

NATIONAL JUNIOR COLLEGE SH2 PRELIMINARY EXAMINATION Higher 2

CANDIDATE NAME

SUBJECT CLASS REGISTRATION NUMBER

CHEMISTRY

Paper 2 Structured Questions

Candidates answer on Question Paper. Additional Materials: Data Booklet

READ THE INSTRUCTIONS FIRST

Write your subject class, registration number and name on all the work you hand in.

Write in dark blue or black pen on both sides of the paper. You may use a soft pencil for any diagrams, graphs or rough working.

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

Answers **all** questions.

For Examiner's Use			
1	/9		
2	/22		
3	/6		
4	/7		
5	/14		
6	/17		
Paper 2 Total	/75		

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

	Marks	Weightings
Paper 1	/30	15%
Paper 2	/75	30%
Paper 3	/80	35%
Paper 4	/55	20%

This document consists of **19** printed pages and **1** blank page.

9729/02 23 August 2024 2 hours Answer all the questions in the spaces provided.

Element A is from Period 4 of the Periodic Table. The first eight ionisation energies of 1 (a) element A, in kJ mol⁻¹, are

> 947 1798 2735 4837 6043 12310 14300 16800

- (i) Identify element A and explain your answer.
- (ii) Explain the difference between the first ionisation energy of element A compared to the element to its right on the Periodic Table.

[2]

 [2]

(b) In organic chemistry, an aldol is a structure consisting of a hydroxy group (-OH) two carbons away from either an aldehyde or a ketone.

Aldols are the product of a carbon-carbon bond-formation reaction, giving them wide applicability as a precursor for a variety of other compounds.

(i) Give the IUPAC name of the structure below:



	IUPAC name:	[4]
(ii)	The compound above undergoes elimination to form the following product: CH(OH)CHCHO.	נין
	Give the reagents and conditions for the reaction.	
		 [1]
(iii)	State the isomerism which the product displays.	
		 [1]

(iv) With the use of a diagram, explain why the cis isomer is formed preferentially.

[2] [Total:9] 2 (a) Some information about NO_3^- and NO_2^- are provided in Table 2.1 and Table 2.2

Table 2.1			
Electron arrangement around N in NO_3^-	3 bond pairs & 0 lone pair		
Electron arrangement around N in NO_2^-	2 bond pairs & 1 lone pair		

Table 2.2

Nitrogen-oxygen bond in NO₃ ⁻	0.124 nm	
Theoretical N-O bond length	0.136nm	
Theoretical N=O bond length	0.115nm	

Fig. 2.1 shows a possible structure of NO_3^- .



Fig.2.1

(i) Use relevant information from the above tables to explain why Fig. 2.1 does not represent an accurate model for the bonding in NO_3^- .

(ii) Nitrogen atoms undergo the same type of hybridisation as carbon atoms do. Suggest the mixing and overlap of atomic orbitals which accounts for the N–O bond length in NO_3^- .

[3]

(iii) The bond angle around nitrogen in NO_3^- and NO_2^- are different.

Use VSEPR theory to explain how the bond angle in NO_3^- is different from that in NO_2^- .

[2]

- (b) When solid magnesium nitrate is heated, it decomposes to give magnesium oxide, oxygen and nitrogen dioxide gas.
 - (i) Write an equation for the decomposition of solid magnesium nitrate.

.....

[1]

(ii) Zinc nitrate decomposes in the same way as magnesium nitrate when it is heated.

Use data from the Data Booklet to explain the difference in decomposition temperature between zinc nitrate and magnesium nitrate.

[3]

- (c) Magnesium and beryllium are Group 2 elements, but beryllium behaves differently from that of magnesium. There is said to be a 'diagonal relationship' between beryllium and aluminium as they show similar chemical behaviour due to their similarities in electronegativity and charge density.
 - (i) Draw the dot-and-cross diagram to show the bonding in $BeCl_2$.

(ii) When a few drops of water are added to solid beryllium chloride, steamy white fumes are evolved and a white solid remains, which is insoluble in water.

Write a balanced equation for this reaction.

[1]

- (iii) At 750 °C, the relative molecular mass of gaseous beryllium chloride corresponds to the formula BeCl₂. At 550 °C, gaseous beryllium chloride exists as a mixture of BeCl₂ and Y (relative molecular mass of Y is 160).
 - (I) Suggest the structure of **Y**, showing any dative bonding.

(II) Determine the relative ratio of $BeCl_2$ and **Y** in a gaseous sample at 550 °C which has a relative molecular mass of 100.

(d) Magnalium is an alloy of aluminium and magnesium which is used in boat-building. The diagram below shows some reactions of magnalium.



Identify A, B and C.

- A:
- B:
- **C**:

[2]

(e) Grignard reagents, RMgX, can be prepared by the reaction of magnesium with halogenoalkane, RX, using dry ether as the solvent.

A Grignard reaction occurs when a Grignard reagent is reacted with a carbonyl compound to prepare alcohols in a two-step reaction. An example of a Grignard reaction is shown below.

- (ii) Step I of the above Grignard reaction is known to proceed via the following two stages:
 - Stage 1: The covalent bond C-Mg in CH_3CH_2MgBr break to give ${}^-CH_2CH_3$ and $MgBr^{\scriptscriptstyle +}$.

Stage 2: ⁻CH₂CH₃ attack the carbonyl carbon in CH₃CHO to give the intermediate

¯O MaBr⁺ $H-\dot{C}-CH_3$ CH₂CH₃

Using the information given above, draw the mechanism to describe step I of the Grignard reaction, showing dipoles, lone pairs, and curly arrows.

(iii) Suggest and explain whether a single enantiomer or a racemic mixture of the organic product is formed in the above Grignard reaction.

[1]

(iv) $CH_3CO(CH_2)_5MgBr$ undergo the Grignard reaction to give a product with molecular formula of $C_7H_{14}O$.

Draw the structural formula of the product.

[1]

[Total: 22]

3 Ethyne, C_2H_2 , can be produced from methane, as shown in the equation below.

 $2CH_4(g) \rightleftharpoons C_2H_2(g) + 3H_2(g) \qquad \Delta H > 0$

At a constant pressure of 4.0×10^6 Pa, 1.20 mol of CH₄ in a sealed vessel is allowed to reach equilibrium. At equilibrium, 70% of the original sample of CH₄ has reacted.

(i) Write the K_{p} expression for the reaction.

[1]

(i) Calculate K_p for the reaction, stating the units.

(ii) Suggest why the reaction becomes spontaneous at high temperature.

4 (a) Cyclohexanone can be converted to compound **T** in 3 steps.

Suggest the reagents and conditions for steps **1** to **3** and draw the structure of the compounds **R** to **S** in the synthetic scheme below.



compound T

step	reagents and conditions
1	
2	
3	
	·

[5]

(b) Suggest a simple chemical test that could be used to distinguish between compounds X and Y. You should state what you would observe for each compound.

HO CH(COOH)CH ₃	HO-CH(OH)CH ₂ CH ₃
compound X	compound Y
Reagent and condition:	
Observation:	
	[2]
	[Total: 7]

[Turn over

5 The Koch reaction is an organic reaction for the synthesis of carboxylic acids from alkenes. The reaction is a strongly acid-catalysed carbonylation using carbon monoxide, and typically occurs at harsh conditions.

The mechanism for the formation of **K** from 2-ethylpent-1-ene is shown below.



[2]

(b) (i) L, a structural isomer of K, is a minor product formed from 2-ethylpent-1-ene in the Koch reaction.

Suggest the structure of L.

(ii) Explain why K is formed preferentially over L.

[2]

(c) 1 mole of compound **M**, C₈H₁₄, was heated with H₂SO₄(aq) and KMnO₄. 2 moles of propanone and 2 moles of CO₂ were produced in the reaction.

Suggest the structure of compound **M**.

[1]

(d) A variation of the Koch reaction is the Gattermann Koch Reaction, which converts a benzene into benzaldehyde as shown in the equation below.



(iii) The Gattermann Koch Reaction was repeated with the following compounds:



Arrange the compounds according in increasing order of reactivity. Explain your answer.

[3]

- (e) At 450 °C, 5.00 g of the hydrocarbon **X** was found to exert a pressure of 50 kPa in a 4.0×10^3 cm³ vessel.
 - (i) Prove that the molar mass of X is 150.2 g mol⁻¹.

[1]

(ii) The actual molar mass of X is 144.0 g mol⁻¹. Explain why the experimental value calculated in (e)(i) is higher than the actual value.

 	[1]
	[']

[Total:14]

6 (a) Gilding metal is a type of brass alloy that consists of copper and a small amount of zinc, ranging from 5 % to 11 % by mass. Copper is very malleable and is hardened by the addition of zinc.

The proportions of copper and zinc determine the exact properties of the gilding metal and can be determined by chemical analysis.

2.72 g of brass **A** was dissolved in 30 cm³ of excess concentrated nitric acid, forming a blue solution **B**, containing both copper and zinc ions.

When solution **B** was heated with ammonium thiocyanate, NH_4SCN , precipitate **C** and a gas were produced. The precipitate **C** was found to have a mass of 4.69 g.

(i) Precipitate **C** has the following composition by mass.

Cu, 52.2%; S, 26.4%; C, 9.9%; N, 11.5%

Calculate the empirical formula of precipitate C.

(ii) Use the information provided and your answer from (a)(i), calculate the percentage by mass of zinc in brass A. Hence, suggest if brass A is a gilding metal.

(iii) Explain why precipitate C is white.

		[2]

(iv) When sulfur dioxide, SO₂, was bubbled into blue solution **B**, the solution turned colourless and no solid was formed.

(I) Construct a balanced equation for the reaction between solution **B** and SO₂. (II) By selecting appropriate E° values from the Data Booklet, explain why it would be expected that this redox reaction would **not** occur.

[2]

(v) With reference to your answer from a(ii), prove that the concentration of copper ion in solution B is 1.29 mol dm⁻³. Hence, explain why the reaction between solution B and SO₂ does in fact occur.

[2]

- (b) When excess potassium thiocyanate, KSCN, were added to a yellow solution, containing Fe(III) ions, a blood red solution containing [Fe(SCN)(H₂O)₅]²⁺(aq) was formed.
 - (i) Draw the dot-and-cross diagram to show the bonding in KSCN.

[2]

(ii) Draw a diagram of the structure of $[Fe(SCN)(H_2O)_5]^{2+}$, showing the 3-dimensional arrangement around the Fe(III) ion.

[1]

[2]

(iii) State the type of reaction taking place and write a balanced equation, with state symbols, for the reaction.

Type of reaction:.....

(iii) Explain why the colours of the aqueous ions, Fe^{3+} and $[Fe(SCN)(H_2O)_5]^{2+}$, are different.

[2]

[Total: 17]

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