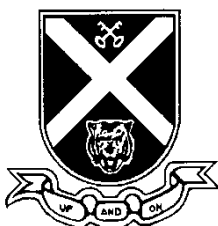


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ST ANDREW'S JUNIOR COLLEGE



JC2 PRELIMINARY EXAMINATION

Chemistry (9729)

12 September 2018

Paper 2 Structured Questions

2 hours

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS:

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

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

A Data Booklet is provided.

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.

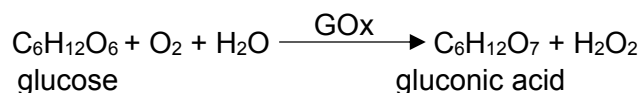
For Examiner's use:

Question	1	2	3	4	5	Total
Marks	19	20	10	7	19	75

This document consists of **20** printed pages (including this page).

Answer **all** the questions.

- 1 Glucose oxidase (GOx) is an enzyme found in certain species of insects and fungi that catalyses the oxidation of glucose to gluconic acid.

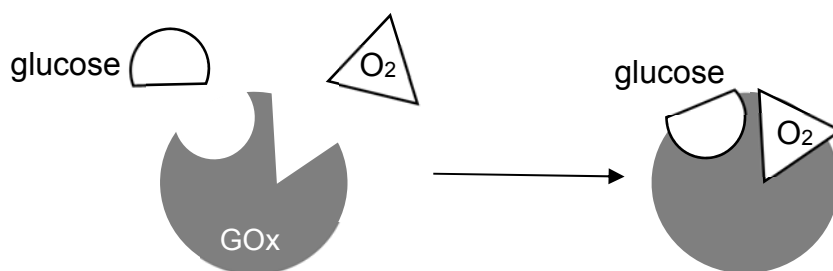


- (a) Write two half-equations to show that this is a redox reaction. [2]

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- (b) The binding of reactants to GOx can be simplified with a diagram as shown below.



- (i) Explain why GOx can be described as a *biological catalyst*. [2]

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- (ii) Based on the diagram above, suggest why the sign of ΔS is negative for the reaction. [1]

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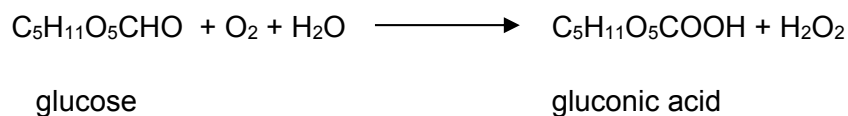
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- 1 (b) (iii) Sketch a graph showing how the rate of this GOx-catalysed reaction varies with the concentration of glucose.



[1]

- (c)** The overall equation can be re-expressed to show the change in functional group.



Calculate the enthalpy change of reaction for the conversion of glucose into gluconic acid. Use relevant data from the *Data Booklet*.

[2]

- 1 (d) Experiments were done to determine the kinetics of the reaction.
In the first investigation, the following reaction mixture was prepared.

$$\text{initial [glucose]} = 5.00 \times 10^{-3} \text{ mol dm}^{-3}$$

$$\text{initial [GOx]} = 1.00 \times 10^{-2} \text{ mol dm}^{-3}$$

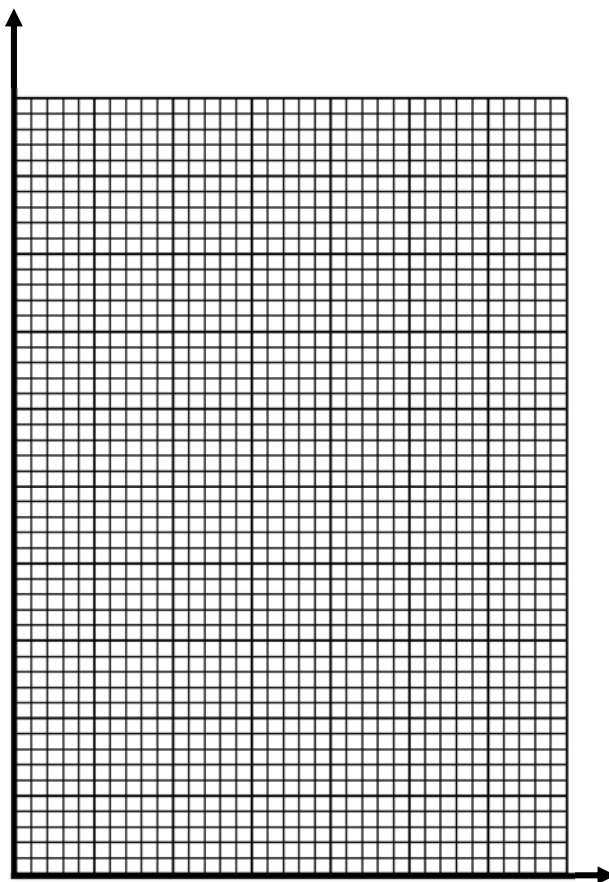
$$\text{initial [O}_2\text{]} = 1.00 \times 10^{-2} \text{ mol dm}^{-3}$$

The following results in **Table 1** were obtained.

Table 1

<i>t/s</i>	[glucose] / mol dm ⁻³
0	5.00 x 10 ⁻³
10	3.40 x 10 ⁻³
20	2.50 x 10 ⁻³
30	1.80 x 10 ⁻³
60	6.00 x 10 ⁻⁴

- 1 (d) (i) To determine the order of reaction with respect to [glucose], use these data to plot a suitable graph on the grid below.



[2]

- (ii) Hence, deduce the order of reaction with respect to [glucose], showing all your working and drawing clearly on your graph.

[2]

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[Please Turn Over

- 1 (d) (iii) In the second and third investigations, the concentrations of oxygen and GOx were changed, but the initial [glucose] was kept the same as before. The following results in **Table 2** were obtained.

Table 2

Investigation	Initial [O ₂] (mol dm ⁻³)	Initial [GOx] (mol dm ⁻³)	Initial rate (mol dm ⁻³ s ⁻¹)
1	1.00 x 10 ⁻²	1.00 x 10 ⁻²	Y
2	5.00 x 10 ⁻³	1.00 x 10 ⁻²	2.00 x 10 ⁻⁴
3	5.00 x 10 ⁻³	2.50 x 10 ⁻³	5.00 x 10 ⁻⁵

Use your graph in (d)(i) to determine the initial rate **Y**, showing all your working and drawing clearly on your graph. Hence, use the information in **Table 2** to determine the orders of reaction with respect to [O₂] and [GOx]. Explain your reasoning.

[3]

- 1 (e) GOx can be used in a biosensor to convert glucose present in body fluids into gluconic acid. The amount of hydrogen peroxide produced is then reduced electrochemically to determine the amount of glucose present.

A 0.1 cm^3 of blood sample from a patient was tested to diagnose if he was at risk of diabetes. The diagnosis is based on the concentration of glucose in the blood.

Condition	[glucose] in blood ($\times 10^{-3} \text{ mol dm}^{-3}$)
Normal	less than 5.6
Pre-diabetes	5.6 – 6.9
Diabetes	More than 6.9

The biosensor gave a current of 1.01 mA for 1 min. ($1000 \text{ mA} = 1 \text{ A}$)

- (i) Calculate the number of moles of hydrogen peroxide produced. Hence, diagnose the condition of the patient. [3]

- (ii) Before the test, the blood sample has to be treated to remove some components present. Suggest why a treated blood sample was necessary for the biosensor to give an accurate reading. [1]

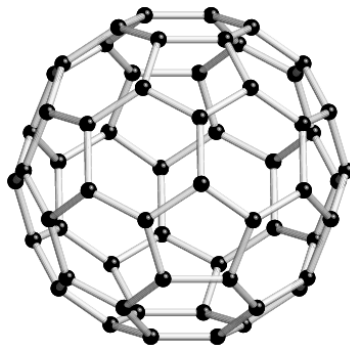
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2 This question deals with carbon and silicon which are both elements in Group 14.

- (a)** C_{60} and diamond are allotropes of carbon. C_{60} is a simple covalent molecule while diamond is a giant covalent molecule. State the type of bonding and describe the lattice structure of solid C_{60} .



C_{60}

[2]

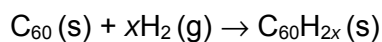
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- (b)** 0.144 g of C_{60} was placed in a 100 cm^3 container of hydrogen gas at $20\text{ }^\circ\text{C}$ and $1.00 \times 10^5\text{ Pa}$.

The reaction occurred as shown in the equation.



When all the C_{60} had reacted, the pressure was found to be $2.21 \times 10^4\text{ Pa}$ at the same temperature.

- (i)** Calculate the amount, in moles, of C_{60} that reacted.

[1]

2 (b) (ii) Calculate the amount, in moles, of hydrogen gas that reacted with C_{60} . [2]

(iii) Use your answers from (i) and (ii) to deduce the molecular formula of the hydrocarbon, $C_{60}H_{2x}$. [2]

(c) (i) Graphite is another allotrope of carbon. State the type of hybridisation and draw the arrangement of the hybrid orbitals about each C atom. [2]

(ii) Graphite is a good conductor of electricity. Explain, with reference to orbital overlap, how graphite has a high electrical conductivity. [2]

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[Please Turn Over

- 2 (c) (iii) The values for the enthalpy change of combustion of graphite and diamond are given in the table below.

Substance	Enthalpy change of combustion / kJ mol^{-1}
Graphite	-394
Diamond	-396

The products of the combustion reactions of graphite and diamond are carbon dioxide and water.

Suggest why the enthalpy change of combustion of graphite is less exothermic than that of diamond.

[1]

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- (d) Silicon is another element in Group 14 which shows the same kind of bonding and structure as diamond.

- (i) When silicon reacts with magnesium, Mg_2Si forms. Mg_2Si is thought to contain the Si^{4-} ion. Compare and explain the difference between the atomic and anionic radii of silicon.

[2]

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- 2 (d) (ii) Suggest why the second ionisation energy of silicon is lower than that of aluminium. [2]

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- (iii) Solid Mg_2Si reacts with dilute hydrochloric acid to form gaseous SiH_4 and a solution of magnesium chloride only. Write an equation, including state symbols, to show the reaction of solid Mg_2Si with dilute hydrochloric acid. [1]

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- (iv) Describe the reaction, if any, of NaCl and SiCl_4 with water, relating any differences to their bonding. Give relevant equations for any reactions and suggest the pH values of each resulting solution. [3]

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[Total: 20]

[Please Turn Over]

- 3 Hydrocarbons that contain other elements are known as heterocompounds. A special class of heterocompounds are thiols. Thiols are sulfur analogs of alcohols and have the general formula R-SH. Its structure is similar to that of an alcohol, but with sulfur in place of oxygen. One such example is CH₃SH.

(a) State the bond angle about the oxygen atom in CH₃OH and explain if the bond angle is bigger than the bond angle about the sulfur atom in CH₃SH. [3]

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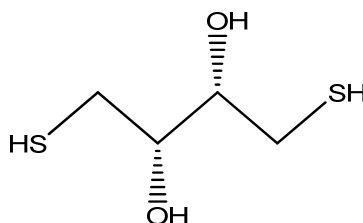
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(b) Thiols can be converted to produce compounds called disulfides. This type of reaction is common in protein structures where it forms disulfide linkages (–S–S–) between two thiols as shown in the following equation:



Based on the above equation, suggest two disulfide products that could be formed when HOCH₂CH₂SH and HOCH₂CH(CH₃)SH are reacted. [1]

(c) Dithiothreitol (**DTT**) is an organic molecule with molecular formula, C₄S₂O₂H₁₀. It has both the functional group of an alcohol and a thiol. The structure of **DTT** is given below.



DTT can be oxidised under suitable conditions to form product **X** with molecular formula, C₄S₂O₂H₈.

3 (c) (i) Draw the structural formula of product **X**. [1]

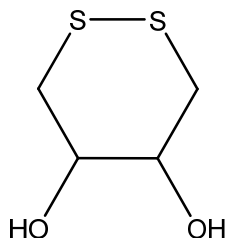
(ii) Product **X** can then undergo nucleophilic addition with hydrogen cyanide under suitable conditions.

Suggest the conditions for this reaction to take place and hence, describe the mechanism of the reaction, In your answer you should show all charges and lone pairs and show the movement of electrons by curly arrows.

[3]

[Please Turn Over

- 3 (d) **DTT** can be oxidised to form a stable six-membered ring with an internal disulfide bond as shown in the following structure.



The oxidised form of **DTT** has a restricted rotation about the C-C bond with the two –OH groups hence enabling it to exhibit cis-trans isomerism.

Draw the cis-trans isomers of the oxidised form of **DTT**.

[2]

[Total: 10]

- 4 Iron salts, usually iron(II) sulfate, catalyses the decomposition of aqueous hydrogen peroxide to water and oxygen. The reaction mechanism involves OH and HO₂ free radicals. The reaction mechanism is given below.



- (a) Define *free radical*.

[1]

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- 4 (b) Draw the dot-and-cross diagram for HO₂ free radical.

[1]

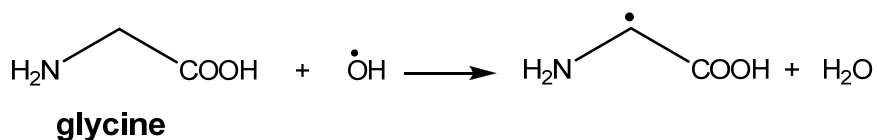
- (c) State the type of catalysis that takes place between iron(II) sulfate and hydrogen peroxide and state the property of iron(II) sulfate that allows it to carry out its function as a catalyst in the above decomposition reaction.

[2]

Type of catalysis:

Property:

- (d) OH radicals can modify amino acids. They behave similarly to chlorine radicals by abstracting a hydrogen in the propagation step of free radical substitution mechanisms. This is represented using glycine as shown below.



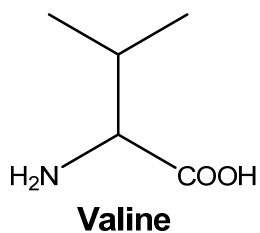
- (i) Suggest why the rate of propagation is slower when glycine exists as an anion.

[1]

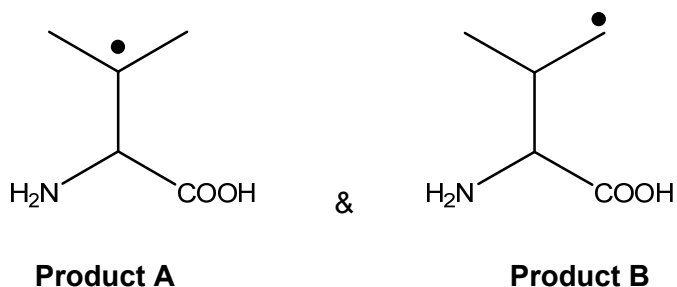
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- 4 (d) (ii) Valine is another amino acid that can react with OH radicals. The structure of valine is as shown below.



Valine reacts with OH radicals to form three radical products, of which two are shown below.



Suggest a reason why product **A** is more stable.

[1]

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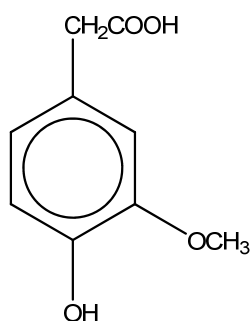
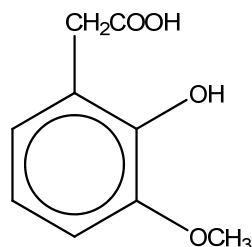
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- (iii) Draw the structural formula of the third radical product for the above reaction in (ii).

[1]

[Total: 7]

- 5 (a) The concentration of hydrogen peroxide can be determined by fluorescence reaction between homovanillic acid (HVA) and hydrogen peroxide. HVA can be found in urine and can be found to exist in two constitutional forms as shown below.

**HVA - I****HVA-II**

- (i) There are two pK_a values associated with **HVA - I**: 3.7 and 5.3. Explain the difference in the pK_a values. [2]

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- (ii) Draw the structural formula of the monoanion produced from the first dissociation of **HVA - II**.
Hence, explain why the first pK_a value of **HVA - II** is much lower than the first pK_a value of **HVA - I**. [2]

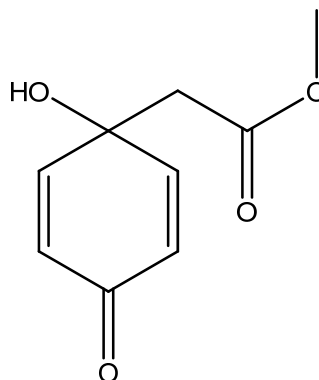
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- 5 (a) (iii) An isomer of HVA is jacaranone which is used in cancer treatments. Its structure is given below.



jacaranone

Identify the functional groups present in jacaranone.

[2]

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- (iv) Suggest a simple chemical test which could distinguish between **HVA - I** and jacaranone. Write the balanced equation for the positive test.

[3]

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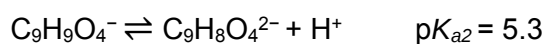
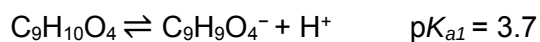
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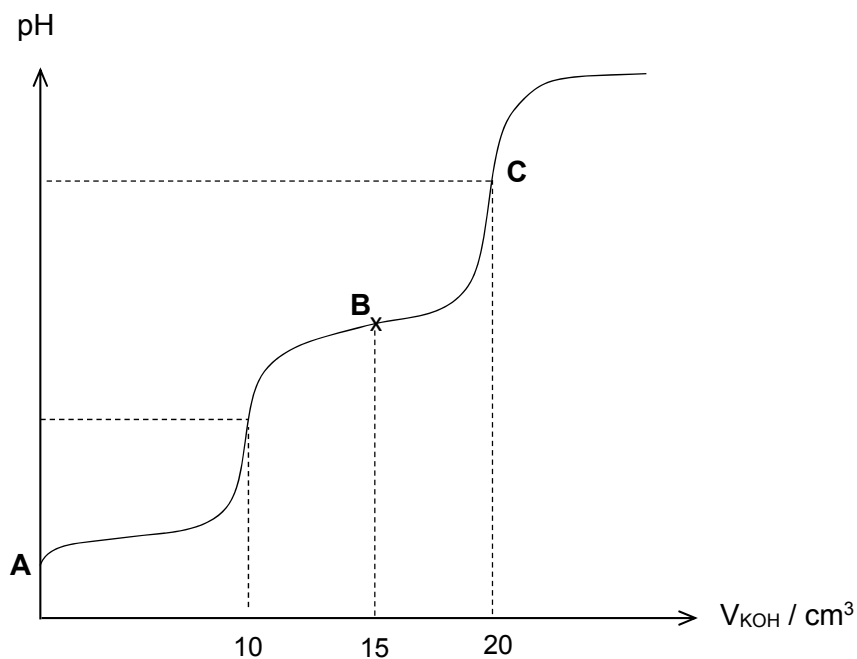
Balanced equation:

- 5 (a) (v) Draw all the carbon-containing products formed when jacaranone is heated with acidified KMnO_4 . [3]

(b) HVA - I, $\text{C}_9\text{H}_{10}\text{O}_4$, is a weak dibasic acid which dissociates in water as follows:



A quantitative analysis was performed on a 25.0 cm^3 sample of HVA - I. It was titrated against 0.75 mol dm^{-3} of potassium hydroxide. The resulting pH curve was plotted as shown below.



- (i) Calculate the concentration of HVA - I present in the sample. [2]

[Please Turn Over

- 5 (b) (ii) Using the first pK_a value, calculate the initial pH at point **A**. [2]

- (iii) State the pH at point **B** and hence, explain the significance of point **B**. [2]

pH:

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- (iv) Write an equation to show that pH at point **C** is more than 7. [1]

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[Total: 19]

~ END OF PAPER ~