

Parent's Signature:

CANDIDATE'S NAME: \_\_\_\_\_ CTG: \_\_\_\_\_

**YISHUN JUNIOR COLLEGE**  
JC2 PRELIMINARY EXAMINATION 2016

**CHEMISTRY  
HIGHER 1**

**8872/02**

**Paper 2: Structured & Free Response Questions**

**16 August 2015  
1400 hrs – 1600 hrs  
2 hours**

**Additional materials:**

Writing papers  
Data Booklet

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**INSTRUCTIONS TO CANDIDATES**

Write your name and CTG in the spaces at the top of this page.

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 paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

You are advised to show all working in calculations.

You may use a calculator.

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

At the end of the examination, fasten all your work securely together.

**For Examiner's Use**

**Paper 1**

**Total**

**/30**

**Paper 2**

**Section A**

**/40**

**B5**

**/20**

**B6**

**/20**

**B7**

**/20**

**Total**

**/80**

**Overall**

**/110**

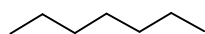
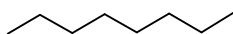
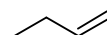
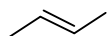
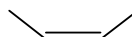
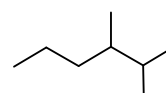
This question paper consists of **13** printed pages.

## Section A

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

- 1 Crude oil is a source of many hydrocarbons.

The skeletal formulae of some of these hydrocarbons are shown below.

**A****B****C****D****E****F****G****H****I**

- (a) (i) Construct an equation for the complete combustion of hydrocarbon **A**.

[1]

- (ii) Use the *Data Booklet* to calculate the enthalpy change for the reaction in (a)(i).

[3]

- (b) (i) Give the letters, **A** to **I**, of the two hydrocarbons that are geometrical isomers of each other.

\_\_\_\_\_ and \_\_\_\_\_

[1]

- (ii) Explain how this geometrical isomerism arises.

\_\_\_\_\_

\_\_\_\_\_, [1]

- (c) Explain why hydrocarbon **F** has a lower boiling point than hydrocarbon **B**.

.....

.....

....., [2]

- (d) Hydrocarbon **C** can be distinguished from the other hydrocarbons with a chemical test. State the reagents and conditions that would be used and the observations that would be made in the chemical test.

Reagents and conditions: .....

Observations: .....

....., [2]

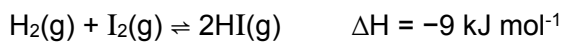
- (e) Both hydrocarbons **H** and **I** react with bromine. State the conditions and type of reaction with bromine for each hydrocarbon.

	<b>H</b>	<b>I</b>
conditions		
type of reaction		

[2]

[Total: 12]

- 2 Hydrogen and iodine react together in a reversible reaction:



$4.00 \times 10^{-3}$  mol  $\text{H}_2(\text{g})$  and  $8.00 \times 10^{-3}$  mol  $\text{I}_2(\text{g})$  are introduced to a vessel with a volume of  $2.0 \text{ dm}^3$ . The vessel was sealed, heated to a constant temperature and allowed to reach equilibrium.

The equilibrium mixture contains  $6.80 \times 10^{-3}$  mol  $\text{HI}(\text{g})$ .

- (a) (i) Write an expression for the equilibrium constant,  $K_c$ , for this reaction.

[1]

- (ii) Calculate the value of  $K_c$  for this equilibrium.

[3]

- (b) (i) The mixture was heated to a higher temperature at constant pressure. Explain how the increase in temperature will affect the value of  $K_c$ .

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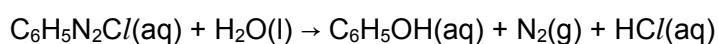
[2]

- (ii) The pressure of the mixture was increased at constant temperature. Explain how the increase in pressure will affect the amount of HI at the new equilibrium.

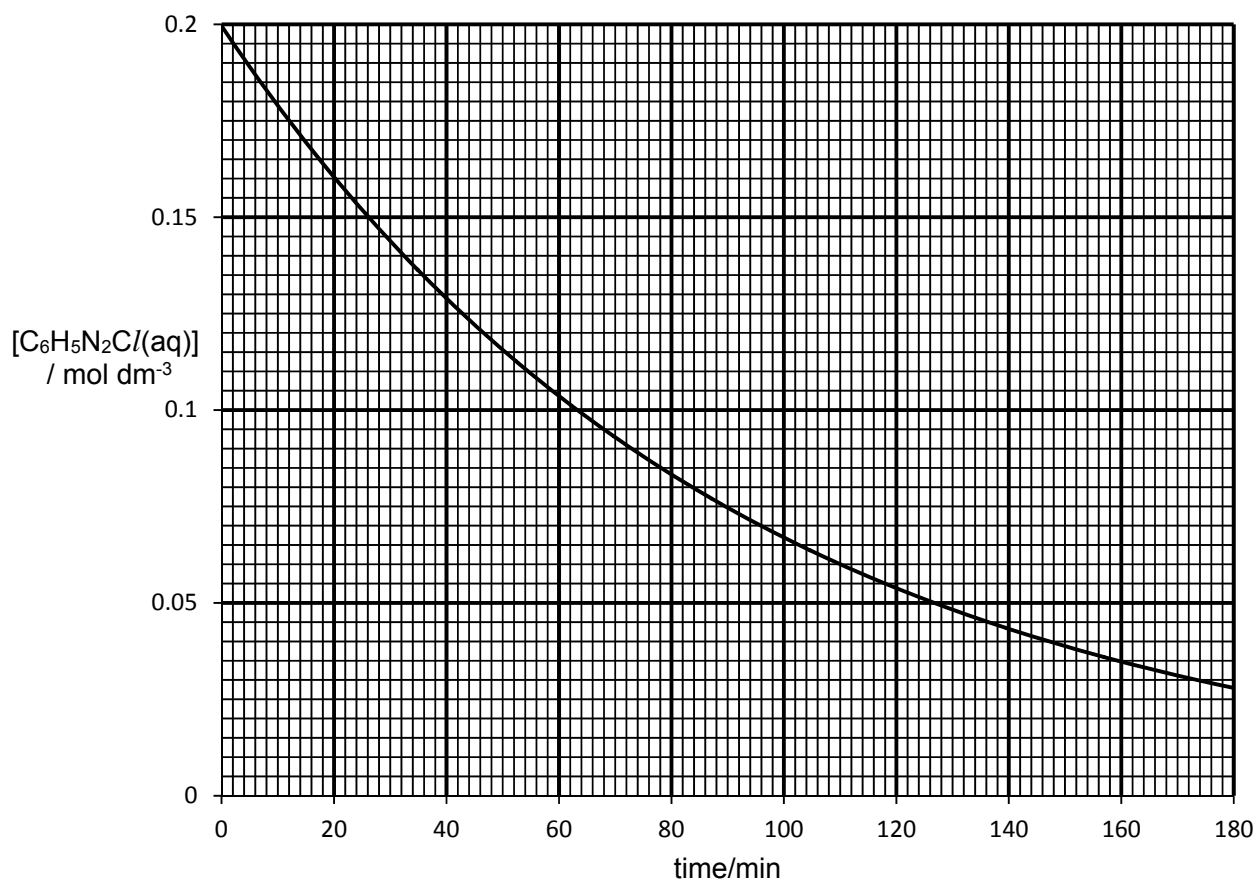
.....  
 .....  
 ....., [1]

[Total: 7]

- 3 In aqueous solution, benzenediazonium chloride,  $\text{C}_6\text{H}_5\text{N}_2\text{Cl}$ , decomposes above  $10^\circ\text{C}$ .



The rate of this reaction was investigated using an excess of water at  $50^\circ\text{C}$ . Measurements were taken at regular intervals during the reaction and then the experimental results were plotted to give the graph below.



- (a) (i) Deduce, showing your working, the order of reaction with respect to  $\text{C}_6\text{H}_5\text{N}_2\text{Cl}$ .

- (ii) Hence, write the rate equation for this reaction and give the units for the rate constant,  $k$ . [2]

rate equation: .....

units for  $k$ : ..... [2]

- (iii) The order of reaction with respect to  $\text{H}_2\text{O}$  is effectively zero. Explain why.

.....

..... [1]

- (b) Sketch a Boltzman distribution curve for the reactants and use it to explain the effect of increasing the temperature on the rate of reaction.

.....

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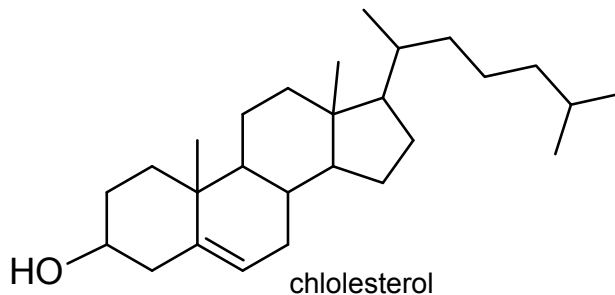
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.....

..... [3]

[Total:8]

- 4 Cholesterol is found in every cell of the body and has important natural functions. It is manufactured by the body but can also be taken in from food. It is waxy and fat-like in appearance. Cholesterol does not mix with the blood, which is water-based. It is therefore carried around the body in the blood by lipoproteins. It is recommended that the daily intake of cholesterol does not exceed 300 mg.



- (a) (i) The molecular formula of cholesterol is  $C_{27}H_{46}O$ . Calculate the maximum number of moles of cholesterol that can be taken daily.

[2]

- (ii) Cholesterol reacts with sodium to produce hydrogen gas. Calculate the volume of hydrogen gas at r.t.p. that can be produced from the amount of cholesterol from (a)(i).

[2]

- (b) Explain why cholesterol does not mix well with blood.

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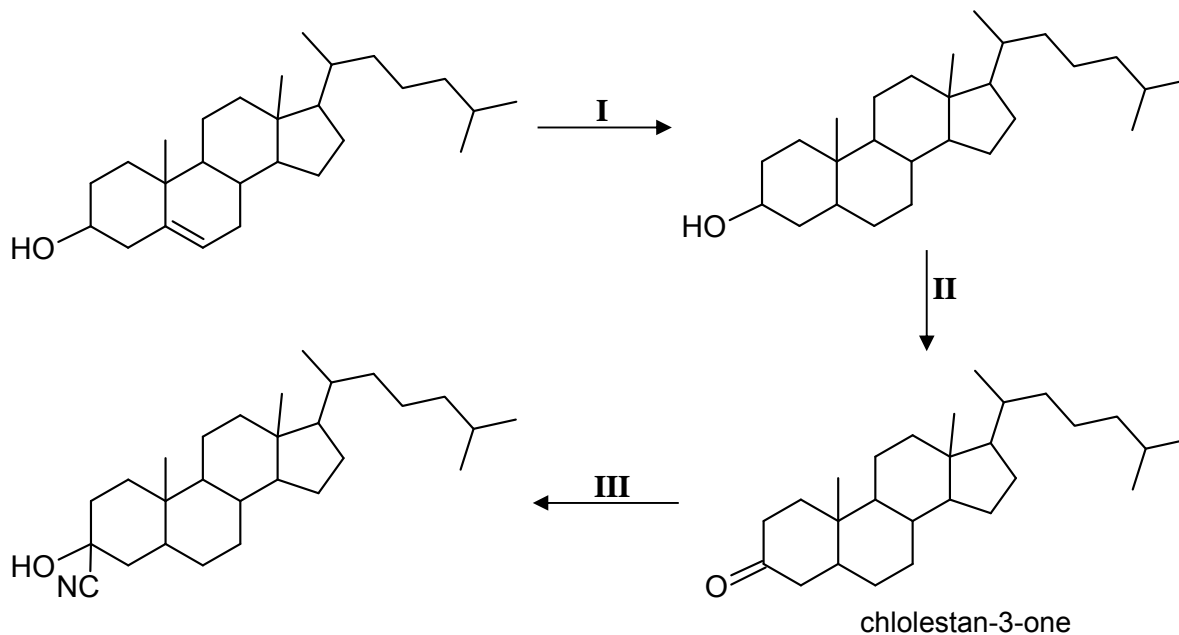
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[2]

- (c) Cholesterol can be converted to chloestan-3-one and then reacted in step **III** as shown by the following flow scheme.



- (i) Give the reagents and conditions for steps **I**, **II** and **III**.

step **I** .....

step **II** .....

step **III** ..... [3]

- (ii) Chloestan-3-one reacts with 2,4-dinitrophenylhydrazine. Draw the structure of the product of the reaction between chloestan-3-one and 2,4-DNPH.

Use  $\diagup \text{C}=\text{O}$  to represent the ketone.

[1]



**(d)** Cholesterol forms an ester with ethanoic acid.

- (i)** State the conditions and the type of reaction cholesterol undergoes with ethanoic acid.

conditions: .....

type of reaction: ..... [2]

- (ii)** Draw the structure of the ester formed.

[1]

[Total:13]

## Section B

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

**5** Chlorine is an element in period 3. Chlorine and its compounds have wide uses in chemistry.

**(a)** Using the chlorides of magnesium, silicon and phosphorus as examples, describe the reactions of the chloride of elements in the third period of the Periodic Table with water. Include balanced equations for the reactions involved. [5]

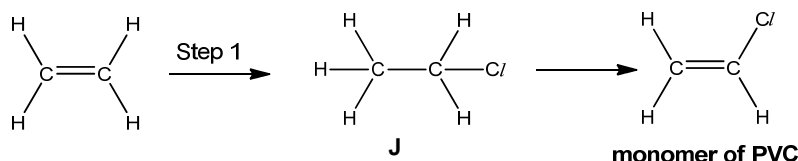
**(b)** Ammonium chloride,  $\text{NH}_4\text{Cl}$ , is a salt which has covalent bonding, dative bonding and ionic bonding.

**(i)** What is a dative bond?

**(ii)** Give the formulae of the ions present in  $\text{NH}_4\text{Cl}$ .

**(iii)** Draw a “dot-and-cross” diagram to show the bonding in  $\text{NH}_4\text{Cl}$ . Show the outer electrons only. [4]

**(c)** Halogenoalkanes have a variety of commercial uses. For example, PVC is a polymer commonly used in insulation of electrical wiring. To produce the monomer of PVC, the following reaction steps are carried out industrially starting with ethene.



**(i)** State the reagent used in Step 1 and state the type of reaction that has occurred.

**(ii)** Ethene can also be converted to ethanol, state the reagents and conditions for this conversion in a laboratory.

**(iii)** Compound **J** can also undergo a variety of reactions. It can react with ammonia under certain conditions. Write an equation for this and state the necessary conditions.

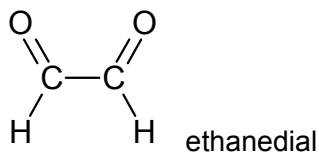
**(iv)** Halogenoalkanes can also react to give alcohols.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$  and  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$  can both give  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ . With reference to the Data Booklet, suggest the relative rates of each reaction. [8]

**(d)** Methylbenzene reacts with chlorine to form (chloromethyl)benzene. Give the conditions used, write the chemical equation including structural formulae and name the type of reaction that occurs. [3]

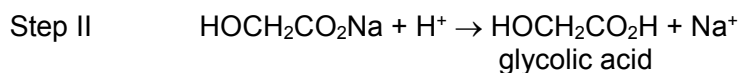
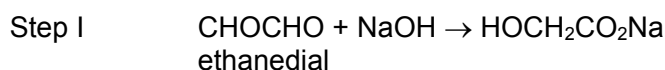
[Total: 20]

- 6 Ethanedial, also known as glyoxal, is used in the production of fabrics which have permanent creases. This yellow coloured liquid is the smallest dialdehyde (two aldehyde groups).

Ethanedial undergoes many of the reactions of aldehydes.



When ethanedial is reacted with NaOH and the product treated with dilute sulfuric acid, the following reaction sequence takes place to produce glycolic acid.



- (a) State the functional groups present in glycolic acid. [1]
- (b) Describe **two** simple test-tube reactions to distinguish ethanedial from glycolic acid. Write balanced equations for the reactions. [6]
- (c) Glycolic acid,  $\text{CH}_2(\text{OH})\text{CO}_2\text{H}$ , is the smallest of  $\alpha$ -hydroxy acid (AHA) which is used in various skin-care products. The acid dissociation constant,  $K_a$ , for glycolic acid,  $\text{HOCH}_2\text{CO}_2\text{H}$ , is  $1.48 \times 10^{-4} \text{ mol dm}^{-3}$ .
- (i) Glycolic acid is a *weak Bronsted acid*. What do you understand by the term in italics?
- (ii) Write an expression for  $K_a$  of glycolic acid.
- (iii) A solution of glycolic acid has a concentration of  $0.20 \text{ mol dm}^{-3}$ . Using the given concentration and  $K_a$  value, calculate the pH of this solution.
- (iv) A solution containing glycolic acid and its glycolate salt acts as a *buffer solution*. What do you understand by the term *buffer solution*? Explain, including appropriate equations, how this buffer solution works. [7]
- (d) Under appropriate conditions, glycolic acid is capable of forming a cyclic compound **K** of molecular formula  $\text{C}_4\text{H}_4\text{O}_4$ . Suggest the structural formula of the product **K**. [1]
- (e) Ethanedial can be synthesised from ethanedioic acid,  $(\text{COOH})_2$ .
- (i) Suggest how the synthesis can be carried out. State the reagents and conditions, and the structure of any intermediate formed
- (ii) Explain, in terms of structure and bonding, the difference in the boiling points of ethanedioic acid and ethanedial. [5]

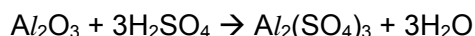
[Total: 20]

- 7 Aluminium is the most abundant metal found on the surface of the earth. Most of the aluminium compounds exhibit low toxicity.

(a) Aluminium foil, often used in food preparation, develops a thin oxide layer over the aluminium metal to protect it from corrosion.

(i) A student attempted to remove the oxide layer on the aluminium foil.

He placed the aluminium foil strips into a polystyrene cup and added 60 cm<sup>3</sup> of 1.2 mol dm<sup>-3</sup> sulfuric acid. 3.0 g of the aluminium oxide coating the metal reacted based on the following reaction.



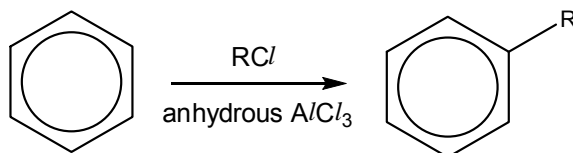
The maximum temperature change was recorded to be 11.5 °C.

Given that the specific heat capacity of the solution = 4.2 J g<sup>-1</sup> K<sup>-1</sup> and assuming the process to be 75% efficient, calculate the standard enthalpy change of neutralisation for the reaction

(ii) Another student proposed a method to remove the aluminium oxide layer using aqueous sodium hydroxide instead. With the aid of balanced chemical equation(s), comment on whether you agree with this proposal.

(iii) With reference to your answer in (a)(i), predict if the standard enthalpy change of neutralisation between ethanoic acid and aluminium oxide is less exothermic or more exothermic. [7]

(b) Aluminium chlorides are very commonly used in chemical industry as a catalyst for Friedel-Crafts reactions. An example of a Friedel-Crafts reaction is shown below.



In this reaction,  $\text{AlCl}_3$  act as a *halogen carrier* to form  $\text{AlCl}_4^-$ , which catalyses the reaction

(i) Suggest the shape and angle found in a molecule of aluminium chloride.

(ii) Explain why aluminium chloride has the ability to act as a *halogen carrier*. [4]

- (c) Aluminium has 2 naturally occurring isotopes,  $^{27}\text{Al}$  and  $^{26}\text{Al}$ .  
A sample of aluminium was analysed to give the following composition of isotopes.

isotopes	abundance (%)
$^{27}\text{Al}$	99.9
$^{26}\text{Al}$	0.1

- (i) Define the term *relative atomic mass*.
- (ii) Calculate the relative atomic mass of the sample of aluminium.
- (iii) Calculate the number of sub-atomic particles in the  $^{27}\text{Al}$  atom and its most stable ion. Tabulate your answers.
- (iv) Successive ionisation energies provide evidence for the existence of different shells in atoms. Using suitable axes, draw a sketch of the successive ionisation energies of aluminium. [9]

[Total: 20]

~ END OF PAPER ~