Catholic Junior College

JC1 Promotional Examinations

Higher 2

CANDIDATE NAME	
CLASS	**1T**

CHEMISTRY 9729/02

Paper 2 Structured Questions

Wednesday 2 October 2019
1 hour

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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 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.

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

For Examiner's Use		
Paper 1		**15**
Paper 2	**Q1**	**/ 8**
	Q2	**/ 4**
	Q3	**/ 3**
	Q4	**/ 5**
	Q5	**/ 6**
	Q6	**/ 9**
		35
Paper 3	**Q1**	**/20**
	Q2	**/20**
		40
Paper 4	**Q1**	**/15**
	Q2	**/15**
		30
TOTAL		**120**
OVERALL/%		
Grade		

Paper 2
Answer **all** the questions.

Write your answers in the spaces provided. You are advised to spend **not** more than one hour on this section.

1 Ethanedioic acid, is a dibasic, organic acid with the formula HO_2CCO_2H. It is commonly found in many leafy vegetables, fruits, nuts and seeds. It is able to react with a base such as sodium hydroxide, NaOH.

(a) **FA 1** is a solution containing 5.00 g dm^{-3} of a similar dibasic, organic acid, $HO_2C(CH_2)_nCO_2H$. When 25.0 cm^3 of **FA 1** is titrated against NaOH of concentration 0.125 mol dm^{-3}, 17.00 cm^3 of NaOH is required.

The equation for this reaction is given as follows.

$$HO_2C(CH_2)_nCO_2H(aq) + 2NaOH(aq) \rightarrow Na_2(O_2C(CH_2)_nCO_2)\ (aq) + 2H_2O(l)$$

(i) Calculate the amount in moles of NaOH required to react with 25.0 cm^3 of the acid solution in **FA 1**.

[1]

(ii) Calculate the amount in moles of the dibasic acid, $HO_2C(CH_2)_nCO_2H$ in 25.0 cm^3 of **FA 1** that has reacted.

[1]

(iii) Calculate the concentration of the acid, $HO_2C(CH_2)_nCO_2H$ in mol dm^{-3} of solution in **FA 1**.

[1]

(iv) Hence, determine the value of ***n*** in the formula of the acid, $HO_2C(CH_2)_nCO_2H$.

[1]

[Turn over

(b) Ethanedioic acid, HO_2CCO_2H (or $H_2C_2O_4$), is also a reducing agent and reacts with an oxidising agent such as acidified potassium manganate(VII), $KMnO_4$. It can be oxidised by acidified $KMnO_4$ to carbon dioxide, when heated to 60°C.

When a 25.0 cm^3 sample of ethanedioic acid is titrated against acidified $KMnO_4$ of concentration 0.0200 mol dm^{-3}, 23.00 cm^3 of $KMnO_4$ is required.

(i) Derive a balanced half-equation for the oxidation of ethanedioic acid to carbon dioxide in acidic conditions.

……..[1]

(ii) By reference to the relevant half-equation from the *Data Booklet* for the reduction of acidified MnO_4^-, derive an overall balanced equation for the reaction between ethanedioic acid and acidified manganate(VII) ion, MnO_4^-.

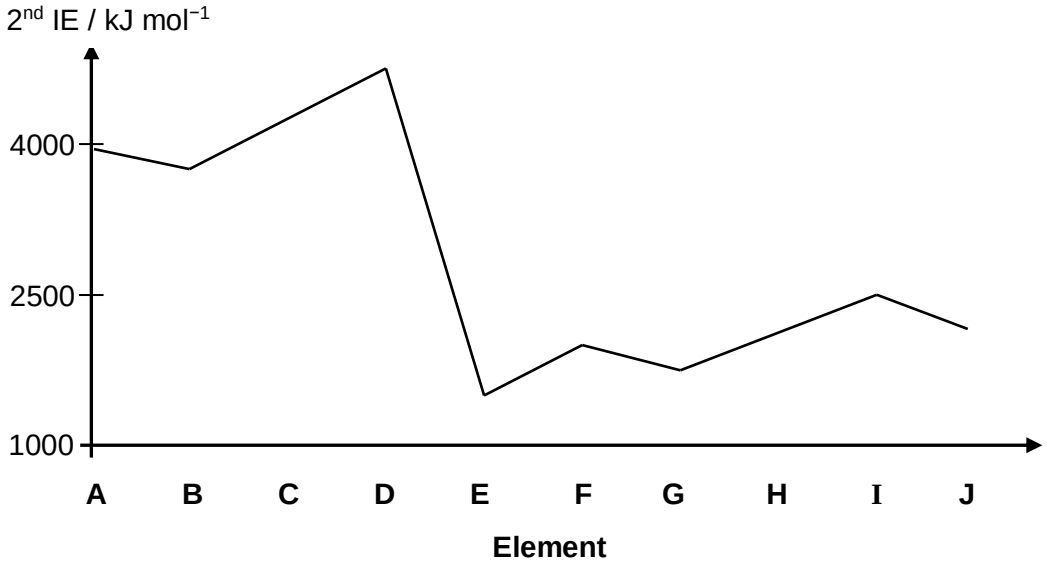
[1]

(iii) Hence, calculate the amount in moles of the acid, HO_2CCO_2H (or $H_2C_2O_4$) reacted and subsequently its concentration in mol dm^{-3}.

[2]

[Total: 8]

2 The graph below shows the second ionisation energies of 10 unknown elements **A** – **J**, of consecutive proton numbers. The letters are not the atomic symbols of the elements. **J**, which has the largest A_r, has an proton number below 20.



(a) Write the ground state electronic configuration of element **F**.

[1]

(b) Generally the second ionisation energy (2nd I.E.) increases across the period. Explain the decrease in 2nd I.E. between element **F** and **G**.

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……

……

……[1]

(c) Sketch and label all the valence orbitals of **F**, clearly showing the labelled axes.

[2]
[Total: 4]

[Turn over

3 Canisters of flammable gas are used as portable fuel, and may contain a few types of short chain hydrocarbons, which are liquefied under high pressure.

A canister was connected to a gas syringe and the valve opened to allow some of the gas into the syringe. It was found that 0.300 g of gas took up 144.0 cm^3 at temperature of 24°C and pressure of 1.02 x 10^5 Pa.

Calculate the average M_r of the gas mixture assuming it behaves ideally.

[3]
[Total: 3]

4 Nitroglycerin, $C_3H_5(NO_3)_3$, is a flammable liquid commonly used to manufacture dynamite. Upon ignition, nitroglycerin decomposes to produce nitrogen, oxygen, carbon dioxide and steam.

Given:

Standard enthalpy change of formation of nitroglycerin(l) / kJ mol^{-1}	–364
Standard enthalpy change of formation of H_2O(g) / kJ mol^{-1}	–242
Standard enthalpy change of formation of CO_2(g) / kJ mol^{-1}	–394

(a) Write a balanced equation, with state symbols, for the decomposition of 1 mol of liquid nitroglycerin.

[1]

(b) With reference to the above data, calculate the standard enthalpy change of decomposition of 1 mol of nitroglycerin.

[1]

[Turn over

(c) By using your answer in **(b)**, calculate $\Delta G^{\ominus}$ at 298 K for this decomposition given that $\Delta S^{\ominus} = +208\ \text{J K}^{-1}\ \text{mol}^{-1}$.

Hence, predict the spontaneity of the reaction at 298 K.

[2]

(d) Is the reaction spontaneous at all temperatures? Explain.

……

……

……

……

……[1]

[Total: 5]

[Turn over

5 Pentenes are often produced as by-products of thermal cracking of petroleum. Pent-2-ene is one of the isomers of pentene and has the following formula:

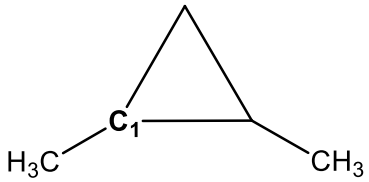
$$CH_3CH{=}CHCH_2CH_3$$

(a) Draw and **label clearly** the two different structural formulae of pent-2-ene that show *cis-trans* isomerism.

[2]

One constitutional isomer of pent-2-ene is 1,2-dimethylcyclopropane, which consists of a cyclopropane ring substituted with two methyl groups attached to adjacent carbon atoms. Due to restricted ring rotation, *cis-trans* isomerism also exists in 1,2-dimethylcyclopropane.

The structure of 1,2-dimethylcyclopropane is shown below (the hydrogen atoms on the ring structure **are not displayed**):

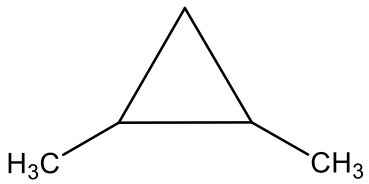


1,2-dimethylcyclopropane

(b) State the hybridisation present at $\mathbf{C_1}$.

…… [1]

(c) Label with an asterisk (*), any chiral carbon atom(s) present in 1,2-dimethylcyclopropane.

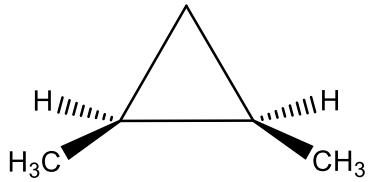


[1]

[Turn over

(d) The effect of plane-polarised light on 1,2-dimethylcyclopropane was investigated and three stereoisomers of 1,2-dimethylcyclopropane were identified.

(i) The following isomer was found to have no effect on plane-polarised light.



1,2-dimethylcyclopropane

Suggest a reason for this observation.

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……

……[1]

(ii) On the other hand, the remaining two isomers are optically active. Draw the 3-D structures for these isomers using wedged and dashed bonds.

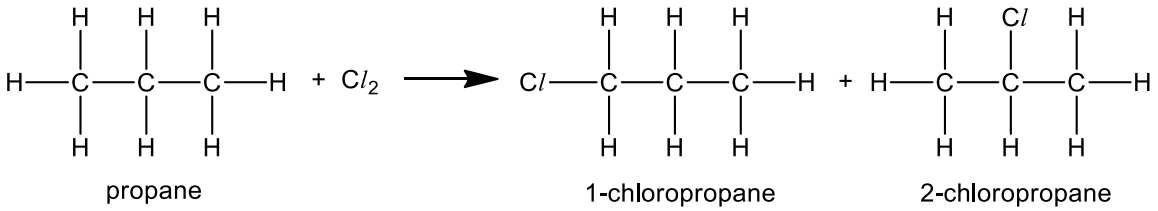
Structure of isomers	
(1)	**(2)**

[1]

[Total: 6]

[Turn over

6 Propane, C_3H_8, reacts with excess chlorine gas, Cl_2, in the presence of *uv* light to form two monochloroalkanes.



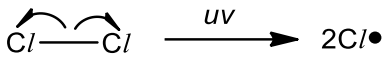
(a) State the name of the reaction mechanism of the monochlorination of propane.

……..[1]

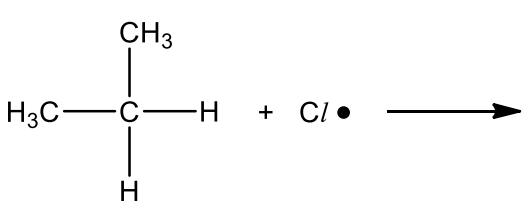
(b) The reaction between propane and chlorine gas proceeds via a three-stage reaction mechanism. The mechanism to form 2-chloropropane is illustrated below.

In the boxes provided below, fill in the blanks with the balanced equations for the propagation and termination steps.

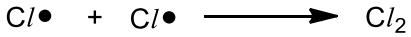
Initiation



Propagation



Termination



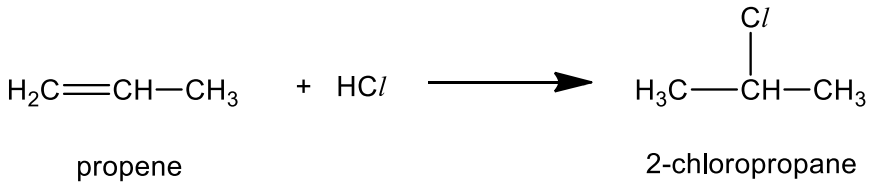
[2]

[Turn over

(c) Based on the different types of environment surrounding the hydrogen atoms, predict the relative proportions of 1-chloropropane and 2-chloropropane that are likely to be formed in the reaction.

1-chloropropane : 2-chloropropane = …… : ……. [1]

(d) 2-chloropropane can also be formed when propene, C_3H_6, is reacted with HC*l* gas.



propene 2-chloropropane

Name and describe the mechanism for the reaction between propene and hydrogen chloride, showing curly arrows, charges, dipoles and any relevant lone pairs.

[3]

(e) Suggest a simple chemical test to distinguish between propane and propene, clearly stating all observations for both compounds.

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……

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……[2]

[Total: 9]

[Turn over