

Name: _____

Class: 14 _____

Reg Number: _____



MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 1

Chemistry

8872/02

Paper 2

16 September 2015
2 hours

Additional Materials: *Data Booklet*
Writing Papers
Graph Paper

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces at the top of this page.

This booklet contains Section **A** and Section **B**.

Section A : Pg 2 to 10

Answer **all** questions in Section A in the spaces provided on the question paper. You are advised to spend about **1 h** on Section A.

Section B : Pg 11 to 16

Answer **2 out of 3** questions in Section B. You are advised to spend about **1 h** on Section B.

Hand in Section **B** *separately* from Section A.

Fasten your answers for Section **B** behind the given **Cover Page**. Detach the **Cover Page** from the last page behind this booklet.

INFORMATION FOR CANDIDATES

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

Examiner's Use		
Paper 1	MCQ	/ 30
	/ 33 %	
Paper 2 Section A	Q1	/ 15
	Q2	/ 12
	Q3	/ 13
Paper 2 Section B	/ 40	
Paper 2 Total	/ 80	
	/ 67 %	
Grand Total	/ 100 %	
Grade		

Section A: Structured Questions

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

- 1 When gaseous phosphorus(V) chloride is heated in a closed container, the following equilibrium is established, producing phosphorus(III) chloride and chlorine.



- (a) (i) Draw the dot-and-cross diagram for phosphorus(III) chloride.

[1]

- (ii) Draw a diagram to show the shape of phosphorus(V) chloride.

[1]

- (b) In terms of structure and bonding, explain whether phosphorus(V) chloride or phosphorus(III) chloride would have a higher boiling point.

[3]

- (c) (i) Define what is meant by *dynamic equilibrium*.

[1]

When 1.0 mol of phosphorus(V) chloride is placed in a 5.0 dm³ vessel at 500 K, the equilibrium amount of phosphorus(III) chloride is found to be 0.508 mol.



- (ii) Write an expression for the equilibrium constant, K_c , for the equilibrium, stating the units.

[1]

- (iii) Calculate the equilibrium constant, K_c , for the reaction.

[3]

[Turn Over]

- (iv)** Explain what would happen to the equilibrium position and rate of reaction when the volume of the reaction vessel is decreased.

[3]

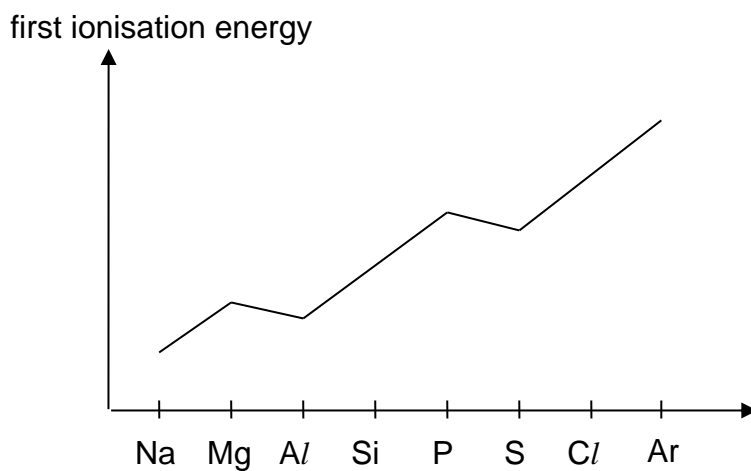
- (v)** The equilibrium can be described as a redox reaction. Explain why, including relevant oxidation numbers in your explanation.

[2]

[Total: 15]

2 In the third period of the Periodic Table, there is considerable variation of chemical and physical properties from sodium to argon.

(a) The graph below shows the first ionisation energy from sodium to argon.



(i) Using an equation, define the term *first ionisation energy of Al*.

[1]

(ii) Explain why the first ionisation energy across the period generally increases.

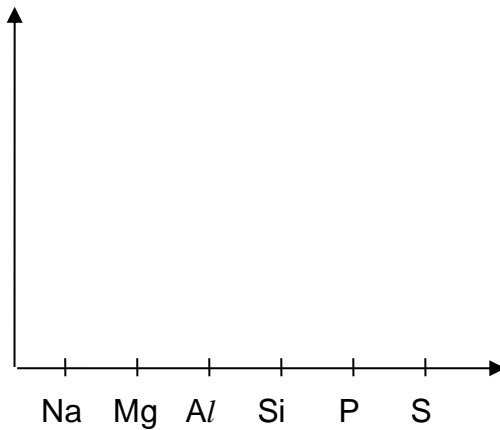
[2]

(iii) Explain the decrease in the first ionisation energy from magnesium to aluminum.

[1]

- (b) (i) On the axes below, sketch a graph to show the pH of the resultant solutions when period 3 chlorides are dissolved in water.

pH of chloride.



[1]

- (ii) Write equations to show how SiCl_4 and PCl_5 react with water.

[2]

- (c) The properties of oxides of the elements of the third period depend on the difference in electronegativity values between the element and oxygen.

The table below shows the electronegativity of elements of the second and third period as proposed by Linus Pauling.

Li 0.98	Be 1.57	B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	Ne –
Na 0.92	Mg 1.31	Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16	Ar –

- (i) Calculate the difference in electronegativity between the element and oxygen for the oxides BeO, Al_2O_3 and SO_2 .

BeO	Na_2O	Al_2O_3	SO_2
	2.52		

[1]

- (ii) Hence, use your values in (c)(i) to predict the following properties of beryllium oxide, BeO.

1. structure and bonding

[1]

2. the acid-base nature

[1]

- (iii) Write equations to describe how aluminum oxide reacts with aqueous HCl and aqueous NaOH respectively.

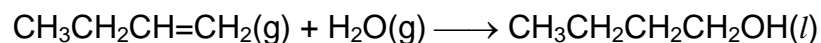
[2]

[Total: 12]

[Turn Over]

3 Alcohols are used as fuels. The first four aliphatic alcohols (methanol, ethanol, propanol and butanol) are increasingly being used as fuels because they can be synthesised chemically or biologically.

- (a) Butan-1-ol can be synthesised from but-1-ene, represented by the chemical equation below.



- (i) Using bond energy values from the *Data Booklet*, calculate the enthalpy change of the reaction.

[3]

- (ii) The calculated value in (a)(i) differs significantly from literature value. Suggest a reason for the discrepancy between the two values.

[1]

- (b)** An experiment was carried out to determine the standard enthalpy change of combustion of butan-1-ol, $\Delta H_c(\text{butan-1-ol})$. A quantity of butan-1-ol was burnt underneath a copper can containing 200 g of water. The following results were obtained.

Volume of butan-1-ol used = 1.2 cm^3

Initial temperature = 27.0°C

Final temperature = 51.5°C

Density of butan-1-ol = 0.810 g cm^{-3}

- (i)** Given that the process was only 80% efficient, calculate $\Delta H_c(\text{butan-1-ol})$.

Given that the heat capacity of the copper can is negligible and that the specific heat capacity of water is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$.

[3]

- (ii)** The true value of the standard enthalpy change of combustion of butan-1-ol is $-2670 \text{ kJ mol}^{-1}$. Suggest a reason for the discrepancy between the true value and that calculated in **(b)(i)**.

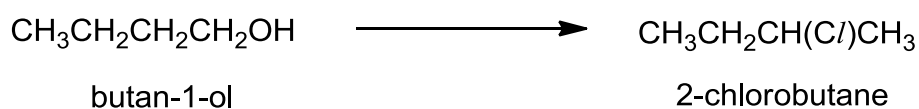
[1]

- (c) The molecular formula of butan-1-ol is $C_4H_{10}O$. There are three other structural isomers with molecular formula $C_4H_{10}O$. One of the isomers is a secondary alcohol.

Describe how the secondary alcohol could be distinguished by a simple chemical test from butan-1-ol.

[2]

- (d) Outline how the following conversion could be carried out from butan-1-ol.



[3]

[Total: 13]

Section B : Free Response Questions

Answer **two** of the following three questions.

Answer these questions on separate answer papers.

- 4 The petrochemical industry produces hydrocarbons of different molecular sizes through cracking, a process which breaks up large hydrocarbon molecules into smaller and more useful fragments.

(a) Two of the most common fragments of cracking are octane and propene.

(i) Suggest a use for propene. [1]

(ii) Octane is used as fuel in the engines of motorised vehicles. The two pollutants present in the exhaust fumes of these engines are carbon monoxide and unburnt hydrocarbons. State the detrimental effects caused by **each** of these two pollutants. [2]

The cracking of *pentacosane*, $C_{25}H_{52}$, produced five smaller fragments, **T**, **W**, **X**, **Y** and **Z**.

(b) Fragment **T** has a relative molecular mass of 58 and has the following composition by mass:

C, 82.8%; H, 17.2%

Calculate the empirical formula and hence the molecular formula of **T**. [3]

(c) A 10 cm^3 sample of fragment **W** was completely burnt in an excess of 100 cm^3 of oxygen. After cooling to room temperature, the gaseous mixture occupied a volume of 75 cm^3 . When this mixture is passed through aqueous potassium hydroxide, there is a volume reduction of 50 cm^3 .

Deduce the molecular formula of fragment **W**. [3]

(d) Fragment **X** is an aliphatic hydrocarbon with a molecular formula of C_4H_8 . When **X** is subjected to chlorine gas under suitable conditions, disubstituted cis and trans isomers are formed. All cis isomers formed are symmetrical.

(i) State the conditions required for the reaction. [1]

(ii) Draw two possible isomers for each of the symmetrical cis isomers formed and their corresponding trans isomers. Label the isomers. [3]

- (e) Fragment **Y** has the structural formula $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2\text{CH}_3$.

Give the structure of the organic products formed when **Y** is reacted with each of the following under appropriate conditions.

(i) steam [1]

(ii) chlorine dissolved in an organic solvent [1]

(iii) hot acidified potassium manganate(VII) [2]

- (f) In an experiment, a sample of fragment **Z**, C_2H_4 , was converted to C_2H_4^- and passed through an electric field. Analysis of the deflection occurring at the electric region revealed that a beam of $^{52}\text{Cr}^{3+}$ gives an angle of deflection of $+4^\circ$.

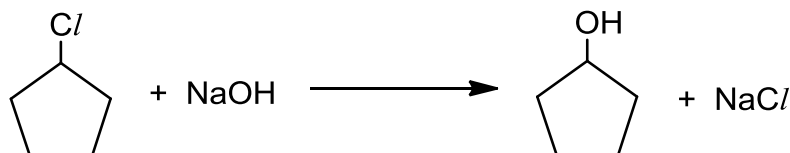
Predict, with reasoning, the angle of deflection for C_2H_4^- . [2]

- (g) Using the information above, write a balanced equation for the cracking of *pentacosane*. [1]

[Total: 20]

5 Chlorocyclopentane is a common starting material for the synthesis of five-carbon cyclic compounds with different functional groups.

- (a) Chlorocyclopentane undergoes substitution reaction with aqueous sodium hydroxide as illustrated in the equation below.



There are two possible mechanisms that this reaction can undergo resulting in different rate equations.

Rate equation of mechanism 1: $\text{rate} = k [\text{NaOH}] [\text{chlorocyclopentane}]$

Rate equation of mechanism 2: $\text{rate} = k [\text{chlorocyclopentane}]$

To investigate which mechanism occurs and how the concentration of each reactant affects rate of reaction, two experiments were carried out. In each experiment, the concentration of chlorocyclopentane is used in excess whilst the concentration of NaOH was measured over time.

The concentration of NaOH was monitored by 'quenching' 10 cm³ of the sample with 20 cm³ of ice-cold water, before titrating the sodium hydroxide in the sample with 0.1 mol dm⁻³ of HCl.

- (i) Why is it necessary to quench the sample before titration? [1]

Data from the two experiments are shown in the table.

	<i>Reaction 1</i> [chlorocyclopentane] = 5.0 mol dm ⁻³	<i>Reaction 2</i> [chlorocyclopentane] = 2.5 mol dm ⁻³
time / s	Volume of HCl used / cm ³	Volume of HCl used / cm ³
0	20.00	20.00
20	12.80	15.00
40	8.20	11.60
60	5.00	8.70
80	3.30	6.50
100	2.00	4.90
120	1.20	3.80

- (ii) Using the same axes, plot graphs of volume of HCl used against time for both *Reaction 1* and 2. Label each curve clearly. [2]
- (iii) Use your graph to determine the order of reaction with respect to NaOH and chlorocyclopentane. Justify your answer in each case. [4]

[Turn Over

(iv) What would be the effect, if any, on the half-life of this reaction by doubling the initial concentration of NaOH? [1]

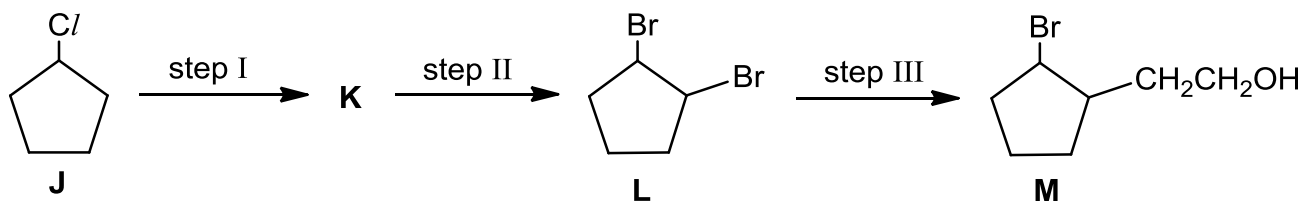
(v) Suggest with reasoning, which mechanism, **1** or **2**, the substitution reaction is consistent with. [1]

(b) The reaction in (a) has an activation energy of 184 kJ mol^{-1} for the forward reaction and 143 kJ mol^{-1} for that of the reverse reaction.

(i) Sketch a labelled reaction pathway diagram for the above reaction. [2]

(ii) Sketch a labelled Boltzmann distribution curve to show how an increase in temperature speeds up the rate of reaction. [2]

(c) Chlorocyclopentane undergoes a series of reaction shown below.



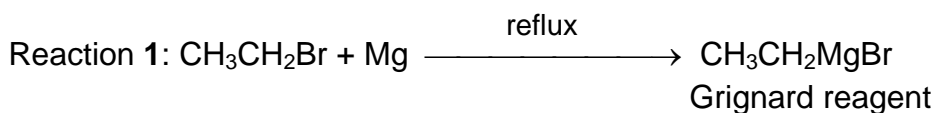
(i) Suggest the structure for **K**. [1]

(ii) Suggest the reagents and conditions for steps **I** and step **II**. [2]

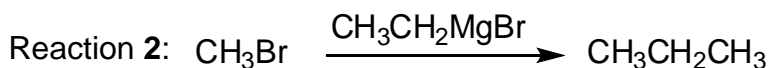
(iii) Describe a simple chemical test to distinguish **J** from **L** and state the expected observations. [2]

(iv) The following description is with regards to step **III** in the reaction scheme in (c).

Grignard reagents have the formula of RMgX where X is a halogen and R is an alkyl group. These reagents can be made by adding halogenoalkane to magnesium in a suitable solvent.



One of the most common applications of Grignard reagents is in their reaction with halogenoalkanes to extend a carbon chain shown below.



1. Suggest the organic compound in step **III** necessary for synthesizing the Grignard reagent to produce **M**. [1]

2. Suggest the type of reaction of step **III**. [1]

[Total: 20]

[Turn Over]

6 Wine contains many chemicals to give its distinct complex flavors and aromas. These include tartaric acid, cyanidin, succinic acid and acetoin.

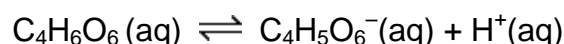
(a) During the fermentation and production process of wine, the pH is adjusted by adding tartaric acid. To analyse the concentration of tartaric acid in the wine, an aliquot of wine can be titrated with aqueous sodium hydroxide.

(i) 0.70 g of pure sodium hydroxide pellets was dissolved in 10 dm³ of water. Calculate the concentration of sodium hydroxide solution in mol dm⁻³. [1]

(ii) Tartaric acid is dibasic. It was determined that 25.0 cm³ sample of tartaric acid required 40.0 cm³ of sodium hydroxide from (a)(i) for complete neutralisation. Calculate the concentration of the tartaric acid. [2]

(iii) The above titration experiment registered a pH 9 at the second end point. Explain why methyl orange is **not** a suitable indicator for this second end point. [1]

(b) Tartaric acid ionises as shown below.



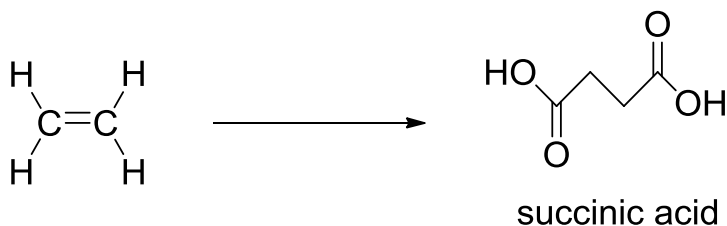
(i) Write an expression for the acid dissociation constant, K_a , for the dissociation above. [1]

(ii) At temperature $T^\circ\text{C}$, 10% of the tartaric acid ionised in 2.00 mol dm⁻³ solution at equilibrium. Calculate the value of K_a at $T^\circ\text{C}$. [2]

(c) Cyanidin, a weak acid is a coloured compound found in red grapes.

Explain with the aid of equations, how a buffer solution of cyanidin (represented as HA) and its sodium salt (represented as Na⁺A⁻) regulates acidity. [3]

(d) Suggest a three-step reaction sequence with appropriate reagents and conditions for the synthesis of succinic acid from ethene, giving structural formulae of the intermediates involved. [4]



- (e) *Acetoin*, $C_4H_8O_2$, was produced during wine yeast fermentation. Compound **E** is an isomer of *acetoin*.

Acetoin gives an orange precipitate with 2,4–dinitrophenylhydrazine and a yellow precipitate with alkaline aqueous iodine when reacted separately.

When **E** was reacted with $Na_2CO_3(aq)$, effervescence was observed. However, after *acetoin* was oxidised by acidified potassium manganate(VII), its product did not form effervescence when reacted with $Na_2CO_3(aq)$.

When reacted with bromine under ultraviolet light, **E** produced **only two** monobromo compounds.

Suggest the structural formula for **E** and *acetoin*. Explain the reactions fully. [6]

[Total: 20]

END OF PAPER