Parent's Signature:

CANDIDATE'S NAME: ____________________________________ **CTG:** ____________

YISHUN JUNIOR COLLEGE

2017 JC2 PRELIMINARY EXAMINATION

CHEMISTRY
HIGHER 1

8872/02

Paper 2 Structured and Free Response Questions

THURSDAY 24 AUGUST 2017
1400hrs − 1600hrs
(2 hours)

Candidates answer Section A on the Question Paper

Additional Materials: Writing Paper
Data Booklet

INSTRUCTIONS TO CANDIDATES

Write your name and CTG in the spaces at the top of this page and on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** the questions

Section B
Answer **two** questions on separate writing 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	
Total	**/ 30**
Paper 2	
Section A	/ 40
B5	/ 20
B6	/ 20
B7	/ 20
Total	**/ 80**
Overall	**/ 110**

Section A

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

1 Antacids can be taken to relieve symptoms of indigestion, heartburn or stomach ulcer by neutralising gastric acid, and commonly contain sodium bicarbonate, magnesium hydroxide, aluminium hydroxide or calcium carbonate. The acidity of gastric acid is contributed mainly by hydrochloric acid.

(a) Sodium bicarbonate, $NaHCO_3$, is a very quick-acting antacid, but it should only be used for temporary relief. This is because its excessive use will lead to an increase in the pH value of the gastric juices above 7, which will lead to rebound acid secretion by the cells in the lining of the stomach.

Aluminium hydroxide, $Al(OH)_3$, and calcium carbonate, $CaCO_3$, are the active ingredients in the more popular antacids available in the market.

(i) Write an equation to illustrate how aluminium hydroxide relieves acid indigestion.

..... [1]

(ii) Suggest a possible advantage of using aluminium hydroxide or calcium carbonate as an antacid compared to sodium bicarbonate.

.....

..... [1]

(b) A popular brand of antacid has the following drug facts on its label.

Drug Facts

Active ingredient (in each tablet)	**Purpose**
Calcium carbonate 500 mg	Antacid

Warnings

Ask a doctor or pharmacist before use if you are now taking a prescription drug. Antacids may interact with certain prescription drugs.
When taking this product do not exceed 15 tablets daily or use the maximum dosage for more than 2 weeks.
Keep out of reach of children.

Directions chew 2 to 4 tablets as symptoms occur

Other information

- each tablet contains calcium 215 mg and magnesium 5 mg
- store at 20 °C − 25 °C

Supplementary Facts

Serving size: 2 Tablets (1.30 g per tablet), Servings: 150,
Amount Per Serving: Total Carb 1 g, Sugars 1 g, Calcium 430 mg

Calcium carbonate reacts with hydrochloric acid to produce carbon dioxide gas as shown in the following equation.

$$CaCO_3(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

A student was given an antacid tablet and tasked to verify the mass of calcium carbonate claimed by the manufacturer on the drug facts label. She crushed five tablets with a pestle and mortar to form a powder and reacted with 100.0 cm^3, an excess, of 0.50 mol dm^{-3} hydrochloric acid. The carbon dioxide produced was collected and found to occupy 550 cm^3 at s.t.p..

(i) Calculate the number of moles of carbon dioxide produced.

number of moles of CO_2 = ... [1]

(ii) Assuming that calcium carbonate is the only ingredient in the antacid tablet that reacts with hydrochloric acid, calculate the mass of calcium carbonate reacted.

mass of calcium carbonate reacted = ... [2]

(iii) Hence, deduce whether the mass of calcium carbonate claimed by the manufacturer on the drug facts label is valid.

.....

.....

..... [2]

[Total: 7]

2 The Periodic Table we currently use is derived from that proposed by Mendeleev in 1869 after he had noticed patterns in the chemical properties of the elements.

Use the third period of the modern Periodic Table, sodium to chlorine, to answer the following questions.

(a) **(i)** Describe how the melting point of these elements varies across the period.

.....

.....

..... [2]

(ii) Describe and explain the trend in atomic radius for the elements sodium to chlorine.

trend .....

.....

explanation .....

..... [2]

(b) State the structure and bonding present in the elements sodium, silicon and chlorine.
How does the bonding present help to explain the variation in electrical conductivity of these elements?

sodium .....

.....

.....

silicon .....

.....

.....

chlorine .....

.....

[6]

(c) **(i)** Describe the structure of a ^{35}Cl atom, in terms of number and type of sub-atomic particles.

.....

..... [2]

(ii) State the electronic configuration of a chloride ion, Cl^-.

..... [1]

(d) Chlorine forms a compound, ClO_2, with oxygen, which exist as covalent molecules.

(i) Draw a dot-and-cross diagram to illustrate the bonding in a ClO_2 molecule, showing the outermost shell electrons only.

[1]

(ii) Explain why ClO_2 is a non-linear molecule.

.....

.....

..... [2]

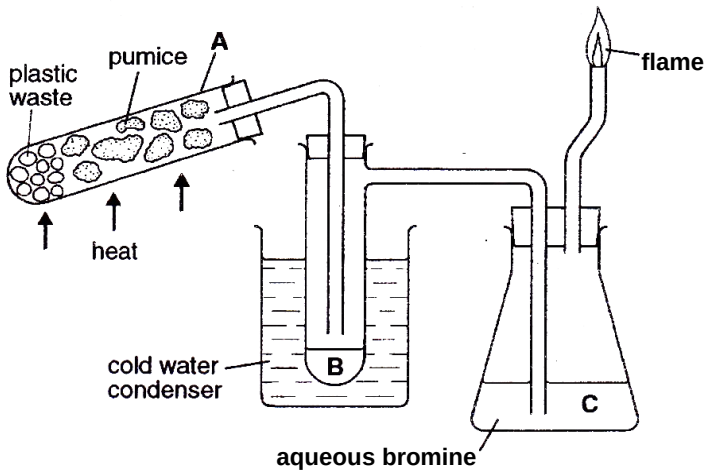
[Total: 16]

3 (a) In some countries, combustion is used in the disposal of plastic waste containing poly(ethene) and poly(propene).

(i) Construct an equation for the complete combustion of poly(propene), taking its formula to be $C_{3n}H_{6n}$, where n is the number of repeat units in a polymer molecule.

.....[1]

One method of recycling plastic waste to produce useful organic products involves heating the plastic waste strongly and passing the vapours over a hot inert surface such as pumice. This process can be demonstrated in the laboratory as shown in the diagram below.



The products of heating poly(propene) are given in the table.

product	percentage
hydrogen	12
methane	24
ethene	12
propene	16
benzene	20
methylbenzene	10
carbon	6

(ii) What will be the main constituent of the residue left in tube **A**, after it has been heated for an extended period of time?

.....[1]

(iii) What are the products that will be collected in tube **B** with the side-arm?

.....[1]

(iv) What will you observe in flask **C** after tube **A** has been heated for some time?

.....

Write a balanced equation for the reaction that may have occurred in flask **C**.

..... [2]

(v) Suggest an advantage (economical or environmental) of this method of plastic waste disposal over the combustion method.

.....

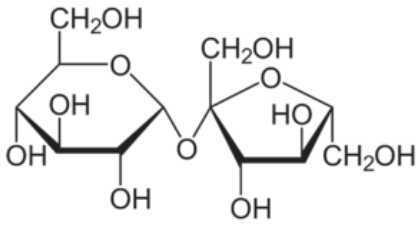
..... [1]

(b) Using an alkene with six carbon atoms, draw labelled structures to illustrate *cis-trans* isomerism.

[2]

[Total: 8]

4 Sugar is composed of sucrose, $C_{12}H_{22}O_{11}$. It is used as a sweetener in many foods and drinks. Carbonated soft drinks typically contain about 110 g of sucrose per dm^3.



sucrose

Carbonated drinks are often sold in 330 cm^3 cans.

(a) **(i)** Calculate the mass of sucrose, in grams, that is present in a can of carbonated soft drink.

mass of sucrose = ... [1]

(ii) Calculate the number of moles of sucrose in your answer to **(a)(i)**.

number of moles of sucrose = ... [2]

When the body uses sucrose in respiration, it does so by first breaking down the sucrose into glucose, $C_6H_{12}O_6$, and then releasing energy according to the following equation.

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

However, the respiration of sucrose can be represented as follows.

$$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l)$$

The data for some enthalpy changes of formation are in the table below.

compound	$\Delta H^{\ominus}_f$ / kJ mol^{-1}
$C_6H_{12}O_6(s)$	−1271
$CO_2(g)$	−394
$H_2O(l)$	−286
$C_{12}H_{22}O_{11}(s)$	−2226

The energy content of most carbonated soft drinks is usually stated with units of 'calories' on the nutrition information label. One calorie has the value of 4.2 kJ. On average, the daily calorie intake for men should be 2500 and for woman 2000.

(b) (i) Calculate the standard enthalpy change, in kJ mol^{-1}, for the respiration of sucrose.

$\Delta H^{\ominus}$ = ... [3]

(ii) Use your results from **(a)(ii)** and **(b)(i)** to calculate the quantity of energy that is available from the sucrose contained in a can of carbonated soft drink.

energy = [1]

(iii) Calculate the percentage of a man's recommended daily calorie intake he will consume by drinking a can of carbonated soft drink.

percentage = ... [2]

[Total: 9]

Section B

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

5 The reaction between propanoic acid and ethanol in the presence of concentrated sulfuric acid to form ethyl propanoate is a *reversible reaction*.

$$CH_3CH_2COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3CH_2COOCH_2CH_3(l) + H_2O(l)$$

propanoic acid ethanol ethyl propanoate

(a) **(i)** What is meant by the term *reversible reaction*? [1]

(ii) Write an expression for the equilibrium constant, K_c, for the reaction between propanoic acid and ethanol shown above. [1]

(iii) Calculate the concentration of ethanol at equilibrium when the concentrations of $CH_3CH_2COOH(l)$, $CH_3CH_2COOCH_2CH_3(l)$ and $H_2O(l)$ are 0.18 mol dm^{-3}, 1.15 mol dm^{-3} and 1.15 mol dm^{-3} respectively.

The numerical value of K_c for this reaction is 3.94. [2]

(b) Propanoic acid can be made from different classes of compounds. Apart from an ester, choose **two** starting organic compounds that have **different** functional groups that can be converted to propanoic acid. Describe the reactions to form propanoic acid including reagents, equations and any observations in your answer. [8]

(c) When a small piece of sodium is added to propanoic acid, a steady flow of bubbles is produced and a sodium salt is formed. Potassium will react with propanoic acid in a similar way.

(i) Write an equation for the reaction of potassium with propanoic acid. [1]

(ii) State what type of reaction this is. [1]

(iii) State how you would identify the gas evolved. [1]

(iv) Predict how the observations for this reaction compare with that of sodium. Suggest an explanation in terms of atomic structure. [2]

(d) Methyl butanoate is isomeric with ethyl propanoate. Write equations to show how methyl butanoate undergoes hydrolysis using HC*l*(aq) and NaOH(aq). [3]

[Total: 20]

6 **(a)** Explain the terms *order of reaction* and *half-life*. [2]

(b) A chemist investigated the reaction between $H_2(g)$ and NO(g) at 300 °C.

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

The following data were obtained.

experiment	initial concentration of $H_2(g)$ / mol dm^{-3}	initial concentration of NO(g) / mol dm^{-3}	initial rate / mol dm^{-3} h^{-1}
1	2.0×10^{-3}	3.0×10^{-3}	3.0×10^{-3}
2	2.0×10^{-3}	6.0×10^{-3}	1.2×10^{-2}
3	4.0×10^{-3}	6.0×10^{-3}	2.4×10^{-2}

(i) Use the data above to deduce the order of reaction with respect to each of the two reagents, showing how you arrive at your answers.

Hence, write a rate equation for the reaction. [3]

(ii) Calculate a value for the rate constant and state its units. [2]

(c) The chemist repeated experiment 1 at 310 °C and found that the initial rate of reaction was approximately double of that at 300 °C.

(i) Draw a graph to show the **energy distribution** of gas molecules at 300 °C.
Label this curve 300 °C. [1]

(ii) On the same axes, sketch the energy distribution of the same gas molecules at a temperature of 310 °C.
Clearly label this curve 310 °C. [1]

(iii) Indicate an activation energy on your graph. [1]

(iv) Use the sketches that you have drawn **and** the collision theory to explain why an increase in temperature causes an increase in the rate of the reaction. [3]

(d) In water, NO(g) reacts with oxygen and water to form nitrous acid, HNO_2, which is a *weak* acid.

(i) What is meant by the term *weak* acid?
Illustrate your answer with an equation. [2]

(ii) Write an expression for the acid dissociation constant. K_a, of nitrous acid, and state its units. [2]

(ii) Calculate the hydrogen ion concentration, $[H^+]$, of a solution of nitrous acid of pH 3.72. [1]

(e) A solution containing nitrous acid, HNO_2, and sodium nitrite, $NaNO_2$, can act as a buffer solution.

Write two equations to show how such a solution behaves as a buffer when a small amount of acid or alkali is added. [2]

[Total: 20]

7 **(a)** Carbon is a major constituent of organic compounds, often combined with the elements, hydrogen and oxygen. One such compound is **D**, which contains C, 66.7%; H, 11.1%; O, 22.2% by mass. The relative molecular mass of **D** is 72.0.

(i) Determine the empirical formula and the molecular formula of **D**. [3]

(ii) **D** is a ketone. Draw its displayed formula. [1]

(b) Compound **E** has the molecular formula C_3H_8O. When **E** is heated with acidified potassium dichromate(VI), $K_2Cr_2O_7$, it forms compound **F**.

F gives a yellow precipitate in the presence of alkaline aqueous iodine, and an orange precipitate in the presence of 2,4-dinitrophenylhydrazine.

When **E** is heated with aqueous sodium bromide and concentrated sulfuric acid, it forms compound **G**. When a solution of silver nitrate in ethanol is added to **G**, a pale cream precipitate appears after a few minutes. When **G** is heated under reflux with concentrated sodium hydroxide in ethanol, compound **H** is formed.

H decolourises aqueous bromine.

Identify and suggest structures for **E**, **F**, **G** and **H**. Show how you deduced these structures, write equations for all of the reactions described above and suggest the types of reactions that are occurring. [10]

(c) Methylbenzene is an important intermediate in organic synthesis. It can undergo two different types of reactions with chlorine, depending on the conditions of the reaction.

For each type of reaction, give the conditions used and draw the structural formulae of the organic product formed. [4]

(d) Chlorofluoroalkanes, CFCs, have been banned as refrigerants and aerosol propellants in many countries since the mid-1990s. Suggest why CFCs have been banned and why fluoroalkanes such as CH_2FCF_3 are used as their replacements. [2]

[Total: 20]

~ END OF PAPER ~