Name:		Class:	

ST ANDREW'S JUNIOR COLLEGE

JC2 Preliminary Examination

Chemistry **8872/2**
Higher 1 **Paper 2**
17th September 2015 **1400 - 1600**
2 hours

Additional Materials: Writing paper, Data Booklet, OAS

READ THESE INSTRUCTIONS FIRST

Write your name and civics group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A:
Answer **all** the questions in this section in the spaces provided.

Section B:
Answer **two** questions from this section on separate answer paper.

You are reminded of the need for good English and clear presentation in your answers. The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiners use only:

Section A			
Question 1	14	Question 3	9
Question 2	10	Question 4	7
Total for Section A			40
Section B			
	20		20
Total for Section B			40
Total			80

This document consists of **17** pages including a blank page.

[Turn Over

[BLANK]

Section A

Answer **all** the questions in this section in the spaces provided.

1 Jet airliners use kerosene as fuel. The formula of kerosene can be taken as $C_{14}H_{30}$. It can be converted into more useful small molecules by the process of cracking.

(a) (i) To which homologous series does kerosene belong?

.....

[1]

(ii) Write a balanced equation to show the cracking of kerosene into heptane, propene and ethene only.

.....

[1]

(iii) Suggest a use of ethene during the cracking process.

.....

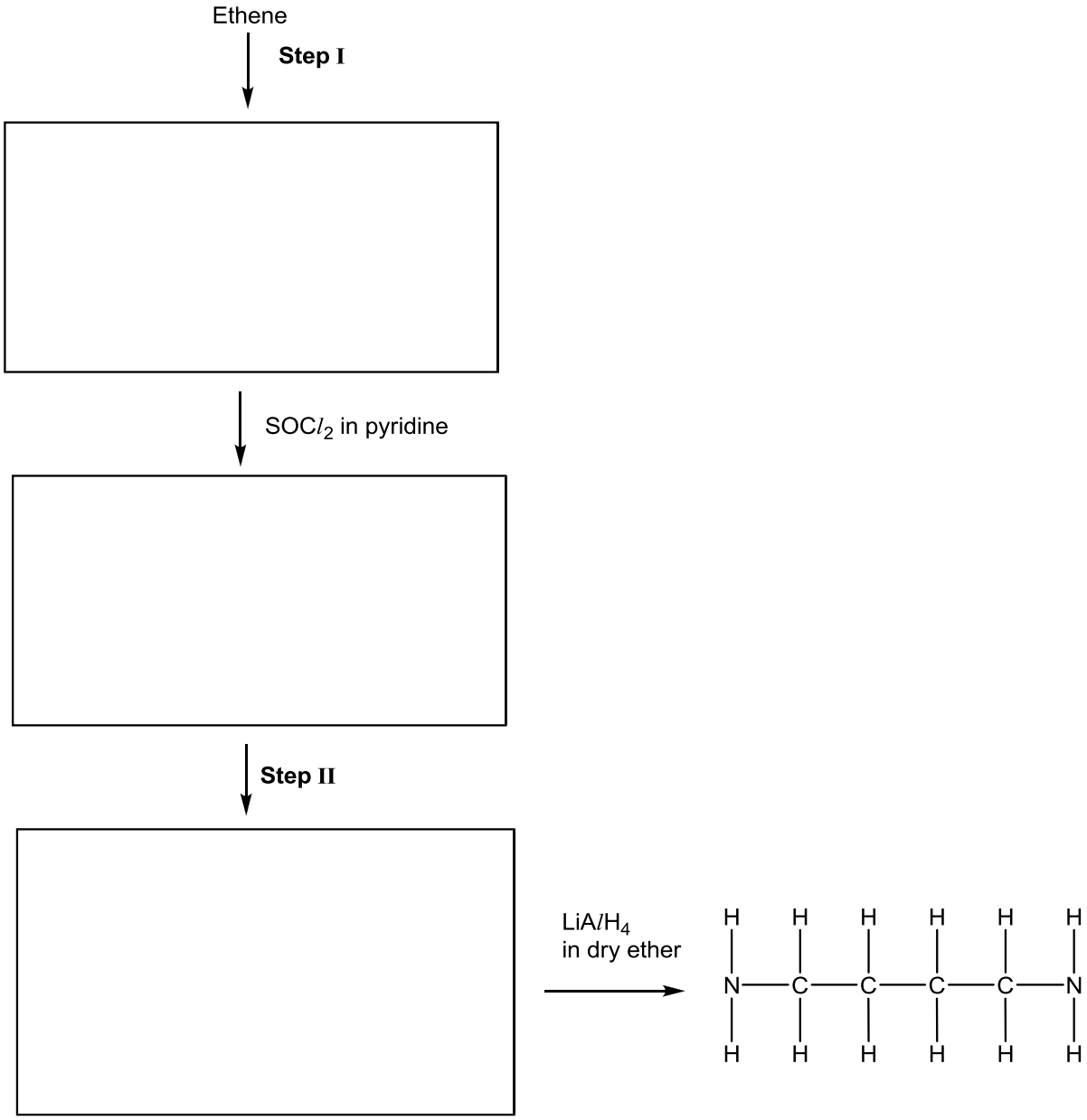
[1]

(iv) With the aid of an equation, define standard enthalpy change of combustion of kerosene.

[1]

[Turn over]

1 **(b)** Fill in the boxes with the appropriate structures and state the reagents and conditions of steps **I** and **II**.



Step **I:** .....

Step **II:** .....

[5]

1 (c) The propene obtained from cracking of kerosene is bubbled into acidified potassium manganate(VII) solution to form ethanoic acid.

20 cm^3 of the ethanoic acid produced is titrated with 3.0 mol dm^{-3} aqueous NaOH using a suitable indicator. The average volume of NaOH used is 12.50 cm^3.

Another 20 cm^3 of the same ethanoic acid is placed into a plastic cup of negligible heat capacity. A 10.0 cm^3 sample of 3.0 mol dm^{-3} aqueous NaOH, at the same initial temperature, is added into the plastic cup. The temperature of the mixture rises by 12.5 K.

(i) Determine the concentration of ethanoic acid.

[1]

(ii) If the specific heat capacity per unit volume of the mixture is 4.2 J K^{-1} cm^{-3}, what is the enthalpy change of neutralization of ethanoic acid?

[2]

(iii) If HC*l* replaces ethanoic acid in the above experiment, would the temperature rise be higher or lower? Explain your answer.

[2]

.....

.....

.....

[Total: 14 marks]

[Turn over]

2 Chlorine dioxide, ClO_2, is used for bleaching paper pulp and for water treatment. Over 95% of the chlorine dioxide produced in the world today is made from acidified sodium chlorate, $NaClO_3$, with a suitable reagent such as hydrogen peroxide, H_2O_2.

The half-equation for the reduction of ClO_3^- ions to ClO_2 is shown below.

$$ClO_3^- + 2H^+ + e^- \longrightarrow ClO_2 + H_2O$$

(a) **(i)** Using the Data Booklet, write the half equation for H_2O_2 in this reaction.

[1]

.....

(ii) Hence, write an equation for the overall reaction.

[1]

.....

(iii) Use oxidation numbers to show which species in your equation is oxidised and which is reduced.

[1]

.....

.....

(b) Metal chlorates can be produced by adding chlorine to hot metal hydroxides as shown below.

$$3\ Cl_2 + 6\ KOH \longrightarrow 5\ KCl\ +\ KClO_3 + 3\ H_2O$$

(i) State the type of the reaction above.

[1]

.....

(ii) Write the electronic configuration of K^+.

[1]

.....

2 **(b)** **(iii)** Draw a dot and cross diagram to illustrate the bonding in $KClO_3$, showing the outermost shell electrons only.

[1]

(c) **(i)** Using VSEPR Theory, predict and explain the shape and bond angle of ClO_2.

[2]

.....

.....

.....

(ii) Chlorine dioxide is highly soluble even in cold water. Explain your answer with reference to structure and bonding.

[2]

.....

.....

.....

[Total: 10 marks]

[Turn over]

3 The body's chemical buffer system consists of three individual buffers: the carbonate/carbonic acid buffer, the phosphate buffer and the buffering of plasma proteins. The first buffer system is usually considered the most important since it is coupled to the respiratory system.

In this buffer system, carbon dioxide combines with water to form carbonic acid (H_2CO_3), which in turn rapidly dissociates to form hydrogen and bicarbonate (HCO_3^-) ions according to the reactions below:

$$2\ H_2O + CO_2 \rightleftharpoons H_2CO_3 + H_2O \quad \text{reaction (1)}$$

$$H_2CO_3 + H_2O \rightleftharpoons H_3O^+ + HCO_3^- \quad \text{reaction (2)}$$

As a buffer, it maintains a relatively constant blood plasma pH and counteracts any change that would alter it. Thus blood pH is regulated to stay within the narrow range of 7.35 to 7.45, making it slightly alkaline. If the pH of the body gets too low (below 7.4), a very serious condition known as acidosis results.

Since carbonic acid is not stable in aqueous solutions, some of it decomposes to form carbon dioxide and water. The respiratory system is responsible for removing the carbon dioxide.

It is the production of carbon dioxide from this reaction that couples the carbonic acid/bicarbonate buffer to the respiratory system.

(a) **(i)** The pH of 0.10 mol dm^{-3} carbonic acid was found to be 3.54. Suggest if carbonic acid is a weak or strong acid. Explain your answer.

[1]

.....

.....

(ii) With the aid of an equation, explain how the carbonate/ carbonic acid buffer system helps to maintain a relatively constant pH when H^+ ions are added to the blood plasma.

[1]

.....

3 **(a)** **(iii)** Explain, with reference to the equilibrium reactions, why a reduction in respiratory activity to remove CO_2 will result in acidosis.

[2]

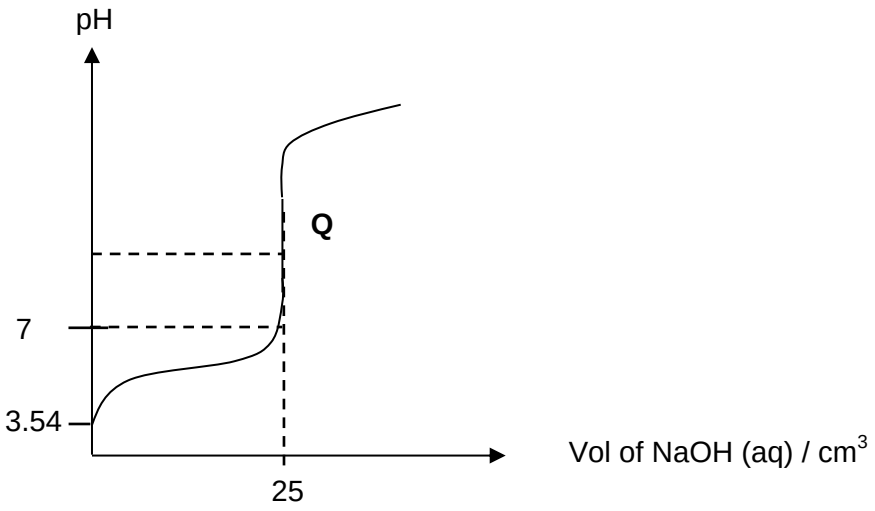
.....

.....

.....

.....

(b) The acid strength of carbonic acid is determined by titration with aqueous NaOH. 25 cm^3 of 0.10 mol dm^{-3} carbonic acid was pipetted into a conical flask and titrated with 0.10 mol dm^{-3} NaOH in the burette. The titration curve of pH against volume of aqueous NaOH added is shown below.
(You may wish to consider carbonic acid as a monobasic acid.)



(i) Write the acid dissociation constant, K_a, expression for the following equilibrium.

$$H_2CO_3\,(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-\,(aq)$$

[1]

.....

[Turn over]

3 **(b)** **(ii)** Hence, calculate the acid dissociation constant, K_a, for the equilibrium in **b(i)**.

[2]

(ii) At point **Q**, the amount of NaOH added just neutralises the acid present to from a salt. State the nature of the salt formed and hence illustrate its behaviour with the aid of an equation.

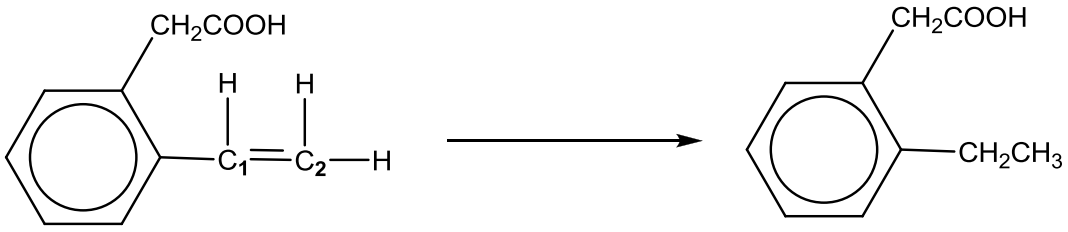
[2]

.....

.....

[Total: 9 marks]

4 Compound **A** is converted to compound **B** as shown in the synthetic route below.



Compound **A** Compound **B**

(a) Draw a labelled diagram to illustrate the sigma and pi bonds formed between the orbitals of C_1 and C_2 in compound **A**.

[2]

4 **(b)** Suggest the reagents and conditions for the conversion of compound **A** to **B**.

[1]

.....

(c) Suggest a simple chemical test to distinguish between compound **A** and **B**.

[1]

.....

.....

.....

(d) Upon oxidation, both compounds **A** and **B** yield compound **C** with molecular formula $C_8H_6O_4$.

State the reagents and conditions needed for the oxidation and draw the structure of compound **C**.

Hence, write a balanced equation for the oxidation of compound **B** to compound **C.** You may use [O] to represent an oxidising agent.

[3]

Reagent and condition: .....

Structure of compound **C**

Balanced equation:

.....

[Total: 7 marks]

[Turn over]

Section B

Answer **two** questions from this section on separate answer paper.

5 Samples of a bromoalkane **A** with the molecular formula $C_5H_{11}Br$ were reacted with aqueous sodium hydroxide at a constant temperature. Several experiments were carried out to investigate the kinetics of the reaction of **A** with aqueous sodium hydroxide. The initial rate of reaction was determined in each case and the following results were obtained.

Expt	Initial [A]/ mol dm^{-3}	Initial $[OH^-]$/ mol dm^{-3}	Initial Rate / mol dm^{-3} min^{-1}
1	0.10	0.10	5.56×10^{-4}
2	0.20	0.05	5.56×10^{-4}
3	0.30	0.10	1.67×10^{-3}

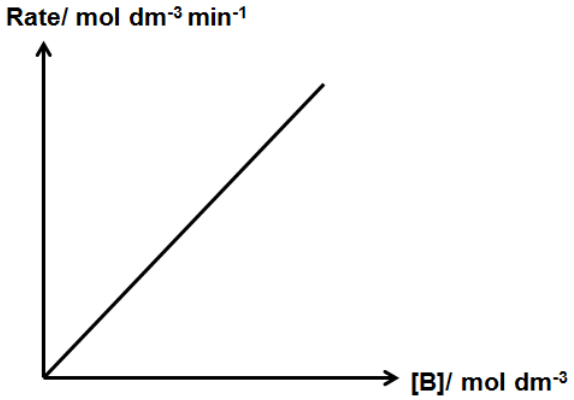
(a) **(i)** Deduce the order of reaction with respect to **A** and OH^- respectively, and hence write the rate equation.

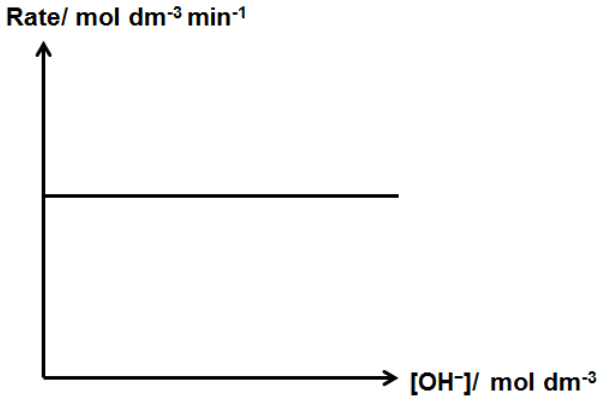
[3]

(ii) Calculate the value of the rate constant and state its units.

[2]

(b) Another bromoalkane **B**, which is a structural isomer of **A**, was reacted with aqueous sodium hydroxide and the kinetics of the reaction was investigated. The following graphs were obtained.



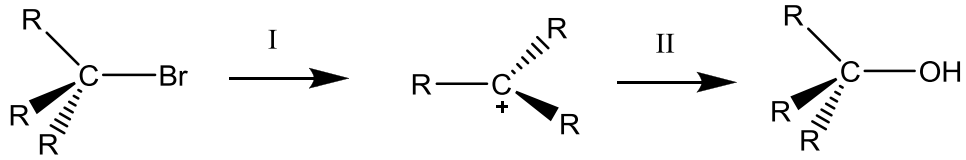


Using the graphs above, write the rate equation for the reaction of compound **B** with aqueous sodium hydroxide.

[1]

5 (c) When compound **B** reacts with aqueous sodium hydroxide, the shape of the organic intermediate differs from that of the reactant and product, as shown below.

(where R is an alkyl group)



Compound **B** **planar intermediate** **Product**

By considering the hybridisation state of carbon, deduce whether the C – R bond is longer in compound **B** or in the planar intermediate. Explain.

[3]

(d) Compound **B**, $C_5H_{11}Br$**,** reacted with hot aqueous sodium hydroxide to form an alcohol **D**. Alcohol **D** was not able to react with hot acidified sodium dichromate (VI) but reacted with ethanoic acid in the presence of hot concentrated H_2SO_4 to produce a sweet smelling liquid **E.**

(i) Suggest the structure of **D** and **E**.

[2]

(ii) Explain, with the aid of the Maxwell-Boltzmann Curve, the role of concentrated H_2SO_4 in the reaction of **D** with ethanoic acid.

[3]

(e) **X**, **Y** and **Z** are elements in the third period of the Periodic Table.

There are two chlorides of **X** which fumes in air.

When 2 mol of dilute HC*l* is added to 1 mol of the oxide of **Y**, the resulting solution is weakly acidic.

The oxide of **Z** is insoluble in water. When one mole of the chloride of **Z** dissolves in water, the resultant solution reacts with 4 moles of aqueous NaOH for complete neutralisation.

(i) Identify the elements **X**, **Y** and **Z**

[3]

(ii) Write an equation for the reaction between the chloride of **Z** with water.

[1]

(iii) Suggest why the oxide of **Z** is insoluble in aqueous sodium hydroxide.

[2]

[Total: 20 marks]

[Turn over]

6 **(a)** Butene (C_4H_8) and butane gas (C_4H_{10}) are commonly used as fuels. The heat energy released when 1 g of a material is combusted is commonly known as its fuel value (in kJ g^{-1}). The standard enthalpy change of combustion of butene is −2715 $kJmol^{-1}$.

(i) Use the following information to calculate the enthalpy change of combustion of butane, C_4H_{10}.

Standard enthalpy change of formation of carbon dioxide = -393 $kJmol^{-1}$
Standard enthalpy change of formation of water = -286 $kJmol^{-1}$
Standard enthalpy change of formation of butane = -126 $kJmol^{-1}$

[2]

(ii) Calculate the fuel value of butane and butene and hence propose a relationship between the hydrogen content and fuel value in hydrocarbons.

[3]

(b) One form of butene exists as a pair of geometrical isomers.

(i) Draw the pair of geometrical isomers.

[2]

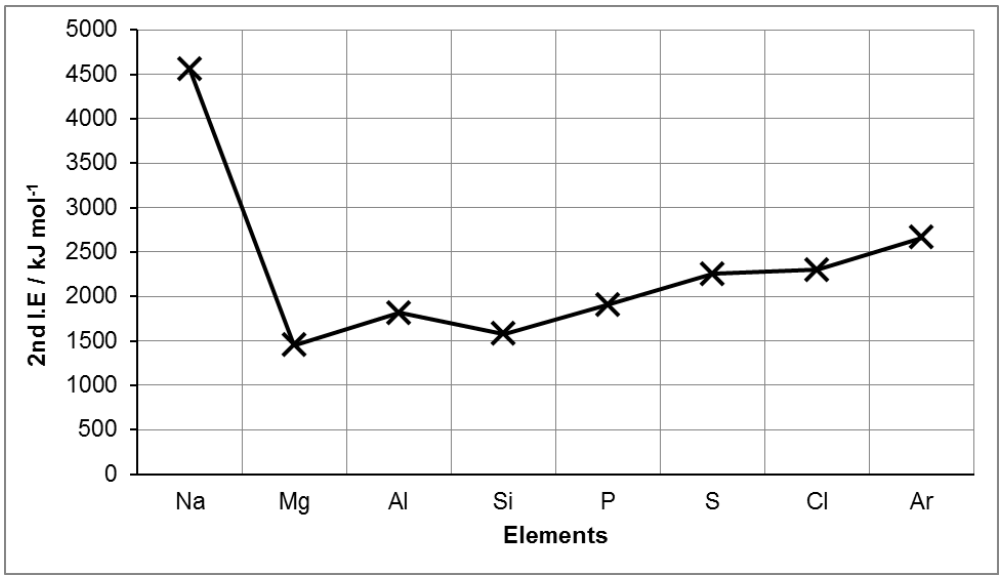
(ii) Propose a three step synthetic route for the formation of propanoic acid from 2-butene, showing the structures of all intermediate organic compounds and the reagents and conditions of each intermediate step.

[4]

(iii) Explain why propanoic acid is more soluble in water than 2-butene.

[2]

6 (c) The graph below shows the trend of second ionisation energies of Period 3 elements.



(i) Write an equation to represent the second ionisation of sodium.

[1]

(ii) Explain why sodium has the highest second ionisation energy.

[1]

(iii) Explain the trend of second ionisation energies from magnesium to argon.

[2]

(iv) Explain the irregularities observed in the second ionisation energies of silicon and chlorine.

[3]

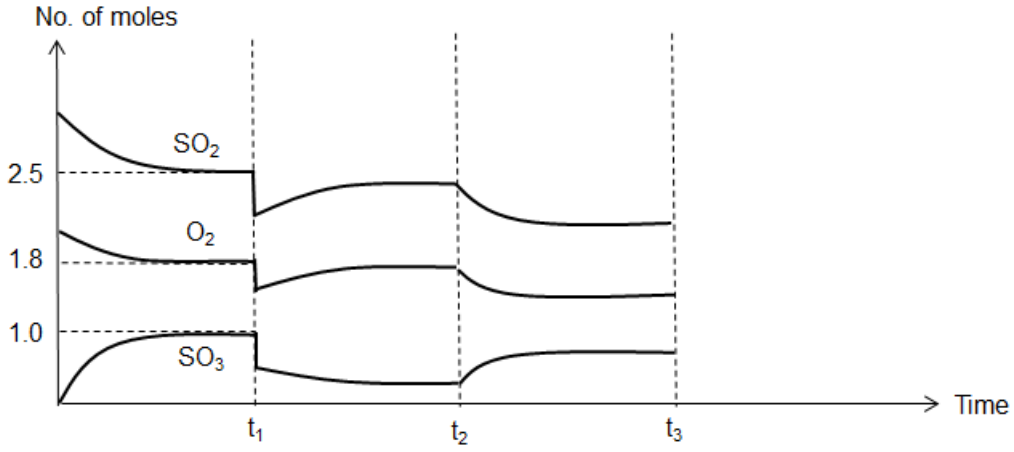
[Total: 20 marks]

[Turn over]

7 (a) The equilibrium system below is part of the industrial process to synthesize sulfuric acid.

$$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$$

A mixture containing 3 moles of sulfur dioxide gas and 2 moles of oxygen are placed in a 2 dm^3 closed vessel at 500 °C. The graph shows how the number of moles of each gas varies with time.



(i) Describe the reaction of sulfur with oxygen with the aid of an equation.

[2]

(ii) Write an expression for the equilibrium constant, K_c of the above equilibrium system, stating its units.

[1]

(iii) Hence, calculate K_c for this equilibrium system at t_1.

[1]

(iv) Describe and explain what had happened to the equilibrium system at t_1.

[2]

(v) At t_2, the reaction chamber was cooled. Suggest and explain if the reaction is endothermic or exothermic.

[2]

(vi) With reference to **a(v)**, explain how K_c is expected to change with increasing temperature.

[2]

7 **(b)** Compound **G** has molecular formula, C_4H_8O. Reaction of **G** with hot acidified potassium manganate (VII) produces compound **H**, $C_3H_4O_4$, and effervescence is observed. One mole of **H** requires two moles of NaOH for complete neutralisation. One mole of **G** reacted with one mole of Cl_2 (g) in the dark to form compound **I**, $C_4H_8OCl_2$. Both **G** and **I** turned hot sodium dichromate (VI) green.

Suggest a possible structure for each of the compounds, **G**, **H** and **I**. Explain the chemistry of the reactions described.

[6]

(c) Draw the structural isomers for the carbonyl compounds with formula C_3H_6O. Describe how you can distinguish between the 2 isomers using a simple chemical test.

[4]

[Total: 20 marks]

~~ End of Paper~~