NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY
Paper 2 Structured

9647/02

Wednesday 3 Sept 2014

2 hours

Answer on the Question Paper.

Additional Materials: Data Booklet

READ THE INSTRUCTIONS FIRST	**For Examiner's Use**	
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. The number of marks is given in brackets [ ] at the end of each question or part question.	**1**	/12
	2	/16
	3	/16
	4	/17
	5	/11
	Total	/72

This document consists of **15** printed pages and **1** blank page.

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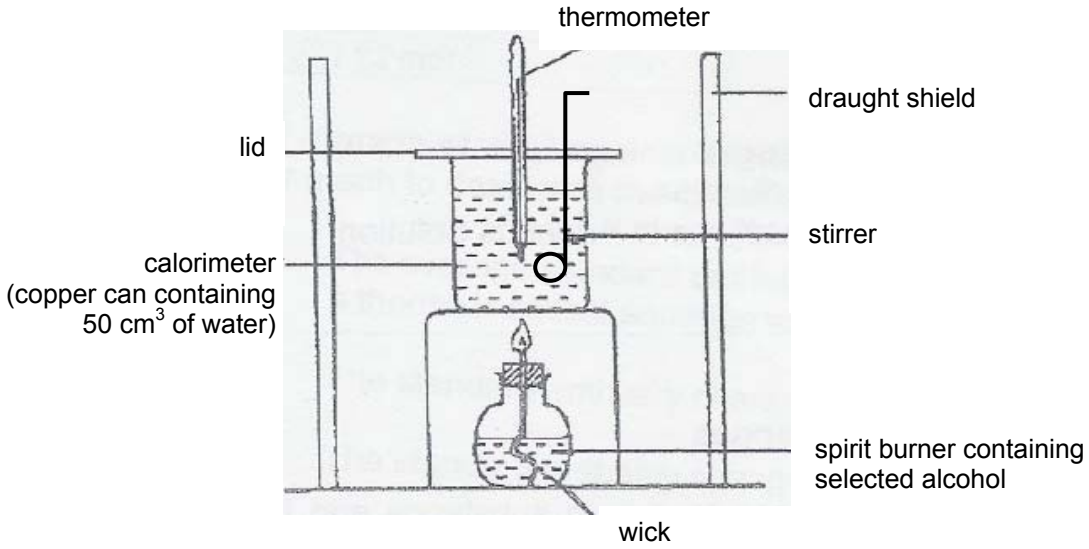
For Examiner's Use

For Examiner's Use

Answer **all** the questions.

1 Planning (P)

A student was provided with a spirit burner. He was asked to determine the enthalpy change of combustion under laboratory conditions, ΔH_c, for ethanol using the following setup.



Knowing that there could be significant heat loss arising from the above experimental setup, he decided to calibrate the calorimeter by burning 0.60 g of methanol (CH_3OH) to determine the calorimeter's heat capacity, $C_{calorimeter}$, which accounts for both the water and the copper can. Heat capacity is defined as the number of Joules of heat needed to raise the temperature of the calorimeter by one Kelvin or one degree Celsius. The temperature of the calorimeter rose from 25.0°C to 33.8°C.

The **same calorimeter** was then used to measure the enthalpy of combustion of ethanol.

(a) Given the enthalpy change of combustion of methanol is − 715 kJ mol^{-1}, use the information above to calculate the heat capacity of the calorimeter, $C_{calorimeter}$, stating its units.

[2]

For Examiner's Use

(b) Given the enthalpy change of combustion of ethanol is approximately −1370 kJ mol^{-1}, calculate the minimum mass of ethanol required to give the same temperature change as that in the calibration.

[2]

(c) Write a plan to determine the enthalpy change of combustion, ΔH_c, of ethanol that the student will carry out.

You may assume that you are provided with:

- a thermometer with divisions of 0.2 °C division;
- the apparatus normally found in a school or college laboratory.

Your plan should include details of

- the procedure to determine the enthalpy change of combustion of ethanol;
- the readings recorded using appropriate table(s), including units;
- precautions taken to ensure reliability of the experiment
- an outline of how the results would be used to determine the enthalpy change of combustion of ethanol based on the plan that you have written using arbitrary values.

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(d) Identify **one** potential safety hazard in this experiment and state how you would minimise this risk.

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.....[1]

[Total: 12]

For Examiner's Use

2 The simplest chemical reactions are those that occur in the gas phase in a single step, such as the transfer of a chlorine atom from C*l*NO_2 to NO.

$$C\mathit{l}NO_2(g) + NO(g) \rightleftharpoons NO_2(g) + C\mathit{l}NO(g)$$

(a) **(i)** An equimolar mixture of C*l*NO_2(g) and NO(g), at a total initial pressure of 3 atm, was allowed to react in a closed vessel at 1000 K. When equilibrium was attained at the 5th minute, the partial pressure of C*l*NO_2 was found to be 0.57 atm.

Calculate the value for the equilibrium constant, K_p , of this system.

(ii) At the 10th minute, more C*l*NO_2 gas was pumped into the vessel at 1000 K, increasing the partial pressure of C*l*NO_2 to 1 atm.
Suggest how the position of the equilibrium would change.

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(iii) Hence illustrate clearly, in the pressure–time graph below, the changes in the partial pressures of C*l*NO_2 and NO_2 when

(I) the above gaseous system first reached equilibrium at the 5th minute,

(II) more C*l*NO_2 gas was added into the vessel at the 10th minute and a new equilibrium was attained at the 15th minute.

(iv) Suggest whether the addition of an inert gas into the vessel would affect the position of the equilibrium.

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[7]

(b) C*l*NO_2 can behave as an *ideal gas* under certain experimental conditions.

(i) State the two assumptions of kinetic theory of ideal gas.

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(ii) Predict whether C*l*NO_2 behaves ideally under high pressure.

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[4]

(c) **(i)** Draw the dot-and-cross diagrams of NO and C*l*NO. Suggest the shape and bond angle of C*l*NO.

(ii) Hence, suggest why the formation of C*l*NO from NO is favoured.

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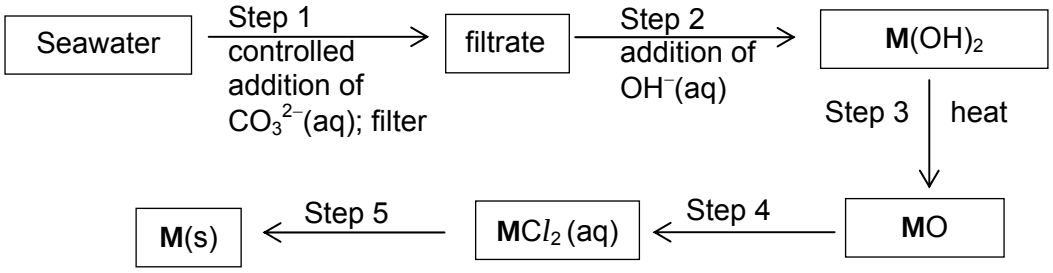
[5]

[Total:16]

3 The four most abundant salts in sea water are given in the table below.

salt	kg m^{-3}
Sodium chloride	27.5
Magnesium chloride	6.75
Magnesium sulfate	5.63
Calcium sulfate	1.80

The following flow scheme shows the series of reactions that involve seawater.



(a) Seawater contains chloride and sulfate ions. To verify the presence of chloride and sulfate ions instead of bromide and sulfite ions in sea water, the following chemicals can be used:

HNO_3(aq), $AgNO_3$(aq), $BaCl_2$(aq), NH_3(aq)

(i) Explain the importance of adding HNO_3(aq) before other chemicals during this verification process.

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(ii) Suggest a sequence of chemical tests that can be used to verify the presence of chloride and sulfate ions in sea water after acidification.

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[3]

(b) **(i)** Calculate the concentration of magnesium and calcium ions in 1 dm^3 of seawater.

(ii) Write an expression for the solubility product of magnesium carbonate.

(iii) Determine the range of concentrations of $CO_3^{2-}(aq)$ required to cause selective precipitation of only one cation in seawater given the following data.

compound	solubility product
Magnesium carbonate	1.0×10^{-5}
Calcium carbonate	5.0×10^{-9}

(iv) Hence deduce the identity of **M** in the above flow scheme.

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[6]

For Examiner's Use

(c) **(i)** Write an equation with state symbols for Step 3 using **M** to represent your cation.

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(ii) Suggest and explain why magnesium hydroxide has a lower thermal stability than calcium hydroxide.

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[3]

(d) **(i)** If the mass of **M**O isolated in Step 3 is 0.05 g, calculate the volume of 0.1 mol dm^{-3} of HC*l* required to convert all **M**O to **M**Cl_2.

(ii) Suggest how Step 5 can be carried out.

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[4]

[Total: 16]

4 Methanol is the simplest alcohol, and is a volatile, colourless and flammable liquid. Methanol is mainly used as an antifreeze, solvent or fuel.

(a) Define the *standard enthalpy change of combustion of methanol* in words.

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[1]

(b) **(i)** Using appropriate data from the *Data Booklet*, calculate the ΔH_r of the following reaction.

$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l) \qquad \Delta H_r$$

(ii) Hence determine the standard enthalpy change of combustion of methanol.

[3]

(c) The theoretical standard enthalpy change of combustion of methanol is −715 kJ mol^{-1}. Give two reasons to explain the discrepancy between this value and your answer in **(b)(ii)**.

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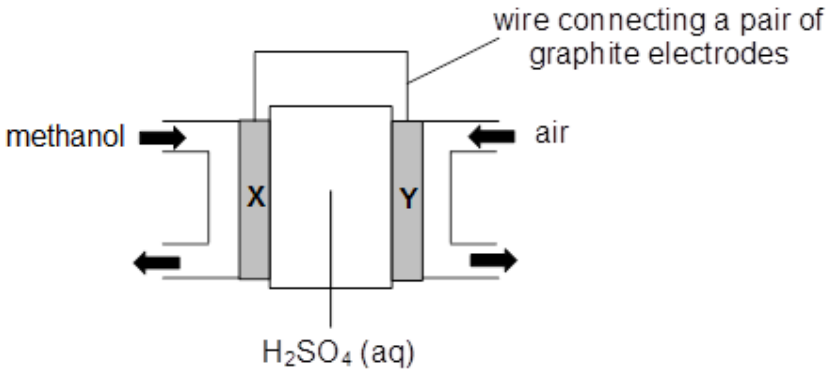
[2]

For Examiner's Use

(d) Other than direct burning of methanol to generate energy, methanol can also be used in a fuel cell. Methanol fuel cells are *more practical* than hydrogen fuel cells. Carbon dioxide and water are the products of the methanol fuel cell.



(i) For each electrode **X** and **Y**, name the type of electrode and state its polarity.

Electrode **X**
Type of electrode: .....

Polarity: .....

Electrode **Y**
Type of electrode: .....

Polarity: .....

(ii) On the diagram above, indicate the direction of electron flow in the wire with an arrow.

(iii) Write the half-equation of the reaction taking place at each electrode.

X: .....

Y: .....

(iv) Explain why methanol fuel cells are *more practical* than hydrogen fuel cells.

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(v) Use appropriate data from the *Data Booklet* to explain why an acidic electrolyte is often preferred to an alkaline or neutral electrolyte.

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[8]

(e) In a laboratory, methanol can also be oxidised to other organic compounds using suitable chemicals.

Give the appropriate reagents and conditions required for the following conversion.

I: Methanol → Methanal

Reagents and conditions: **……..**

II: Methanol → Methanoic acid

Reagents and conditions: **……..**

III: Methanol → Carbon dioxide

Reagents and conditions: **……..**

[3]

[Total:17]

For Examiner's Use

5 Lactic acid is a carboxylic acid with the formula $CH_3CH(OH)CO_2H$.

(a) State the type of stereoisomerism exhibited by lactic acid. Draw appropriate structures to illustrate your answer.

[2]

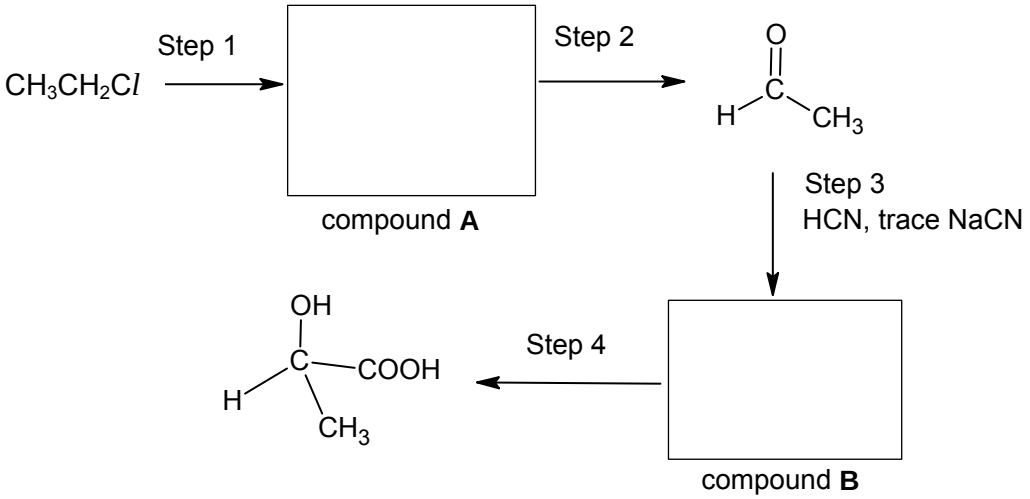
(b) In solution, lactic acid can lose a proton from the carboxyl group, producing the lactate ion $CH_3CH(OH)CO_2^-$. Compared to ethanoic acid, lactic acid is more acidic as it deprotonates ten times more easily than ethanoic acid.

Other than the electron withdrawing effect of –OH group, suggest **another** factor which explains the additional stability of the lactate ion. Illustrate your answer with a diagram.

[2]

(c) A student tries to synthesise lactic acid from chloroethane using a series of reactions as shown.

(i) Fill in the intermediate organic compounds **A** and **B** in the following flow scheme.



(ii) State the reagents and conditions for Step 1.

Reagents and conditions: **……**

(iii) State the type of reaction for Step 4 and write a balanced equation for this step.

Type of reaction: **……**

Balanced equation: **……**

(iv) Lactic acid formed in the above flow scheme is a racemic mixture while lactic acid formed via bacteria fermentation contains only one optical isomer. Explain.

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[7]

[Total: 11]