HWA CHONG INSTITUTION
Preliminary Examination
Higher 1

CANDIDATE NAME		**CT GROUP**	**14S**

CHEMISTRY

8872/02

Paper 2

2 Sept 2015

2 hours

Candidates answer **Section A** on the Question Paper.

Additional Materials: Data Booklet
Writing paper

READ THESE INSTRUCTIONS FIRST

Write your name and CT group 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, correction fluid or tapes.

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 together.
The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINERS' USE ONLY

Paper 1	**Paper 2**				**TOTAL**
Multiple Choice	**Section A (Structured)**		**Section B (Free Response)**		
	Q1	/18	Q4	/ 20	
	Q2	/10	Q5	/ 20	
	Q3	/12	Q6	/ 20	
/ 30	**Subtotal**	**/ 40**	**Subtotal**	**/ 40**	**110**

This question booklet consists of **14** printed pages.

Section A

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

1 There is concern over the way the oceans are becoming more acidic as more carbon dioxide dissolves in them

(a) (i) Draw a “dot-and –cross” diagram for carbon dioxide

[1]

(ii) Use your diagram to state and explain the shape and bond angle of a carbon dioxide molecule.

……

……

……

……

…… [3]

(iii) Carbon dioxide forms hydrogen bonds with water.

Draw a diagram to illustrate this.

[2]

(iv) Carbon dioxide is not very soluble in water.

Suggest an explanation for this in terms of hydrogen bonding.

……

……

…… [2]

(b) When carbon dioxide dissolves in water of the ocean, the following reactions occur.

$$CO_2(g) = CO_2(aq) \qquad \textbf{equation 1}$$

$$CO_2(aq) + H_2O(l) = HCO_3^-(aq) + H^+(aq) \qquad \textbf{equation 2}$$

$$HCO_3^-(aq) = H^+(aq) + CO_3^{2-}(aq) \qquad \textbf{equation 3}$$

(i) The reaction in **equation 3** can reach a state of dynamic equilibrium. Explain what is meant by the term *dynamic equilibrium*.

……

……

……

[2]

(ii) Suggest why the balance of $CO_2(g)$ in the atmosphere and $CO_2(aq)$ in the oceans cannot be regarded as a dynamic equilibrium.

……..

……

[1]

(iii) Explain why an increase in the concentration of dissolved carbon dioxide leads to an increase in the acidity of the water.

……

……

……

……

[1]

(iv) The pH of the oceans is buffered by the reaction in **equation 2.**

Explain the meaning of buffered.

……

……

……

……

[1]

(v) Give the important condition necessary for this equilibrium to result in buffering, in terms of concentration of species present.

……..

…….. [1]

(vi) Reference books states that the pH of the oceans has changed from 8.179 in pre-industrial times to 8.069 today.

Calculate the percentage increase in $[H^+]$

% increase in $[H^+]$ = ……..[1]

(c) The shells of some sea creatures are made of calcium carbonate.

Use the equations below to explain a possible effect of increased acidity on the shells of these sea creatures.

$CaCO_3(s) = Ca^{2+}(aq) + CO_3^{2-}(aq)$ **equation 4**

$CO_3^{2-}(aq) + H^+(aq) = HCO_3^-(aq)$ **equation 5**

……

……

……..
[2]

(d) The concentration of a saturated solution of carbon dioxide in water is 3.3×10^{-3} mol per 100 g at room temperature and pressure.
1.0 kg of this saturated solution is boiled, releasing all the CO_2.

Calculate the volume that this CO_2 would occupy at room temperature and pressure.
One mole of gas at room temperature and pressure occupies 24 dm^3.

Volume of CO_2 : …….. [1]

Total [18]

2 (a) E300 is an oxidant used in white wines. The maximum allowed concentration of E300 in drinks is 150 mg dm^{-3}.

A student performed the following redox titration procedure to find out if a 250.0 cm^3 sample of a drink containing E300 was within this limit.

The sample was acidified followed by the addition of 25.0 cm^3 of 0.00500 mol dm^{-3} $KIO_3(aq)$. Excess KI(aq) was then added to form I_2 in solution.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

(i) Calculate the amount, in moles, of iodine, I_2, formed in this reaction.

[1]

(ii) Some of the I_2 formed reacted with the E300 in the 250.0 cm^3 sample of the drink.

$$\underset{\textbf{E300}}{C_6H_8O_6} + I_2 \rightarrow C_6H_6O_6 + 2H^+ + 2I^-$$

The amount of unreacted I_2 was found by titrating with sodium thiosulfate, $Na_2S_2O_3(aq)$, using starch indicator. At the end point, 20.4 cm^3 of 0.00500 mol dm^{-3} $Na_2S_2O_3(aq)$, had been added.

The following reaction occurred:

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

Calculate the amount, in moles, of iodine, I_2, remaining after the E300 had reacted.

[1]

(iii) Determine the concentration of the E300 in the 250.0 cm^3 sample of the drink

and hence whether the drink is within the limit allowed.

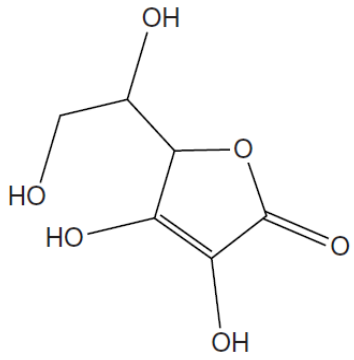
M_r (E300) = 176

Concentration = …… units = ……

Is the drink within the allowed limit for E300? ……

[3]

(b) E300 has a C=C bond with two different groups on each carbon. It does not, however, show geometrical isomerism whereas 1,2-dichloroethene does.



E300

Explain why 1,2-dichloroethene shows geometrical isomerism **and** suggest a reason why E300 does not.

……

……

……

……

……

[3]

(c) The **primary** alcohol group in E300 reacts with $C_{17}H_{35}COOH$ to form another

antioxidant.

(i) Draw the structural formula of the compound formed in this reaction.

[1]

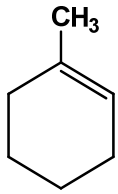
(ii) What else must be added to a mixture of E300 and $C_{17}H_{35}COOH$, to make the new antioxidant?

……..

[1]

Total [10]

3 1-methylcyclohexene is a naturally occurring hydrocarbon that can be used as a starting material to make other chemicals.



(a) Draw a labeled diagram to show the orbitals that form the C=C bond in an alkene.

[1]

(b) When 1-methylcyclohexene is added to bromine in an inert organic solvent, there is

a fast reaction that decolourises the bromine.

Suggest the structure of the organic compound formed.

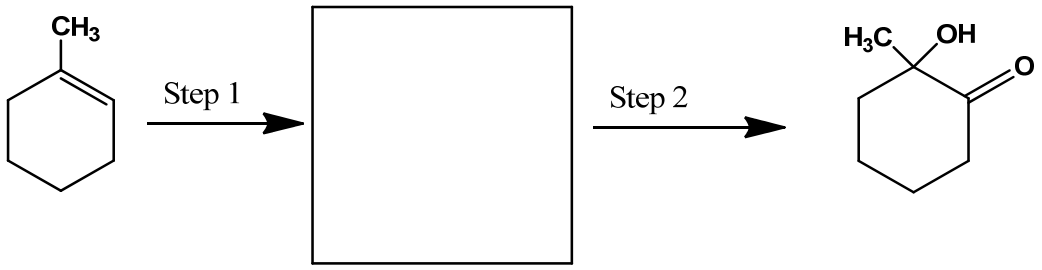
[1]

(c) 1-methylcyclohexene also decolourises aqueous bromine.
When water is present, a different organic compound with molecular formula $C_7H_{13}OBr$ can be formed.
Suggest the structure of this organic compound.

[1]

(d) State the reagents and conditions needed to convert 1-methylcyclohexene into each of the three organic compounds shown below in two steps. Show the structure of the intermediate organic compound in each case.

(i)



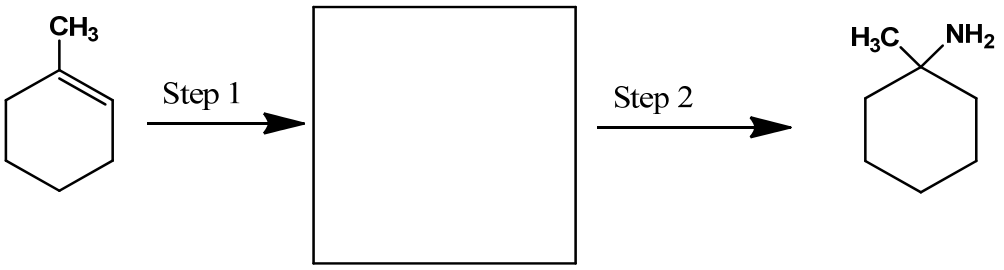
Reagents and conditions

Step 1 ……..

Step 2 ……

[3]

(ii)



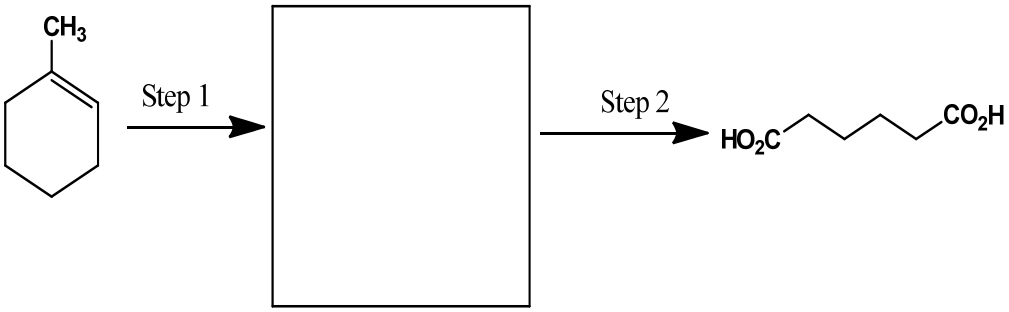
Reagents and conditions

Step 1 ……..

Step 2 ……

[3]

(iii)



Reagents and conditions

Step 1 ……

Step 2 ……

[3]

Total [12]

End of Section A

SECTION B

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

4 **(a)** Describe what you see when magnesium, phosphorus and sulfur are separately burned in air or oxygen.
Write equations for the reactions that occur.

[3]

(b) The oxides of phosphorus and sulfur resulting from the reactions in (a) both react with water. Write equations, including state symbols for both these reactions.

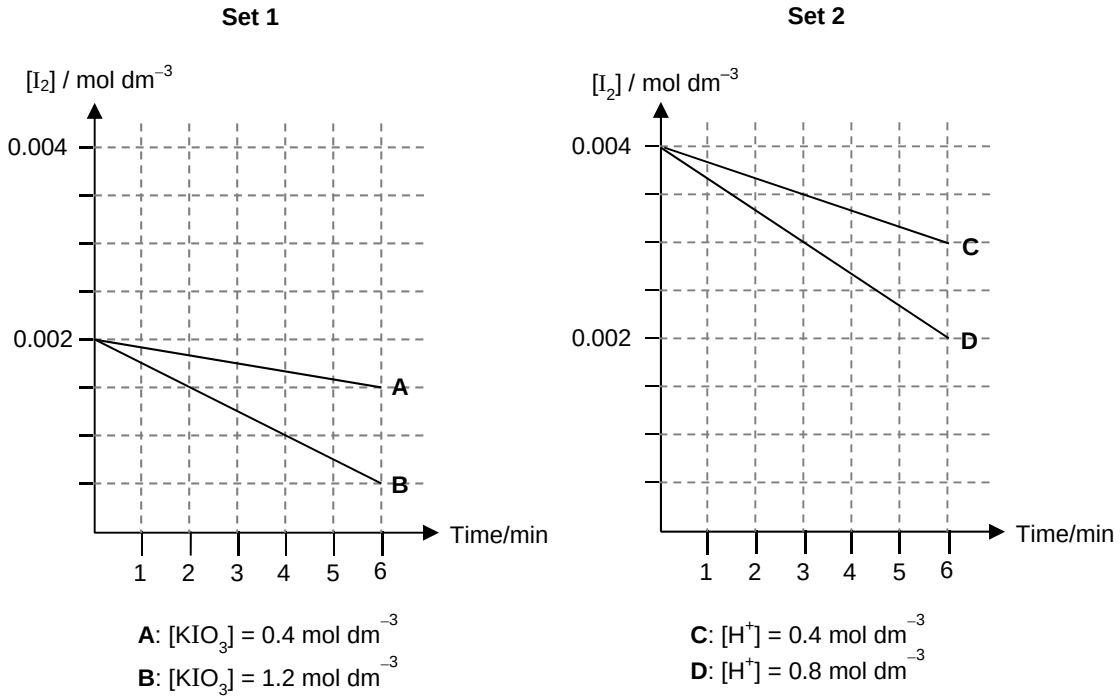
[2]

(c) Potassium iodate(V), KIO_3, in hydrochloric acid solution oxidises iodine to ICl_2^-.

$$IO_3^- + 2I_2 + 10Cl^- + 6H^+ \rightarrow 5ICl_2^- + 3H_2O$$

The rate of this reaction can be measured by following the decrease in colour intensity of brown iodine with the use of a colorimeter.

Two sets of experiments were performed in which the initial concentrations of KIO_3 and H^+ were varied. The results are shown below in graphical form.



(i) Use the graphs to determine the order of reaction with respect to the concentrations of KIO_3, iodine and H^+. Show your reasoning clearly.

(ii) Given that the reaction is zero order with respect to Cl^-, write the overall rate equation for the reaction, stating the units of the rate constant.

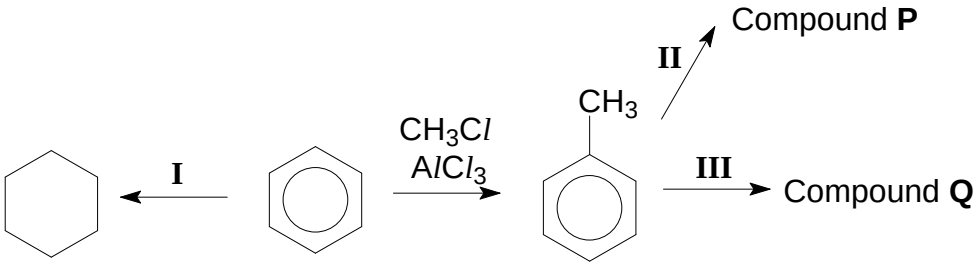
(iii) Explain how the rate of reaction would change if chlorine is used instead of iodine.

(iv) With an aid of a suitable diagram **and** collision theory, explain the effect on the rate of above reaction if it is carried out in an ice bath.

[9]

(d) Benzene and methylbenzene are important starting material for the synthesis of other

organic compounds. The following reaction scheme shows some reactions.



(i) State the type of reaction that took place for the conversion of benzene to methylbenzene

(ii) State the type of reaction that took place in reaction **I**.

(iii) Compounds **P** and **Q** are formed from methylbenzene using **two different sets** of reagents. Both are isomers with molecular formula **C_7H_7Cl**

Draw the structures of compound **P** and **Q** and propose the reagents and conditions required for reaction **II** and **III** respectively.

[6]

Total [20]

5 **(a)** Magnesium, silicon and phosphorus are all elements in Period 3 of the periodic table. Describe the variations in atomic radius, melting point, electrical conductivity and bonding for these three elements.

[5]

(b) In an experiment to determine the enthalpy change of combustion of ethanol, •Hc, a quantity of the fuel was burned underneath a copper can containing 200 g of water. It was found that the temperature of the water rose by 30.0 ^{o}C after 1.50 g ethanol had been burned.

(i) Calculate the apparent •Hc of ethanol from these figures. Ignore the heat capacity of the copper can, and use the figure 4.18 $Jg^{-1}K^{-1}$ for the specific heat capacity of water.

(ii) The true value of •Hc of ethanol is -1367 kJ mol^{-1} . What is the percentage efficiency of this combustion experiment **and** suggest a reason for the inefficiency.

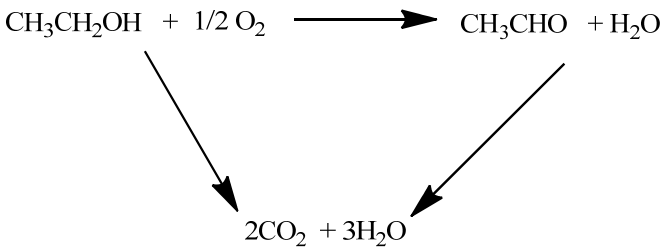
[5]

(c) An industrial method for manufacturing ethanol involves passing ethanol vapour and air over a heated copper catalyst.

$$CH_3CH_2OH + 1/2\ O_2 \xrightarrow{\text{Cu at } 300\ ^{o}C} CH_3CHO + H_2O$$

(i) Using bond energy data from the *Data Booklet,* calculate the enthalpy change for this reaction.

(ii) Using your result from c(i) and the value for •Hc of ethanol given in b(ii) deduce the enthalpy change of combustion of ethanal with the aid of the Hess law cycle below.



(iii) Would you expect the enthalpy change of combustion for ethanoic acid, CH_3CO_2H, to be more or less exothermic than that for ethanal? Explain your answer.

[4]

(d) A student is given two containers without labels and told they contain pure sample of two of the following four compounds.

propanoic acid, propanone, propanal , propanol

(i) Describe **one** test that could show that the samples are propanal and propanol and not the other compounds.

(ii) Describe **two** other tests that could distinguish between propanal and propanone.

In each case state the required reagent and conditions used and what observations you would make.

[6]

Total [20]

6 **(a)** Both magnesium and silicon react with chlorine to give their chlorides, which differ in their reaction with water.
Write equations for the reactions with water.
Describe these differences, and explain them in terms of the different structures and types of chemical bonding with the chlorides.

[4]

(b) On heating, magnesium nitrate decomposes to give magnesium oxide, nitrogen dioxide gas and oxygen gas.

(i) Write an equation, including state symbols, for the above reaction.

(ii) The lattice energies of sodium bromide is -733 kJ mol^{-1} and that for magnesium oxide is -3890 kJ mol^{-1}. Explain why the two ionic compounds have different magnitude of lattice energies.

[2]

(c) The water–gas shift reaction is often used to produce hydrogen. This involves the highly exothermic reaction of carbon monoxide with steam to produce carbon dioxide and hydrogen.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \quad \Delta H < 0$$

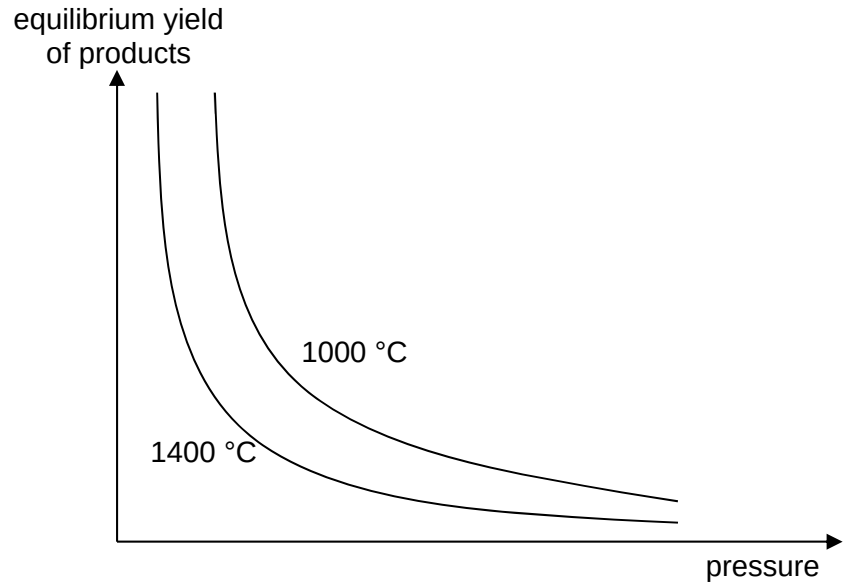
The equilibrium constant, K_c is found to be 0.64 at 1000 K.

(i) Write an expression for K_c for this reaction.

(ii) A mixture containing 0.80 mol of CO, 0.80 mol of H_2O, 0.40 mol of CO_2 and 0.40 mol of H_2 was placed in a 2 dm^3 flask and allowed to come to equilibrium at 1000 K.
Calculate the amount, in moles, of each substance present in the equilibrium mixture at 1000 K.

[4]

(d) The graph below shows the variation in equilibrium yield of the products with temperature and pressure for the water–gas shift reaction.

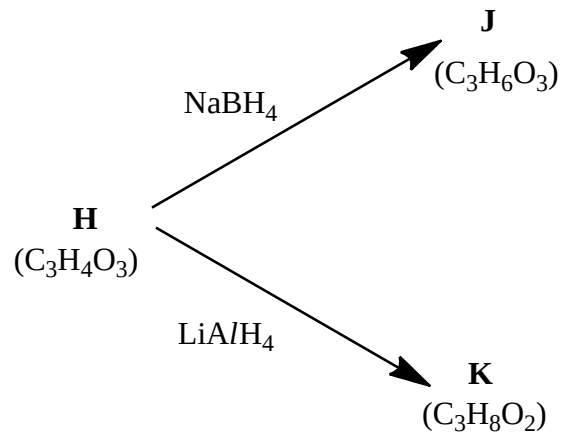


(i) State *Le Chatelier's Principle*.

(ii) Hence, comment on the accuracy of the graph with respect to **both** temperature and pressure.

[5]

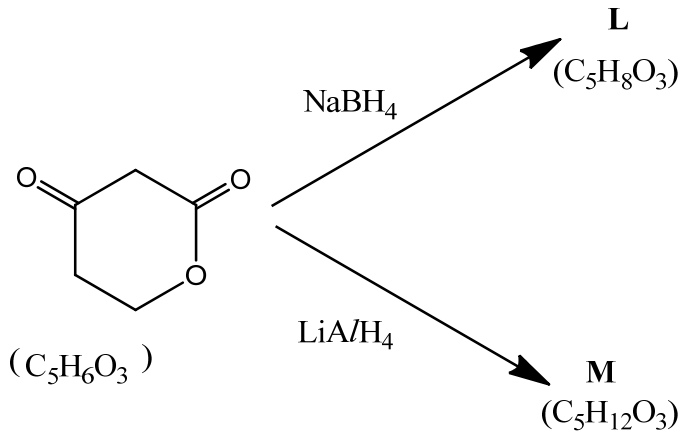
(e) $LiAlH_4$ and another complex hydride, sodium borohydride, $NaBH_4$, are useful reducing agents in organic chemistry. $LiAlH_4$ is the more powerful of the two, as the following scheme shows.



All three compounds **H, J** and **K** give a yellow precipitate with alkaline aqueous iodine, and all three react with sodium metal. Compounds **H** and **J** also react with $Na_2CO_3(aq)$, but compound **K** does not.

(i) Suggest structures for **H, J** and **K**.

(ii) Predict the structures of the products, **L** and **M**, of the following reactions.



[5]

Total [20]

The *END*