HWA CHONG INSTITUTION
Preliminary Examination
Higher 1

CANDIDATE NAME		**CT GROUP**	**15S**

CHEMISTRY **8872/02**

Paper 2 **30 August 2016**

2 h

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

Additional Materials: Data Booklet
Writing paper; Graph 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	/10	Q4	/ 20	
	Q2	/14	Q5	/ 20	
	Q3	/16	Q6	/ 20	
/ 30	**Subtotal**	**/ 40**	**Subtotal**	**/ 40**	**110**

This question booklet consists of **13** printed pages.

Section A

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

1 (a) An equilibrium exists between aqueous chromate (VI) ions and dichromate (VI) ions as shown by the expression below:

$$\underset{\text{Yellow}}{2CrO_4^{2-}(aq) + 2H^+(aq)} \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq) + H_2O(l)}$$

(i) State the meaning of the term *dynamic equilibrium*.

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…………………………………………………………………………………………

…………………………………………………………………………………………[1]

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

[1]

(iii) The initial concentration of CrO_4^{2-} ions and H^+ ions are 0.850 mol dm^{-3} and 1.20 mol dm^{-3} respectively. After equilibrium is reached, the concentration of $Cr_2O_7^{2-}$ ions is 0.200 mol dm^{-3}.

Calculate the value of K_c for this equilibrium and state its units.

K_c = ……………………… units = ………………………

[3]

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

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……………………………………………………………………………………[1]

(ii) Describe and explain what happens to the colour in the beaker when aqueous sodium hydroxide is added.

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……………………………………………………………………………………………[2]

(iii) When the beaker containing aqueous chromate (VI) and dichromate (VI) ions in equilibrium is heated, the solution becomes more yellow. Explain whether the equilibrium is exothermic or endothermic.

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………………………………………………………………………………………… [2]

[Total: 10]

2 **A, B, C, D, E** and **F** are all structural isomers with the molecular formula C_4H_8O

(a) **A, B** and **C** all give an orange precipitate when treated with 2,4- DNPH but only **A** and **B** give a brick-red precipitate when warmed with Fehling's solution.

(i) Draw the structural formulae of **A, B** and **C**

A	B	C

(ii) Name the type of structural isomerism shown by **A** and **B**

…………………………………………………………………………………………..

(iii) State what you would see when a sample of **A** is warmed with Tollens' reagent.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

(iv) State the reagents used that give a positive test for **C** but not **A** and **B**.

…………………………………………………………………………………………

[6]

(b) D, E and F (all with molecular formulae C_4H_8O) all decolourise bromine and effervescence slowly with sodium metal.
E shows geometrical isomerism.
Only D has branched chain.
None of these isomers contains C=O

(i) Give the structures of D, E and F. Show the two stereoisomers of E and **label** the stereoisomerism shown.

D	
E ……………	E ………………..
F	

(ii) Write balanced equation showing how one of these isomers react with sodium metal.

………………………………………………………………………………………………

[6]

(c)

Another compound, **G**, C_3H_6O, has the same functional group as A.

Give equations for the reactions of **G** with acidified potassium dichromate(VI) and sodium tetrahydridoborate, $NaBH_4$, using [O] or [H] as appropriate.

(i) reaction with acidified potassium dichromate(VI)

………………………………………………………………………………………………..

(ii) reaction with sodium tetrahydridoborate $NaBH_4$

………………………………………………………………………………………………..

[2]
[Total: 14]

3 ‘Water gas’ is an equimolar mixture of hydrogen and carbon monoxide. It is used as a gaseous fuel in the industry. It is produced when steam is blown through white-hot coke in the following reaction.

$$H_2O(g) + C(s) \rightarrow H_2(g) + CO(g)$$

Another widely-used industrial fuel is natural gas, which consists mainly of methane. $\Delta H^{\ominus}_c$ values are given in the table below.

Substance	Standard enthalpy change of combustion, $\Delta H^{\ominus}_c$/ kJ mol^{-1}
CH_4	-890
H_2	-242
CO	-283
C	-394

(a) (i) Define the term *standard enthalpy change of combustion,* $\Delta H^{\ominus}_c$

……………………………………………………………………………………..

……………………………………………………………………………………..

………………………………………………………………………………………

…………………………………………………………………………………… .[2]

(ii) Using the data given, calculate the volume of methane required to produce 1 MJ of heat energy when burned.

[2]

(iii) Calculate the volume of “water gas” required to produce the same amount of heat energy as methane. (1 mole of gas occupies 22400 cm^3 at stp)

[2]

(b) In recent years, there has been worldwide interest in the extraction of 'shale gas' as an important energy source.
One of the problems associated with using shale gas is its variable composition.
Table 1 shows the percentage composition of shale gas from four different sources **J**, **K**, **L** and **M**.

	Percentage composition				
Source of shale gas	CH_4	C_2H_x	C_3H_y	CO_2	N_2
J	80.3	8.1	2.3	1.4	7.9
K	82.1	14.0	3.5	0.1	0.3
L	88.0	0.8	0.7	10.4	0.1
M	77.5	4.0	0.9	3.3	14.3

Table 1

In the formulae above, x and y and variables.

(i) Draw the structures of three possible compounds with the formula C_3H_y.

[2]

(ii) Which source of shale gas **J**, **K**, **L** or **M,** will provide the most energy when burned? Explain your answer.

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…………………………………………………………………………………

………………………………………………………………………………… ……[1]

(iii) Suggest **two** methods (physical or chemical) by which carbon dioxide can be removed from shale gas.

1. ……………………………………………………………………………..

……………………………………………………………………………………

2. …………………………………………………………………………………

……………………………………………………………………………………[2]

(c) **Table 2** shows a comparison of the relative amounts of pollutants produced when shale gas, fuel oil and coal are burned to produce **the same amount of energy**.

Air pollutant	**Shale gas**	**Fuel oil**	**Coal**
CO_2	117	164	208
CO	0.040	0.033	0.208
NO_2	0.092	0.548	0.457
SO_2	0.001	1.12	2.59
Particulates	0.007	0.84	2.74

Table 2

(i) Suggest why shale gas produces the smallest amount of CO_2.

……………………………………………………………………………………

……………………………………………………………………………………[1]

(ii) Explain which of the three fuels, shale gas, fuel oil or coal, is the **largest** contributor to 'acid rain'.

……………………………………………………………………………………

……………………………………………………………………………………[1]

(iii) NO_2 is produced by the combustion of nitrogen gas in engines. Suggest a reason why fuel oil and coal produce more NO_2 than shale gas.

……………………………………………………………………………………..

……………………………………………………………………………………[1]

(iv) State one environmental consequence of raised levels of

CO, ……………………………………………………………………………………

CO_2, ……………………………………………………………………………………[2]

[Total: 16]

Section B

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

4 **(a)** Suggest suitable reagents and conditions for the following reactions of propan-1-ol.

$$CH_3CH_2CH_2Br \xleftarrow{\text{(i)}} CH_3CH_2CH_2OH \xrightarrow{\text{(ii)}} CH_3CH_2CO_2H$$

propan-1-ol

(iii) What products would be formed in (i) and (ii) if propan-2-ol is used instead of propan-1-ol?

(iv) Suggest how butanoic acid, $CH_3CH_2CH_2CO_2H$ can be synthesised starting from 1-bromopropane, $CH_3CH_2CH_2Br$. State the reagents, conditions and the intermediate compounds.

[6]

(b) Alcohols **A** and **B** are isomers.

$CH_3CH(OH)CH_2CH_3$ **A** $\quad\quad$ $(CH_3)_3COH$ **B**

(i) Draw the structural formula of one other alcohol isomeric with **A** and **B**.

(ii) What reagent and condition would you use to dehydrate **A** and **B** to alkenes?

(iii) Draw two geometric isomers resulting from dehydrating **A** and state the reasons why geometric isomerism arise?

(iv) Describe how **A** could be distinguished from **B** using a chemical test.

[8]

(c) (i) Explain the term *amphoteric.*

(ii) Write balanced equations to illustrate the amphoteric nature of aluminium oxide, Al_2O_3 .

(iii) How do the oxides of elements either side of aluminium in the third period differ in their acid/base behaviour? Write balanced equations to illustrate your answer.

[6]

[Total: 20]

5 (a) Sketch a graph showing the variation of first ionisation energy across the third period of the Periodic Table, and explain qualitatively its shape. [3]

(b) Explain the meaning of the following terms.

(i) Order of reaction

(ii) Half-life. [2]

(c) The reaction between hydrogen peroxide and acidified potassium iodide releases iodine.

$$H_2O_2 + 2I^- + 2H^+ \rightarrow 2H_2O + I_2$$

The rate of reaction can be followed by measuring the amount of iodine produced after various times, from which the concentration of H_2O_2 remaining can be calculated. The following reaction mixture was prepared.

Initial $[H^+]$ = 0.200 mol dm^{-3}

Initial $[I^-]$ = 0.200 mol dm^{-3}

Initial $[H_2O_2]$ = 0.0200 mol dm^{-3}

The following table shows $[H_2O_2]$ at various times.

time/ s	$[H_2O_2]$ / mol dm^{-3}
0	0.0200
80	0.0167
183	0.0135
315	0.0103
490	0.0071
760	0.0039

Plot these data on suitable axes and, showing all your working and drawing clearly any construction lines on your graph, use your graph to determine:

(i) the order of reaction with respect to $[H_2O_2]$

(ii) the initial rate, in mol $dm^{-3}s^{-1}$

Further experiments were carried out changing $[H^+]$ and $[I^-]$, but keeping the initial $[H_2O_2]$ the same as before. The following results were obtained.

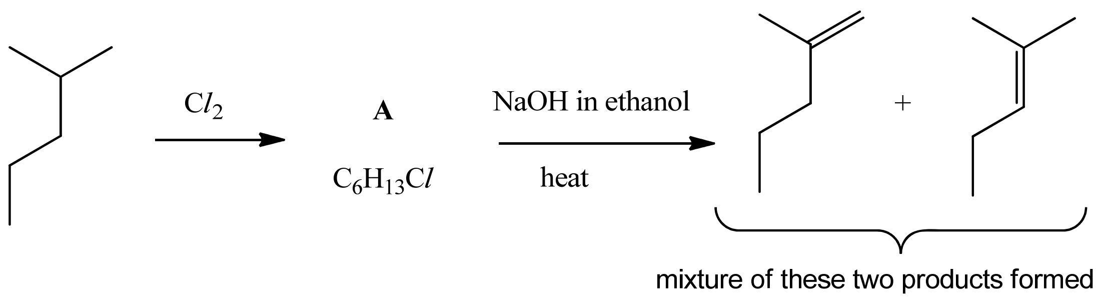
Initial $[H^+]$ / mol dm^{-3}	Initial $[I^-]$ /mol dm^{-3}	initial rate / mol dm^{-3}s^{-1}
0.400	0.200	8.4×10^{-5}
0.300	0.200	6.3×10^{-5}
0.200	0.100	2.1×10^{-5}

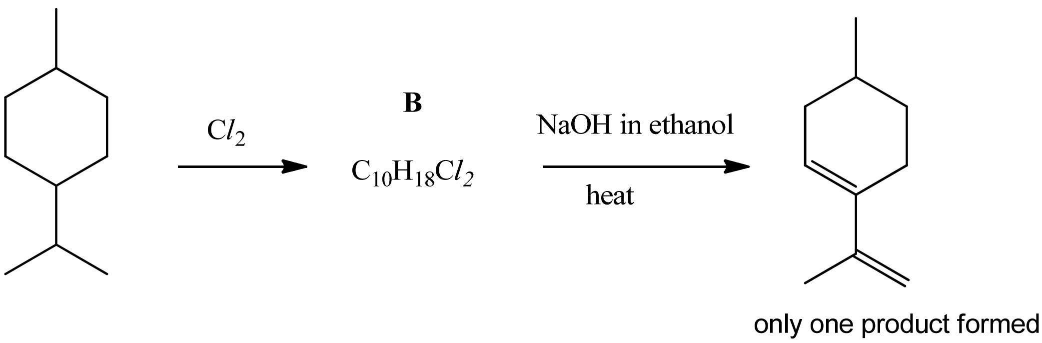
(iii) Determine the orders with respect to $[H^+]$ and $[I^-]$. Explain your reasoning.

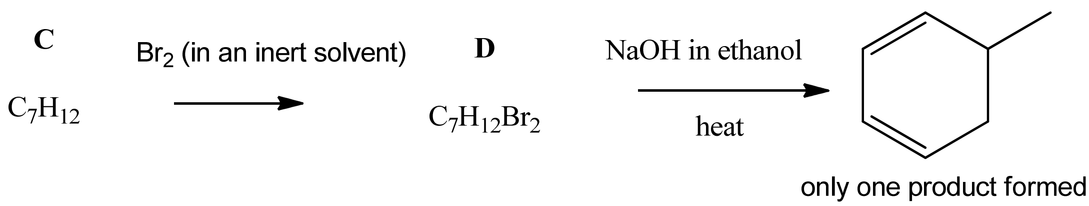
(iv) Hence write the rate equation for the reaction.

[8]

(d) Suggest a structural formula for each of the compounds A-D in the following schemes.







[4]

(e) Chlorofluoroalkanes, CFCs, were once used as refrigerant fluids and aerosol propellants. In many applications they have now been replaced by alkanes. This is because CFCs contribute to the destruction of the ozone layer.

(i) Suggest one reason why CFCs, were originally used for these purposes.

(ii) Explain how CFCs destroy the ozone layer.

(iii) Suggest one potential hazard of using alkanes instead of CFCs.

[3]

[Total: 20]

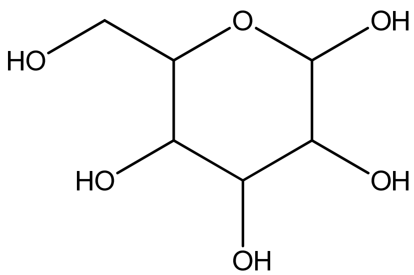
6 **(a)** Molecular shapes can be explained using the Valence Shell Electron Pair Repulsion Theory.

(i) Predict and explain the shape of sulfur hexafluoride SF_6.

(ii) Caesium fluoride, CsF, has a similar formula mass to sulfur hexafluoride. State and explain two differences you would expect to find in the physical properties of the two compounds.

[4]

(b) The structure of glucose is given below.



glucose

(i) What type of intermolecular force is likely to be responsible for the binding of water to glucose? Draw a diagram to illustrate your answer.

[2]

(ii) State two requirements for two molecules to form the intermolecular force that you have identified in b(i). [2]

(c) HC*l*, HBr and HI are strong acids when dissolved in water, whereas HF is a weak acid, with Ka = 5.6×10^{-4} mol dm^{-3}

(i) Use the Data Booklet to suggest a reason for this difference.

(ii) Calculate the pH of 0.50 mol dm^{-3} solutions of HC*l* **and** HF

[3]

(d) When methylbenzene is reacted with Cl_2 and $AlCl_3$, a monochloro compound **K** is formed. Treatment of **K** with more Cl_2 in the presence of light produces compound **L**. When **L** is heated with NaCN in ethanol, compound **M**, C_8H_6ClN, is formed. **M** can be converted into an acidic compound **N** by heating under reflux with dilute H_2SO_4. Heating **L** with NaOH(aq) produces compound **P**, C_7H_7ClO. When a mixture of **N** and **P** is heated with a small amount of concentrated H_2SO_4, compound **Q**, $C_{15}H_{12}Cl_2O_2$, is produced.

Identify the six compounds **K - Q**. State the *type* of **each** reaction described above.

[9]

[Total: 20]