NATIONAL JUNIOR COLLEGE

SH2 PRELIMINARY EXAMINATION

Higher 1

H

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

CHEMISTRY 8872/02

Paper 2

Wednesday 3 Sept 2014

Candidates answer Section A on the Question Paper
Additional Materials: Answer Paper
Data Booklet

2 hours

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.

Section **A**
Answers **all** questions.

Section **B**
Answer **two** questions on separate answer paper.

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

For Examiner's Use	
A1	
A2	
A3	
A4	
B5	
B6	
B7	
Total	

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

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For Examiner's Use

Section A

For Examiner's Use

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

1 **(a)** The element sulfur has four naturally occurring isotopes, ^{32}S, ^{33}S, ^{34}S and ^{36}S. Their natural abundance are shown in the table below.

Isotope	Percentage abundance (%)
^{32}S	95.02
^{33}S	
^{34}S	
^{36}S	0.02

Use the above data to calculate the individual percentage abundance of ^{33}S and ^{34}S given that A_r of S is 32.093.

[2]

(b) 0.05 mol of solid sulfur is burned in excess oxygen in a calorimeter to form SO_2 gas. The heat produced is used to heat up 815 cm^3 of water with an initial temperature of 28 °C. Given the enthalpy change of combustion of sulfur, $\Delta H_C^{\theta}(S)$, is −297 kJ mol^{-1}, calculate the final temperature of the water.

[3]

(c) The given diagram shows the results obtained when beams of deuterium and ^{1}H nuclei are passed between two plates carrying a certain electric charge. [Deuterium= ^{2}H]

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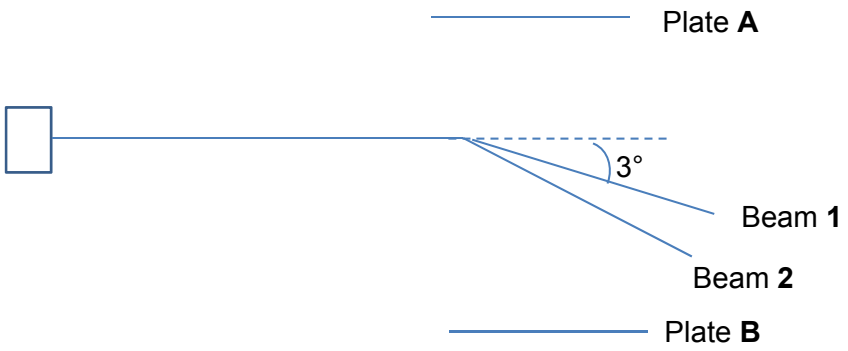

(i) What is the polarity of plate **B**? Explain your answer.

……

……

(ii) Explain whether Beam **1** or Beam **2** belongs to the nuclei of deuterium.

……

……

(iii) On the diagram above, draw Beam **3**, the beam expected when the nuclei of tritium is passed between the two plates. Label the angle of deflection clearly. [tritium = ^{3}H]

[5]

[Total:10]

2 A sequence of reactions, starting from compound **A**, is shown below.

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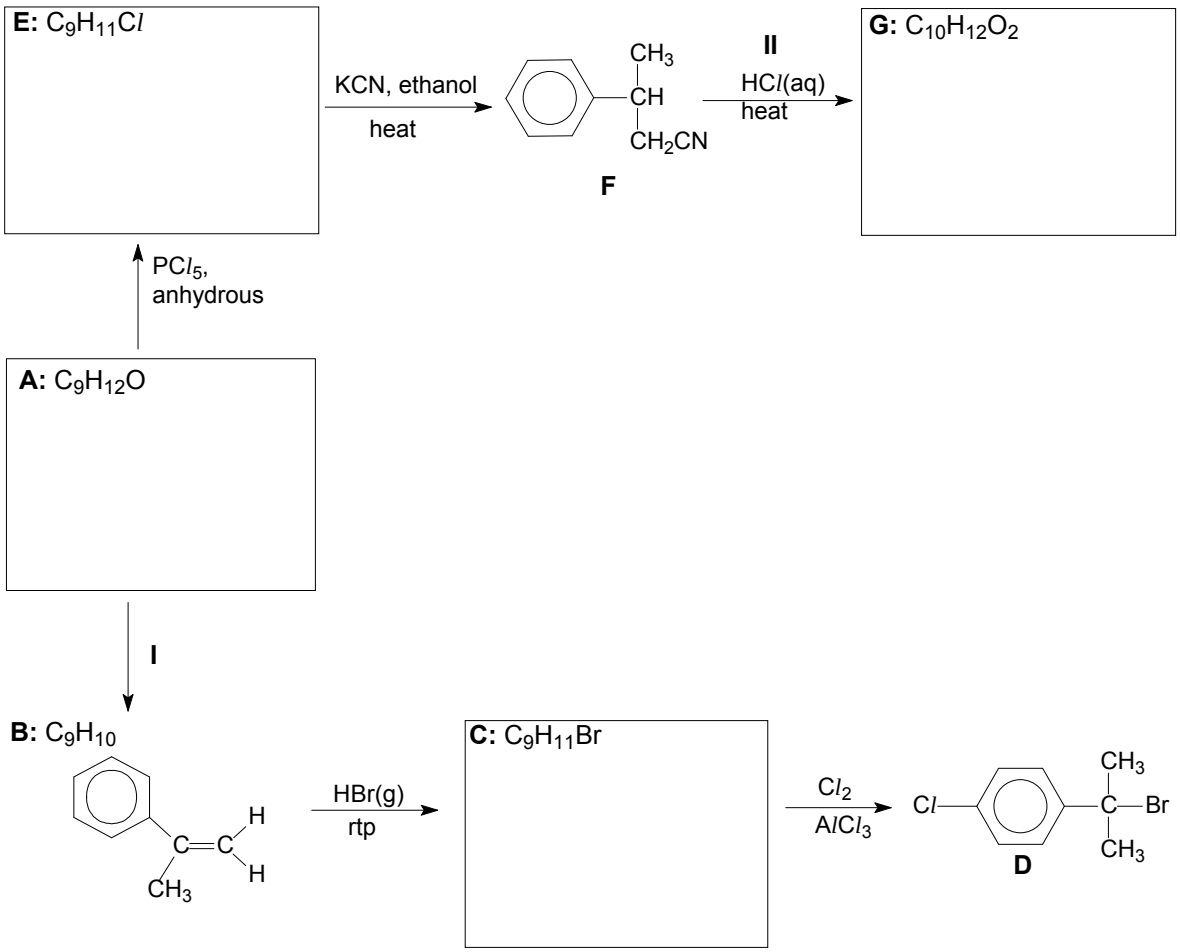

(a) In the appropriate boxes, draw the structures of compounds **A**, **C**, **E** and **G**.

[4]

(b) For the reactions in the scheme shown above, state

- the reagents and conditions for reaction **I**,

.....

- the type of reaction in reaction **II**.

.....

[2]

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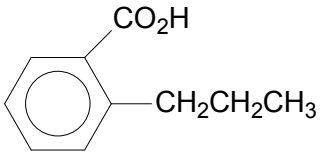
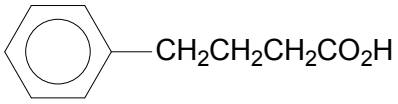
(c) Two isomers of compound **G** are shown below.



Compound **H**



Compound **J**

Explain why the pK_a of compound **H** is lower than that of compound **J**.

.....

.....

.....

[2]

[Total:8]

3 **(a)** *Use of the Data Booklet is relevant to this question.*

Explain, in terms of structure and bonding,

(i) the difference in melting point between MgO and Na_2O.

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.....

.....

(ii) the difference in melting point between Mg and Ba.

.....

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.....

.....

[4]

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(b) Element **M** belongs to Period 3 of the Periodic Table and exhibits the following properties.

Melting point: 190 °C
Boiling point: 420 °C
pH of aqueous solution is less than 7.

0.0025 mol of the chloride of **M**, **M**Cl_n is added to water and this aqueous solution requires 25.00 cm^3 of 0.300 mol dm^{-3} silver nitrate for complete precipitation of chloride ions.

(i) Calculate the amount of chloride ions released from one mole of **M**Cl_n .

(iii) The relative molecular mass of **M**Cl_n is 267 when it is dissolved in benzene. Identify **M** and draw a *displayed formula* for the chloride of **M**.

[4]

[Total: 8]

4 Fireworks were invented in ancient China in the 12th century to scare away evil spirits. It was then considered as one of ancient China's finest inventions. Today, fireworks are still extensively used for the purpose of entertainment and in celebration to mark special occasions. The thrill and excitement generated by fireworks as they brighten up the night sky up makes them a crowd-pleaser.

An important compound used in fireworks is the oxidisers, which supply the oxygen required to burn the mixture. Two common oxidisers are nitrate and perchlorate.

(a) Nitrate is known to lose $\frac{1}{3}$ of its oxygen during thermal decomposition to give a salt and oxygen as the only products.

Using potassium nitrate as an example, write an equation to illustrate the above reaction.

.....

[1]

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(b) Perchlorate has the formula ClO_4^-. Unlike nitrate, perchlorate gives up **all** of its oxygen during thermal decomposition to give a salt and oxygen as the only products, causing a more spectacular reaction.

(i) Using potassium perchlorate as an example, write an equation to illustrate this above reaction.

.....

(ii) Draw dot-and-cross diagrams to show the bonding in $KClO_4$ and KNO_3, showing the outermost shell electrons only.

	Dot-and-cross diagram
ClO_4^-	
KNO_3	

[3]

(c) Besides the oxidisers, reducing agents such as sulfur are also important components in fireworks. They burn in oxygen produced by the oxidisers to produce hot gases, and generate high pressure which is required to propel the fireworks into the sky. The required pressure can be determined by applying the ideal gas equation shown below:

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$$PV = nRT$$

where P = pressure (in Pascal),
V = volume (in m^3)
n = amount of gas
R = 8.31 J K^{-1} mol^{-1}
T = temperature (in Kelvin)

The minimum pressure required to propel the fireworks into the sky is 5.00×10^8 Pascal (Pa).

(i) Determine whether the rocket will be propelled into the sky when 0.200 mol of O_2 is heated to 150 °C in a 1 cm^3 tube.

(ii) A sample **Z** contains 85% by mass of potassium perchlorate.
Use your answers from **b(i)** to calculate the mass of sample **Z** necessary to provide 0.200 mol of O_2 used in **c(i)**.

[5]

(d) In fireworks, sulfur also reacts with nitrate to produce sulfur dioxide and nitrogen monoxide via a redox reaction.

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(i) Use oxidation numbers to show which species is reduced and which is oxidised in the above reaction.

(ii) Hence, write a balanced ionic equation for the reaction between sulfur and nitrate in an acidic medium.

.....

(iii) The reaction did not take place at room temperature. However, when the student heated up the reaction mixture, the gases were evolved more readily.

Explain with an aid of an appropriate diagram how higher temperatures affect the rate of reaction.

.....

.....

.....

[5]

[Total:14]

Section B

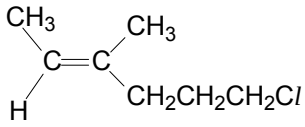
Answer **two** questions from this section on separate paper.

5 **(a)** Sodium, aluminium and phosphorous can react with chlorine to form chlorides.

State the pH of the solutions formed when the chlorides are dissolved in water. Write equations to explain pH of the solutions formed.

[4]

(b) An organic compound **P** with formula, $C_7H_{13}Cl$, was reacted with aqueous NaOH under suitable conditions. The solution was acidified and aqueous silver nitrate is then added to test for the presence of a functional group. A white precipitate was formed after a few minutes.



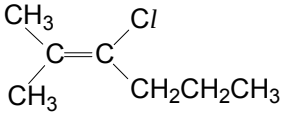
Compound **P**

(i) State the type of reaction occurring when compound **P** was reacted with aqueous NaOH.

(ii) Hence, write a balanced equation for the reaction in **b(i)**.

(iii) Suggest the identity of the white precipitate.

(iv) Suggest a chemical test to verify for the presence of the *other* functional group present in compound **P.**

(v) The above procedure was carried out with compound **Q**, with the formula  . However, no precipitate was observed after a long time.

Explain why no precipitate was formed for compound **Q**.

[6]

(c) Compound **P** can also react with a suitable reagent under certain conditions to form compound **R,** with the condensed formula $CH_3CH{=}C(CH_3)CH_2CH{=}CH_2$.

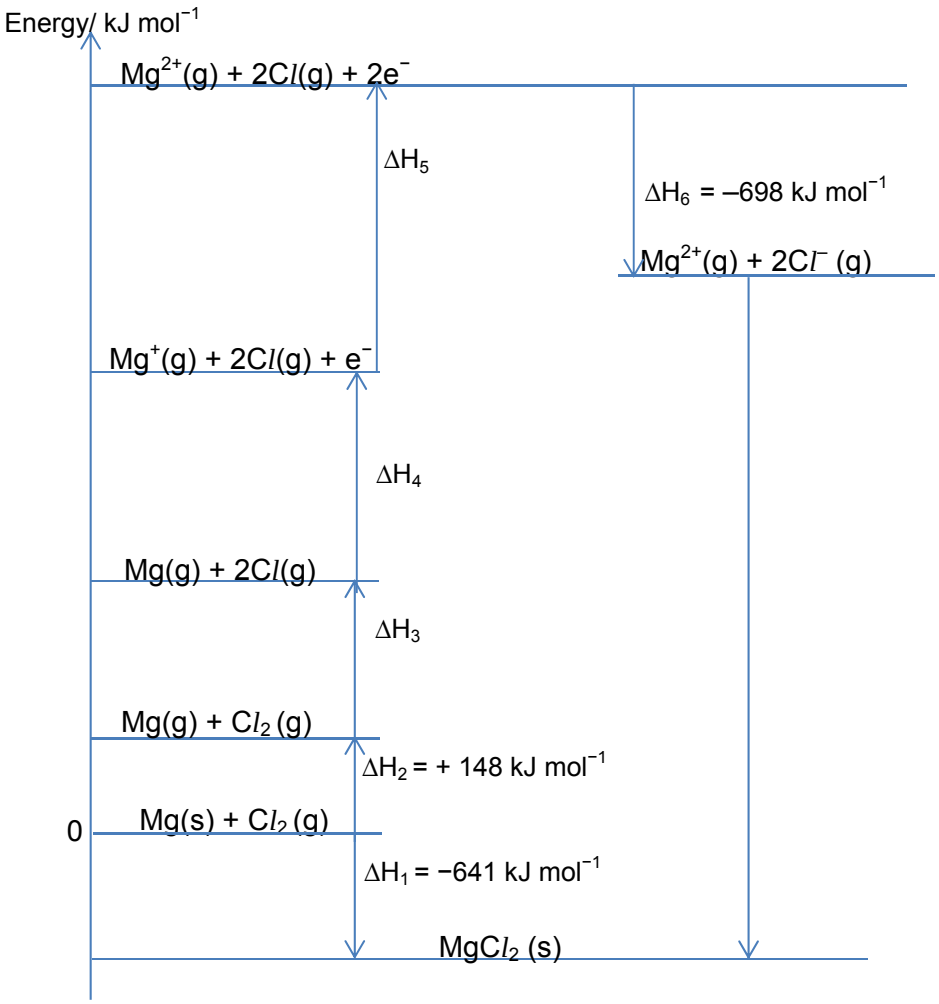
(i) State the type of reaction occurring.

(ii) Suggest the reagents and conditions used.

(iii) Draw and label the geometric isomers of compound **R**.

[3]

5 **(d)** *Use of the Data Booklet is relevant to this question.*
The energy level diagram of magnesium chloride can be constructed to determine its lattice energy.



(i) State the name of the standard enthalpy change represented by ΔH_1.

(ii) Explain how ΔH_6 would vary if chloride ion is replaced by iodide ion.

(iii) State the values of ΔH_3, ΔH_4 and ΔH_5.

(iv) Making use of the values in the energy level diagram and your answer in **d(iii)**, calculate the lattice energy of $MgCl_2$.

(v) The literature value of lattice energy of $MgCl_2$ is –2326 kJ mol^{-1}, which deviates from that calculated in **d(iv)**. Explain why is it so.

(vi) Hence, explain if the deviation between the literature value of lattice energy of MgI_2 and its value determined experimentally will be *greater*, *the same* or *smaller*.

[7]

[Total: 20]

6 Propanone, $(CH_3)_2CO$ also known as acetone, is used as an active ingredient in nail polish remover. It is also widely used as an important industrial solvent. Larger ketones such as octanone, $CH_3CO(CH_2)_5CH_3$ cannot be used for the same purpose as they are insoluble in water.

(a) **(i)** Describe, in terms of orbital overlap, the bonding of the the carbon and oxygen atom of the C=O bond in propanone. A clearly labelled diagram may clarify your answer.

(ii) Account for the difference in solubility of propanone and octanone in water.

[6]

(b) Cyanohydrins can be made by reacting propanone with an acidified solution of sodium cyanide.

$$(CH_3)_2C{=}O + H^+ + CN^- \longrightarrow (CH_3)_2C(OH)CN$$

In a series of experiments, the reaction was carried out with different concentrations of the three reagents, and the following relative initial rates were obtained.

Experiment No	$[(CH_3)_2CO]$ /mol dm^{-3}	$[H^+]$ /mol dm^{-3}	$[CN^-]$ /mol dm^{-3}	relative initial rate / mol dm^{-3} s^{-1}
1	0.020	0.050	0.060	1.000
2	0.015	0.100	0.030	0.375
3	0.020	0.050	0.050	0.833
4	0.020	0.025	0.060	1.000

(i) Use the data in the table to deduce the order of reaction with respect to propanone, hydrogen ions and cyanide ions.
Hence, write a rate equation for the reaction.

(ii) Calculate a value for the rate constant, including units.

(iii) Sketch a graph of $[(CH_3)_2C{=}O]$ against time for this reaction, assuming $[H^+]$ and $[CN^-]$ are present in large excess.

(iv) Sketch a graph of rate against $[H^+]$ for this reaction, assuming $[(CH_3)_2C{=}O]$ and $[CN^-]$ are present in large excess.

[8]

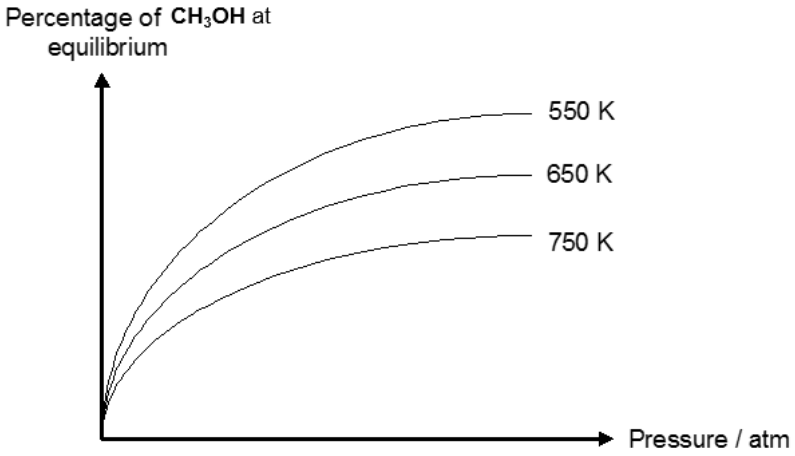
(c) Methanol, CH_3OH, is a liquid fuel. It is widely preferred over hydrogen to be used as fuel.
Methanol can be synthesised from methane and steam through a process that occurs in two stages.

Stage 1 : $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\quad \Delta H_1 = +206$ kJ mol^{-1}
Stage 2 : $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\quad \Delta H_2$

(i) Suggest **one** advantage of using methanol instead of hydrogen gas as fuel.

(ii) Draw and label the energy profile diagram for ***Stage 1***.

6 **(c)** **(iii)** The following graph shows the effect of temperature and pressure on the percentage of methanol at equilibrium in ***Stage 2.***



Deduce whether the reaction in **Stage 2** is endothermic or exothermic. Explain your answer.

[6]

[Total: 20]

7 This question is about nitrogen-containing compounds.

Methylamine, CH_3NH_2, is a weak base used in the synthesis of a wide range of agricultural chemicals such as herbicides and insecticides.

(a) **(i)** The pH of an aqueous solution of methylamine is 10.5.
Calculate the molar concentration of hydroxide ions, $[OH^-]$, in the solution.

(ii) In a titration reaction, 25.0 cm^3 of the aqueous solution of methylamine in **(i)** was found to react completely with 22.75 cm^3 of 0.20 mol dm^{-3} HC*l*(aq).
Calculate the concentration of methylamine solution.

(iii) With reference to your results in **(a)(i)** and **(a)(ii),** explain why CH_3NH_2 is a weak base.

(iv) Which of the indicators from the table below could you use for this titration? Explain your answer.

Indicator	pH range of colour change
Bromocresol green	3.8 – 5.4
Phenol red	6.8 – 8.4
Phenolphthalein	8.2 – 10.0

[7]

(b) **(i)** Suggest a suitable compound that can be added to a solution of methylamine to make the resulting mixture a *buffer solution*.

(ii) Explain, with the aid of equations, how the *buffer solution* which you suggested in **(b)(i)** works.

[3]

7 **(c)** When methylamine vapour is burned in an excess of oxygen, the following reaction occurs.

$$CH_3NH_2(g) + \frac{13}{4}O_2(g) \longrightarrow CO_2(g) + NO_2(g) + \frac{5}{2}H_2O(l) \qquad \Delta H_c(CH_3NH_2)$$

Compound	ΔH_f / kJ mol mol^{-1}
CH_3NH_2	−23.0
CO_2	−93.6
H_2O	−241.9
NO_2	+33.0

(i) Calculate the enthalpy change of combustion of methylamine.

(ii) A student proposed to calculate the enthalpy change of combustion of methylamine by using bond energies values from the *Data Booklet*.

Other than bond energies being average values, suggest why this calculated value is less accurate than that in **c(i)**.

[3]

(d) Nitrogen monoxide, NO, can be formed when nitrosyl chloride, NO*Cl*, dissociates according to the following equation.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

The value of the equilibrium constant, K_c, is 1.50 at 500 K.

When a certain amount of $NOCl_2$ is placed in a vessel and allowed to reach *dynamic equilibrium*, the concentration of Cl_2 is found to be 0.30 mol dm^{-3} when equilibrium is reached.

(i) Define the term *dynamic equilibrium.*

(ii) Write the expression for the equilibrium constant, K_c, for the dissociation of NO*Cl*, including units.

(iii) State the equilibrium concentration of NO.

(iv) Using your answer in **(d)(ii)** and **(iii)**, calculate the equilibrium concentration of NO*Cl*.

(v) Explain how the value of K_c will change when the pressure of the system is halved at constant temperature.

[7]

[Total: 20]

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