECTION B – continued
TURN OVER

Question 3 (10 marks)
Methanol can be formed from the reversible reaction between carbon monoxide and hydrogen gases.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = 88 \text{ kJ mol}^{-1}$

a. Samples of carbon monoxide and hydrogen are added to an empty 2.00 L reactor at 120 ^oC. Their concentrations are shown on the graph below.



i. Show on the graph which curve represents the concentration of hydrogen gas and which curve represents the concentration of carbon monoxide gas 2 marks

ii. Draw in carefully the curve for the concentration of methanol 1 mark

b. **i**. Calculate a value for K at 120 ^oC for this reaction. 2 marks

_____

_____

_____

ii. What amount of methanol gas is present at equilibrium? 1 mark

_____

_____

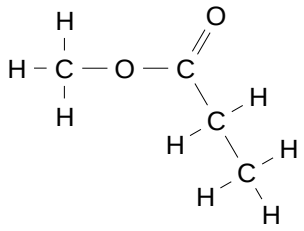
SECTION B – Question 3- continued

c. At the 5 minute mark, the volume of the reactor is doubled. Show on the graph,

i. the immediate impact upon the reactant concentrations 2 marks

ii. the movement in the reactant concentrations after the 5 minute mark. 2 marks

Question 4 (6 marks)
The molecule below is an ester.



a. **i**. Name this ester _____ 1 mark

ii. What is the empirical formula of the ester? _____ 1 mark

b. The ester is hydrolysed back to the alkanol and carboxylic acid that it was formed from.

i. Write a balanced chemical equation for the hydrolysis reaction. 1 mark

_____

ii. Write a balanced equation for the complete combustion of the alkanol that was formed. 1 mark

_____

iii. Determine the amount of energy released from the combustion of 1.00 g of alkanol 2 marks

_____

_____

_____

SECTION B – continued
TURN OVER

Question 5 (7 marks)
Three aqueous solutions are connected in series and an electric current is passed through the solutions. The solutions are $CuCl_2(aq)$, $MgBr_2(aq)$ and KCl(aq).

a. A student observes the following in the middle cell; a colourless gas evolved at the anode and a colourless gas evolved at the cathode. The rate gas is evolved at the cathode is faster than the rate of that at the anode.

Identify the cell which is in the middle and write half equations and an overall reaction for this cell.

Cell contents: _____ 3 marks

Anode half equation: _____

Cathode half equation: _____

b. A metal is deposited in one of the cells. What mass of metal will be deposited in 20.0 minutes if the current is 2.55 amps? 4 marks

_____

_____

_____

Question 6 (9 marks)
A traditional car battery uses sulfuric acid as an electrolyte.
The half equations for this cell are

Anode: $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e$

Cathode: $PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e \rightarrow PbSO_4(s) + 2H_2O(l)$

a. **i**. Write an overall equation for the cell. 1 mark

_____

ii. Explain how a pH reading on the electrolyte could be used to determine the degree to which this cell is charged. 1 mark

_____

_____

SECTION B – Question 6- continued

iii. This cell is a secondary cell. Give one important difference between a secondary cell and a primary cell.

1 mark

_____

iv. Suggest two reasons why the research into electric cars has involved finding alternatives to this traditional car battery.

2 marks

_____

_____

b. Write a half equation for the reaction occurring at the anode when this cell is recharging.

1 mark

_____

c. An alternative cell that has been trialled in cars in Britain is the sodium-sulfur cell. This cell is of interest because it uses abundant and cheap materials and the voltage is a promising 2.08 V.
One of the disadvantages of the cell is that it needs to be at temperatures of over 300 ^{0}C for the sulfur to be molten.

The overall equation for this cell is

$2Na + 3S \rightarrow Na_2S_3$

i. Use the spaces provided to write balanced half equations for the reactions occurring in this cell.

2 marks

anode: _____

cathode: _____

ii. The cell does not operate in an aqueous environment. Suggest one reason for this.

1 mark

_____

_____

SECTION B –continued
TURN OVER

Question 7 (12 marks)

A 3.600 g sample of an organic molecule is found to contain 1.650 g of carbon and 0.322 g of hydrogen. The remainder is chlorine.

a. **i**. What is the mass of chlorine? _____ 1 mark

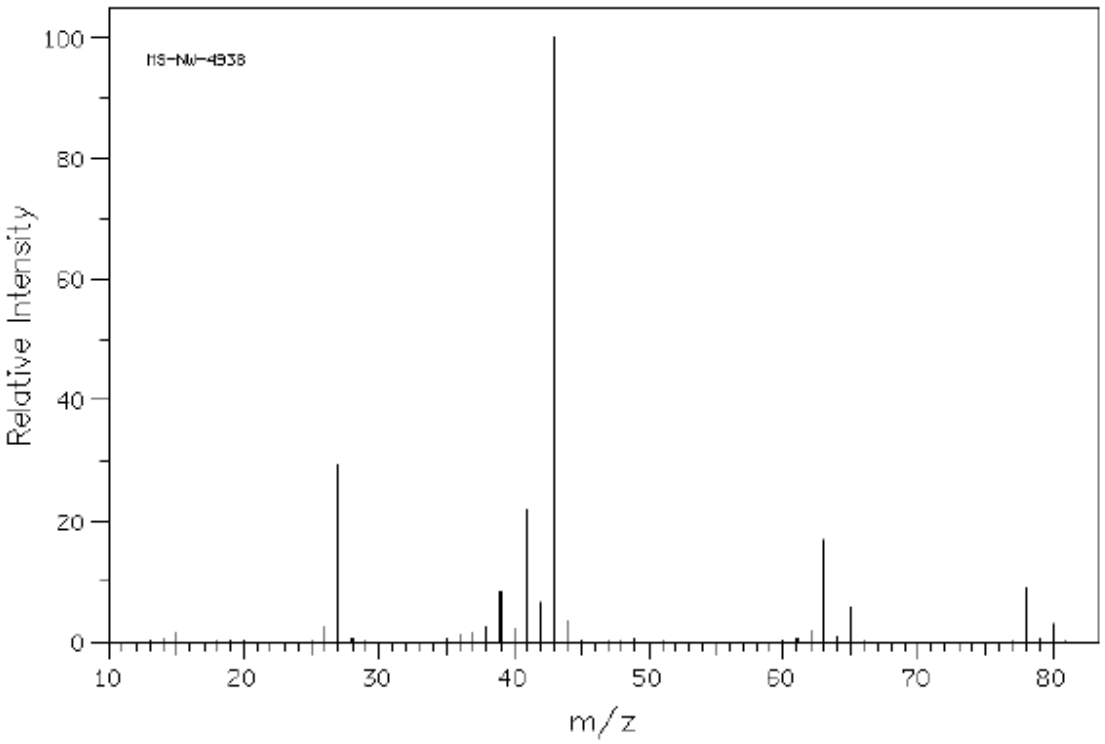
ii. Determine the empirical formula of the compound. 2 marks

_____

_____

_____

The mass spectrum of the molecule is shown below.



b. **i**. Explain why the molecule has two parent molecular ions, one with a m/z ratio of 78 and the other 80.

1 mark

_____

_____

SECTION B – **Question 7**- continued

ii. What fragment might have been knocked off the compound to have caused the peak at m/z ratio of 63? _____

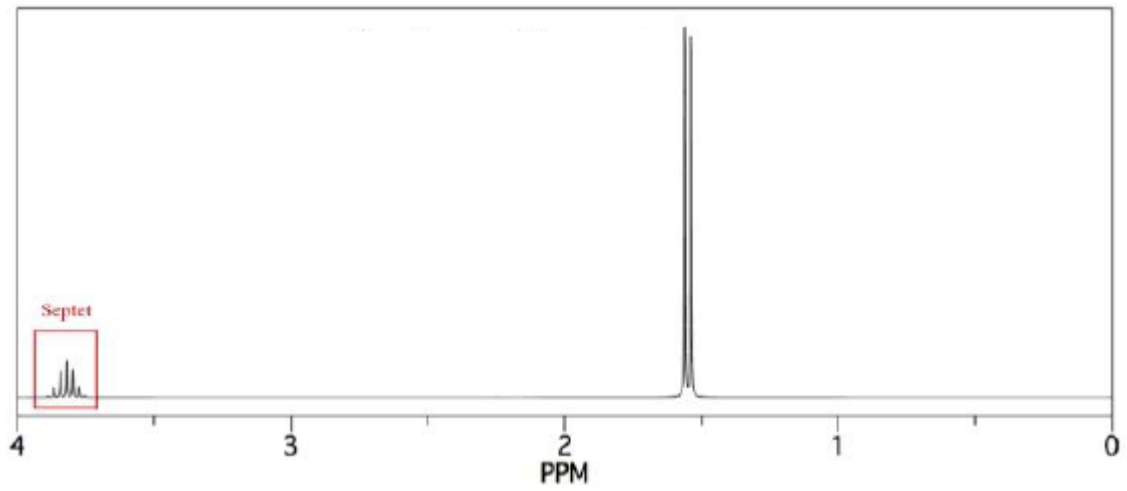
1 mark

iii. What is the molecular formula of the compound? _____ 1 mark

c. The molecule has two possible isomers. Draw and name both 4 marks

Isomer 1: _____ Isomer 2: _____

The proton-NMR is supplied below.



d. Use this spectrum to explain which isomer is the molecule in question. 2 marks

_____

_____

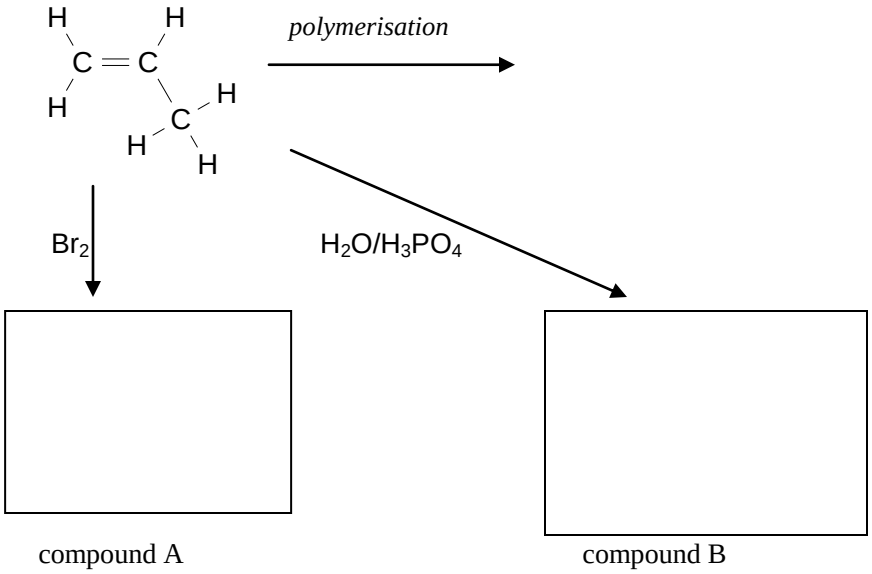
_____

SECTION B – continued

TURN OVER

Question 8 (9 marks)

The second member of the alkene series is propene. It can be used as a starting point in the synthesis of many organic molecules.



compound A compound B

a. Explain why propene has the following properties

i. Low solubility in water 1 mark

ii. Low boiling point 1 mark

b. Propene can react with itself to form a polymer. Use the space provided on the flow chart to draw in a segment of this polymer. 1 mark

c. **i**. Use the box provided to draw a structural formula for compound A. 1 mark

ii. Use the reaction that forms compound A to explain what a 'bromine test' is. 2 marks

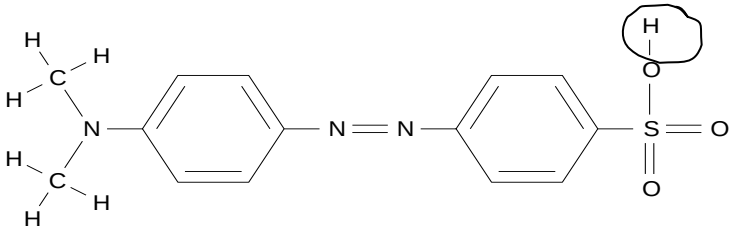
d. **i**. Use the box provided to draw a structural formula for compound B. 1 mark

ii. Suggest one method that could be used to distinguish between compound A and compound B. Explain how this test will distinguish between the two molecules. 2 marks

SECTION B – continued

Question 9 (7 marks)

Indicators are weak acids. The molecule shown is methyl orange. The hydrogen atom circled is the hydrogen atom that methyl orange donates to act as an acid.



The colour of the molecule above is red. After it donates the H^+, the remaining molecule is orange in colour.

Methyl orange can be represented for simplicity as HMe since it is a weak acid. Its reaction in water can be shown as

$$HMe(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + Me^-(aq)$$

a. Ethanoic acid is also a weak acid but it cannot be used as an acid/base indicator. What feature of methyl orange makes it an indicator? 1 mark

_____

b. Methyl orange is added to a sample of hydrochloric acid in a flask. 2 marks
Explain, using Le Chatelier's Principle, the impact on the indicator of the addition of acid.

_____

_____

c. Methyl orange is added to a sample of sodium hydroxide in a flask. 2 marks
Explain, using Le Chatelier's Principle, the impact on the indicator of the addition of acid.

_____

_____

d. Write an expression for K_a for methyl orange. 2 marks
At its transition point, the concentration of methyl orange and its conjugate base are equal. If the K_a value is 2.0×10^{-4}, calculate the expected pH of the transition point.

_____

_____

SECTION B - continued
TURN OVER

Question 10 (7 marks)
The combustion of 1.500 g of ethanol in a bomb calorimeter causes the temperature of the calorimeter to change from 22.4 ^{0}C to 31.3 ^{o}C.

a. i. Calculate the energy released by the ethanol 2 marks

_____

_____

ii. Calculate the calibration factor for the calorimeter. 1 mark

_____

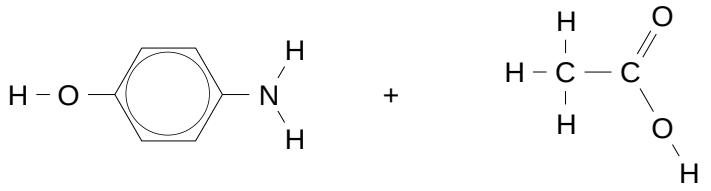
b. A sample of sodium is added to the calorimeter. The mass of the sodium is 0.145 g. The temperature rise is 0.87 ^{o}C.
Calculate ΔH for the reaction between sodium and water. 4 marks

_____

_____

_____

Question 11 (6 marks)
The anti-inflammatory drug paracetamol is formed from the reaction between the two molecules shown. Paracetamol contains an amide linkage.



a. Circle and name three functional groups present in the molecules above. 3 marks

b. i. Draw the structure of paracetamol. 1 mark

ii. What other molecule is formed when paracetamol is formed? _____ 1 mark

SECTION B – Question 11- continued

iii. What is the name and molecular formula of the molecule represented as a hexagon in the structure above? 1 mark

_____

_____

END OF QUESTION AND ANSWER BOOK