H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

CLASS

TUTOR'S NAME

CHEMISTRY

8872/02

Paper 2

11 Sep 2017

2 hours

Candidates answer Section A on the Question Paper

Additional Materials: Answer Paper
Data Booklet
Graph paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, 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 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 Examiner's Use	
Section A	
B5	
B6	
B7	
Total	**/80**

For Examiner's Use

Section A

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

1 (a) (i) The bond energy of the carbon-carbon single bond in the ethane molecule is 350 kJ mol^{-1}. It was expected that bond energy of the carbon-carbon double bond in the ethene molecule to be twice that of the carbon-carbon single bond in the ethane. However, actual bond energy of the carbon-carbon double bond in the ethene molecule is only 610 kJ mol^{-1}. Account for the difference.

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…….....[2]

(ii) Ethanol is miscible in water because of interactions between molecules of ethanol and water. Draw a labelled diagram to show the interaction between a molecule of ethanol and a molecule of water.

[1]

(iii) Explain why unlike ethanol, butanol is immiscible in water.

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…….....[1]

(b) The molecule of benzene, C_6H_6, is a regular hexagon in which the π electrons are described as being delocalised.

(i) Draw a diagram to illustrate the delocalisation of π electrons in benzene.

[1]

(ii) The delocalised π electrons results in characteristic chemical properties of benzene. Explain why benzene undergo substitution rather than addition reactions.

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…….....[1]

(iii) Compare the relative ease of oxidation of benzene and methylbenzene. State the reagents and conditions necessary for oxidation to take place.

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…….....[2]

(c) Free chlorine atoms, initially formed in the upper atmosphere by the action of ultraviolet light on chlorofluorocarbons, CFCs, are believed to be responsible for the destruction of the ozone layer.

By reference to the Data Booklet, suggest why industrial use of CFCs such as CF_2CI_2 were replaced by flurohydrocarbons such as $C_2H_2F_4$.

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[2]

[Total: 10]

2 (a) Lead(II) chromate, $PbCrO_4$, has a vivid yellow colour and is insoluble in water. It is used in paints under the name chrome yellow. However when exposed to atmosphere containing sulfur dioxide, SO_2, the yellow colour slowly changes due to formation of Cr^{3+}.

(i) Write the half equation for the reaction of CrO_4^{2-} to form Cr^{3+}.

……[1]

(ii) In an experiment, 0.0150 mol of CrO_4^{2-} reacted with 0.0225 mol of SO_2. Determine the new oxidation number of sulfur.

[2]

(iii) Hence predict identity of the sulfur product from the table of sulfur-containing compounds.

Compound	S^{2-}	HSO_3^{2-}	SO_3^{2-}	SO_4^{2-}

Identity of sulfur-containing product: …….

[1]

(b) 20.00 g of lead(II) chromate is dissolved in 100 cm^3 of acid solution and allowed to stand for a long time to reach equilibrium according to the equation below:

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

$K_c = 7.55 \times 10^{12}\ mol^{-3}\ dm^9$

(i) Write a K_c expression for the above equilibrium.

[1]

(ii) Calculate initial concentration of $CrO_4^{2-}(aq)$.

[1]

(iii) At equilibrium, only **one-fifth** of the original amount of $CrO_4^{2-}(aq)$ remain, determine the equilibrium concentration of $CrO_4^{2-}(aq)$ and $Cr_2O_7^{2-}(aq)$.

[2]

(iv) Hence calculate pH of the solution.

[1]

(v) Given that aqueous CrO_4^{2-} solution is yellow in colour while aqueous $Cr_2O_7^{2-}$ solution is orange in colour, predict and explain what will be observed when aqueous NaOH is added to the above mixture in equilibrium.

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…….....[2]

[Total: 11]

3 An unknown compound X has the molecular formula C_3H_8O and is a liquid at room temperature.

A student placed 5 cm^3 of X in a test tube and added a strip of sodium into the test tube. He observes bubbles forming vigorously at the surface of the sodium strip and floats to the surface. He suggest collecting the gas and devise a method to test it.

(a) Describe how the gas can be tested to confirm its identity, and what would be observed to confirm the identity of the gas.

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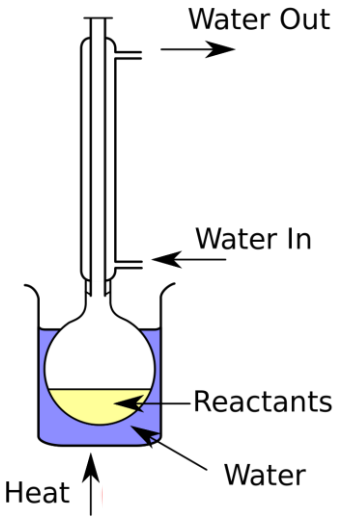
……..[2]

The following apparatus was assembled to carry out further experiment on X.



He first put 5 cm^3 of dilute sulfuric acid in the round bottom flask. He then added 5 drops of potassium dichromate(VI) solution followed by 2 cm^3 of X. The mixture was heated till it started boiling and a colour change was observed.

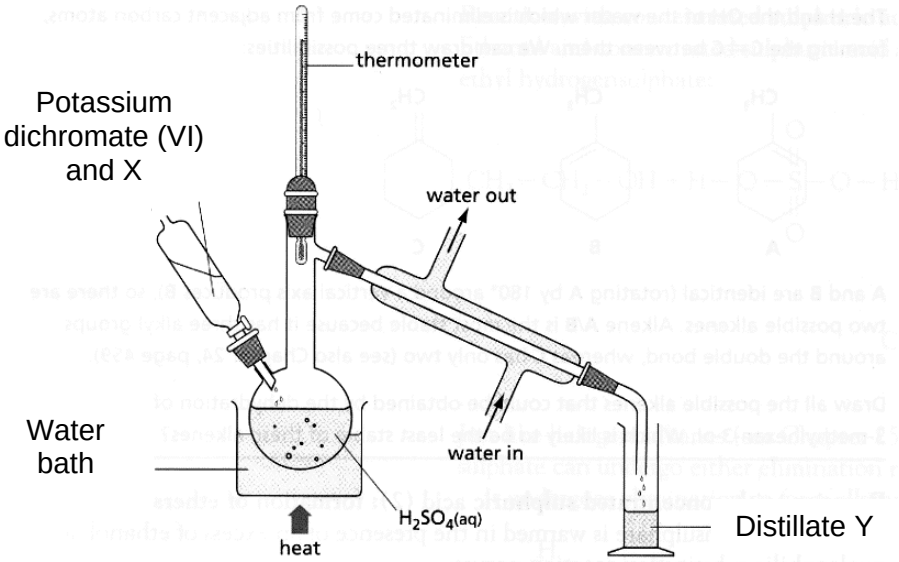
(b) **(i)** What colour change would the student see as the reaction is carried out?

…… [1]

(ii) Name the type of reaction that has occurred.

Type of reaction: …… [1]

The set-up was rearranged as shown.



He repeated the process of adding 5 cm^3 of dilute sulfuric acid into the round bottom flask, followed by 5 drops of potassium dichromate(VI) solution and 2 cm^3 of X. The distillate collected was labelled as Y.

The student observed reddish brown precipitate when he gently warmed a small sample of Y with Fehling's solution in a test tube.

(c) **(i)** Draw the structures of X and Y.

[1]

(ii) Write equation for reaction between Y and Fehling's solution.

……[1]

(iii) Suggest a simple chemical test to distinguish between X and Y. Describe clearly what will be observed. Do not repeat reagents that had been mentioned in this question.

……..

……..

……..[2]

[Total: 8]

4 The Paris Agreement, signed in 2015 by 195 countries, was aimed to slow down global warming by reducing human activities that generate emission of gases that cause harm to the environment.

Over the past decade, Singapore has adopted cleaner energy sources to fuel electricity demand, moving away from petroleum products such as diesel and fuel oil to the more environmentally-friendly fossil fuel alternative: natural gas (Methane, CH_4). It has been found that combustion of methane releases 890 kJ of heat and emits about 35 per cent less carbon dioxide than the petroleum-based oil that Singapore was using.

In many developing countries however, there is still heavy reliance on the use of coal to generate electricity. Combustion of carbon generates only 394 kJ of heat and is known to be much more polluting. The following table compares these two types of power generation.

Type of power station	Overall efficiency of power station	Amount of by-product produced per MJ of electrical energy (1MJ = 10^6J)	
		SO_2	NO_2
Coal	40%	0.31 g	0.64 g
Natural gas	51%	0.0015 g	0.11 g

For your calculations, assume that coal consists of 95% of carbon and 5% of non-combustible ash.

'Water-gas' is an equimolar mixture of hydrogen and carbon monoxide and in some cases is used in place of methane as an industrial gaseous fuel. It is produced when steam is blowing through white-hot coke in the following reaction.

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

Complete combustion of hydrogen and carbon monoxide releases 242 kJ and 283 kJ of heat respectively.

(a) Define the term *enthalpy change of combustion*.

……

……..[1]

(b) Write balanced equation with state symbols for the complete combustion of

(i) Carbon: ……..

Methane: ……..
[1]

(ii) Calculate how many moles of carbon and methane need to be burned in order to produce 1 MJ of **heat** energy.

[1]

(iii) Calculate how many moles of methane and carbon need to be burned in order to produce 1 MJ of **electrical** energy.

[1]

(c) Calculate the mass of ash that would be produced per MJ of electrical energy in a coal-fired power station.

[1]

(d) **(i)** Explain why it is important to cut down CO_2 emissions?

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……[1]

(ii) Despite the obvious environmental impact of generating electricity using coal, many countries continue using coal burning power station because it is cheaper and easier to operate. Suggest why this is so.

……

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……[1]

(e) **(i)** Use answer from **(b)(ii)** to calculate the volume of methane required to produce 1 MJ of heat energy.

[1]

(ii) Calculate the volume of water gas required to produce 1 MJ of heat energy.

[2]

(iii) Based on your calculations, or on other considerations, suggest an advantage of using natural gas rather than water gas. Give reasons for your answers.

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……[1]

[Total: 11]

Section B

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

5 **(a)** Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidifed potassium manganate(VII) solution using a suitable indicator.

The ionic equation is shown below.

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

A 5.00 g sample of spathose was reacted with sulfuric acid and then filtered.

The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) solution for complete reaction.

Calculate the percentage by mass of iron(II) carbonate in the sample of spathose. [3]

(b) The following table compares the pK_a values of malonic acid, a dicarboxylic acid with that of propanol and propanoic acid.

acid	formula	pK_1	pK_2
malonic acid	$HO_2CCH_2CO_2H$	2.83	5.69
propanol	$CH_3CH_2CH_2OH$	16.1	–
propanoic acid	$CH_3CH_2CO_2H$	4.88	–

(i) Explain why the pK_a value for propanoic acid is smaller than the pK_a of propanol. [2]

(ii) Explain why the pK_1 value is smaller than the pK_2 for malonic acid. [1]

The monosodium salt of malonic acid is added to some foodstuffs as buffers.

(iii) Explain what is meant by the term *buffer solution*. [1]

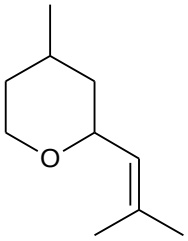
(iv) Write two equations to show how monosodium malonate, $HO_2CCH_2CO_2^-Na^+$, acts as a buffer. [2]

(c) Separate samples of Na_2O and P_4O_{10} were added to water.

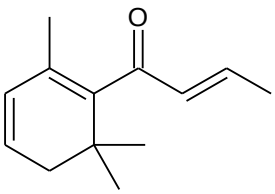
(i) For each oxide, write a balanced equation for its reaction with water and suggest a numerical value for the pH of the resulting solution. [4]

(ii) Construct a balanced equation for the reaction that occurs when a solution of Na_2O in water reacts with a solution of P_4O_{10} in water. [1]

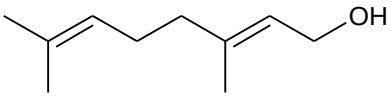
(d) Rose oil is extracted from the petals of various types of rose. It contains the following organic compounds.



rose oxide



damascenone



geraniol

Describe two chemical tests that would allow you to distinguish between separate unlabelled samples of rose oxide, damascenone, geraniol. State what you would observe in each test, for each compound. Write equations for each positive test. [6]

[Total: 20]

6 Iodine and chlorine are commonly used for chemical purification of water outdoors.

(a) Iodine treatment of water involves the use of iodine tincture. It is usually made up of 2-7% elemental iodine with sodium iodide, dissolved in a mixture of ethanol and water. When sodium iodide is added with elemental iodine in water, an equilibrium is established and triiodide ions are formed.

$$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$$

Chlorine treatment of water involves the use of tablets that contain sodium chlorite(III), $NaClO_2$. When sodium chlorite(III) dissolves in water, chlorine dioxide, ClO_2, which is a radical is formed. It is an effective disinfectant against most waterborne pathogenic agents.

(i) Draw the dot-and-cross diagrams of I_3^- ion and ClO_2 molecule. Use the Valence Shell Electron Pair Repulsion (VSEPR) theory to state and explain the shape of the species. [4]

(ii) Elemental iodine has low solubility in water. Sodium iodide is added to increase its solubility.

Explain why the triiodide ion formed is more soluble in water. Draw a labelled diagram to show how a water molecule can be attached to a triiodide ion and the type of interaction involved. [2]

(iii) The enthalpy change of vaporisation of chlorine dioxide is less endothermic than elemental iodine. Explain why. [2]

(b) **(i)** Define, with an equation, the first ionisation energy of chlorine. [2]

(ii) Explain why the first ionisation energy of iodine is lower than the first ionisation energy of chlorine. [2]

(iii) Sketch the trend of first ionisation energy across Period 3 and account for any anomaly to the general trend. [5]

(c) Hydrocarbon undergoes reactions with chlorine under different conditions.

Suggest the structures of the products formed when the following hydrocarbons react under different conditions with chlorine.

(i) butane with chlorine gas in the presence of uv light [1]

(ii) but-1-ene with chlorine gas in the dark [1]

(iii) methylbenzene with chlorine gas and anhydrous aluminium chloride [1]

[Total: 20]

7 **(a)** **(i)** Using the chlorides of magnesium, silicon and phosphorus as examples, describe their reactions, if any, with water. Explain the trend in the pH of the solutions formed. Write balanced equations for any reactions that take place. [4]

(ii) Suggest how the type of bonding present in these three chlorides affect their reaction with water. [1]

(b) Hydrogen peroxide decomposes in the presence of iodide ions according to the following equation.

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$$

To study the kinetics of the above reaction, a 80 cm^3 mixture containing the following was prepared.

- 30 cm^3 of 0.100 mol dm^{-3} of H_2O_2
- 30 cm^3 of 1.00 mol dm^{-3} of iodide ions
- 20 cm^3 distilled water

At every five minutes interval, 10.0 cm^3 samples were removed and 50 cm^3 of cold water was added, followed by a titration against a solution of fixed concentration of potassium manganate(VII).

The experiment was repeated using 2.00 mol dm^{-3} of iodide ions.

The following results were obtained.

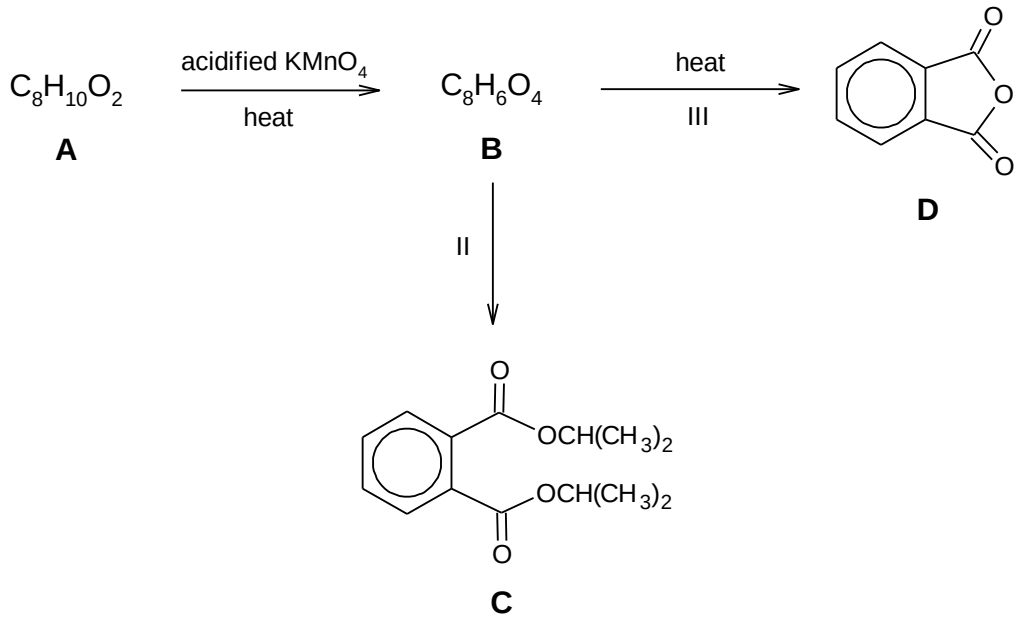
Experiment	Time/min	0	5	10	15	20	25
1	Volume of $KMnO_4$ / cm^3 when [iodide ions] = 1.00 mol dm^{-3}	30.00	20.00	15.00	11.00	7.50	5.00
2	Volume of $KMnO_4$ / cm^3 when [iodide ions] = 2.00 mol dm^{-3}	30.00	15.00	7.50	3.75	1.875	0.938

(i) Explain why 50 cm^3 of cold water was added prior to the titration. [1]

(ii) Plot a graph of these results, putting all the data on the same axes. Label each curve clearly. [1]

(iii) Use your graph to deduce the order of reaction with respect to hydrogen peroxide and iodide ions. Hence, write a rate equation for this reaction and state the units of the rate constant. [5]

(c) **(i)** Suggest structures for compounds **A** and **B** in the following scheme, explaining all the reactions involved. Hence, write a balanced equation for the conversion from **A** to **B**.



[4]

(ii) State the type of reaction, and reagents and conditions for reaction II. [2]

(iii) Describe a simple chemical test that would allow you to distinguish between compounds **C** and **D**. [2]

[Total: 20]