JURONG JUNIOR COLLEGE
2015 JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME	
CLASS	**15S**

CHEMISTRY

8872/02

Paper 2 Structured Questions

28 August 2015
2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class and exam index number 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 staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** the questions.

Section B
Answer **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	
2	
3	
4	
B5	
B6	
B7	
Total	

This document consists of **14** printed pages and **no** blank page.

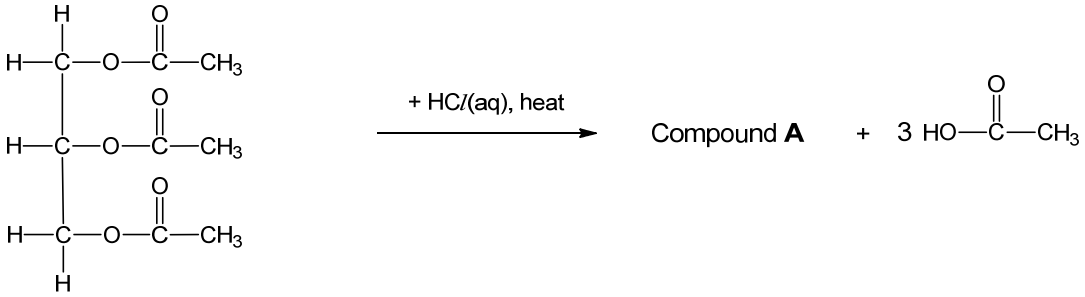
[Turn over

Section A

Answer **all** the questions.

For Examiner's Use

1 Ethanoic acid, also known as acetic acid, is a colourless liquid that has a strong and distinct pungent and sour smell. Aside from culinary uses, as flavouring and as a preservative, ethanoic acid is used to make many polymers and fibres. It can be made by the following method:



(a) Draw the structure of compound **A**.

[1]

(b) **(i)** Ethanoic acid can be formed from the oxidation of ethanol. Suggest suitable reagent and conditions to perform this reaction.

_____

(ii) Write a balanced equation to represent the reaction in **(b)(i)**.

[3]

_____

(c) 2-chloroethanoic acid can be formed from ethanoic acid using suitable reagents and conditions via substitution reaction. Explain why 2-chloroethanoic acid and ethanoic acid has different acidity.

_____

_____

_____

_____

_____

[2]

For Examiner's Use

1 (d) A gas is said to exhibit *ideal* gas behavior if it obeys the **ideal gas equation**

$pV = nRT$

where p = pressure of gas in Pa,

V = volume of gas in m^3,

n = amount of gas (mol),

R = 8.31 J K^{-1} mol^{-1} (a constant),

and T = temperature in K.

Three experiments were performed where different masses of ethanoic acid were expanded into a vessel of volume 0.0150 m^3 at different pressures and at a temperature of 100 ^oC.

Experiment	Mass of ethanoic acid/ g	Pressure/ Pa	Relative molecular mass
1	0.002	6.346	
2	0.015	31.011	
3	0.050	86.128	

(i) Assuming ideal behaviour, calculate the relative molecular mass of ethanoic acid for each experiment 1 to 3 and enter the values into the above table.

(ii) In gaseous state just above the boiling point, the monomer and dimer forms of ethanoic acid exist together in equilibrium.

$$2CH_3COOH \quad = \quad (CH_3COOH)_2$$

Draw a fully labelled diagram to illustrate the bond formed when ethanoic acid dimerises.

1 (d) (iii) Use Le Chatelier's Principle to predict and explain how an increase in pressure will affect the position of equilibrium in **d(ii)** and the trend in relative molecular mass of ethanoic acid.

_____

_____

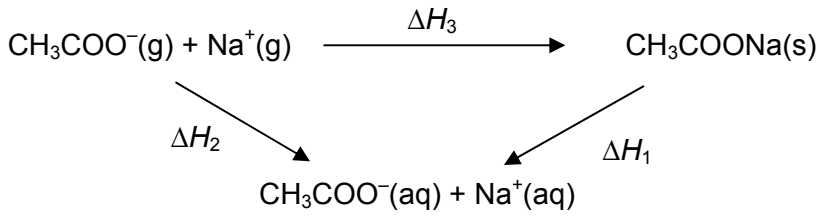
_____

_____

[4]

(e) The salt of ethanoic acid, sodium ethanoate, may be added to food as a seasoning. It is often used to give potato chips a salt and vinegar flavor.

The enthalpy change for the solution of sodium ethanoate in water, ΔH_1 can be determined by using the energy cycle given below.



$\Delta H_2 = -780$ kJ mol^{-1}

$\Delta H_3 = -763$ kJ mol^{-1}

(i) Name the enthalpy change that is represented by ΔH_3.

_____

(ii) With reference to the energy cycle and the data given above, calculate ΔH_1.

[2]

[Total: 12]

For Examiner's Use

2 **(a)** The element iron is a transition metal that is very common in our planet. It has many uses in different industries and even in the human body.

It has four naturally occurring isotopes.

isotope	Relative abundance / %
^{54}Fe	5.845
^{56}Fe	91.754
^{57}Fe	2.119
^{58}Fe	0.282

(i) Write the full electronic configuration of iron.

(ii) Use the relative abundance data to calculate the relative atomic mass of iron to 3 decimal places. Show your working.

[2]

(b) Iron is used as a catalyst in the manufacture of ammonia in the Haber process.

$$N_2(g) + 3H_2(g) = 2NH_3(g)$$

(i) State the optimum industrial conditions of temperature and pressure used in the Haber process.

(ii) Explain why these particular conditions are chosen.

2 (b) (iii) With the aid of the Boltzmann distribution curve, explain how the presence of a catalyst affects the rate of this process.

[7]

(c) Nitrogen is one of the Period 2 elements and it forms the nitride ion, N^{3-}. State and explain how you would expect the radius of the following ions to compare with the radius of nitride ion.

- fluoride ion, F^-
- lithium ion, Li^+

[2]

[Total: 11]

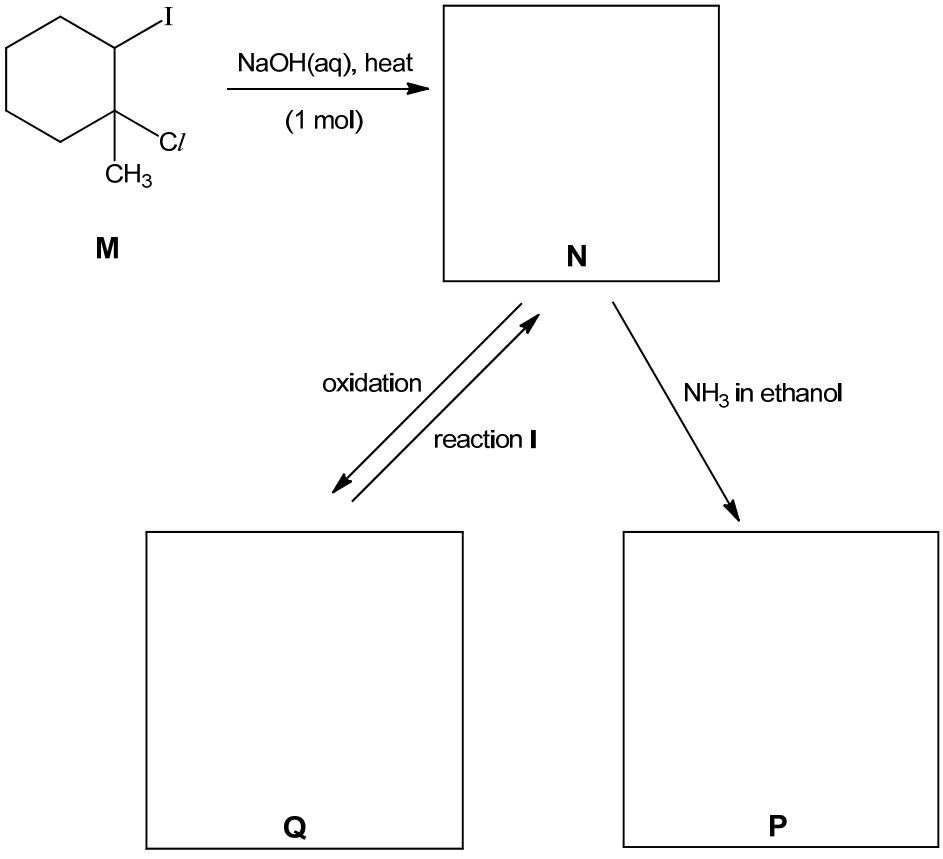
For Examiner's Use

3 Halogenoalkanes are used widely in the industry to produce organic compounds commercially. Halogenoalkanes can also undergo hydrolysis with sodium hydroxide to produce alcohol commercially.

(a) Using monohalogenohexanes, $C_6H_{13}X$, as an example, describe and explain the relative reactivity of chloro and iodo–compounds towards aqueous sodium hydroxide.

[2]

(b) **(i)** A sequence of reactions, starting from compound **M**, a dihalogeno compound, is shown below.



In the appropriate boxes draw the structures of compounds **N**, **P** and **Q**.

For Examiner's Use

3 (b) (ii) For the reactions in the scheme shown above suggest

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

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

[5]

(c) Draw the structure of a suitable alkene needed to form compound **M** in **(b)(i)**.

[1]

[Total: 8]

For Examiner's Use

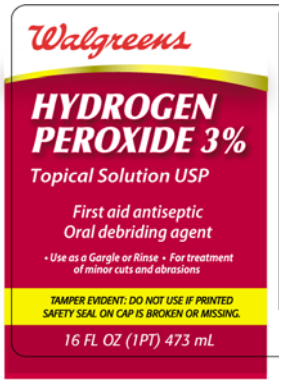
4 Dental hygiene is big business; sales of teeth-whitening products are soaring. There are two ways that teeth may become discoloured. The antibiotic tetracycline, excess fluoride, or trauma can darken or reveal the yellow inner tooth. Coffee, tea or smoking attacks the outer surface. Common whitening methods target only outer stains.

The yellow layer beneath the white enamel protects your teeth as you chew. Enamel, the hardest substance in your body, is composed primarily of calcium phosphate. When spaces between the **rods** fill with organic material, the stain become too deep to brush away.

All teeth-whitening options, except natural method, use hydrogen peroxide (H_2O_2) as the oxidising agent. Carbamide peroxide is used as the H_2O_2 source in many products. The molecule decomposes in water yielding H_2O_2 as indicated in the equation below.

carbamide peroxide → urea + H_2O_2

H_2O_2 reacts rapidly with the electron-rich molecules that discolour the teeth. The stain molecules are broken into smaller molecules with lighter colour, so the teeth appear whiter. The whiteness of the teeth and the time required depend upon the concentration of the solution.



According to the American Dental Association, bleaching with 3% hydrogen peroxide is considered safe and effective. Bleaching may initiate temporary sensitivity or gum irritation, and the stronger concentrations may cause damage, but they generally contain fluoride to protect the enamel.

(a) Carbamide peroxide contains 12.6% carbon, 6.4% hydrogen, 29.0% nitrogen and 52.0% oxygen by mass. Calculate the empirical formula of carbamide peroxide.

[2]

For Examiner's Use

4 **(b)** Using your answer to part **(a)**, the information given above and that the oxygen atom is only bonded to the carbon atom, deduce the structural formula of urea and draw its displayed formula.

[1]

(c) Calculate the amount of hydrogen peroxide that is present in one bottle of 16 FL OZ (473 ml) of 0.100 mol dm^{-3} hydrogen peroxide (3%) topical solution.

[2]

(d) Hence, calculate the mass of carbamide peroxide powder required to prepare the hydrogen peroxide topical solution.

[1]

(e) A cheaper alternative to whiten teeth without spending tons of money on expensive products or treatments is to make use of one of the common household products, baking powder. Baking powder, which contains sodium hydrogencarbonate, $NaHCO_3$, is a mild abrasive which effectively removes stains from the teeth.

(i) Identify the anion present in sodium hydrogencarbonate.

_____

(ii) How many electrons are present in the anion? ……

(iii) Sodium hydrogencarbonate decomposes on heating to form sodium carbonate, carbon dioxide and water. Write a balanced equation for this reaction.

[3]

_____

[Total: 9]

Section B

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

5 **(a)** The oxides of the Period 3 elements include the following: Na_2O, Al_2O_3 and SO_2.

(i) Draw dot–and–cross diagrams to illustrate the bonding in Na_2O and SO_2.

(ii) In terms of structure and bonding, explain the difference in the melting point of Na_2O and SO_2.

(iii) Describe and explain what you would see when a sample of Na_2O(s) and Al_2O_3(s) are separately added to a solution of Universal indicator. Write equations for any reactions that occur. [7]

(b) Al_2O_3 is used in the dehydration of alcohols to alkenes. Two isomeric alcohols, **A** and **B**, are shown below.

$CH_3CH(OH)CH_2CH_3$	$(CH_3)_3COH$
A	**B**

(i) Draw the structural formula of **one** other alcohol isomeric with **A** and **B**.

(ii) Draw the structural formula of an alkene that is obtained by dehydrating **A**.

(iii) Suggest how alcohols, **A** and **B**, could be distinguished from each other. Give the reagents, conditions and observations with each alcohol. [4]

(c) Both alcohols and alkenes can be converted to halogenoalkanes.

(i) State the type of reaction undergone and name a reagent used to convert propan-1-ol to 1-chloropropane .

(ii) Use bond energy values from the *Data Booklet* to calculate the enthalpy change for the reaction between propene and hydrogen chloride as shown in the given equation.

$$CH_3CH{=}CH_2 + HCl \rightarrow CH_3CHClCH_3$$ [4]

(d) Ethylbenzene can undergo two different halogenation reactions with chlorine.

(i) Write an equation and state the conditions necessary for **each** of these reactions to occur.

(ii) Describe a chemical test to distinguish between the products obtained in the different halogenation reactions. State the reagents, conditions, and the observations for each compound.

[5]

[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.

(a) Describe the bonding between the carbon and oxygen atom of the C=O bond in propanone in terms of the **overlap of orbitals**. Draw diagrams to illustrate your answer. [3]

(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) By considering the reversible reaction at equilibrium in ***Stage 2***:

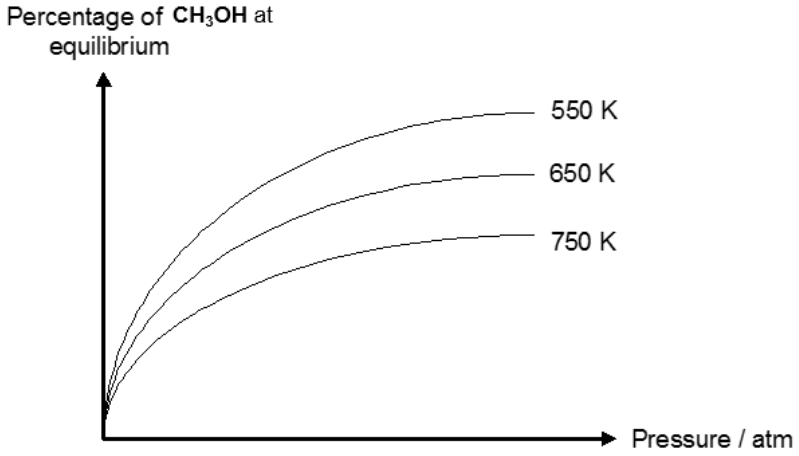
$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

When 2.00 mol of hydrogen and 1.00 mol of carbon monoxide are mixed and heated to a high temperature in a container of volume 1.50 dm^3, the equilibrium yield of methanol is 0.80 mol.

(iii) Write the equilibrium constant, K_c, for this reaction and state its units.

(iv) Calculate a value for the equilibrium constant, K_c, for the reaction at this temperature.

(v) 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. [9]

[Total: 20]

7 Carboxylic acids are weak acids whereas many inorganic acids are strong acids.

Johannes Bronsted and Martin Lowry independently came to similar conclusions about acid-base behavior early in the 20th century.

(a) **(i)** Define a Bronsted acid and a Bronsted base.

(ii) Write an equation for the reaction between ethanoic acid, CH_3CO_2H, and water. Indicate which species are the acid, the base and their conjugate pairs in the reaction.

(iii) What is meant by the term pH?

Calculate

- the hydrogen ion concentration, $[H^+(aq)]$, of a solution of ethanoic acid of pH 4.0;
- the pH of a solution of 0.20 mol dm^{-3} solution of sulfuric acid;
- the pH of a solution of 0.05 mol dm^{-3} barium hydroxide.

[6]

(b) Lactic acid, 2-hydroxypropanoic acid, can be synthesised from ethanal in a reaction route as shown.

$$CH_3CHO \xrightarrow{\text{I}} CH_3CH(OH)CN \xrightarrow{\text{II}} CH_3CH(OH)CO_2H$$

Lactic acid

(i) Name the type of reaction that occurs in Step **I**

(ii) Suggest the reagents and conditions needed for Steps **I** and **II**.

[3]

(c) Lactic acid, $CH_3CH(OH)COOH$, reacts with sodium hydroxide to form sodium lactate, $CH_3CH(OH)COO^- Na^+$.

A mixture of lactic acid and its sodium salt forms an acidic buffer.

(i) Explain what is meant by a buffer solution. Using relevant equations, show how a solution of lactic acid and sodium lactate buffer controls pH when a small amount of HC*l*(aq) or NaOH(aq) is added.

(ii) Given the following data,

Indicator	Working pH range
Methyl orange	3.2 – 4.4
Phenolphthalein	8.2 – 10.0

Suggest the indicator that is suitable for the titration of lactic acid with sodium hydroxide, explain your reasoning. State the colour change at the end point.

[5]

(d) The chlorides $MgCl_2$, $AlCl_3$ and $SiCl_4$ differ considerably in their structures and chemical properties. The chlorides become more acidic across the period.

Illustrate this statement by describing the reactions, if any, of the **three** chlorides with water, suggesting the pH of the resulting solutions and writing equations where appropriate.

[6]

[Total: 20]