ANDERSON JUNIOR COLLEGE

2015 JC 2 PRELIMINARY EXAMINATIONS

NAME:_____ **PDG:**____ /14

CHEMISTRY **8872/02**

Higher 1 **16 September 2015**

Paper 2 **2 hours**

Candidates answer Section A on the Question Paper.

Additional Materials: Data Booklet
Writing paper

READ THESE INSTRUCTIONS FIRST

Write your name, PDG and register number on all the work you hand in.
Write in dark blue or black pen.
You may use a 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.

Section B
Answer **two** questions on separate writing paper.
Start each question on a fresh sheet of paper.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use							
Paper 1 (33%)	Paper 2 (67%)						
	Section A				Section B		Total
	Q1	Q2	Q3	Q4			
/30							/ 80
				Final marks			/ 100
				Grade			

This document consists of **14** printed pages.

Section A

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

1 **(a)** Na, Si and P are elements found in the third period of the Periodic Table.

The ionic radii of Na, Si and P are listed in the *Data Booklet*.

State and explain the differences between the

(i) ionic radii of Na and Si

……

……

(ii) ionic radii of Si and P

……

……

[3]

(b) **A**, **B**, **C** and **D** are oxides of the third period elements. Some properties of the oxides are given in the table.

oxide	melting point / ^{o}C	electrical conductivity when molten	reaction with H_2O	resulting pH
A	2850	good	very little	8
B	1720	poor	none	7
C	1280	good	exothermic	14
D	580	poor	exothermic	1

(i) The structures of **A**, **B**, **C** and **D** can be simple or giant, and their bonding can be covalent or ionic. Use these terms to describe the structure and bonding in each of the oxides **A**, **B**, **C** and **D**.

	Structure	Bonding
A	……	……
B	……	……
C	……	……
D	……	……

(ii) Hence, suggest possible identities of **A**, **B**, **C** and **D**.

	Identity
A	……
B	……
C	……
D	……

[4]

(c) The melting points of sodium chloride and silicon tetrachloride are 801 ^{o}C and –70 ^{o}C respectively. Explain the difference in the melting points in terms of the structure of, and bonding in, the two chlorides.

……..

……..

……..

[2]

[Total: 9]

2 (a) Kerosene is a combustible hydrocarbon liquid widely used as a fuel in industry and households. It is commonly used to power jet engines of aircraft and also used as a cooking and lighting fuel in homes. The formula of kerosene may be taken as $C_{14}H_{30}$.

(i) Using the molecular formula of kerosene, write a balanced equation for its complete combustion in air, including state symbols.

……

(ii) Use the relevant bond energies from the *Data Booklet* to calculate a value for the enthalpy change of combustion of kerosene.

(iii) The enthalpy change of combustion of diesel fuel is about –45 kJ g^{-1}. Based on your calculations, suggest which of the fuel, kerosene or diesel fuel, is a more efficient fuel. Give a reason for your answer.

……

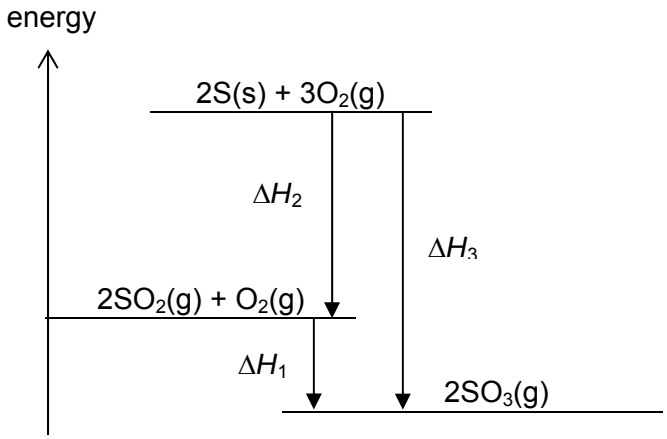
……

[6]

(b) Another source of fuel comes from fossil fuels. They are found in deposits beneath the ground and have been formed from plants and animals that lived up to 300 million years ago.

Most of the sulfur present in fossil fuels is removed at oil refineries. It is used to produce SO_2 which is converted, in the Contact process, into SO_3 which is used for the manufacture of sulfuric acid.

The diagram below shows an energy cycle involving SO_2.



(i) In the energy cycle above, what enthalpy change is represented by ΔH_1?

……

(ii) At 298 K, $\Delta H_c^{\ominus}(SO_2) = -99$ kJ mol^{-1} and $\Delta H_f^{\ominus}(SO_2) = -297$ kJ mol^{-1}.

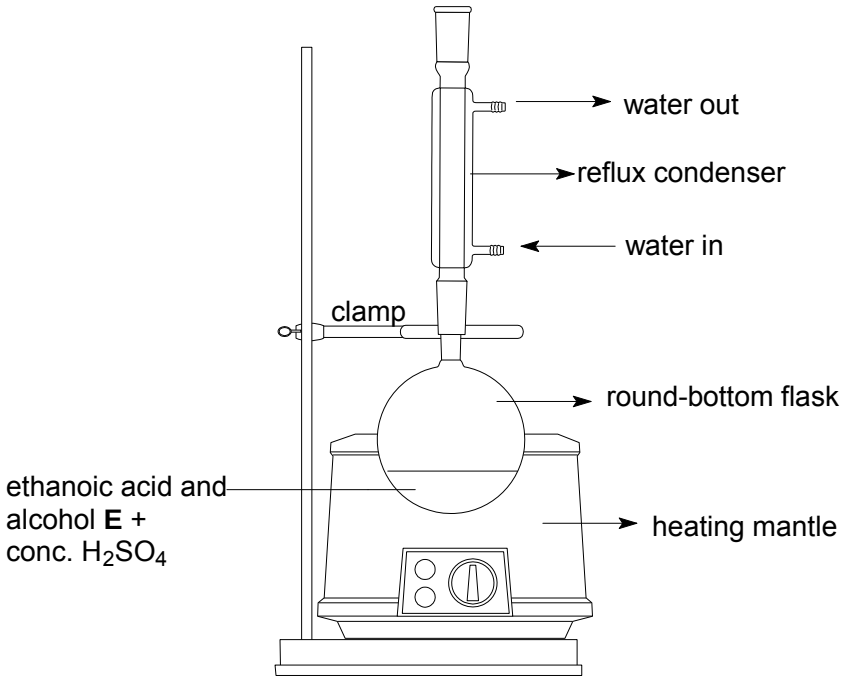
Use these data to calculate the standard enthalpy change of formation of SO_3.

[3]

[Total: 9]

3 (a) Esters can be prepared in the laboratory by heating carboxylic acid and alcohol with excess concentrated sulfuric acid.

The diagram below shows a reflux set–up that is used to prepare a sample of the ester with the molecular formula of $C_5H_{10}O_2$.



Alcohol **E** gives a yellow precipitate with alkaline aqueous iodine.

(i) Suggest the structural formula of alcohol **E**.

(ii) Hence, suggest the structure of the ester formed in this reaction.

(iii) Write a balanced equation for the hydrolysis of the ester you have suggested in **(a)(ii)** in basic conditions.

……....

(iv) What is a possible organic impurity present in the reaction mixture?

……....

(v) Describe one chemical test to confirm the identity of the impurity. You should state the reagents and conditions you would use and what observation you would make.

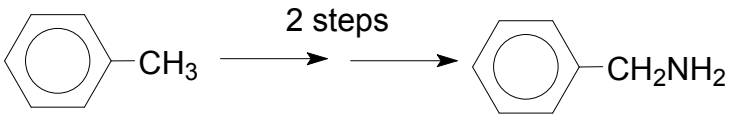
……....

……....

……....

[6]

(b) Benzylamine can be made from methylbenzene in two steps.



State reagents and conditions for each of the two steps in the following synthesis, and give the structure of the intermediate compound.

Step I

Reagent: ……

Condition: ……..

Step II

Reagent: ……

Condition: ……..

structure of intermediate

[3]

[Total: 9]

4 Acetals are compounds formed when aldehydes are reacted with an alcohol in the presence of an acid catalyst.

$$\underset{\text{propanal}}{CH_3CH_2CHO(l)} + 2\underset{\text{ethanol}}{CH_3CH_2OH(l)} \overset{H^+}{\rightleftharpoons} \underset{\text{acetal } \mathbf{F}}{CH_3CH_2CH(OCH_2CH_3)_2(l)} + H_2O(l)$$

A student mixed 0.10 mol of propanal in a conical flask with 9.2 g of ethanol in 25.0 cm^3 of an inert solvent dioxan. Then, he carefully added concentrated sulfuric acid, H_2SO_4. The flask was sealed with a stopper and allowed to equilibrate in a thermostatic water bath.

After equilibrium is reached, the student titrated quickly the entire contents of the conical flask with a solution containing aqueous NaOH and 1.00 mol dm^{-3} aqueous $KMnO_4$, from a burette.

The solution turned permanently purple when 25.30 cm^3 of $KMnO_4$ had been added.

The student postulated that the following equation describes one of the two reactions taking place.

$$4MnO_4^- + 3CH_3CH_2OH \longrightarrow 4MnO_2 + 3CH_3CO_2^- + 4H_2O + OH^- \qquad \textbf{equation (1)}$$

(a) Calculate the number of moles of ethanol that are initially placed into the conical flask.

[1]

(b) **(i)** Why is the reaction mixture left to equilibrate in a thermostatic water bath?

……

(ii) Besides providing an alkaline condition for the titration, suggest another role of aqueous NaOH in this experiment.

……

[2]

(c) **(i)** What type of reaction took place during the titration?

……

(ii) Write a balanced equation for the other reaction that took place between MnO_4^- and CH_3CH_2CHO during the titration.

……

(iii) Use the information given and the results of the calculations you have carried out so far to complete the table below.

Let x be the amount of propanal reacted when equilibrium is reached.

	propanal(l)	ethanol(l)	acetal **F**(l)	water(l)
initial amount / mol				
change in amount / mol	$-x$			
equilibrium amount / mol				

(iv) Calculate the total number of moles of $KMnO_4$ used in the titration.

(v) Hence, calculate the **equilibrium** amount, in moles, of all the reactants and products.

amount of propanal = …….mol

amount of ethanol = …….mol

amount of acetal **F** = …….mol

amount of water = …….mol

[7]

(d) Write an expression for the equilibrium constant, K_c, for the reaction between propanal and ethanol and calculate the value of K_c, stating its units.

[3]

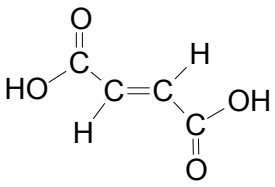
[Total: 13]

Section B

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

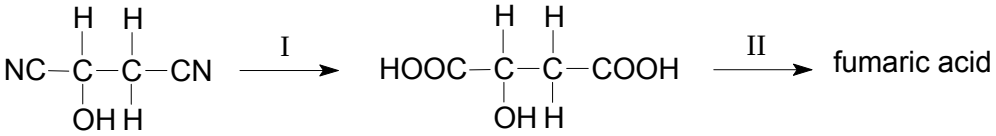
5 Inadequate control of the pH can result in the growth of undesirable bacteria in the product and it could be a potential health hazard. "Acidity regulators" are normally added to food so as to control the pH of foodstuffs.

Fumaric acid and its sodium salt are often added to foods as an acidity regulator and flavouring agent. They are commonly used in bread, fruit drinks, pie fillings and wine.



fumaric acid

(a) Fumaric acid can be made in the laboratory by the following route.



(i) State the reagents and conditions needed for reaction I and II.

The above route also produces compound **G**, a geometrical isomer of fumaric acid.

(ii) Draw the structure of **G**.

(iii) Explain how this isomerism arises.

(iv) Draw a diagram to show how hydrogen bonding occurs between two molecules of fumaric acid.

(v) By reference to the type and extent of intermolecular forces present, suggest why the melting point of **G** is lower than that of fumaric acid.

[10]

(b) Fumaric acid is a dibasic acid. When 20 cm^3 of a solution of fumaric acid was titrated against 0.05 mol dm^{-3} sodium hydroxide, the volume of sodium hydroxide required to completely neutralise fumaric acid was found to be 32 cm^3. The pH at this end point was approximately 8.5.

(i) Calculate the concentration of fumaric acid used in the titration.

(ii) Suggest an indicator that could have been used to observe the end point of this reaction, giving a reason for your choice.

[5]

(c) Ethanoic acid and sodium ethanoate buffer system can also be used as "acidity regulators" in food.

The following equilibrium is established in an ethanoic acid / sodium ethanoate buffer system.

$$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

The numerical value of the equilibrium constant, K_a, is 1.84×10^{-5}.

(i) Write an expression for K_a, for the equilibrium shown above.

(ii) In a buffer solution, the equilibrium concentration of ethanoic acid and ethanoate ion is found to be 0.30 mol dm^{-3} and 0.20 mol dm^{-3} respectively. Calculate the pH of this solution.

(iii) Write two equations to show how this solution regulates the pH of foodstuff.

[5]

[Total: 20]

6 **(a)** The following equilibrium exists in a sample of aluminium chloride vapour.

$$Al_2Cl_6(g) \rightleftharpoons 2AlCl_3(g) \qquad \Delta H = +63 \text{ kJ mol}^{-1}$$

(i) Draw a dot–and–cross diagram of the Al_2Cl_6 molecule, including its co–ordinate (dative covalent) bonds.

(ii) Predict the effect of increasing temperature on the above equilibrium. Explain your answer.

[4]

(b) State the pH and the colour observed when $AlCl_3$ is bubbled into water containing Universal Indicator. Give reasons for your answers and write balanced equations where appropriate.

[3]

(c) **L** and **M** are atoms of elements in the Periodic Table. Some data concerning the particles derived from **L** and **M** are given in the table below.

Particle	Mass number	Number of		
		protons	electrons	neutrons
$\mathbf{L^{2+}}$	111	*h*	47	*i*
$\mathbf{M^{2-}}$	51	*j*	27	*k*

(i) Determine the value of the *h*, *i*, *j* and *k*.

(ii) Use the *Data Booklet* to predict a value for the energy required to form one mole of gaseous $\mathbf{L^{2+}}$ ions from one mole of its gaseous atoms.

Explain your answer.

(iii) When a beam of $^{40}Ca^{2+}$ particles travels through a uniform electric field which is at right angles to its direction of travel, it is deflected at an angle of +10.0°.

Determine the angle of deflection of a beam of $\mathbf{M^{2-}}$ particles if it travels at the same speed through the same electric field.

[5]

(d) Compound **P** has the molecular formula of $C_{10}H_{14}O$. When **P** is heated with acidified potassium manganate(VII), it forms compound **Q**, $C_7H_6O_2$. The solution remains orange when **P** is heated with acidified potassium dichromate(VI).

Heating **P** under reflux with a mixture of sodium bromide and concentrated sulfuric acid gives compound **R**. When **R** is heated under reflux with ethanolic sodium hydroxide, a mixture of two different isomeric alkenes **S** and **T** is formed and both does not exhibit cis–trans isomerism.

Suggest structures for **P**, **Q**, **R**, **S** and **T**. Show how you deduced these structures and suggest the types of reactions that are occurring.

[8]

[Total: 20]

7 Propanone, CH_3COCH_3, is commonly known to be the main component in nail polish remover. It is also widely used as a solvent or starting material in many organic reactions.

(a) The acid–catalysed reaction of propanone with iodine to form iodopropanone is represented by the equation below.

$$CH_3COCH_3(aq) + I_2(aq) \xrightarrow{H^+} CH_3COCH_2I(aq) + HI(aq)$$

The kinetics of the above reaction was investigated experimentally by measuring the time taken for the pale brown solution to turn colourless. In this method, the rate of reaction is measured in terms of the rate at which the iodine concentration changes,

$$\text{i.e. rate of reaction } \alpha \ \frac{\text{volume of aqueous iodine used}}{\text{time for colour of iodine to disappear}}$$

The following results were obtained for a series of experiments with different volumes of each reagent used.

experiment number	volume of propanone / cm^3	volume of $I_2(aq)$ / cm^3	volume of HC*l* / cm^3	volume of water / cm^3	time taken / s
1	40	20	40	0	21
2	40	20	20	20	42
3	40	40	20	0	84
4	20	40	30	10	112
5	10	20	20	0	t_5

(i) Use the relationship given above to calculate the rate of reaction for each of the experiments 1 to 4 and use the results to show that the rate equation for this reaction is rate = k $[CH_3COCH_3]$ $[H^+]$.

(ii) Hence, state the units of the rate constant, k, for this reaction.

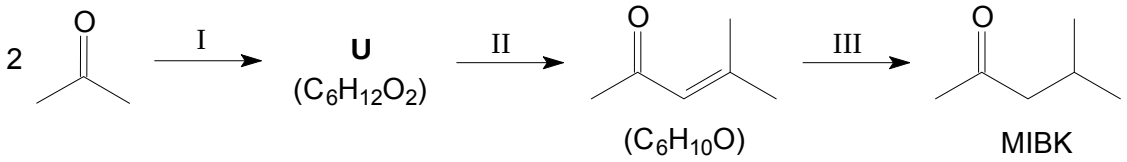
(iii) Predict the value of t_5, the time taken for experiment 5.

(iv) Explain, with the aid of the Maxwell–Boltzmann distribution curve, how the use of an acid catalyst will increase the rate of the reaction.

(v) Suggest the identity of the carbon–containing products if the reactants are warmed with NaOH(aq) instead of HC*l*.

[11]

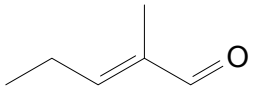
(b) Propanone is used as a starting material to manufacture methyl isobutyl ketone (MIBK), which is another industrially important solvent. The reaction scheme below shows how MIBK can be manufactured from propanone.



(i) State the type of reaction that occurred in step II.

(ii) Suggest the identity of **U**.

(iii) Another carbonyl compound also undergoes the same reaction in step I and II to produce 2–methyl–2–pentenal.



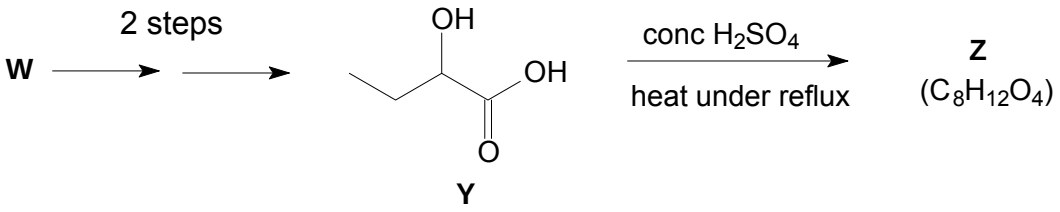
Suggest the structure of the carbonyl compound.

[3]

(c) Compounds **V** and **W** have the same molecular formula as propanone. White fumes are produced when **V** is reacted with anhydrous PCl_5, while **W** gives a red–brown precipitate when reacted with Fehling's solution.

(i) Draw the displayed formula of **V** and **W**.

Compound **Z** could be produced by the following route.



(ii) Suggest the reagents and conditions for a two–step synthesis of **Y** from **W**, identifying the intermediate.

(iii) Suggest the identity of compound **Z**.

[6]

[Total: 20]