Anglo-Chinese Junior College

JC2 Preliminary Examination
Higher 1

A Methodist Institution
(Founded 1886)

CANDIDATE NAME				FORM CLASS	
TUTORIAL CLASS	2CHX			INDEX NUMBER	

CHEMISTRY **8873/02**

Paper 2 Structured Questions 21 August 2024
2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section **A**
Answer **all** questions.

Section **B**
Answer **one** question.

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

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

For Examiners' use only	
Section A	
1	**/ 14**
2	**/ 10**
3	**/ 13**
4	**/ 10**
5	**/ 13**
Section B	
6 or 7	**/ 20**
Presentation	
Total	**/ 80**

Section A

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

1 Aqueous hydrogen peroxide, H_2O_2, slowly forms water and oxygen at room temperature and pressure, r.t.p. This rate of reaction is increased by the addition of a small amount of solid manganese(IV) oxide.

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

(a) **(i)** Define the term, *rate of reaction*.

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……[1]

(ii) State the role of manganese(IV) oxide and explain the reason.

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……[2]

(iii) State the test for oxygen gas.

……[1]

(iv) State the effect on the mass of oxygen gas produced if the mass of manganese(IV) oxide is increased.

……[1]

(b) A student investigates the rate of formation of oxygen gas when manganese(IV) oxide is added to aqueous hydrogen peroxide.

The volume of oxygen gas formed is measured at regular time intervals at r.t.p.

The results are plotted onto the graph in Fig. 1.1.

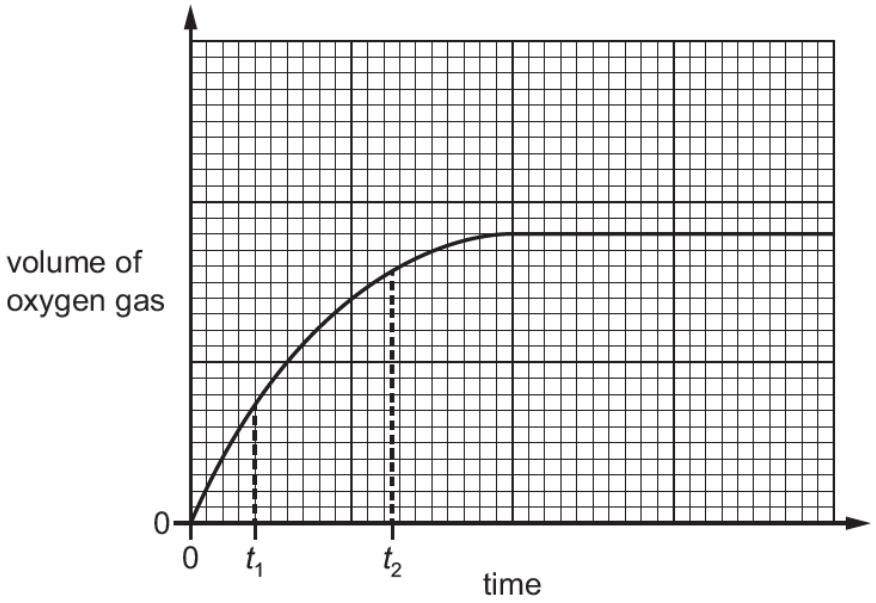

Fig. 1.1

(i) State how the graph in Fig. 1.1 shows the rate of reaction at time t_2, is lower than at time t_1.

……[1]

(ii) Explain, using collision theory, why the rate of reaction at time t_2 is lower than at time t_1.

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……[2]

(iii) On Fig. 1.1, sketch the graph obtained when the experiment is repeated using aqueous hydrogen peroxide at a higher temperature. All other conditions remain the same. [1]

(c) The experiment is repeated at an increased temperature. All other conditions stay the same.

Draw labelled Boltzmann distribution curve(s) to explain why the rate of reaction increases at a higher temperature.

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……[3]

(d) Manganese(IV) oxide is added to 20 cm^3 of aqueous hydrogen peroxide. The total volume of oxygen gas produced is 72 cm^3 at r.t.p.

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

(i) Calculate the number of moles of hydrogen peroxide that reacted.

[1]

(ii) Calculate the concentration of aqueous hydrogen peroxide in g dm^{-3}.

[1]

[Total: 14]

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2 Methane reacts with steam to produce hydrogen gas.

equation 2.1 $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +200\ kJ\ mol^{-1}$

The reaction takes place at 1000 °C and 100 kPa pressure.

(a) The reaction is reversible and reaches dynamic equilibrium in a closed system.

(i) State two features of a dynamic equilibrium.

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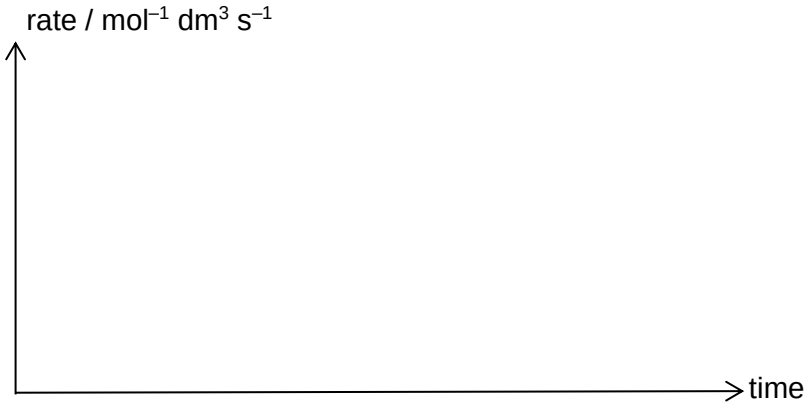
……[2]

(ii) Sketch a labelled graph to show how the **rates** of the forward and reverse reactions change from the start of the reaction to the time the reaction reaches equilibrium.



[2]

(b) State and explain, the effect on the amount of hydrogen when:

(i) the pressure is increased

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……[2]

(ii) the temperature is increased

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……

……[2]

(c) **(i)** Write the expression for the equilibrium constant, K_c, for equation 2.1.

[1]

(ii) State the effect of decreasing temperature on the equilibrium constant, K_c.

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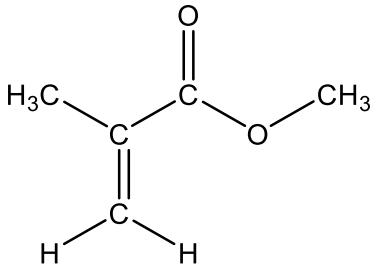
……[1]

[Total: 10]

3 Perspex, a transparent thermoplastic, is commonly utilised in sheet form as a lightweight, shatter-resistant substitute for glass. It also finds application as a casting resin, inks, and coatings.

Moreover, Perspex, poly(methyl 2-methylpropenoate), is formed by polymerising methyl 2-methylpropenoate, a single monomer.



methyl 2-methylpropenoate

(a) **(i)** Identify **all** the functional groups in methyl 2-methylpropenoate

……[1]

(ii) State the functional group that reacts with bromine in CCl_4 and the expected observation.

……[1]

(b) **(i)** Describe the term *polymer*.

……

……[1]

(ii) State the type of polymerisation the monomer undergoes to form Perspex. Draw the structural formula for Perspex, showing two monomer units.

[2]

(iii) Describe two characteristics of thermoplastics in terms of their structure and bonding.

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……[2]

(iv) State two different physical properties of thermoplastics and thermosets.

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……[2]

(v) Although Perspex is a thermoplastic, it has only a limited degree of flexibility as its polymer chains do not slide over each other effectively. When it is stressed too far, it tends to crack in a brittle manner. State two reasons to explain this.

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……[2]

(vi) State and explain whether Perspex is biodegradable.

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……[2]

[Total: 13]

4 (a) Nano tape, also called gecko tape, is a synthetic adhesive tape. This nanomaterial consists of arrays of carbon nanotubes transferred onto a backing material of flexible polymer tape. The structure of nano tape closely mimics that of gecko feet. It works on a variety of surfaces, including glass and sandpaper.

(i) Define the term *nanomaterial*.

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……[1]

(ii) Suggest the structure and interactions of nano tape that closely mimics that of gecko feet.

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……[2]

(b) In March 2017, residents in a small town northwest of Edmonton were surprised by bright pink water flowing from their taps. Upon investigation, it was found that the town's water treatment plant was conducting a filter wash using potassium manganate(VII), $KMnO_4$, which can turn water pink when used in large quantities.

$KMnO_4$ is used to remove Mn^{2+} present in water. $KMnO_4$ will oxidise Mn^{2+} to form only solid MnO_2 under treatment conditions which can easily be filtered from the water.

(i) Suggest the appearance of solid MnO_2.

……[1]

(ii) With reference to the *Data Booklet*, write down the oxidation and reduction half equations during the treatment of the water.

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……[2]

(iii) Hence, give the overall equation that shows the removal of Mn^{2+} during the treatment of water.

……[1]

(iv) During the treatment of water, the concentration of $KMnO_4$ used is 1 mg dm^{-3}. Calculate the maximum mass of MnO_2 that can be precipitated per cubic metre of water.

[3]

[Total: 10]

5 Respiration within the human body generates carbon dioxide and water as byproducts, which can be combined to produce hydrogen ions. However, the blood contains a hydrogen carbonate buffer system that helps maintain pH balance by converting carbonic acid into hydrogen carbonate ions and hydrogen ions. The pH of blood is 7.4.

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

(a) (i) Define an *acidic buffer* solution.

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……[2]

(ii) Identify the acid-conjugate base components in the blood buffer and write an expression for K_c for the blood buffer.

[2]

(iii) Describe what happens when a small amount of strong alkali is added to the buffer solution. Write an equation to explain your answer.

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……[2]

(b) Haemoglobin also forms oxyhaemoglobin when it reacts with oxygen. This process requires iron, and individuals deficient in iron, known as anaemic, often experience fatigue and lethargy. Vitamin C facilitates the absorption of iron from the diet, aiding in its incorporation into haemoglobin.

The bone marrow produces around 10,000 million new blood cells daily, with red blood cells having a lifespan of approximately 120 days. Healthy individuals should have about 15 grams of haemoglobin per 100 cm^3 of blood and a red blood cell count of 5 million per cm^3. Iron constitutes approximately 4% of the mass of the haemoglobin molecule.

To combat anaemia, individuals often supplement their diet with iron tablets, typically containing iron(II) sulfate. Each tablet typically contains 200 mg of iron. These iron ions can undergo reactions with potassium manganate(VII) ions, MnO_4^-, for various purposes. The equation for the reaction is shown.

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

(i) For 100 cm^3 of a healthy individual's blood, calculate

1. the mass of iron that should be present ~~in~~

[1]

2. ~~the mass~~ the number of red blood cells that would be present

[1]

(ii) Calculate the amount of iron, in mol, that needs to be available each day within the bone marrow for the production of new red blood cells.

[2]

(iii) Suggest why a person does **not** need to consume the amount of iron each day that was calculated in part **b(iii)**.

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……[1]

(c) Calculate the number of iron tablets ~~have been~~ dissolved in a solution that will react with 35.80 cm^3 of 0.020 mol dm^{-3} potassium manganate(VII) solution in a titration.

[2]

[Total: 13]

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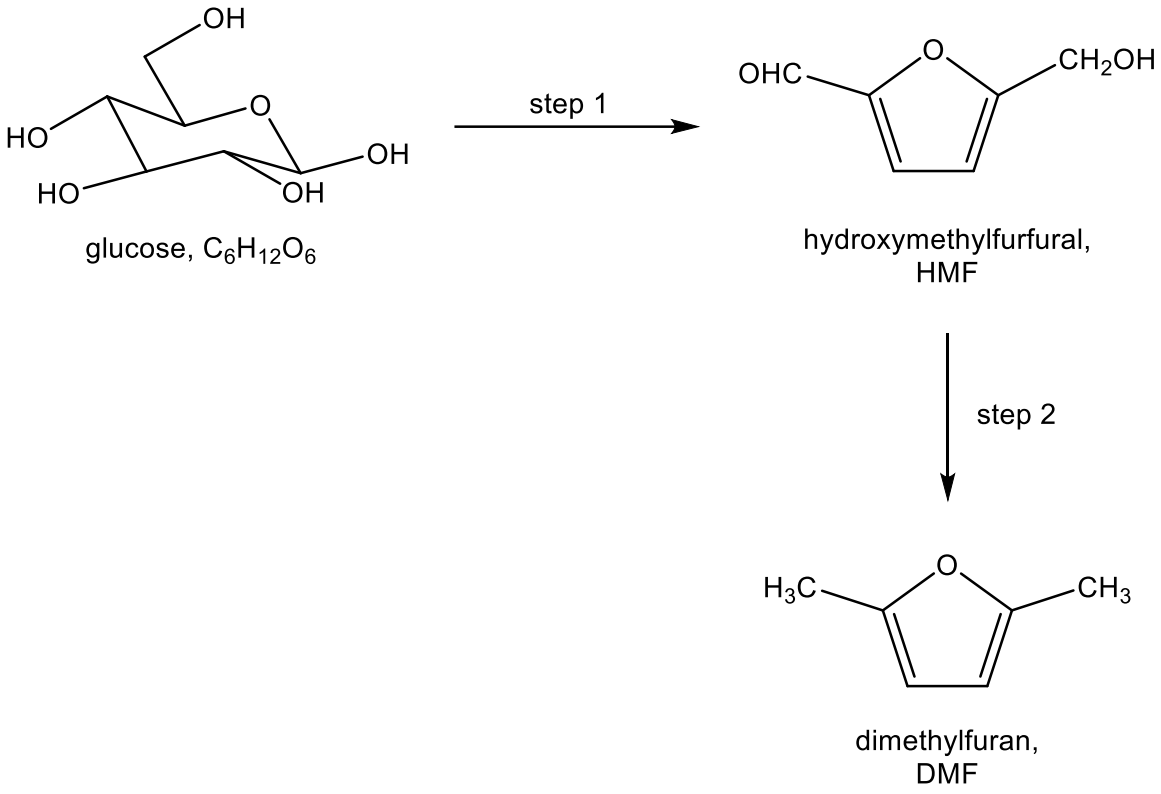
Section B

Answer **one** question from this section in the spaces provided.

6 Dimethylfuran, DMF, is a colourless volatile liquid with boiling point 92 °C, which is comparable to that of heptane (98 °C), a component of gasoline. It has a role as a human urinary metabolite, an antifungal agent, a bacterial metabolite, a fumigant and a fuel. It is obtained from glucose in a two-step reaction.



glucose, $C_6H_{12}O_6$

hydroxymethylfurfural, HMF

dimethylfuran, DMF

(a) **(i)** Suggest the molecular formula of the compounds HMF.

HMF: ……[1]

(ii) Suggest the types of reaction for steps 1 and 2.

step 1: ……

step 2: ……[2]

(iii) State and explain whether DMF is polar.

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……..…[2]

(iv) Suggest a chemical test to identify between the compounds HMF and DMF. State the observations for both compounds.

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……..[2]

(v) Draw the product formed when DMF reacts with hydrogen gas and state the type of reaction.

type of reaction: ……...[2]

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

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……[1]

(ii) Write a balanced equation for the complete combustion of DMF. Use bond energy data from the *Data Booklet* to calculate its enthalpy change of combustion.

[3]

(iii) *Use of the Data Booklet is relevant to this question*.

A sample of DMF was burned under laboratory conditions in an apparatus that only 80% of the heat evolved is transferred to heating a container of water. The burning of 1.00 g of DMF raised the temperature of 200 g of water by 32 K.

Calculate the experimental enthalpy change of combustion, and comment on the difference between this value and that calculated in **(b)(i)** using bond energies.

[4]

(iv) Draw an energy profile diagram showing the complete combustion of DMF.

[3]

[Total: 20]

7 (a) The oxygen family, also called the chalcogens, consists of the elements found in Group 16 of the Periodic Table and is considered among the main group elements. It consists of the elements oxygen, sulfur, selenium, tellurium and polonium.

(i) State and explain the trend in the first ionisation energy of the Group 16 elements down the group.

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……[2]

(ii) Compare the first ionisation energy of $_{34}$Se to that of $_{35}$Br and explain your answer.

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……[2]

(iii) Describe the structure of a ^{128}Te atom, in terms of number and type of sub-atomic particles and give the valence electronic configuration for a tellurium(II) ion, Te^{2+}.

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……...[3]

(iv) State the formula of the oxide of tellurium in its highest oxidation state.

formula: ……..[1]

(v) State one physical property that you would expect this oxide of tellurium to possess. Explain, in terms of the structure and bonding present, why it possesses this property.

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……[2]

(vi) Write an equation to illustrate the behaviour of this oxide of tellurium in water and predict the pH of the solution formed.

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……..[2]

(b) When SO_3 is distilled into ICl_3 at 10 ^oC, a single ionic product is formed.

$$ICl_3 + SO_3 \longrightarrow (ICl_2^+)(SO_3Cl^-)$$

(i) Draw dot-and-cross diagrams to illustrate the bonding in each of the ions and predict their shapes.

[4]

(ii) The boiling point of ICl_3 is 97.4 ^oC and the boiling point of $(ICl_2^+)(SO_3Cl^-)$ is found to be higher. Explain using structure and bonding, the difference in boiling points of $(ICl_2^+)(SO_3Cl^-)$ and ICl_3.

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……...[3]

(iii) SO_3 dissolves in water to form sulfuric acid, $H_2SO_4(aq)$ which is a dibasic Bronsted-Lowry strong acid.

Explain the term *dibasic Bronsted-Lowry strong acid*.

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……[1]

[Total: 20]

– End of Paper –