Name:		Class:	

ST ANDREW'S JUNIOR COLLEGE

JC2 Preliminary Examinations

Chemistry
Higher 1 **8872/02**
Paper 2 **9th September 2008**
2 hours

Candidates answer Section **A** on the question Paper

Additional Materials: Answer Paper, Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in dark blue or black pen on both sides of the paper
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** questions

Section B
Answer **two** questions on separate answer paper
At the end of the examination, fasten all your work securely.
The number of marks is given in brackets [ ] at the end of each question or part question.

For examiner's use		
Section A		
Section B		
Total		

BLANK PAGE

Section A

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

1 (a) An organic acid has the following composition by mass: C, 26.64%; H, 2.22%; O, 71.14%. Analysis shows that it is a dibasic acid. 4.5 g of the acid requires 50.00 cm^3 of 2.00 mol dm^{-3} sodium hydroxide for complete neutralisation.

(i) Calculate the empirical formula of the acid.

(ii) Calculate the relative molecular mass of the acid.

(iii) Determine the molecular formula of the acid.

[4]

[Turn Over

1 (b) Ethanedioic acid is able to act as a reducing agent. In a reaction, 25.0 cm^3 of potassium manganate(VII) solution is required to react completely with a 6.75 g sample of the acid. The acid is oxidised to carbon dioxide, and manganate(VII) ions is reduced to manganese(II) ions.

(i) Write a balanced half equation for the oxidation of the acid.

……

(ii) Calculate the number of moles of acid used in the reaction.

(iii) Calculate the concentration of the manganate(VII) solution used.

[4]

[Total: 8]

[Turn Over

2 (a) Draw dot-cross diagrams of the following molecules in the spaces provided.
Hence, predict shapes and the bond angles in these molecules.

(i) **ClO_2**

Shape of molecule: ……..

Bond angle: …….

(ii) **SO_3**

Shape of molecule: ……..

Bond angle: …….

[4]

[Turn Over

2 (b) Explain each of the following observations as fully as you can:

(i) Silicon oxide melts at 1830°C but silicon chloride melts at 58°C.

……

……

……

(ii) The bond angles in the H_2O, H_2S and H_2Se decreases as shown:

Molecule	H_2O	H_2S	H_2Se
Bond angle	109°	92°	83°

……

……

……

[4]

[Total: 8]

3 (a) Cracking is a chemical process carried out to break down longer chain alkanes that predominate in crude oil into shorter chain alkanes and alkenes.

(i) Give a reason on why cracking is important in the petroleum industry?

……

[Turn Over

3 (a) (ii) Oil refineries carry out catalytic reforming to convert straight chain hydrocarbon, in the presence of a catalyst, to an aromatic molecule such as benzene. Describe a laboratory test which will distinguish benzene from benzaldehyde.

……

……

……

[3]

(b) In a motor car engine, petrol vapour and air are ignited by an electric spark, producing an explosive reaction which drives the pistons of the engine. Why are products of incomplete combustion formed in the car engine from the combustion of the petrol vapour?

……

[1]

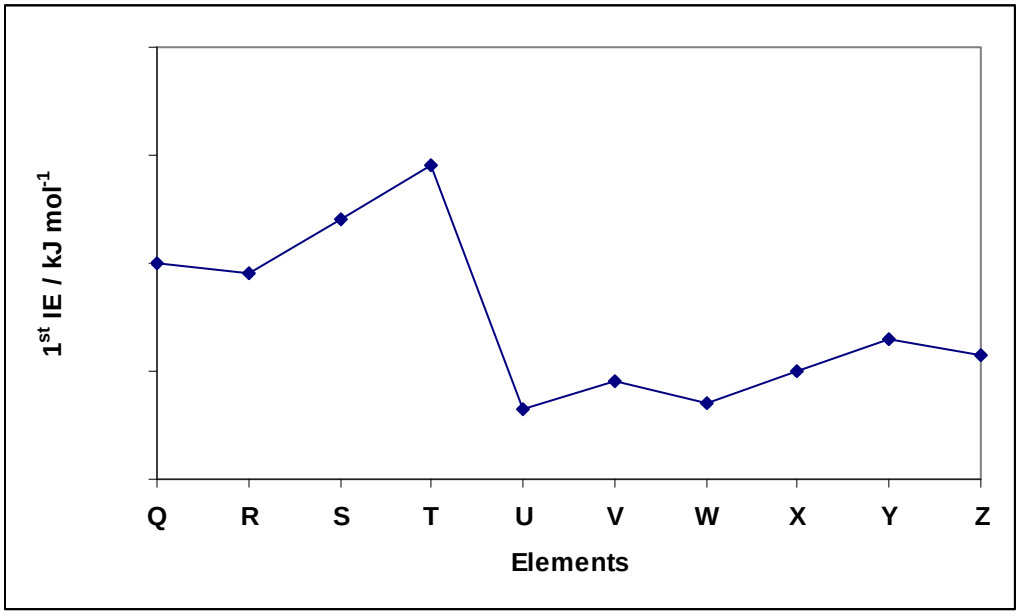
(c) Cracking produces pentene with production exceeding one million tonnes annually in the United States. Pentene is able to display structural isomerism. Draw all possible isomers of pentene.

[4]

[Total: 8]

[Turn Over

4 In an analytical chemistry laboratory, samples of unknown elements **Q** to **Z** were passed through a plasma torch. Their first ionisation energies were recorded and plotted as shown below. Elements **Q** to **Z** are consecutive elements in the Periodic Table and have atomic numbers below 20.



(a) Identify the Group to which element **W** belong to in the Periodic Table and hence state the identity of element **W**.

Element **W** belongs to Group ……..

Identity of element **W**: ……

[2]

(b) (i) State the electronic configurations of the ions, $\mathbf{W}^+$ and $\mathbf{X}^+$.

$\mathbf{W}^+$: ……

$\mathbf{X}^+$: ……

[Turn Over

4 (b) (ii) Predict, with reasons, how the **second** ionisation energy of **X** differ from that of **W**.

……

……

…… **[4]**

(c) Explain the decrease in **first** ionisation energy between elements **Y** and **Z**.

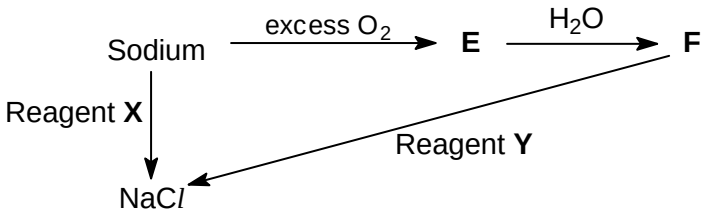
……

……

…… **[2]**

[Total: 8]

5 (a) The following diagram shows a reaction scheme of sodium.



(i) Identify the molecular formulae for the following compounds:

E: ……

F: ……

Reagent **X**: ……

Reagent **Y**: ……

[Turn Over

5 (a) (ii) Write an equation for the reaction between **F** and aluminium oxide. State the type of reaction.

Equation:

……

Type of reaction: ……..

[4]

(b) The melting points of three chlorides are given below.

Compound	**Formula**	**Melting Point /°C**
Sodium chloride	NaC*l*	801
Potassium chloride	KC*l*	772
Aluminium chloride	A*l*Cl_3	180

Explain the difference in the melting points between:

(i) NaC*l* and KC*l*

……

……

……

(ii) NaC*l* and A*l*Cl_3

……

……

…… **[4]**

[Total: 8]

[Turn Over

Section B

Answer **two** of the three questions in this section on separate paper.

6 (a) Chlorine was placed in a 1.00 dm^3 flask containing 0.001 mol of hydrogen and heated to 400K. An equilibrium was rapidly established as shown by the equation below:

$$H_2\,(g) + Cl_2\,(g) \rightleftharpoons 2HCl\,(g)$$

The equilibrium constant, K_c for the reaction is 7.41×10^{-3}.

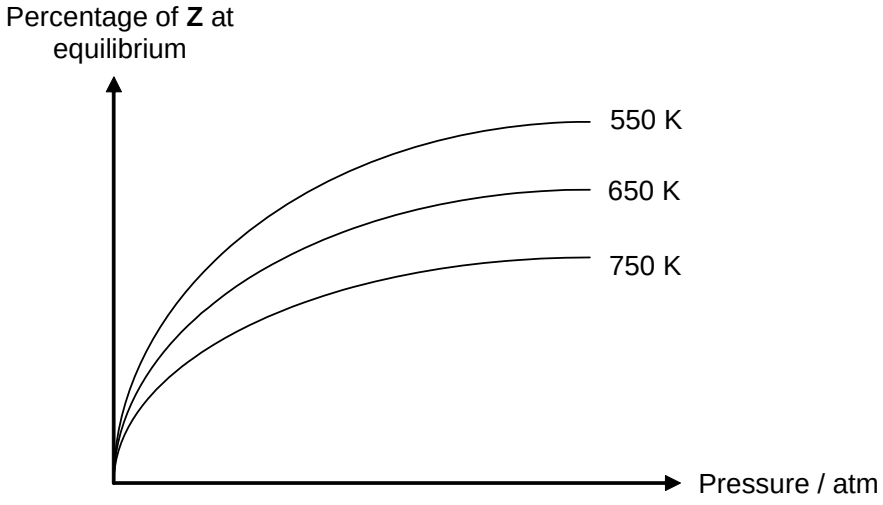
(i) Write an expression for the equilibrium constant, K_c, for the reaction.

(ii) Calculate the concentration of each substance present when equilibrium is reached.

(iii) Explain how the final concentration of HC*l* will be affected when a catalyst is introduced. State the effect on K_c.

[6]

(b) The following graph shows the effect of temperature and pressure on the percentage of product **Z** at equilibrium in a gaseous reaction.



Deduce whether

(i) the reaction is endothermic or exothermic. Explain your answer.

(ii) the reactants or products contain a higher number of gaseous molecules. Explain your answer.

[4]

[Turn Over

6 (c) (i) Define the term *standard enthalpy change of combustion*.

(ii) Write a balanced equation which represents the standard enthalpy change of combustion of propene, $CH_3CH=CH_2$ (g).

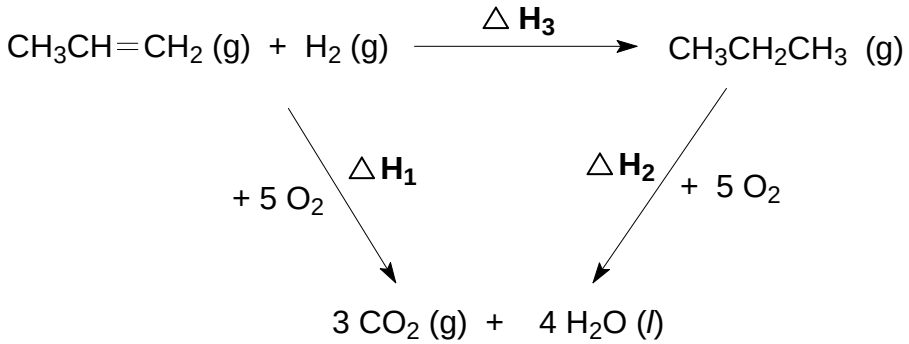
(iii) With reference to the *Data Booklet*, calculate a value for the standard enthalpy change of combustion of propene.

(d) **Given:**

Standard enthalpy change of combustion of $CH_3CH_2CH_3 = -2202$ kJ mol^{-1}

Standard enthalpy change of combustion of $H_2 = -286$ kJ mol^{-1}

(i) Consider the energy cycle below involving the enthalpy changes, ΔH_1, ΔH_2 and ΔH_3. Calculate the enthalpy change, ΔH_1, using your answer in **c(iii)**.



(ii) Hence, calculate the enthalpy change, ΔH_3.

[10]

[Total: 20]

[Turn Over

7 (a) 2-methylbutanoic acid is a weak monobasic acid with a K_a value of 1.81×10^{-5} mol dm^{-3}.

(i) Give the equation which represents the dissociation of 2-methylbutanoic acid in water.

(ii) Write an expression for the acid dissociation constant, K_a, for 2-methylbutanoic acid.

(iii) Given that **$[H_3O^+] = [CH_3CH_2CH(CH_3)COO^-]$**, find the pH of a solution when 10.0 g of 2-methylbutanoic acid is dissolved in water and the resulting solution made up to 250 cm^3.

(iv) What is the colour of 2-methylbutanoic acid solution in methyl red indicator, given the information below?

[HCl] / mol dm^{-3}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
Colour of methyl red in 2 drops of HCl	Red	Red	Red	Red	Orange	Yellow	Yellow

[4]

(b) Explain with the aid of an equation, why an aqueous mixture of 2-methylbutanoic acid (represented as HA) and sodium 2-methylbutanoate (Na^+A^-) can act as a buffer solution on the addition of an alkali.

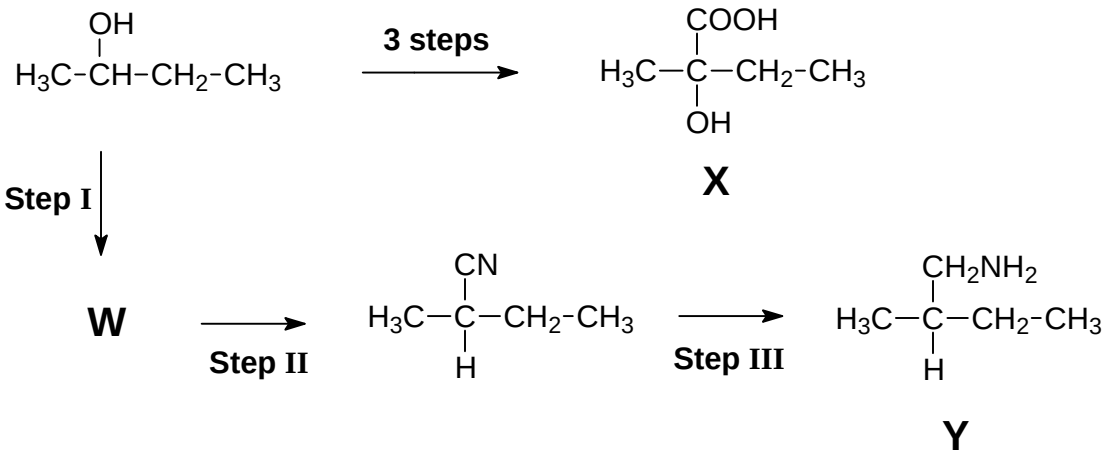
[2]

(c) An aqueous solution of another acid, HX, of concentration 0.0010 mol dm^{-3} has a pH of 3.0. Explain with reasons, whether HX is a strong or a weak acid.

[2]

[Turn Over

7 (d) The reaction scheme below represents a route for the synthesis of compounds **X** and **Y** from 2-butanol.



(i) Suggest reagents and conditions for **steps I**, **II**, and **III**.

(ii) Draw the structural formula of compound **W**.

(iii) Suggest a **three** step synthesis whereby 2-butanol can be converted into Compound **X**.

[7]

(e) (i) Suggest a chemical test, giving reagents and observations whereby compounds **X** and **2-butanol** show **similar** observations. Write a relevant equation using **2-butanol** and state the type of reaction involved in the test you proposed.

(ii) Explain why the structure for **X** causes it to behave as an acid in its reactions.

[5]

[Total: 20]

[Turn Over

8 (a) Compound **K**, $C_9H_{10}O_3$, is an aromatic compound. A solution of **K** turns damp blue litmus paper red. When **K** is treated with methanol in reflux with concentrated sulphuric acid, an ester **L**, $C_{10}H_{12}O_3$, is formed. With alkaline aqueous iodine, **K** forms **M** and a yellow precipitate with an antiseptic smell. On acidification of **M**, benzene-1,2-dicarboxylic acid, is formed.

(i) Draw the ***displayed*** formula for benzene-1,2-dicarboxylic acid.

(ii) Deduce the structures of **K**, **L** and **M**. Explain the chemistry of the reactions described, writing equations where appropriate.

[6]

(b) (i) Reaction of an alkene, **Q**, with hot concentrated potassium manganate (VII) produced benzene-1,2-dicarboxylic acid and $CH_3COCH_2COCH_3$. Suggest the structural formula of **Q**.

(ii) Suggest with a reason if **Q** is able to exhibit geometric isomerism.

[2]

(c) Benzene-1,2-dicarboxylic acid contains a benzene ring which is a regular hexagon where the π electrons are described as being delocalised. Hence, benzene is resistant to oxidation and addition reactions because these reactions would destroy the cyclic π orbitals of the benzene ring. Explain, with the aid of a diagram, what is meant by the delocalisation of π electrons as exemplified by benzene.

[2]

(d) Benzene-1,2-dicarboxylic acid is soluble in both polar and non-polar solvents. Explain.

[2]

[Turn Over

8 (e) The acid catalysed hydrolysis of methyl methanoate may be represented by the equation:

$$HCOOCH_3 + H_2O \underset{}{\overset{H^+}{\rightleftharpoons}} HCOOH + CH_3OH$$

When the hydrolysis was carried out in the presence of excess aqueous hydrochloric acid in a constant-temperature bath, the following results were obtained.

Time / minute	**Fraction of methyl methanoate remaining**
0	1
10	0.62
20	0.38
30	0.24
40	0.14
50	0.08
60	0.05
70	0.03
80	0.02

(i) Explain what is meant by the term '*order of reaction*'?

(ii) Plot an appropriate graph to show that the reaction is first-order with respect to the ester and hence determine the rate constant for the reaction.

(iii) Why was the hydrolysis carried out in the presence of excess hydrochloric acid?

(iv) Sketch a labelled reaction pathway diagram for the uncatalysed hydrolysis reaction given the activation energy of the forward reaction is +152 kJ mol^{-1} and for the reverse reaction is +184 kJ mol^{-1}. Hence, determine the enthalpy change of the reaction.

(v) On your sketch in **e(iv)**, draw the reaction pathway of the acid catalysed reaction. Label this clearly.

[8]

[Total: 20]

******* End Of Paper *******