



Catholic Junior College

JC2 Preliminary Examinations

Higher 2

CANDIDATE
NAME

CLASS

2T

CHEMISTRY

9729/02

Paper 2 Structured Questions

18 August 2017

2 hours

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.

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			
Paper 1			30
Paper 2	Q 1	12	75
	Q 2	19	
	Q 3	18	
	Q 4	9	
	Q 5	10	
	Q 6	7	75
Paper 3	Q 1	22	80
	Q 2	20	
	Q 3	18	
	Q 4	20	
	Q 5	20	
Total			185

This document consists of 14 printed pages and 0 blank page.

[Turn over

Answer **all** the questions.

- 1** Sedimentary rocks formed at the earth's surface by the accumulation of particulate matter are usually transported to the place of deposition by water, wind, or mass movement of glaciers. Dolostone, a sedimentary rock, consists of a mixture of minerals such as calcium and magnesium carbonates.

Table 1.1 below shows some properties of calcium carbonate and magnesium carbonate.

Table 1.1

	Numerical values of K_{sp} at 25 °C	Decomposition temperature / °C
calcium carbonate	5.0×10^{-9}	900
magnesium carbonate	1.0×10^{-5}	540

- (a) (i)** Write an expression for the solubility product, K_{sp} , of calcium carbonate.

.....[1]

- (ii)** Calculate the solubility, in mol dm^{-3} , of calcium carbonate in water at 25 °C.

[1]

- (iii)** A saturated solution **X** containing calcium hydroxide and calcium carbonate has a pH of 13 at 25 °C.

Given that the K_{sp} of calcium hydroxide is $5.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$ and using your answer in **(a)(i)**, calculate the solubility of calcium carbonate in solution **X**.

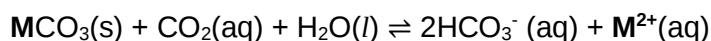
[2]

- (iv) Comment on, and explain, the difference in the solubilities of calcium carbonate in water and in solution X.

.....

[2]

- (v) When rainwater runs over dolostone, a chemical reaction occurs as shown below:



where **M** is a group 2 metal

- I. Suggest the source of $\text{CO}_2(\text{aq})$ for the reaction.

.....[1]

- II. When a sample of saturated solution of $\text{Ca}(\text{HCO}_3)_2$ is heated, a reaction occurs and a precipitate is formed. Using the equation above, suggest why this happens.

.....

[2]

- (b) Calcium carbonate can be decomposed by heating at high temperatures.

- (i) Write an equation for the thermal decomposition of calcium carbonate.

.....[1]

- (ii) Calcium carbonate decomposes at a higher temperature than magnesium carbonate. Explain why this is so.

.....

[2]

[Total: 12]

[Turn over

- 2 (a) Table 2.1 gives data about some physical properties of the elements calcium and copper.

Table 2.1

physical property	calcium	copper
relative atomic mass	40.1	63.5
atomic radius (metallic) / nm	0.197	0.128
ionic radius (2+) / nm	0.099	0.069
melting point / °C	839	1085
boiling point / °C	1484	2562

- (i) Explain why the atomic radius of copper is smaller than that of calcium.

.....

[2]

- (ii) Explain why copper has a higher melting point than calcium.

.....

[2]

- (iii) Apart from the properties given in Table 2.1, state clearly the difference in one other physical property between copper and calcium.

.....
[1]

- (b) Copper, scandium and zinc are d-block elements. However, copper is a transition element while scandium and zinc are not.

- (i) Define the term *transition element*.

.....
[1]

- (ii) Explain why scandium is not classified as a transition element.

.....
[1]

- (c) Manganese is also a transition element and shows great tendency to form stable coloured complexes with ligands.

(i) Define the term *ligand*.

.....
 [1]

(ii) Draw the shape of the complex ion, $[\text{Mn}(\text{CN})_6]^{4-}$.

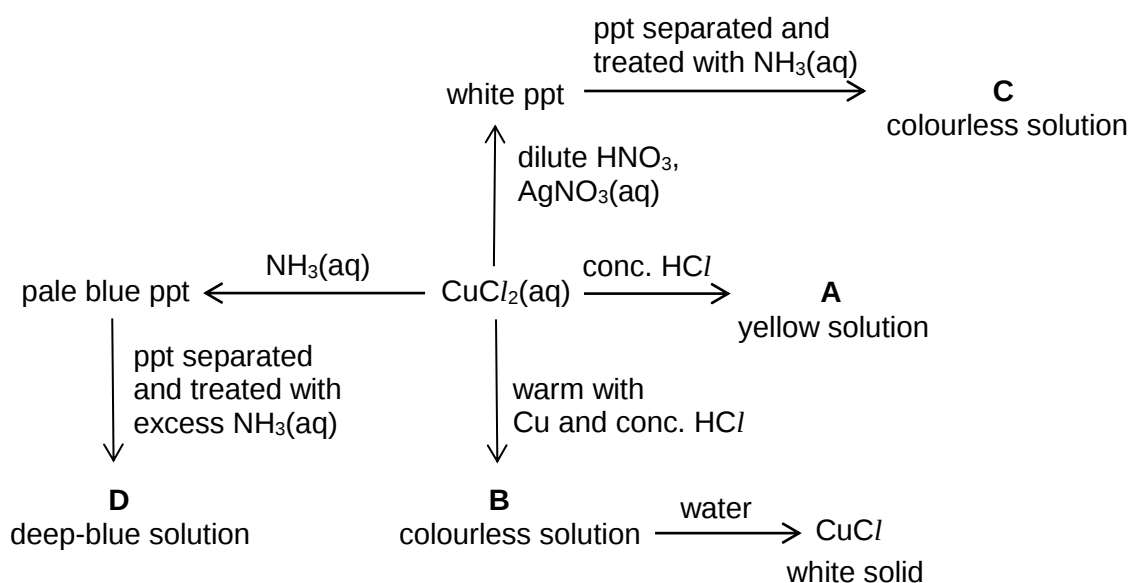
[2]

- (d) Copper has more than one oxidation state and many of its compounds have colours in the blue-green-yellow part of the visible spectrum.

Write the *spdf* electronic configuration of copper(II) ions.

Cu^{2+} [1]

- (e) Aqueous copper(II) chloride, CuCl_2 , is a blue solution which gives the following reactions.



Both **A** and **B** contain complex ions of copper and chlorine.

(i) State the formula of compound **C**.

..... [1]

[Turn over

- (ii) Suggest the formula and shape of the complex ion present in **D**.

Formula [1]

Shape [1]

- (iii) What type of reaction occurs when **A** is formed from $\text{CuCl}_2(\text{aq})$?

..... [1]

- (iv) Explain why **A** is yellow in colour.

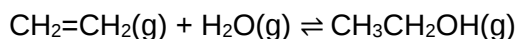
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.....
..... [3]

- (v) Explain why **B** is colourless.

.....
.....
..... [1]

[Total: 19]

- 3 Industrially, ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, is manufactured by reacting ethene with steam in the presence of a catalyst. The reaction is reversible and the equation is as follows:



At equilibrium, only 5 % of the ethene is converted into ethanol. To increase the overall yield of ethanol, ethanol is regularly removed from the equilibrium mixture as it is formed and more ethene is added into the reaction mixture. The volume of steam is not increased as this may disable the catalyst.

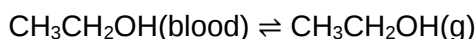
- (a) Apart from the methods mentioned above, suggest one other method which will increase the conversion of ethene into ethanol. Explain your answer briefly.

.....
[2]

Alcoholic beverages can contain up to 40 % of ethanol. Excessive consumption of ethanol depresses the activity of the central nervous system. The blood alcohol concentration (BAC) is a good measure of the extent to which the activity of the central nervous system is depressed. It is usually defined as follows

$$\text{BAC} = \text{mg of ethanol per } 100 \text{ cm}^3 \text{ of blood}$$

Ethanol is sufficiently volatile to pass from the blood into the air in the lungs and the following equilibrium is set up:



- (b) (i) Suggest an expression for K_c for the equilibrium of ethanol between the blood and the air in the lungs.

[1]

- (ii) Using your answer to (b)(i) and given that the equilibrium constant, K_c , for this process is 4.35×10^{-4} , calculate the breath alcohol concentration (in mg of ethanol / 100 cm^3 of air) which corresponds to the $80 \text{ mg} / 100 \text{ cm}^3$ of blood legal limit for BAC.

[1]

[Turn over

(iii) Hence determine the legal limit of breath alcohol concentration in mol dm^{-3} .

[2]

- (c) The handheld breathalyser contains an electrochemical cell in which ethanol is oxidised. At one electrode, atmospheric oxygen is reduced to water and the other electrode ethanol is oxidised to ethanoic acid. The electric current produced gives an approximation of the overall blood alcohol concentration (BAC).

Give the half-equation for each electrode reaction and hence give the overall equation showing the oxidation of ethanol.

.....

 [2]

- (d) Ethanol can be burned in excess oxygen as fuel. Complete combustion of ethanol releases 1367 kJ mol^{-1} of heat energy.

- (i) Write an equation to show the standard enthalpy change of combustion of ethanol.

..... [1]

- (ii) Use the bond energies given in the *Data Booklet* to calculate another value for the standard enthalpy change of combustion of ethanol.

[3]

- (iii) Suggest a reason for the discrepancy between this value and that quoted in (d).

.....
.....[1]

- (e) (i) The complete combustion of ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}$, releases 873 kJ mol^{-1} of energy. Use this value and the enthalpy change of combustion of ethanol given in (d) to construct an energy cycle to calculate the enthalpy change when 1.0 mol of ethanol in the body is oxidised to ethanoic acid and water only.

[3]

- (ii) The metabolism of ethanol in the human body leads to partial oxidation which releases 770 kJ mol^{-1} of energy. Assuming that ethanol is oxidised to ethanoic acid and carbon dioxide only, use your answer to (e)(i) and any other relevant data to calculate the proportion of ethanol metabolised to ethanoic acid and to carbon dioxide respectively.

[2]

[Total: 18]

[Turn over

- 4 (a) Aerosol spray is a type of dispensing system which creates an aerosol mist of liquid particles. This is used with a can that contains a product and propellant under pressure. Hair spray is a common example of an aerosol spray where butane is often used as the propellant.

- (i) A typical can of hair spray has a volume of 300 ml and 70 % of which is the hair product. Given that the can has an internal pressure of 100 psi, at 27 °C, calculate the maximum amount of butane present in the can. (1 psi = 6894.76 Pa)

[2]

- (ii) The can of hair spray is used such that only the propellant, butane gas, remained and the internal pressure of the can decreased to 20 psi. If the can is left in a car that reaches 50 °C on a hot afternoon, what is the new pressure in the can?

[1]

- (iii) As a safety precaution, the propellant has to be completely expelled from the can prior to disposal and subsequent incineration. Using concepts from the Ideal Gas Law, explain qualitatively, why this precaution is necessary.

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.....

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..... [1]

- (b) In 1873, Johannes D. van der Waals, a physicist proposed a modification to the ideal gas equation to better model real gas behaviour. The new equation, usually referred to as the van der Waals equation, has the following expression.

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

P is the observed pressure exerted by the gas.

V is the volume of the container in which the gas is contained.

The constants a and b have positive values and are characteristic of a gas.

Suggest why the term $\frac{an^2}{V^2}$ is **added** to P and the term nb is **subtracted** from V respectively.

$P + \frac{an^2}{V^2}$:

.....

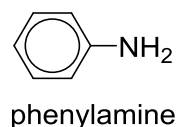
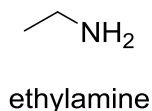
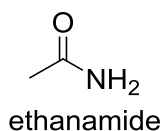
..... [1]

$V - nb$:

.....

..... [1]

- (c) Arrange the following three compounds in increasing order of basicity.



Order of basicity:

Explain your answer.

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.....

.....

.....

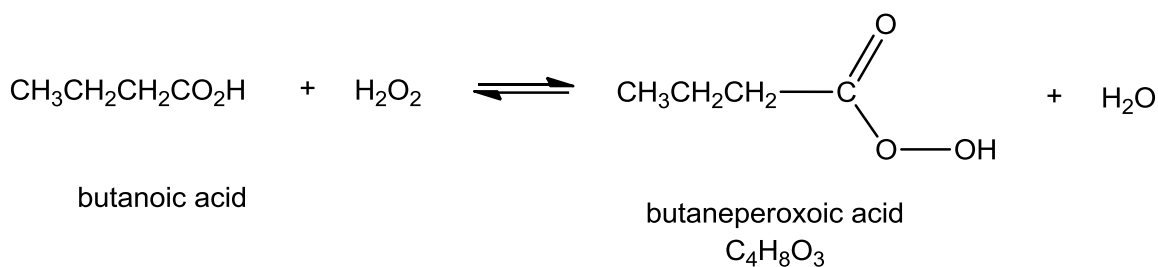
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..... [3]

[Total: 9]

[Turn over]

- 5 (a)** Butaneperoxoic acid, a type of peroxyacid, is produced when butanoic acid reacts with hydrogen peroxide.



- (i) Identify the type of hybridisation involved for the C atom of $\text{O}=\text{C}-\text{O}$ in butaneperoxoic acid and hence state its bond angle.

Hybridisation of C

Bond angle [2]

- (ii) Non-cyclic compounds **A** and **B** are functional group isomers of butaneperoxoic acid. 1 mole of hydrogen gas is produced when 1 mole of **A** and 1 mole of **B** are reacted with Na metal separately. **A** produces yellow precipitate when reacted with aqueous alkaline iodine while **B** does not. When reacted with hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$, orange $\text{K}_2\text{Cr}_2\text{O}_7$ turns green in the presence of **A** but not **B**.

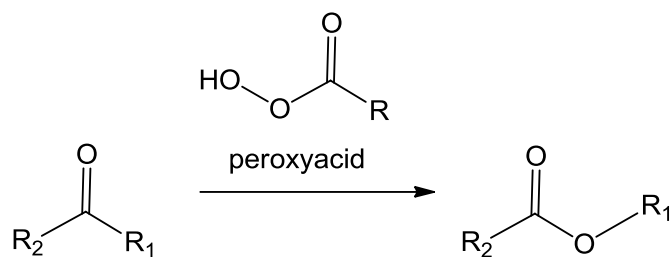
Draw the displayed formula of **A** and **B**, hence state the specific type of isomerism between **A** and **B**.

Compound A	Compound B
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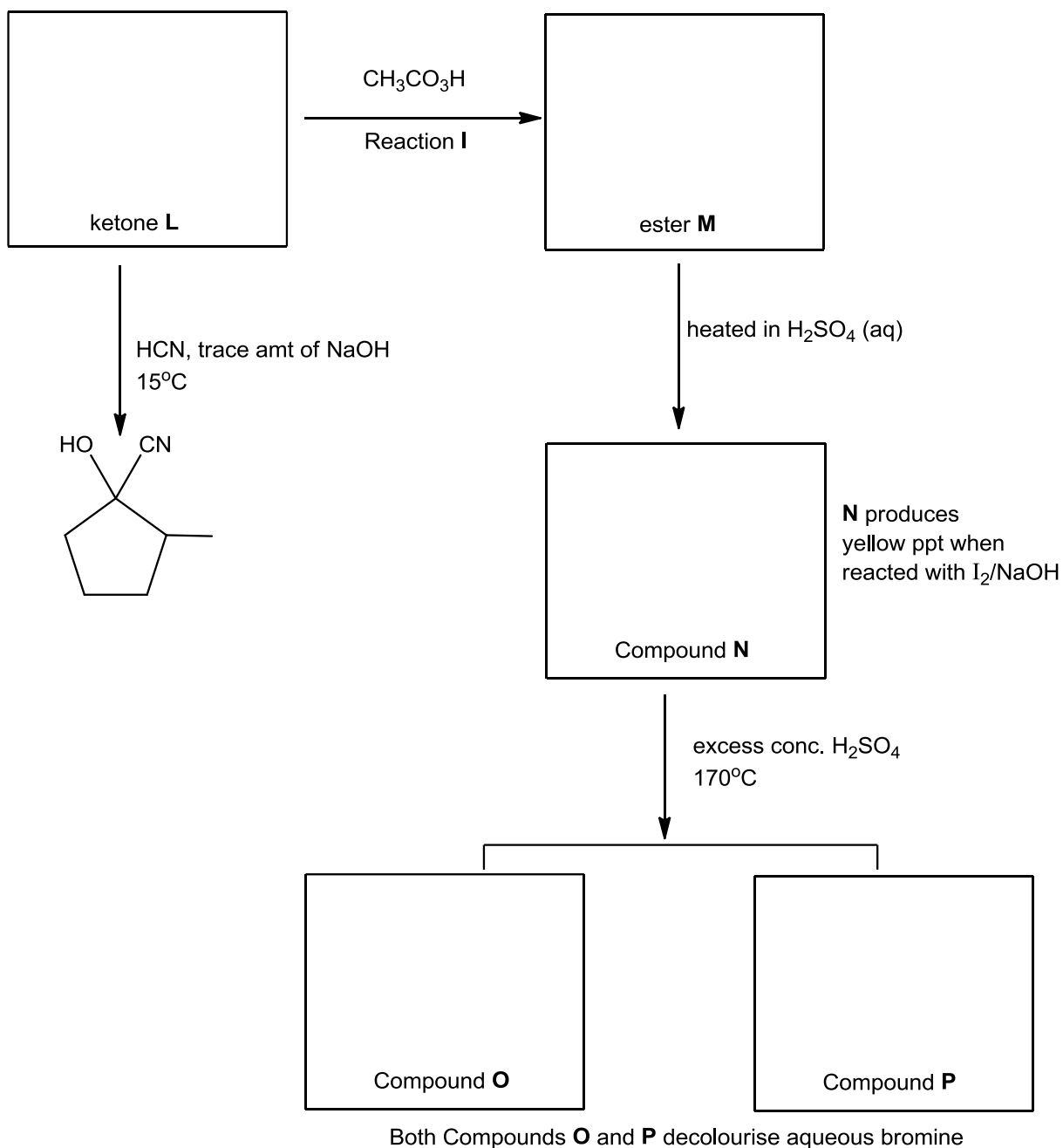
[2]

Type of isomerism between **A** and **B** [1]

- (b) The Baeyer-Villiger oxidation is an organic reaction that converts ketones into esters using peroxyacids.



In the following reaction scheme, reaction I is a Baeyer-Villiger oxidation. Give the structural formulae of compounds **L**, **M**, **N**, **O** and **P**. [5]



[Total: 10]

[Turn over

- 6 2-methylbut-2-ene is reacted with bromine in an inert solvent in the absence of light.

(a) Describe the mechanism for the above reaction.

[3]

- (b) (i) State the type of isomerism exhibited by the organic product(s) formed in the above reaction, and hence, draw the structures of the isomers.

type of isomerism[1]

Structures of isomers:

[1]

- (ii) It was found that the product(s) formed from (a) do not rotate plane of polarised light. Using the mechanism drawn in (a), suggest why this is so.

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.....[2]

[Total: 7]