Parent's Signature:

CANDIDATE'S NAME: _____ CTG: _____

YISHUN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION 2015

CHEMISTRY 8872/02
HIGHER 1
Paper 2: Structured & Free Response Questions **18 August 2015**
2 hours

Additional materials:
Writing papers
Data Booklet

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 **12** printed pages.

Section A

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

1 Nitrogen and phosphorus are elements from Group V.

(a) Explain why nitrogen has a higher first ionisation energy than phosphorus.

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..... [2]

(b) Ammonia, NH_3 and phosgene, PH_3 are both gaseous Group V hydrides. The boiling points of ammonia and phosgene are shown in the table below.

Group V hydride	Boiling point / ^{0}C
ammonia	−33
phosgene	−88

Explain why phosgene has a lower boiling point than ammonia.

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..... [2]

(c) Ammonia reacts with molecules of boron trifluoride, BF_3 to form H_3NBF_3. One of the bonds in H_3NBF_3 is a dative covalent bond.

(i) Define the term *dative bond*.

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(ii) Draw a dot-and-cross diagram to show the bonding in H_3NBF_3.

(iii) The H−N−H bond angle in ammonia is 107^0. A student predicted that the H−N−H bond angle is H_3NBF_3 is larger.

Explain why the student might expect the H−N−H bond angle to be larger in H_3NBF_3 than in ammonia.

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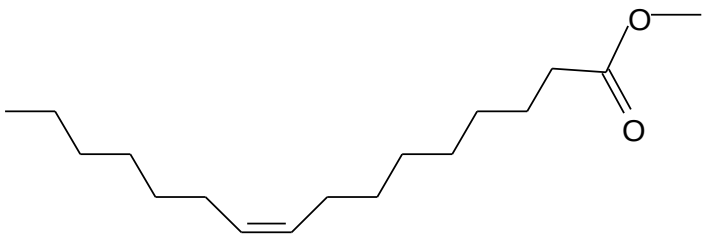
..... [5]

[Total: 9]

2 Compound **A** is found in biodiesel. It has the skeletal formula shown below.



Compound **A**

(a) Name the **two** functional groups that are present in compound **A**.

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[2]

(b) Compound **B** is a geometrical isomer of compound **A**.
Draw the structure of compound **B**.

[1]

(c) Draw the structure of the products formed when compound **A** reacts with hot aqueous sodium hydroxide.

[2]

(d) A student determined the enthalpy change of combustion for compound **A**. In her experiment, 2.50 g of compound **A** was used to heat 100 g of water. The temperature rose from 25.0 ^{0}C to 56.5 ^{0}C.

(i) Define the term *standard enthalpy change of combustion*.

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(ii) Given that the specific heat capacity of water is 4.18 $Jg^{-1}K^{-1}$, calculate the heat released in the experiment.

(iii) The molecular formula of compound **A** is $C_{17}H_{32}O_2$. Calculate the number of moles of compound **A** used in the experiment.

(iv) Hence, calculate the enthalpy change of combustion of compound **A**.

[5]
[Total: 10]

3 In order to determine the structure of compound **C**, C_8H_8O, chemical tests were carried out and the results are tabulated below.

	Test	Observations
1	2,4-dinitrophenylhydrazine	Orange precipitate formed
2	Tollen's reagent	Silver mirror formed
3	Fehling's solution	No precipitate formed
4	Hot acidified $KMnO_4$	Purple $KMnO_4$ decolourised

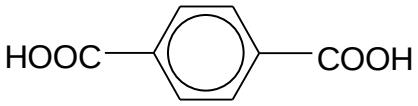
(a) What can be deduced about the nature of compound **C** in the following tests?

Test **1** .....

Test **2** .....

Test **3** ..... [3]

(b) For test **4**, the structure of the organic product is



Deduce the structure of compound **C**.

[1]

(c) Draw the structure of a structural isomer of compound **C** that will give a **different** observation for one of the above tests.

[1]

(d) Compound **C** contains a benzene ring. Describe the bonding in benzene in terms of orbitals overlap. You may draw a diagram to illustrate your answer.

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..... [3]

[Total: 8]

4 Potassium manganate(VII), $KMnO_4$ can be prepared in the laboratory by a two-step synthesis starting from manganese(IV) oxide, MnO_2.

Step 1
In this step, manganese(IV) oxide MnO_2 is heated strongly with potassium hydroxide, KOH and potassium chlorate(V), $KClO_3$ which is a powerful oxidising agent.

Manganese(IV) oxide, MnO_2 is oxidised to manganate(VI) ions, MnO_4^{2-} while chlorate(V) ions, ClO_3^- are reduced to chloride ions, Cl^-.

Step 2
Potassium manganate(VI) is separated from the alkaline mixture from **step 1** as a green solid.

In this step, potassium manganate(VI) is heated in water. Manganate(VI) ions disproportionate to form manganate(VII) ions and a precipitate of manganese(IV) oxide. The following equilibrium is set up.

$$3MnO_4^{2-}(aq) + 2H_2O(l) \rightleftharpoons 2MnO_4^-(aq) + MnO_2(s) + 4OH^-(aq)$$

Aqueous potassium manganate(VII), $KMnO_4$, in acidic conditions can be used in analysis.

A student analyses an impure sample of sodium sulfite, Na_2SO_3, using the following method.

- The student dissolves 2.00 g of impure sodium sulfite in water and the solution is made up to 250 cm^3.
- 25.0 cm^3 of this solution was titrated with 0.0200 $moldm^{-3}$ of $KMnO_4$ under acidic conditions. The titration required 26.80 cm^3 of $KMnO_4(aq)$ to reach the end-point.

$$2MnO_4^- + 5SO_3^{2-} + 6H^+ \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$$

(a) Write oxidation and reduction half-equations for the reaction in **step 1**. Hence, write a balanced overall equation for the reaction in **step 1**.

oxidation half-equation: .....

reduction half-equation: .....

Overall equation: ..... [3]

(b) Suggest and explain, with the aid of an equation, how the percentage composition of manganate(VII) ions, MnO_4^- will change when carbon dioxide gas is bubbled through the equilibrium mixture in **step 2**.

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..... [3]

(c) **(i)** In terms of change in oxidation state in the reaction between sodium sulfite, Na_2SO_3 and potassium manganate(VII), $KMnO_4$, explain the term *redox* reaction.

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(ii) Calculate the number of moles of potassium manganate(VII) needed to react with 25.0 cm^3 of sodium sulfite solution.

(iii) Hence, determine the percentage purity of the sample of sodium sulfite.

[7]
[Total:13]

Section B

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

5 Sulfuric acid is used in many industrial processes of major importance.

The first stage in the manufacture of sulfuric acid is to pass air over burning sulfur to produce sulfur dioxide and sulfur trioxide.

(a) Draw a dot-and-cross diagram to show the bonding in a sulfur dioxide molecule and a sulfur trioxide molecule and use the VSEPR (valence shell electron pair repulsion) theory to predict the shapes of both molecules. [4]

(b) Aluminium is in the same period as sulfur.

Describe and explain the reactions, if any, of the oxides of aluminium and sulfur with aqueous sodium hydroxide and dilute hydrochloric acid. Include balanced equations for the reactions. (You may use only one of the oxides of sulfur in your answer.) [4]

(c) The key stage in the manufacture of sulfuric acid is the reaction between sulfur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJmol}^{-1}$$

5 moles of sulfur dioxide and 2 moles of oxygen were added to a 2 dm^3 vessel. Equilibrium was established at 700 ^{0}C and it was determined that 40% of the sulfur dioxide remained in the equilibrium mixture.

(i) Write an expression for the equilibrium constant, K_c for this reaction, including its units.

(ii) Calculate a value for K_c.

(iii) Describe and explain the effect of increasing the temperature on the position of this equilibrium. [6]

(d) Sulfuric acid is a *strong Bronsted acid*.

(i) Explain the terms in itallics.

(ii) Given that a solution of sulfuric acid has a pH of 1.2, calculate the concentration of sulfuric acid. [4]

(e) Concentrated sulfuric acid is used in many organic reactions. One such reaction involves alkenes.

(i) State the type of reaction involving alkenes and concentrated sulfuric acid.

(ii) Draw the displayed formula of the product formed when but-2-ene reacts with concentrated sulfuric acid. [2]

[Total: 20]

6 The use of ethanol is thought to date back to pre-history where it would have been produced by the natural fermentation of sugars in fruits. It has many everyday uses ranging from solvents, cleaning products, fuel for cooking, industrial applications and even medical uses.

(a) Ethanol can be oxidised to form **two** different products. Describe the reactions to produce these two different products, including reagents and conditions, equations and any observations in your answer. [5]

(b) A student investigated the rate of reaction between sodium and ethanol. A freshly cut piece of sodium was weighed and added to a large excess of ethanol.

(i) Write an equation for the reaction between sodium and ethanol.

The volume of gas liberated was recorded every minute. The results are tabulated below.

time / min	0	1	2	3	4	5	6	7
volume of gas / cm^3	0	23.0	36.5	46.0	51.0	54.5	57.0	58.5

(ii) Given that the total volume of gas evolved from the reaction is 60 cm^3, draw a suitable graph and explain why the experimental results indicate that the overall kinetics is first order.

(iii) In this experiment, the kinetics appears zero order with respect to ethanol. Suggest a reason for this.

(iv) Calculate the mass of sodium weighed out at the start of the experiment.

(v) Explain, with the aid of an equation, why sodium needs to be freshly cut.

(vi) Sketch a Boltzman distribution curve for the reactants and use it to explain the effect increasing the temperature on the rate of the reaction. [13]

(c) Suggest a chemical test to distinguish ethanol from propanol. Give reagents and conditions for the reaction and state what you would observe. [2]

[Total: 20]

7 Chlorine is used in the manufacture of a wide range of consumer products, about two-thirds of them are organic chemicals such as polyvinyl chloride, as well as many intermediates for production of plastics. As a common disinfectant, elemental chlorine and chlorine-generating compounds are used more directly in swimming pools to keep them clean and sanitary.

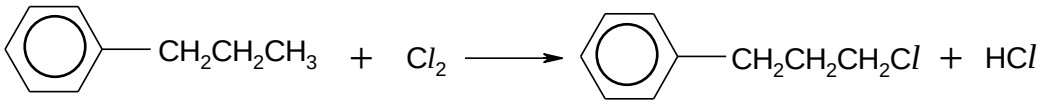
(a) Chlorine is in period 3 of the Periodic Table.

(i) Describe and explain the trend in ionic radius for the elements sodium to chlorine.

(ii) In terms of structure and bonding, describe and explain the trend in melting point for the elements sodium to chlorine.

[6]

(b) Chlorine reacts with propylbenzene as shown in the following equation.



(i) Draw the structures of the two other organic products that can be formed from this reaction.

(ii) State the type of reaction that propylbenzene has undergone and the conditions necessary for this reaction to occur.

(iii) Use bond energy values from the *Data Booklet* to estimate the enthalpy change for this reaction.

(iv) Using your answer from **(b)(iii)**, construct a reaction pathway diagram for this reaction.

(v) Propylbenzene can also undergo another halogenation reaction with chlorine.
State the conditions necessary for this reaction to occur and draw the structures of the organic products. [11]

(c) Explain the following observations as fully as you can. The use of the *Data Booklet* is recommended.

compound	**observations after adding $AgNO_3(aq)$**
1-chloropropane	ppt forms after 10 minutes
1-bromopropane	ppt forms after 2 minutes
1-iodopropane	ppt forms almost immediately
chlorobenzene	no ppt forms

[3]
[Total: 20]

~ END OF PAPER ~