H

NATIONAL JUNIOR COLLEGE
SH2 PRELIMINARY EXAMINATIONS
Higher 1

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

CHEMISTRY 8872/02

Paper 2 Structured Questions

Wednesday 24 August 2016
2 hours

Candidates answer Section A on the Question Paper.

Additional Materials: Answer Paper, Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid/tape.

Section A
Answers **all** the questions.

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

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
A1	/10
A2	/10
A3	/11
A4	/9
B5	/20
B6	/20
B7	/20
Total	/80

This document consists of **15** printed pages.

Section A

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

1 "Lethal Dose", LD, is a means of measuring toxicity. LD_{50} is the amount of a material which causes the death of 50% of a group of test animals. Its value is expressed as the mass of a chemical administered per kg body mass of a test animal.

"Lethal Concentration", LC, is another means of measuring toxicity. The value of LC_{50} is the concentration of a chemical in air that kills 50% of the test animals during the observation period.

The table below shows the values for the LD_{50} and LC_{50} along with the toxicity ratings.

Toxicity Rating	Commonly used term	LD_{50}: Oral (mg kg^{-1})	LC_{50}: Inhalation (ppm)
1	Extremely Toxic	1 or less	10 or less
2	Highly Toxic	1 – 50	10 – 100
3	Moderately Toxic	50 – 500	100 – 1000
4	Slightly Toxic	500 – 5000	1000 – 10,000
5	Practically Non-toxic	5000 – 15,000	10,000 – 100,000
6	Relatively Harmless	15,000 or more	100,000 >

(a) 1 mol of an organic toxic compound with a volume of 157.7 cm^3 was used for testing. The density of the compound was given as 1.23 g cm^{-3}.

(i) Determine the M_r of the compound. [1]

(ii) The composition of the organic compound was found to be 49.5% C, 5.15% H, 16.5% O and 28.85% N by mass.

Determine the empirical formula and hence the molecular formula of the compound. [2]

(iii) 9.90×10^{-4} mol of the compound was found to cause death in 50% of the test animals weighing 1 kg.

Calculate the LD_{50} of the compound and state its toxicity rating. [2]

(b) Phosphine, PH_3, is a gas that is widely used in the semi-conductor industry as a dopant and as a precursor for the deposition of compound semiconductors.

For safety reasons, the permissible limits of phosphine must not exceed $\frac{1}{10}$ of its LC_{50} value.

When expressing the concentration of a small quantity of gas, parts per million (ppm) can be used. Ppm is usually used for volume of gases and is expressed as shown in the equation below:

$$\text{Concentration of gas (in ppm)} = \frac{\text{volume of gas}}{\text{volume of air}} \times 10^6$$

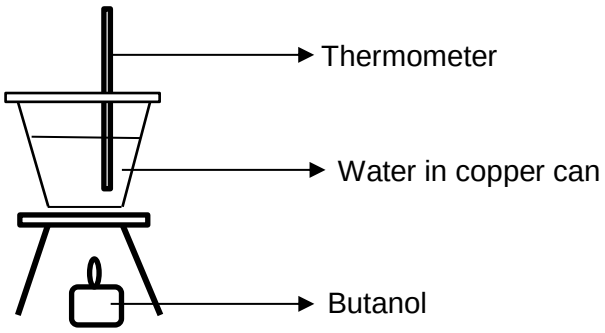
(i) Given that the LC_{50} for phosphine is 55 mg m^{-3} at room temperature, convert the LC_{50} to ppm and determine its toxicity rating. [3]

(ii) A semiconductor factory releases 36 g of phosphine in a day.

Using your value in **(i)**, determine the minimum volume of the factory that will allow the volume of phosphine to be within permissible limits at room temperature. [2]

[Total:10]

2 **(a)** Butanol was burnt in a spirit burner under a copper can of water as shown in the diagram.



The experimental results obtained are shown below.

mass of water	= 200 g
original temperature of water	= 29.4 ^{o}C
final temperature of water	= 36.9 ^{o}C
original mass of burner + butanol	= 50.64 g
final mass of burner + butanol	= 50.44 g

(i) Calculate the enthalpy change of combustion, $\Delta H_{C,}$ for butanol.

Ignore the heat capacity of the copper can and use the figure of 4.18 J g^{-1} K^{-1} for the specific heat capacity of water. [3]

(ii) Explain why the value of the ΔH_C obtained in **(i)** differs from the true value of −2676 kJ mol^{-1} and suggest an improvement to the set-up. [2]

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……

……

(iii) Write the equation that represents the combustion of butanol. [1]

……

(iv) Using bond energy data from the *Data Booklet*, calculate another value for the enthalpy change of combustion for butanol. Show your workings clearly. [2]

(b) The table below shows the solubility of some alcohols.

Alcohol	Butanol	Pentanol	Hexanol	Heptanol
Solubility/ g per 100 g of water	0.11	0.030	0.0058	0.0008

Explain why the solubility of alcohols decreases as the number of carbons increases. [2]

……

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……

……

[Total:10]

3 Sodium carbonate, Na_2CO_3, is the water-soluble sodium salt of carbonic acid, H_2CO_3. Sodium carbonate is a food additive used as an acidity regulator, anticaking agent, raising agent and stabiliser. It is one of the components of *kansui*, a solution of alkaline salts used to give ramen noodles their characteristic flavour and texture.

A number of equilibria exist within a solution of *Kansui*.

I $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$

II $HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$

III $HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

(a) (i) Write the K_c expression for equilibrium **I** and state its units. [1]

(ii) K_c for equilibrium **I** has a numerical value of 2.5×10^{-6}.

Calculate the concentration of $OH^-(aq)$ ions in this equilibrium when the concentration of CO_3^{2-} is 0.45 mol dm^{-3}. [2]

(iii) Use the value calculated in **(ii)** to calculate the pH of *Kansui*. [1]

(iv) Hence, suggest and explain whether sodium carbonate is a strong base or weak base given that the initial concentration of sodium carbonate is 0.100 mol dm^{-3}.

……

……

……

[2]

(b) If the container containing *Kansui* in equilibrium is heated, the pH of the solution will increase.

Use the information above to deduce whether equilibrium **II** is exothermic or endothermic, explaining your answer.

……

……

……

……

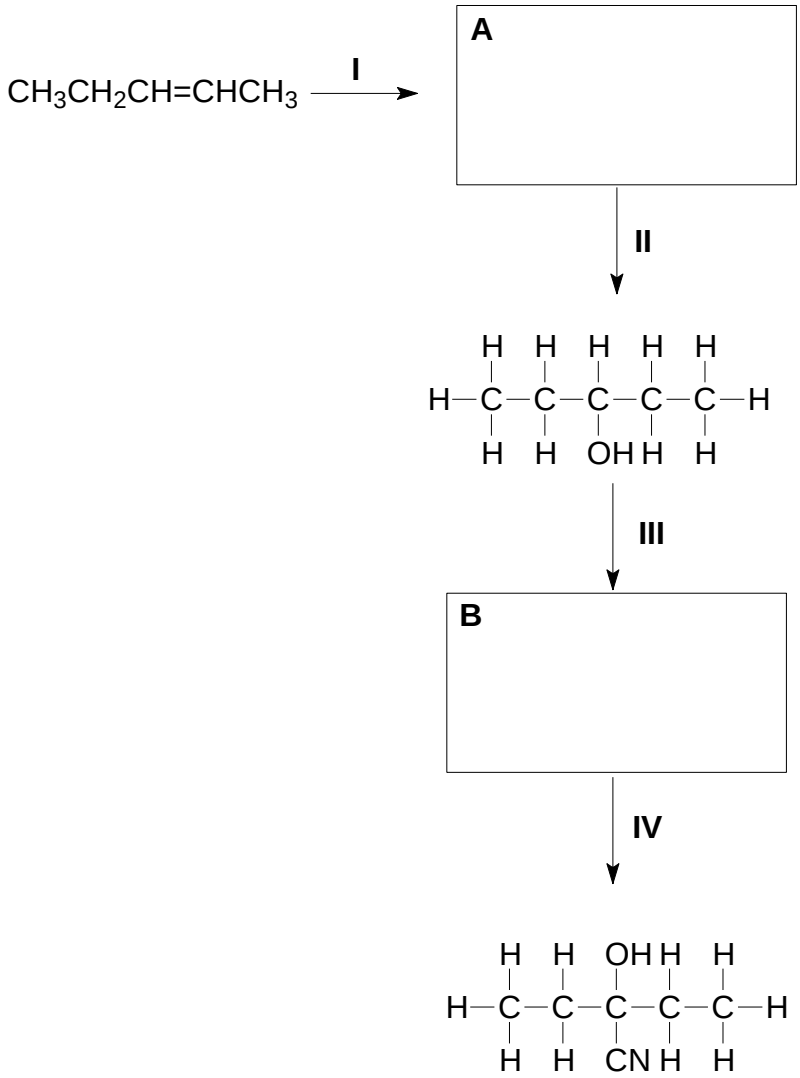
[2]

(c) In order to increase the rate of reaction, a catalyst can be added.

Explain in detail how a catalyst works. Draw an energy distribution diagram to illustrate your answer.

[3]
[Total:11]

4 A sequence of reactions starting from pent-2-ene, is shown below.



(a) In the appropriate boxes, draw the structures of compounds **A** and **B**. [2]

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

- the type of reaction in reaction **I**,

  ……

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

  ……

- the reagent and conditions for reaction **IV**.

  ……

[3]

(c) Pent-2-ene has geometrical isomers.

Draw the structural formulae of **each** of the two isomers so as to identify this isomerism and label each structure.

[2]

(d) Reaction **I** produced an isomer of **A.**

Draw the structural formula of the isomer and state the type of isomerism exhibited.

[2]

[Total:9]

Section B

Answer **two** questions of the three questions in this section on separate paper.

5(a) Propanone reacts with iodine in an aqueous solution of sulfuric acid as shown below.

$$CH_3COCH_3\ (aq) + I_2\ (aq) \rightarrow CH_2ICOCH_3\ (aq) + H^+\ (aq) + I^-\ (aq)$$

The rate of this reaction was investigated by withdrawing samples from the reaction mixture, *'quenching'* by adding the sample to a large volume of ice-cold water, then measuring the amount of iodine in the sample by a reaction which turned the solution colourless.

(i) Why is it necessary to *quench* the sample before measuring the amount of iodine? [1]

Four separate experiments were carried out to determine the initial rates of reaction and the results obtained are given in the table below.

Expt	Volume of CH_3COCH_3 / cm^3	Volume of 1 mol dm^{-3} H_2SO_4 /cm^3	Volume of 0.01 mol dm^{-3} I_2 /cm^3	Volume of H_2O /cm^3	Time taken for solution to turn colourless /s
1	20	10	10	150	8
2	10	10	10	160	16
3	20	5	10	155	16
4	20	5	5	160	8

(ii) Why is it necessary to vary the volume of water in each experiment? [1]

(iii) What is the relationship between the time taken for the solution to turn colourless and the rate of reaction? [1]

(iv) Deduce the orders of reaction with respect to propanone, sulfuric acid and iodine. Hence, write the overall rate equation for this reaction. [3]

(b) A student was given two containers without labels and told that they contained pure samples of **two** of the following three compounds.

- Propanone, CH_3COCH_3
- 2-iodopropanone, CH_2ICOCH_3
- Propene, $CH_2=CHCH_3$

(i) Describe **one** test that could show that the samples contained propanone and 2-iodopropanone and not propene. [2]

(ii) Describe **one** test that could distinguish between propanone and 2-iodopropanone. [2]

(iii) Describe **three** tests that could identify propene. [6]

In each case, you should say what reagents and conditions you would use and what observations you would make.

(c) Suggest how propanone could be prepared from propene in not more than **three** steps. [4]

[Total:20]

6 **(a)** Compound **P** has molecular formula, C_4H_6O. Reaction of **P** with hot acidified potassium manganate(VII) produces compound **Q**, $C_3H_4O_3$, and effervescence is observed. The gas gives a white precipitate when passed through $Ca(OH)_2$(aq).

One mol of **Q** requires one mol of KOH(aq) for complete neutralisation. Both **P** and **Q** give a yellow precipitate when warmed with alkaline aqueous iodine.

P decolourises bromine in CCl_4 to form compound **R**, $C_4H_6OBr_2$. Both **P** and **R** give a orange precipitate with 2,4-dinitrophenylhydrazine.

Deduce a possible structure for each of the compounds **P** to **R** and explain the chemistry of the reactions described.

[8]

(b) Hydrochloric acid can be formed from the reaction between hydrogen gas and chlorine gas.

$$H_2\,(g) + Cl_2\,(g) \rightleftharpoons 2\,HCl\,(g) \qquad \Delta H_r = -182\ kJ\ mol^{-1}$$

(i) A mixture at equilibrium was found to contain 0.1 mol of H_2, 0.1 mol of Cl_2 and 0.2 mol of HCl in a 2 dm^3 vessel.

Determine the K_c for the reaction. [2]

(ii) State and explain how the equilibrium position is affected if the pressure of the equilibrium mixture from **(i)** is increased. [2]

(iii) Suggest and explain how the yield of HCl can be increased without adding or removing any reagents. [2]

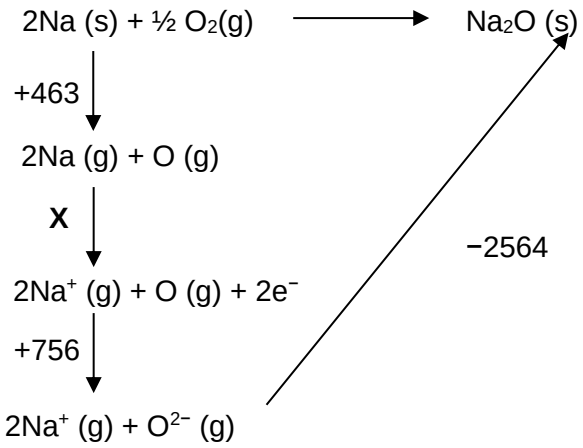
(c) Elements **S**, **T** and **U** are in Period 3.
Chlorides of **S** and **T** dissolve in water to form an acidic solution (pH ≈ 3) and a neutral solution (pH = 7) respectively. The oxide of element **U** is insoluble in water, while its chloride forms a strongly acidic solution (pH ≈ 2).

(i) Identity elements **S** and **T**, and explain the above observations as fully as you can with the aid of equations. [4]

(ii) Identify element **U** and explain why the chloride of **U** forms a strongly acidic solution with the aid of an equation. [2]

[Total:20]

7 **(a)** The energy cycle to form sodium oxide from reacting sodium and oxygen is shown below:



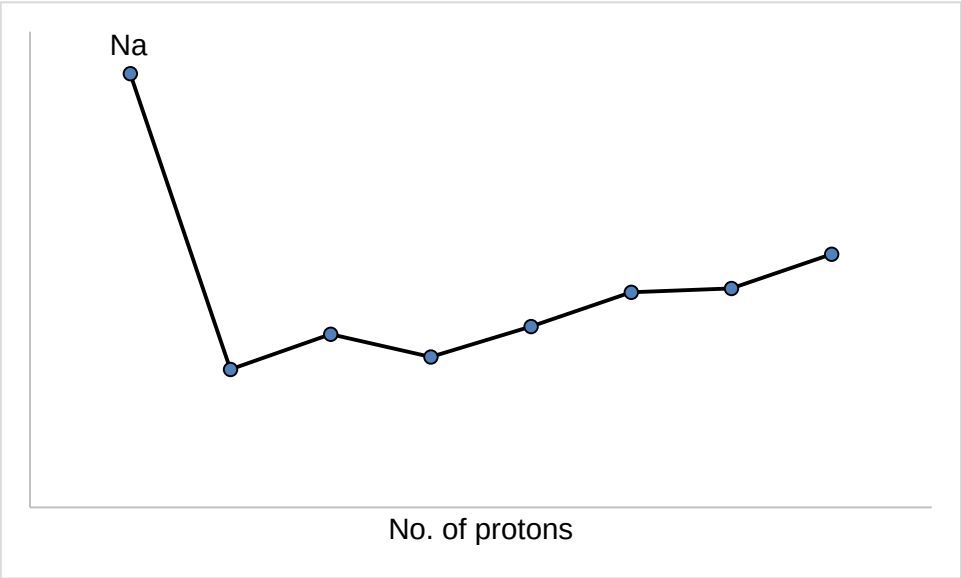
(i) Define the term *enthalpy change of formation*. [1]

(ii) With the aid of the *Data Booklet*, determine the value for the enthalpy change of **X**. [1]

(iii) Hence, calculate the value of enthalpy change of formation of Na_2O. [2]

(iv) Suggest, with reasons, how the magnitude of the lattice energy of Na_2O might compare to that of Na_2S. [2]

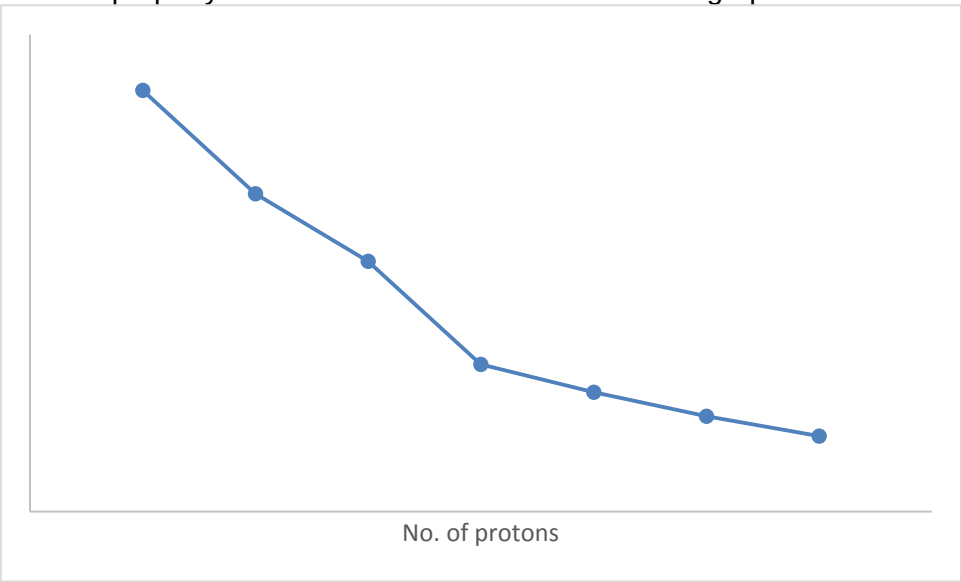
(b) The graph below shows the variation of a property of Period 3 elements with Na being labelled.



Suggest and explain which property is exhibited in the graph above.

[2]

(c) Another property of Period 3 elements is shown in the graph below:



Suggest and explain which property is exhibited in the graph above. [2]

(d) **(i)** Draw the 'dot-and-cross' diagrams of Na_2O and SO_2. [2]

(ii) State the bond angle in SO_2 and explain how this angle arises. [2]

(iii) Suggest, in terms of structure and bonding, why the melting point of Na_2O is higher than that of SO_2. [2]

(e) 1 mol dm^{-3} of NaOH(aq) and 1 mol dm^{-3} butanoic acid is mixed in a 1:2 ratio, forming a *buffer solution*.

(i) Explain what is meant by the term *buffer solution* and how does mixing NaOH(aq) with butanoic acid form a *buffer solution*.

[2]

(ii) With the aid of two equations, explain how the solution of butanoic acid and NaOH(aq) resist changes in pH of the solution.

[2]

[Total:20]