NATIONAL JUNIOR COLLEGE

SH2 PRELIMINARY EXAMINATION

Higher 1

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY

8872/02

Paper 2 Structured Questions

Thursday 24 Aug 2017
2 hours

Candidates answer **Section A** on the Question Paper.

Additional Materials: Data Booklet
Answer Paper
Graph paper (2sheets)

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.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answers **all** 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	
1	/10
2	/7
3	/13
4	/10
5	/20
6	/20
7	/20
Paper 2	/80
Paper 1	/30
Paper 1 Percentage	/33
Paper 2 Percentage	/67
Overall Percentage	%

This document consists of **17** printed pages and **1** blank page.

For Examiner's Use

Section A

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

1 **(a)** Chlorine is a yellow-green gas and is the 2nd most abundant halogen after fluorine.

A mass spectrometer provides the following information about the relative abundances of the 2 isotopes.

isotope	relative abundance / %
^{35}Cl	75.76
^{37}Cl	24.24

(i) Define the term *relative isotopic mass*.

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[1]

(ii) Using the data above, calculate the relative atomic mass of chlorine and give your answer to 4 significant figures.

[1]

(b) The table below shows the boiling points of several halogenoalkanes.

compound	boiling point / °C
1–fluorobutane	32
1–chlorobutane	78
1–bromobutane	102
1–iodobutane	127
1–chloro–2–methylpropane	68

For Examiner's Use

(i) State and explain the trend in the boiling points from 1–fluorobutane to 1–iodobutane.

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[3]

(ii) Explain why the boiling point of 1–chloro–2–methylpropane is lower than that of 1-chlorobutane.

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[2]

(c) Suggest a synthetic route of not more than 2 steps to form butane–1,4–dioic acid, $HO_2C–CH_2CH_2–CO_2H$, from 1,2–dibromoethane. State the reagents and conditions for each step and show the structure of the organic intermediate compound.

[3]

[Total:10]

For Examiner's Use

2 **(a)** The mineral hydromagnesite is a hydrated carbonate of magnesium, with the formula $Mg_y(CO_3)_x(OH)_2.\mathbf{n}H_2O$ and a molar mass of 466 g mol^{-1}.

Hydromagnesite decomposes upon heating to form a white solid, magnesium oxide. The thermal decomposition of hydromagnesite can be expressed as follows:

$$Mg_y(CO_3)_x(OH)_2.\mathbf{n}H_2O \rightarrow \mathbf{y}MgO + \mathbf{x}CO_2 + (\mathbf{n}+1)H_2O$$

where **x**, **y** and **n** is a whole number.

(i) When 1.000 g of a pure sample of hydromagnesite is heated, it decomposes to give magnesium oxide, a white solid, till a constant mass is attained. During the decomposition, 0.378 g of carbon dioxide was given off, together with steam.

Using the above information, calculate the value of **x**.

[2]

(ii) The remaining white solid, magnesium oxide, from the above decomposition was completely dissolved in 50 cm^3 of a 1.0 mol dm^{-3} solution of hydrochloric acid and diluted to 250 cm^3.

25.0 cm^3 of the unreacted HC*l* was pipetted out from the resultant solution and required 28.50 cm^3 of a 0.10 mol dm^{-3} solution of sodium hydroxide for complete neutralisation.

I. Calculate the amount of unreacted HC*l* in 25.0 cm^3 of the resultant solution. Hence, calculate the total amount of unreacted HC*l* in 250 cm^3 of the diluted solution.

[1]

For Examiner's Use

II. Calculate the total amount of HC*l* in 50.0 cm^3 of 1.0 mol dm^{-3} of hydrochloric acid. Hence, calculate the amount of HC*l* used to react with magnesium oxide.

[1]

III. Calculate the amount of magnesium oxide obtained from the decomposition of hydromagnesite and hence, calculate the value of **y**.

[1]

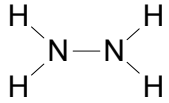
(iii) Using your answers from **a(i)**, **a(ii)** and the molar mass of hydromagnesite, deduce the value of **n** and hence, write the balanced equation for the thermal decomposition of hydromagnesite.

[2]

[Total: 7]

For Examiner's Use

3 **(a)** Hydrazine, N_2H_4, is useful as a rocket fuel.



Liquid hydrazine undergoes combustion according to the following equation.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l)$$

(i) Define standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, of hydrazine.

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[1]

(ii) A student conducted an experiment to determine the standard enthalpy change of combustion of hydrazine. 0.42 g of hydrazine was ignited in excess oxygen and combusted to heat up a beaker containing 200 cm^3 of water. The temperature of water rose by 8 °C. The heat transfer from the combustion of hydrazine is found to be 80 % efficient.
Calculate the enthalpy change of combustion, $\Delta H_c^{\ominus}$, of hydrazine.

[2]

For Examiner's Use

(iii) The bond energy of N≡N is found to be 945 kJ mol^{-1}.

Use the above bond energy of N≡N and the bond energy values from the *Data Booklet* to calculate the enthalpy change of combustion of hydrazine.

[2]

(iv) Suggest a reason why there is a discrepancy in the calculated value of the standard enthalpy change of combustion of hydrazine in **a(iii)** and **a(ii)**.

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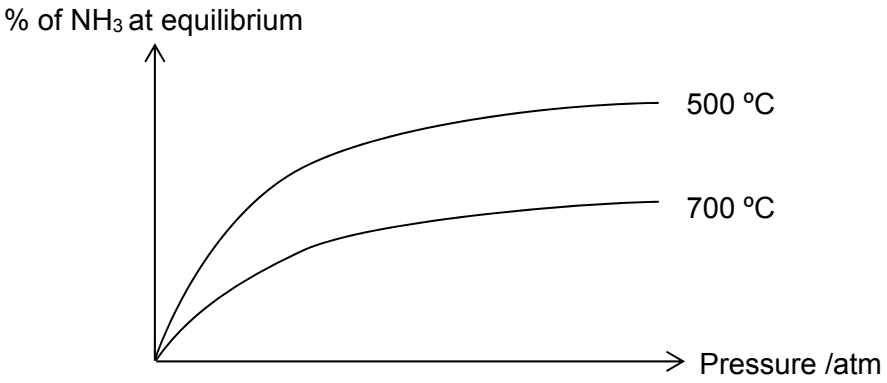
[1]

For Examiner's Use

(b) In the industry, ammonia, which is used to prepare hydrazine, is synthesised by the Haber process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) The figure below shows how percentage of ammonia in the equilibrium mixture varies with pressures at 500 ^oC and 700 ^oC respectively.



Use the above data to deduce whether the production of NH_3 is exothermic or endothermic process. Explain your answer.

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[2]

(ii) Describe and explain what would happen to the yield of NH_3 if more H_2 is added to the reaction vessel.

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[2]

For Examiner's Use

(iii) In an experiment, 2 moles of nitrogen and 7 moles of hydrogen are placed in a 2 dm^3 reaction vessel initially and allowed to reach equilibrium at 573 ^oC. The equilibrium mixture contains 3.2 moles of NH_3. Calculate the value of equilibrium constant, K_c, at this temperature. State the units of K_c.

[3]

[Total: 13]

For Examiner's Use

4 Most of earth's crust consist of solid oxides that are formed as a result of the elements being oxidised by air.

The pH of the oxides of the elements from sodium to sulfur is given in the table below:

compound	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2
pH of solution	13	8	7	7	2	2
melting point / ^oC	1132	2852	2072	1700	24	–72

(a) Explain, in terms of structure and bonding, why MgO has a higher melting point than Na_2O.

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[3]

(b) **(i)** Suggest briefly, in terms of structure and bonding, why the pH of the solution containing SiO_2 is 7?

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[2]

For Examiner's Use

(ii) A sample of silicon dioxide has been contaminated with some aluminium oxide. Describe a method which can be used to obtain a pure sample silicon dioxide. Include equations for any reactions.

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[2]

(c) **(i)** Draw dot-and-cross diagram of SO_2.

[1]

(ii) Explain, with the aid of equations, the observed pH of solution when SO_2 dissolves in water.

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[2]

[Total:10]

Section B

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

5 **(a)** Compound **H**, $C_xH_yO_z$, is found to contain 62.1 % carbon and 10.3 % hydrogen by mass. The relative molecular mass, M_r, of **H** is 58.

(i) Prove that the empirical formula and molecular formula of **H** is C_3H_6O. [2]

Compound **H** does not react with sodium, but it gives orange precipitate when warmed with 2,4–dinitrophenylhydrazine.

(ii) Use your answer in **a(i)**, draw and name two structural isomers of compound **H** that satisfy the above reactions. [3]

(iii) Compound **H** does not decolourised hot acidified $KMnO_4$. Hence, write a balanced equation for the reaction between compound **H** and 2,4–dinitrophenylhydrazine and state the type of reaction. [2]

(b) Compound **M** is another isomer of compound **H** with the structural formula of CH_2=$CHCH_2(OH)$.

(i) How will compound **M** reacts with

(I) cold, $KMnO_4$ in dilute NaOH

(II) PCl_5

(III) ICl

In **each** case, draw the structural formula of the organic product formed.[3]

(ii) Suggest a chemical test (not repeating the above-mentioned reagents and conditions in **b(i)** that can be used to distinguish compound **M** from propan–2–ol and state the expected observation for each compound. [2]

(c) Secondary fermentation of blackberries wine converts compound **J**, $C_4H_6O_5$, to compound **K**, $C_3H_6O_3$, to decrease the acidity of the wine.

Compounds **J** and **K** undergo the following reactions.

- Both **J** and **K** react with sodium carbonate and hot acidified $K_2Cr_2O_7$, but not with 2,4–dinitrophenylhydrazine.
- Both **J** and **K** react with excess hot concentrated H_2SO_4, but only **J** gives a mixture with a pair of cis-trans isomers.
- 0.234 g sample of **J** reacts completely with 35 cm^3 of 0.10 mol dm^{-3} NaOH(aq).
- **K** give a yellow precipitate with alkaline aqueous iodine.
- 7.5×10^{-4} mol of **K** produces 18 cm^3 H_2 gas at r.t.p. when excess Na is added.

Use the information above to deduce a structure for compounds **J** and **K** and explain all the reactions involved. [8]

[Total: 20]

6 Nitrogen monoxide, NO, is a by-product of the combustion of hydrocarbon fuels in internal engines.

(a) NO is considered to be involved in the formation of 'acid rain'. State one other undesirable consequence of the presence of NO in the atmosphere. [1]

(b) The reaction between $H_2(g)$ and NO(g) was studied.

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

The rate of reaction was measured at different times at a constant temperature and the results are shown in the table below.

$[H_2]$ / mol dm^{-3}	2.20	2.00	1.80	1.50	1.25	0.80
rate / mol dm^{-3} s^{-1}	22.7 x 10^{-4}	21.1 x 10^{-4}	18.9 x 10^{-4}	15.7 x 10^{-4}	13.1 x 10^{-4}	8.3 x 10^{-4}

(i) Plot a graph of rate against $[H_2]$. [2]

(ii) Use your graph to find the order of reaction with respect to H_2. [1]

To determine the order of reaction with respect to NO, a series of experiments using different concentration of H_2 and NO were carried out at a constant temperature. The results are shown in the table below.

experiment	initial concentration of $H_2(g)$ / mol dm^{-3}	initial concentration of NO(g) / mol dm^{-3}	initial rate / mol $dm^{-3}s^{-1}$
1	2.0 x 10^{-3}	2.0 x 10^{-3}	3.0 x 10^{-7}
2	4.0 x 10^{-3}	4.0 x 10^{-3}	2.4 x 10^{-6}

(iii) Use the data above, deduce the order of reaction with respect to NO. [2]

(iv) Write the rate equation for the reaction between H_2 and NO. [1]

(v) Calculate the value for the rate constant, *k*, using the data from the experiment 1 result. State the units for *k*. [3]

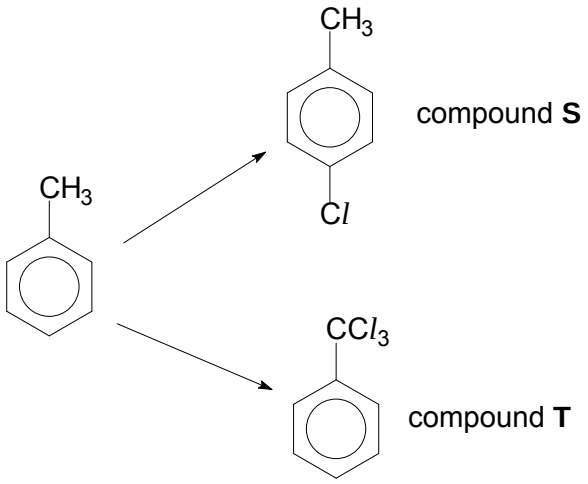
(c) Nitrogen monoxide, NO, is one of the atmospheric pollutants emitted from petrol car engines. It can be removed by passing the exhaust gases through a catalytic converter which has a platinum-rhodium mixture coated onto a fine-meshed aluminium alloy filter. The nitrogen monoxide is decomposed by excess carbon monoxide to form nitrogen and carbon dioxide.

(i) Write a balanced equation, with state symbols, to show how nitrogen monoxide is removed in the catalytic convertor. [1]

(ii) Suggest why the catalyst in the catalytic converter is in the form of a fine mesh? [1]

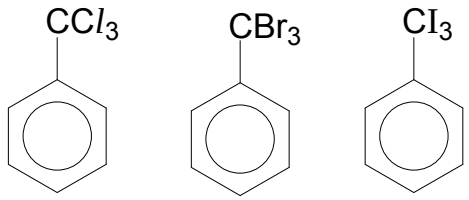
(iii) Explain why a catalyst is used in the catalytic converter with the aid of an energy distribution diagram to illustrate your answer. [3]

(d) Methylbenzene can undergo halogenation reaction with chlorine under different conditions to form two organic compounds, **S** and **T**.



(i) State the reagents and conditions for the formation of compounds **S** and **T**. [2]

(ii) Using your knowledge of the halogenoalkanes, arrange in increasing order of reactivity for the hydrolysis of the following three compounds. [1]



I **II** **III**

(iii) Hence, explain the difference in the reactivity for the above three compounds. [2]

[Total: 20]

7 **(a)** **(i)** Sketch a graph to show the variation in the first ionisation energy of the elements across Period 3 from Na to C*l*. [2]

(ii) Suggest explanation for the observed variation in the first ionisation energy of the elements across Period 3. [3]

Chloroethane can be formed from the reaction between ethane and chlorine. When chloroethane undergoes hydrolysis with sodium hydroxide, hydrogen chloride is produced and dissolves in water to form hydrochloric acid, which reacts with excess sodium hydroxide present in the solution.

(iii) State the type of reaction that has occurred between hydrochloric acid and sodium hydroxide and write a balanced equation. [2]

(iv) Hence, calculate the standard enthalpy change of reaction between hydrochloric acid and sodium hydroxide given the following enthalpies:

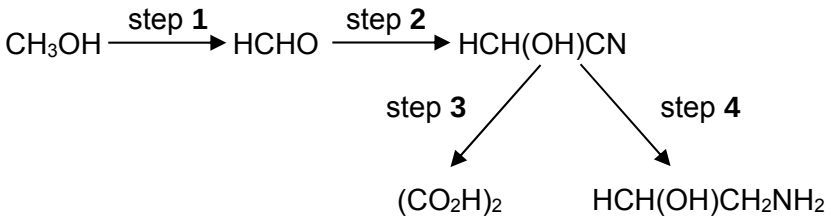
compound	$\Delta H^{\ominus}_f$ / kJ mol^{-1}
NaOH(aq)	–469.15
NaC*l*(aq)	–407.27
HC*l*(aq)	–167.20
$H_2O(l)$	–285.83

[2]

(v) Using your answer in **a(iv)**, suggest a value for the enthalpy change of neutralisation, $\Delta H^{\ominus}_{neu}$, of the reaction when barium hydroxide, $Ba(OH)_2$, which acts as a strong base, is reacted with hydrochloric acid instead. [1]

(b) **(i)** Calculate the oxidation number of carbon in methanol, CH_3OH. [1]

(ii) Methanol can undergo the following reaction scheme.



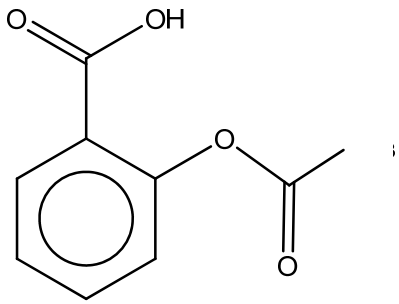
State the reagent and conditions for steps **1**, **2**, **3** and **4**. [4]

(c) In human body, carbon dioxide, that is produced, will dissolve in water present in the blood to form a carbonic acid–hydrogen carbonate (H_2CO_3/HCO_3^-) buffer system.

(i) Explain, with the aid of equations, how the buffer system helps to control and maintain the pH in the blood. [2]

(ii) Although the blood has a pH value of 7.4, the pH in the stomach is 2.5. Calculate the hydrogen ion concentration, $[H^+]$, present in the stomach. [1]

(d) Aspirin is also known as acetylsalicylic acid and the structure of aspirin is as shown below.



Draw the organic products formed when aspirin reacts with HC*l* (aq) in the presence of heat. [2]

[Total: 20]

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