## NATIONAL JUNIOR COLLEGE H1 Chemistry Preliminary Examination

## CHEMISTRY 21 August 2008

# PAPER 2 TIME: 2 hours

## **INSTRUCTIONS TO CANDIDATES**

**Do not open this booklet until you are told to do so.** Write your name, class and registration number in the spaces provided at the top of this page.

## Section A:

Answer **ALL** questions in the spaces provided on the question paper. The number of marks is given in brackets [] at the end of each question or part question.

#### Section B:

Answer any **two** questions on the writing paper provided. Begin each question on a fresh sheet of paper. Staple your answers at the back of this booklet. Circle the questions answered on the cover page of this booklet. The number of marks is given in brackets [] at the end of each question or part question.

#### **INFORMATION FOR CANDIDATES**

A Data Booklet is provided. You may use a calculator.

For Examiner's Use		
Section A		
1	/ 9	
2	/ 9	
3	/ 12	
4	/ 10	
Section B		
5	/ 20	
6	/ 20	
7	/ 20	
Total P2		

This question paper consists of **<u>10</u>** printed pages (including this page).

#### Section A: Structured Questions (40 Marks)

- Use of *Data Booklet* is relevant to this question. Gallium was first discovered by Lecoq de Boisbaudran in 1875 when he was studying zinc blende from the Pyrennees. In present day, it is now widely distributed in minute quantities and is used in thermometers for temperatures up to 100°C, where it is an alloy with indium and tin in liquid state. It is also used in the semiconductor industry in the manufacture of diodes and transistors.
  - (a) (i) Describe the relative charges and masses of protons, neutrons and electrons. Explain fully how these particles are arranged in a Gallium atom.

(ii) State the number of protons, electrons and neutrons in an atom of  $^{69}$ Ga.

[1]

[3]

- (b) Gallium exists as two isotopes,  $^{69}$ Ga and  $^{71}$ Ga in the proportion of 3:2.
  - (i) Define the term isotope.

[1]

(ii) Calculate the relative atomic mass of gallium.

[2]

(iii) A gaseous mixture of <sup>69</sup>Ga<sup>3+</sup> and <sup>71</sup>Ga<sup>3+</sup> is passed through an electric field which is at right angles to their direction of travel. State and explain which one of the two ions will be deflected to a larger angle.

[2] [Total: 9] 2. Nitrogen monoxide can be produced by the oxidation of ammonia according to the equation below.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

- (a) (i) The NO bond energy in nitrogen monoxide is 607 kJ mol<sup>-1</sup>. Explain what is meant by the term *bond energy* with reference to the NO molecule.
  - (ii) Calculate the enthalpy change for the reaction above using (a)(i) and other bond energy values from the *Data Booklet*.

[3]

[2]

[1]

(b) The standard enthalpy change of formation of the respective compounds are given below.

Compound	ΔH <sub>f</sub> <sup>θ</sup> / kJ mol <sup>-1</sup>
NH <sub>3</sub> (g)	- 46
NO (g)	+90
H <sub>2</sub> O (I)	-285.8

- (i) Suggest a value for  $\Delta H_f^{\Theta}$  of  $O_2(g)$  and explain your answer briefly.
- (ii) Calculate the enthalpy change of the reaction above.
- (iii) Compare the answers obtained in (a)(ii) and (b)(ii) and suggest a reason for the difference.

[1] [Total: 9] **3.** (a) Draw the structures of the organic product(s) formed when Compound **A** below reacts with each of the following reagents.



Compound  $\boldsymbol{\mathsf{A}}$ 

Reagents and Conditions	Organic Product(s) formed
<b>(i)</b> HBr(g)	
(ii) KMnO <sub>4</sub> ; dilute H <sub>2</sub> SO <sub>4</sub> ; reflux	
(iii) Cold dilute alkaline KMnO₄	
(iv) Cl <sub>2</sub> (g) / AlCl <sub>3</sub> ; dark	[0]

(b) State the observation and write a balanced equation when Compound A reacts with the reagents and conditions in (a)(iii).

[2]

(c) State the type of isomerism exhibited by Compound **A** and hence draw the structures of the two isomers formed.

[2] [Total: 12] 4. (a) Chlorine was discovered in 1774 by Swedish Chemist C.W. Scheele. He added manganese dioxide, MnO<sub>2</sub> to hydrochloric acid and found that a gas was evolved. In this reaction, hydrochloric acid converts manganese dioxide to manganese(II) chloride, MnCl<sub>2</sub>. The other products were water and the unknown gas. Scheele initially thought that the gas was oxygen. It was only until 1810 that Sir Humphery Davy identified the gas as an element and named it *Chlorine*, which means greenish-yellow in Greek, due to its appearance.

# [For this question, 1 mole of chlorine gas occupies a volume of 24 dm<sup>3</sup> at room temperature and pressure.]

- (i) Suggest a balanced equation for the reaction that Scheele performed.
  - [1]
- (ii) Use your equation to calculate the volume of chlorine produced at room temperature and pressure when 5 g of manganese dioxide reacts with 25.0 cm<sup>3</sup> of 6.0 mol dm<sup>-3</sup> of hydrochloric acid.

[2]

(iii) Which species in the above reaction acts as the reducing agent?

[1]

(b) Chlorine gas is toxic. It affects the eyes at concentrations of only 3 ppm and it irritates the throat at 15 ppm. At 50 ppm, it can cause danger to human health even for a short time.

Due to its toxic nature, chlorine was thus used as an offensive weapon in World War I in Flanders. It was first deployed in 1915 when the German army released the gas from hundreds of cylinders. The threat of causing many men dying in agony was eventually countered by issuing gas masks, termed the "hypo helmet", which was a hood that was dipped in aqueous sodium thiosulphate,  $Na_2S_2O_3$ .

(i) Using the above information, calculate the number of moles of chlorine in 24 dm<sup>3</sup> of air that would be dangerous to human health.

(ii) When chlorine gas was absorbed by sodium thiosulphate found in the "hypo helment", chlorine was reduced to chloride while thiosulphate ions,  $S_2O_3^{2-}$  was oxidized to sulphate ions,  $SO_4^{2-}$ . Write a balanced equation for the reaction between chlorine and thiosulphate ions in an acidic medium.

[1]

(iii) Assuming that each treated "hypo helmet" effectively absorbed 500 cm<sup>3</sup> of chlorine gas during a battle at room temperature and pressure, and the production of each "hypo helmet" required 700 cm<sup>3</sup> of aqueous sodium thioshulphate, calculate the concentration in mol dm<sup>-3</sup> of sodium thiosulphate required.

[3] [Total: 10]

#### Section B: Free–Response Questions (40 Marks)

**5.** (a) (i) Sketch a graph of ionic radius against proton number for the Period 3 elements from sodium to chlorine. Explain the shape of your graph.

[3]

- (ii) When heated in oxygen, magnesium, aluminium and sulphur form oxides.(I) State the formulae of the oxides formed.
  - (II) By means of equations, indicate whether or not each of these oxides react with sodium hydroxide and hydrochloric acid.

[5]

(iii) Arrange the melting point of the oxides formed by magnesium, aluminium and sulphur in increasing order. Explain your answer.

[3]

(b) The kinetics of the reaction below can be followed via iodometric titrations.

$$IO_3^-(aq) + 6H^+(aq) + 5I^-(aq) \rightarrow 3I_2(aq) + 3H_2O(I)$$

The results are shown in the table below:

	Volume / cm <sup>3</sup>				Initial Rate /	
Expt.	lO₃⁻(aq)	l⁻(aq)	H⁺(aq)	H <sub>2</sub> O	Total	mol dm <sup>-3</sup> min <sup>-1</sup>
1	100	500	600	800	2000	1.0
2	50	250	600	100	1000	4.0
3	100	250	600	50	1000	8.0
4	50	125	600	225	1000	2.0

All solutions used are of concentration 1 mol dm<sup>-3</sup>.

(i) Use the above data to determine the order of reaction with respect to  $IO_3^-(aq)$ ,  $I^-(aq)$  and  $H^+(aq)$ . Hence write down the rate equation for the above reaction.

[4]

(ii) Why are the total volume of the solutions kept constant at 1000 cm<sup>3</sup> for experiments 2, 3 and 4 and how is this done in the experiments?

[2]

(iii) With the aid of a suitable diagram, explain how an increase in temperature will increase the rate of a chemical reaction.

[3] [Total: 20] 6. The ester, ethyl propanoate, can be synthesized from the reaction between acid **B** and alcohol **C** via the following equilibrium.

		acid <b>B</b> (I) + alcohol <b>C</b> (I) $\leftarrow$ ethyl propanoate (I) + water (I)	
(a)	Expl	ain what is meant by dynamic equilibrium.	[1]
(b)	Expl	ain how concentrated $H_2SO_4$ increases the yield of ethyl propanoate.	[2]
(c)	(i)	Write the $K_c$ expression for the above reaction.	[1]
	(ii)	When the reaction was carried out with equal concentrations of acid <b>B</b> a alcohol <b>C</b> at a fixed temperature and pressure, the equilibrium concentration ethyl propanoate was 0.4 mol dm <sup>-3</sup> . Given that the K <sub>c</sub> value is 3.5 under the conditions, calculate the equilibrium concentrations of <b>B</b> and <b>C</b> .	nd of se
	(iii)	Given that $K_c$ value for the reaction increases when temperature increase predict with a reason whether the forward reaction is exothermic endothermic.	es, or
(d)	(i)	Suggest the identities of <b>B</b> and <b>C</b> .	[2] [2]
	(ii)	When <b>C</b> was reacted with $PCI_5$ , white fumes are observed and Compound <b>D</b> produced. <b>D</b> then reacts with alcoholic KOH to give Compound <b>E</b> which decolourises aqueous bromine.	is
		Deduce the structures of Compounds <b>D</b> and <b>E</b> , explaining the chemistry of th reactions involved.	ie [4]
	(iii)	State the reagents and conditions needed for the conversion of <b>B</b> to propan $CH_3CH_2CHO$ in two steps.	al, [3]
(e)	(i)	A solution contains acid <b>B</b> and the sodium salt of acid <b>B</b> .	
		What is the type of solution formed called?	
	(ii)	Write equations to show what happens when a small amount of $H^+$ and $OH^-$ is added to two separate test-tubes containing the solution in <b>(e)(i)</b> . [Total: 2	is [3] 20]

**7.** (a) Sketch a graph of the first ionisation energies of the elements sodium to argon against proton number. Explain the shape of the graph that you have drawn, accounting for any anomalies.

[3]

- (b) When heated in chlorine, sodium, aluminium and phosphorus form chlorides.
  - (i) State the formulae of the chlorides formed by the three elements.

[1]

(ii) Describe the reactions, if any, of the chlorides with water, suggesting the pH of the resulting solutions and writing equations where appropriate.

[6]

- (c) A compound **F** has the following composition by mass: C: 51.9% H: 9.7% CI: 38.4%
  - (i) Given that the relative molecular mass of compound **F** is 92.5, find the molecular formula of compound **F**.

[2]

(ii) When compound F is treated with hot aqueous sodium hydroxide, Compound G is formed. G then reacts with aqueous alkaline iodine. G can be oxidized to H by hot acidified KMnO<sub>4</sub>. Give the structures of F, G and H. Explain the chemistry of the reactions involved with equations where appropriate.

[5]

(iii) If the halogen in compound **F** is changed to bromine, state and explain the difference in the rate of the reaction with hot aqueous sodium hydroxide. Explain your answer with relevant data from the *Data Booklet*.

[3] [Total: 20]

--- End of Paper ---