H

INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

CHEMISTRY

9647/02

Paper 2 Structured Questions

11 September 2012

2 hours

Candidates answer on the Question Paper Additional Materials: *Data Booklet*

READ THESE INSTRUCTIONS FIRST

Write your index number, name and civics group.
Write in dark blue or black pen.
You may use pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the space provided.
A Data Booklet is provided.

You are advised to show all working in calculations.
You are reminded of the need for good English and clear presentation in your answers.
You are reminded of the need for good handwriting.
Your final answers should be in 3 significant figures.

You may use a calculator.

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

At the end of the examination, fasten all your work securely together.

For Examiner's Use	
Section A	
1	12
2	12
3	15
4	12
5	11
6	10
Significant figures	
Handwriting	
Total	72

This document consists of **18** printed pages.

For Examiner's Use

Answer ALL questions on the spaces provided.

1 Planning (P)

A student was given 50 cm^3 of three acidic solutions labelled **X**, **Y** and **Z**. She was asked to provide the identities of them by conducting a simple experiment.

The identities of the three solutions are

1 mol dm^{-3} ethanoic acid, CH_3COOH
1 mol dm^{-3} hydrochloric acid, HC*l*
2 mol dm^{-3} hydrochloric acid, HC*l*

Her teacher advised her to measure the temperature change of the reactions and calculate the enthalpy change of neutralisation of an acid and base reaction. The student is also provided with 200 cm^3 of 1 mol dm^{-3} sodium hydroxide, NaOH.

The student let the volume ratio of each of the three solutions to sodium hydroxide be 1:1. She tested the experiment and realised that with this volume ratio, she is unable to differentiate the different concentrations of hydrochloric acid.

(a) Construct balanced equations for the reactions between the given acids and base.

[1]

(b) The following table shows the volumes used by the student.
Explain, with the aid of calculation, why the student's experiments will **not** aid the differentiation of the different concentrations of hydrochloric acid.

Experiment	Volume of 1 mol dm^{-3} NaOH / cm^3	Volume of 1 mol dm^{-3} HC*l* / cm^3	Volume of 2 mol dm^{-3} HC*l* / cm^3
1	50	50	
2	50		50

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.....[2]

For Examiner's Use

(c) Write a plan which will allow an identification of the three solutions to be made. You may use the reagents and apparatus normally found in a school or college laboratory. However, you are **not** provided with an indicator.

In your plan you should give essential details, including quantities, of the identification procedure.

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....[6]

For Examiner's Use

(d) Explain how you can make use of your experimental data to identify the three solutions.

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……[2]

(e) Discuss one possible source of error in conducting your experiment and suggest improvement to produce a more reliable result.

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……..[1]

[Total: 12]

For Examiner's Use

2 **(a)** Iodine is not very soluble in water but in the presence of iodide ions, it can dissolve to form a tri-iodide complex as follows:

$$I_2 + I^- \rightarrow I_3^-$$

(i) Draw a dot and cross diagram for the tri-iodide ion and hence state its shape and bond angle.

Shape……

Bond angle……

(ii) Explain why fluorine does not form the corresponding F_3^- ion.

……

……

[3]

(b) IF_7 is a colourless gas prepared by the direct combination of iodine and fluorine. The I–F bond energy can be obtained from thermochemical data.

Standard enthalpy change of formation of $IF_7(g)$ = −944 kJ mol^{-1}
Standard enthalpy change of atomisation of iodine = +107 kJ mol^{-1}

(i) Define what is meant by the *standard enthalpy change of formation* of IF_7.

……

……

(ii) Draw an energy cycle diagram to determine the I–F bond energy.
Incorporate values from the data above and any other relevant data from the *Data Booklet* into the diagram.

For Examiner's Use

(iii) Explain why the I–F bond energy is not the mean of the I–I and F–F bond values.

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……

[6]

(c) The typical daily food requirement of a person can be considered to be 1.2 kg of carbohydrate. The person obtains energy by oxidation of the carbohydrate, which can be represented by the formula $(CH_2O)_n$.

(i) Construct an equation for the complete oxidation(combustion) of the carbohydrate $(CH_2O)_n$.

……

(ii) The empirical relative formula mass of the carbohydrate is 30. Use your equation in **(i)** to calculate the number of moles of oxygen required by the person each day.

(iii) Calculate the volume of oxygen at room temperature and pressure for a human with a lifetime of 70 years.

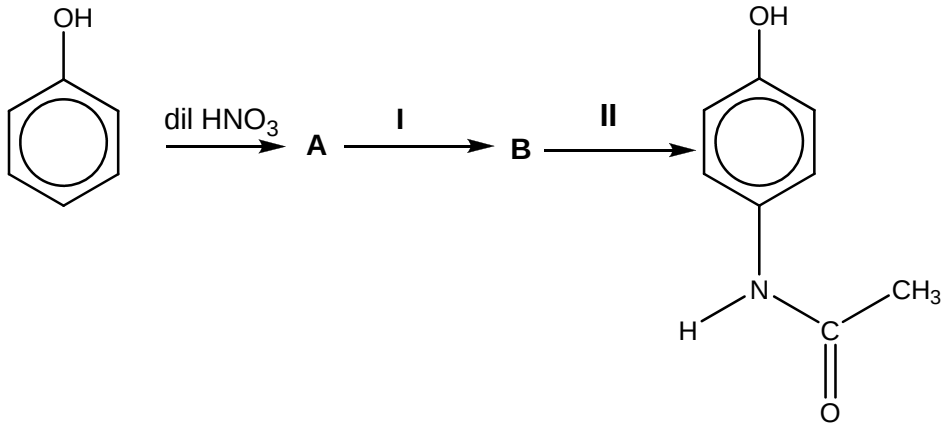
[3]

[Total:12]

For Examiner's Use

3 **(a)** Panadol is the trade name for paracetamol or acetaminophen which is an over the counter analgesic (pain reliever) and antipyretic (fever reducer).

It can be synthesised in the lab from phenol via a series of steps.



paracetamol

(i) State the reagents and conditions for step I and step II.

Step I:

Reagent(s): ……..……..

Condition(s): ….……..

Step II:

Reagent(s): ……..……..

Condition(s): ….……..

(ii) Draw the structures of compound **A** and **B** in the boxes below.

A:	**B**:

For Examiner's Use

Paracetamol can be easily hydrolysed by aqueous NaOH to produce compound **C** and **D**. In the spaces below, write the formulae of the two products.

(iii)

C:	**D**:

[6]

(b) One of the causes of fever is bacterial infection. Alcohol solutions are used as disinfectants on the skin as it can penetrate the bacterial cell wall and *denature* the proteins inside the cell.

(i) What do you understand by the term *denaturation* of proteins?

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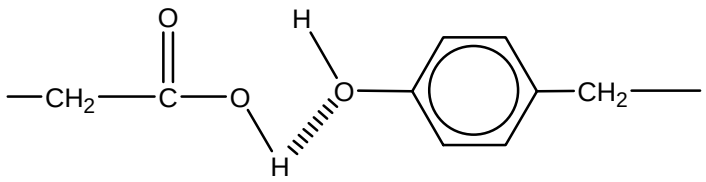
(ii) The part of the protein molecule which is affected by the ethanol added is as follows:



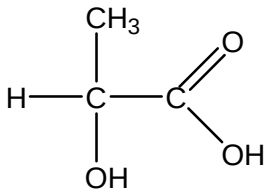
IIIIIIIIII represents R group interaction

Suggest what R group interaction was disrupted by ethanol.

……

For Examiner's Use

(iii) Another application of denaturation is found in the making of cheese. Casein is the predominant protein found in milk. When Lactobacillus bacterium is added to milk, lactic acid (2-hydroxypropanoic acid) is produced.



2-hydroxypropanoic acid

Besides hydrogen bonding, suggest and write an equation to explain what R group interaction is disrupted when lactic acid is produced.

Explanation……

……

Equation ……

[4]

(c) The following table compares the *pKa* values of ethanol, 2-hydroxypropanoic acid with that of ethanoic acid.

compound	formula	*pKa*
Ethanol	CH_3CH_2OH	15.9
Ethanoic acid	CH_3COOH	4.76
2-hydroxypropanoic acid	$CH_3CH(OH)COOH$	3.86

(i) Suggest a reason why pK_a value of ethanoic acid is so much less than ethanol.

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For Examiner's Use

(ii) Suggest a reason why 2-hydroxypropanoic acid is more acidic that ethanoic acid.

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[3]

(d) The degree of dissociation (ionisation) of ethylamine, $CH_3CH_2NH_2$, in 0.010 mol dm^{-3} aqueous solution is 0.17.

(i) Calculate the hydroxide ion concentration of this solution.

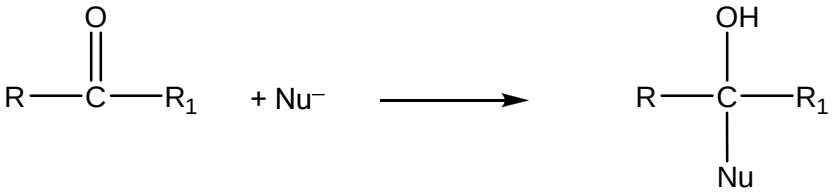
(ii) Calculate a value for the base dissociation constant, K_b, for ethylamine, stating the units.

[2]

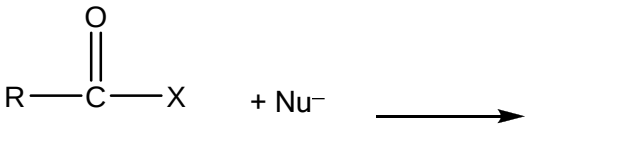
[Total: 15]

For Examiner's Use

4 (a) Nucleophiles are electron-rich species that can donate electrons and attack regions of low electron density. Reactions 1 and 2 show how the nucleophile, Nu^-, reacts with two different carbonyl groups.



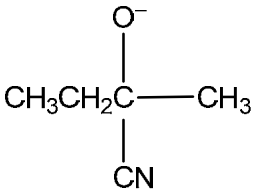
Reaction 1



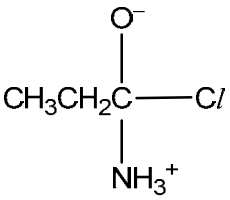
Reaction 2

where X: C*l*, Br, I

The intermediates, **X** and **Y**, shown below are formed by nucleophilic attack on two different compounds containing a carbonyl group of low electron density.



X



Y

(i) State the nucleophile required to form intermediate **X** and **Y** respectively.

Nucleophile for intermediate **X**: ……

Nucleophile for intermediate **Y**: ……..

(ii) Identify the organic starting material to form intermediate **X**.

(iii) State the type of reaction that gives intermediate **Y**.

……..

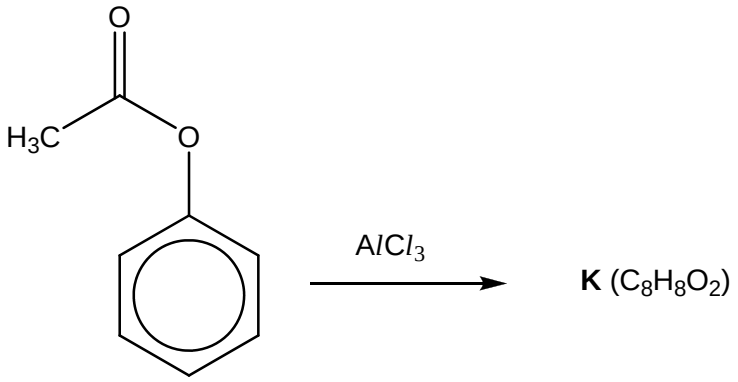
For Examiner's Use

(iv) Suggest a mechanism for the complete reaction in which **Y** is an intermediate.

[7]

(b) In a reaction discovered just over 100 years ago by the German chemist Karl Fries, compound **G** is converted into compound **K** when it is heated with A*l*C*l*$_3$.

Compound **K** is a structural isomer of **G**.



Compound **G**

Compound **K** is a 1,4-disubstituted benzene derivative. It is insoluble in water, but dissolves in NaOH(aq). It gives a white precipitate with Br_2(aq), and a yellow precipitate with alkaline aqueous iodine.

For Examiner's Use

(i) Use the information given, **name** the functional groups in compound **K**.

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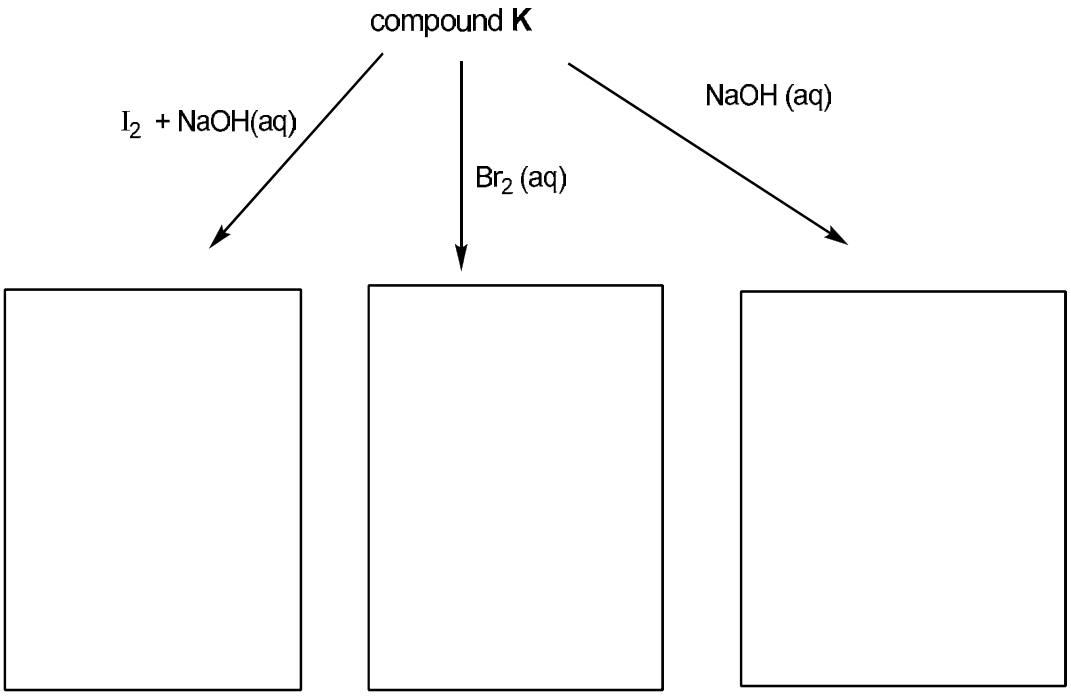
……

(ii) Deduce the structural formula of **K**.

(iii) Draw the structural formulae for the aromatic products when compound **K** undergoes the following reactions.



[5]

[Total: 12]

For Examiner's Use

5 **(a)** An element **M** forms an oxide which is a powerful oxidising agent.
An acidified solution of the oxide of **M**, $\mathbf{M}O_x$ (x = 1, 2 or 3) will oxidise $Mn^{2+}(aq)$ to $MnO_4^-(aq)$, itself reduced to the element **M**.
When 10.0 cm^3 of 0.5 mol dm^{-3} of $\mathbf{M}O_x$ was reacted with 0.40 $moldm^{-3}$ $Mn^{2+}(aq)$ in the presence of $H^+(aq)$, 15.0 cm^3 of $Mn^{2+}(aq)$ was needed for complete reaction.

(i) Calculate the number of moles of electrons donated by Mn^{2+}.

(ii) Calculate the mole ratio of $\mathbf{M}O_x$ and electrons accepted by $\mathbf{M}O_x$.

(iii) Determine the original oxidation number of **M** and the value of x.

(iv) Construct an equation for the reaction between $\mathbf{M}O_x(aq)$ and acidified $Mn^{2+}(aq)$.

[4]

For Examiner's Use

(b) Water, H_2O, covers 70.9% of the Earth's surface and is vital for all known forms of life. About 0.005% of water molecules consist of an oxygen atom bonded to two atoms of the hydrogen isotope, deuterium, $^{2}_{1}D$.

Deuterium oxide, D_2O, is known as 'heavy water' and is used for research in chemical reactions because deuterium atoms react less quickly than normal hydrogen atoms, $^{1}_{1}H$.

Like H_2O, pure D_2O is weakly ionised.

$$2D_2O \rightleftharpoons D_3O^+ + OD^-$$

For D_2O, we can use the term K_D instead of K_W and pD instead of pH.

(i) Explain what is meant by *dynamic equilibrium*.

……

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……

(ii) For pure D_2O, $K_D = 1.35 \times 10^{-15}$. Calculate the values of the following.

I. $[D_3O^+]$

II. pD

(iii) For this system, K_D increases when temperature increases. Suggest and explain whether the ionic dissociation of 'heavy water' is an exothermic or endothermic process.

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For Examiner's Use

(iv) When pure H_2O and pure D_2O are mixed, exchange of H and D atoms takes place and the following equilibrium is established.

$$D_2O(l) + H_2O(l) \rightleftharpoons 2HDO(l)$$

A mixture of 30 g of D_2O and 27 g of H_2O was placed in a vessel at 298 K. At equilibrium, it was found that the degree of dissociation of D_2O is 0.49. Calculate the K_c for this system.

[7]

[Total: 11]

For Examiner's Use

6 Many copper minerals are found in hydrothermal deposits where they were formed by crystallization from very hot solutions which were trapped underground at high pressures. One such copper mineral is chalcopyrite, $CuFeS_2$.

Copper is extracted from the ore chalcopyrite, $CuFeS_2$, in a three-stage process.
In the first stage of this extraction, the chalcopyrite is heated with silicon dioxide and oxygen.

(a) Balance the following equation for this first stage in which copper sulfide is formed.

…...$CuFeS_2$ + ……..SiO_2 + ……..O_2 ⟶ Cu_2S + …….$FeSiO_3$ + ……SO_2

[1]

(b) Write the electronic configuration for Cu^+ in Cu_2S:

Cu^+ ……

[1]

(c) When water is added to white anhydrous $CuSO_4$, the solid dissolves to give a blue solution. On addition of concentrated NH_4Cl (aq), the solution changes to a yellow-green due to formation of copper containing species **D**. Concentrating the solution produces green crystals **E** of an ammonium salt with empirical formula $CuN_2H_8Cl_4$.

(i) Suggest the formulae of cation present in **E**.

Cation present in **E** .....

(ii) Suggest the formulae of anion **D**.

Anion **D**……

(iii) Suggest a balanced equation for the formation of anion **D** from aqueous $CuSO_4$.

……

When excess of NH_3 (aq) is added to species **D**, the yellow green solution turns to a deep blue solution.

(iv) Use this information and the information above to suggest the strength of NH_3, H_2O and Cl^- ligands in decreasing order.

…… > …… > ……

[4]

For Examiner's Use

(d) When a dilute aqueous solution containing a bidendate ligand, ethanedioate ion, $C_2O_4^{2-}$, is added to a solution containing aqueous copper(II) ions, a ligand exchange reaction occurs. In this reaction, four water molecules in the hydrated copper ion are replaced and a new complex **F** is formed.

(i) Explain what is meant by a bidendate ligand.

……

……

(ii) Suggest the formulae of complex **F** formed.

Identity of **F** ……

(iii) In the complex **F** formed, the two water molecules are opposite each other. Draw a diagram to show how the ethanedioate ions are bonded to a copper ion and give a value for one of the O-Cu-O bond angles. You are not required to show the water molecules.

O-Cu-O bond angle: …… [4]

[Total: 10]