INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS | INDEX NUMBER

CHEMISTRY 8872/02

Paper 2 Structured and Free Response Questions **15 September 2008**

2 hour

Section A: Structured
Candidates answer Section A on the Question Paper

Section B: Free Response
Additional Materials: Writing Papers
Graph Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your index number, name and civics group on all the work you hand in.
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.

Section A: Structured Questions (40m)
Answer **all** questions in the space provided.

Section B: Free Response Questions (40m)
Answer **two** questions on separate writing papers.

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	/10
2	/12
3	/10
4	/8
Significant Figures	
Handwriting	
Total	/40

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

For Examiner's Use

Section A
Answer ALL questions on the space provided

1. Hydrazine is a chemical compound with the formula N_2H_4. It has an ammonia-like odour, and is derived from the same industrial chemistry processes that manufacture ammonia. However, hydrazine has physical properties that are more similar to those of water. Hydrazine is used as rocket fuel as it decomposes into ammonia and nitrogen gas. This reaction is extremely exothermic and thus very suitable as an efficient thruster propellant.

(a) Draw the Lewis structure for the hydrazine molecule. State its shape and indicate the H–N–H bond angle.

Shape: ……

[2]

(b) Write a balanced equation to illustrate the decomposition of hydrazine.

……..……..…….. [1]

(c) Suggest a reason why the decomposition reaction is highly exothermic.

……..……..…… [1]

(d) Hydrazine is also commonly used as a strong reducing agent. It reacts according to the following equation:

$$N_2H_4 \longrightarrow N_2 + 4H^+ + 4e^-$$

It was found that 25.0 cm^3 of 1.40 mol dm^{-3} hydrazine requires 35.0 cm^3 of 1.00 mol dm^{-3} of acidified $KMnO_4$ (aq) for reaction. Determine the final oxidation number of manganese in the product.

[3]

(e) Hydrazine (b.p. 114^{o}C) and ethene, C_2H_4 (b.p. – 104^{o}C) have similar molecular masses but have very different boiling points.

(i) Draw a diagram of N_2H_4 to illustrate the bonding in the compound.

[1]

(ii) Explain the difference in their boiling points in terms of structure and bonding.

……..…….

……..…….

……..…….

……..…….

……..…….

[2]

[Total: 10]

2 *The use of the Data Booklet is relevant to this question.*

(a) The ^{68}Ge isotope of the Group IV element germanium is medically useful because it undergoes a natural radioactive process to give a gallium isotope, ^{68}Ga, which can be used to detect tumours. This transformation of germanium occurs when an electron enters the nucleus, changing a proton into a neutron.

(i) State the number of protons and neutrons in the ^{68}Ga isotope formed.

Number of protons : …….

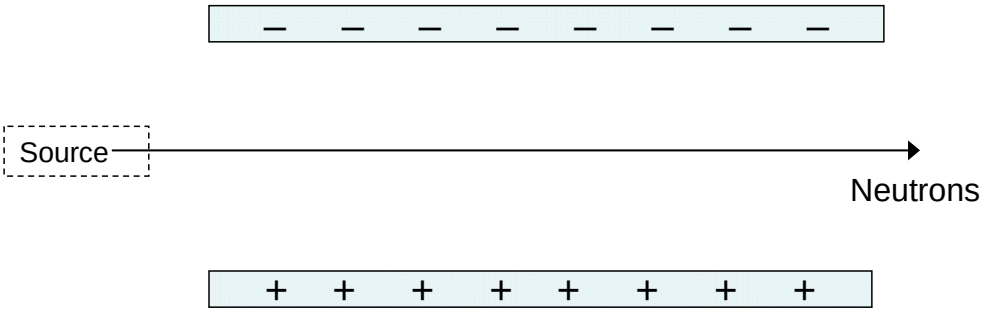
Number of neutrons: …….

[1]

(ii) While undergoing radioactive decay, the isotope will give out an alpha particle, **α** which is the nucleus of helium atom.

If the angle of deflection of the alpha particle, **α,** is 3^o.

I. Draw the path for which the alpha particle, will take when placed in an electric field shown below.



[1]

II. Give reasons and suggest the angle of deflection of the deuterium ion, ${}^{2}_{1}D^{+}$.

……..…….

……..……. [1]

(b) Aluminium is by far the most abundant and important metal in earth's crust. Aluminium reacts directly with non-metallic elements to form compounds such as aluminium oxide and aluminium chloride.

(i) Write balanced equation(s) for the following reactions

1. Aluminium oxide with hot sodium hydroxide

……..…….

……..…….

2. Aluminium chloride with water

……..…….

……..…….

[2]

(ii) Aluminium chloride sublimes at 179^{o}C and dimerises to form gaseous Al_2Cl_6 molecules. Draw the structure that represents the vapour at this temperature.

[1]

(c) Aluminium can form an ion which is isoelectronic with an oxygen ion.

(i) Explain what is meant by *isoelectronic*.

……..…….

……..…….[1]

(ii) State the electronic configuration of the aluminium ion.

……..…….[1]

(iii) Sketch and label the shapes of the two types of electron orbital found in the aluminium atoms.

[2]

(iv) Explain why the first ionisation energy of aluminium atom is less than that of magnesium atom.

……..…….

……..…….

……..…….

[2]

[Total: 12]

3 Ammonia is manufactured by direct synthesis in the Haber process:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) Write an expression for the equilibrium constant, K_c, for this reaction, stating its units.

[1]

(b) Predict and explain the effect on the position of the equilibrium above when the following changes were made.

(i) Increasing the pressure whilst keeping the temperature constant.

……

……

……

(ii) Adding finely-divided iron whilst keeping the pressure and temperature constant.

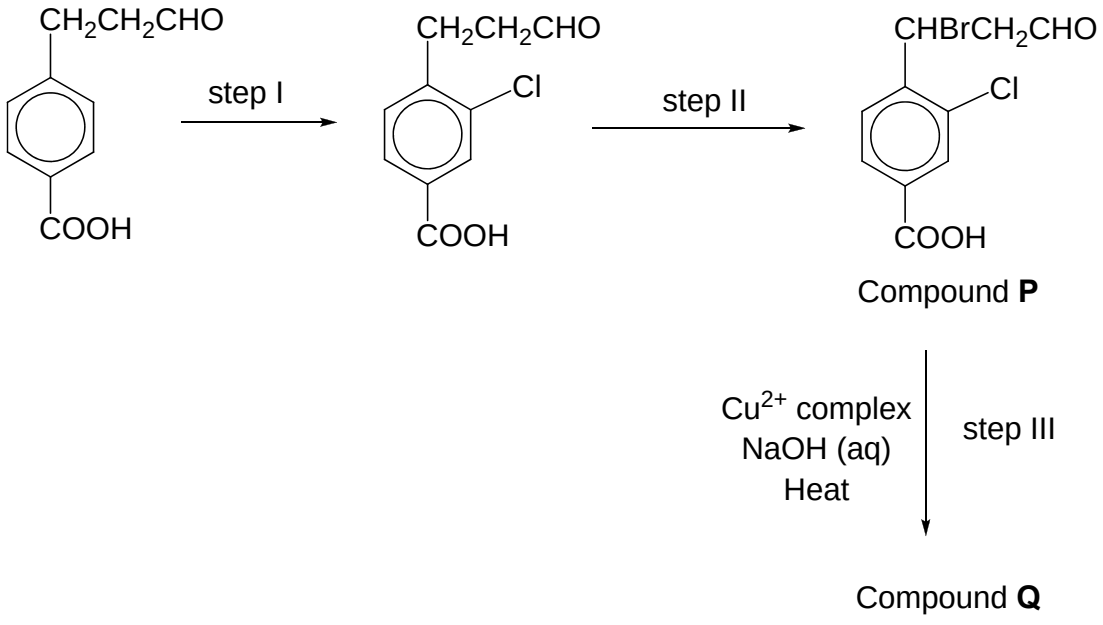
……

……

……

[3]

(c)



(i) State the reagent(s) and conditions of each step.

step I
Reagent(s) and Conditions:

……

step II
Reagent(s) and Conditions:

……
[2]

(ii) Draw the displayed formula for compound **Q**.

[2]

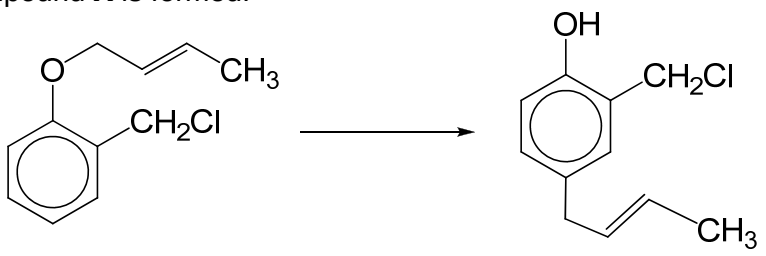
(iii) Name the type of reaction in step II and briefly describe why this is not a good method to obtain compound **P**.

……

……

……[2]
[Total: 10]

4 When compound **Y** is heated, a migration known as aromatic Claisen rearrangement occurs and compound **X** is formed.



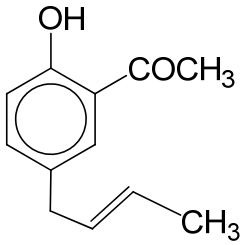
compound **Y** compound **X**

(a) Give the structural formula of the organic products formed when compound **X** is reacted with the following reagents.

(i) NH_3, heat in sealed tube	**(ii)** HBr, room temperature

[2]

(b) Describe one simple chemical test you could use to distinguish compound **X** from compound **Z.**



compound **Z**

State the reagents, conditions and observations.

Reagent(s) and Conditions: ……...

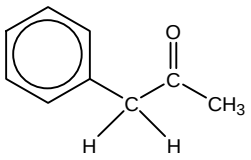
Observations for

Compound **X**: ……

Compound **Z**: ……

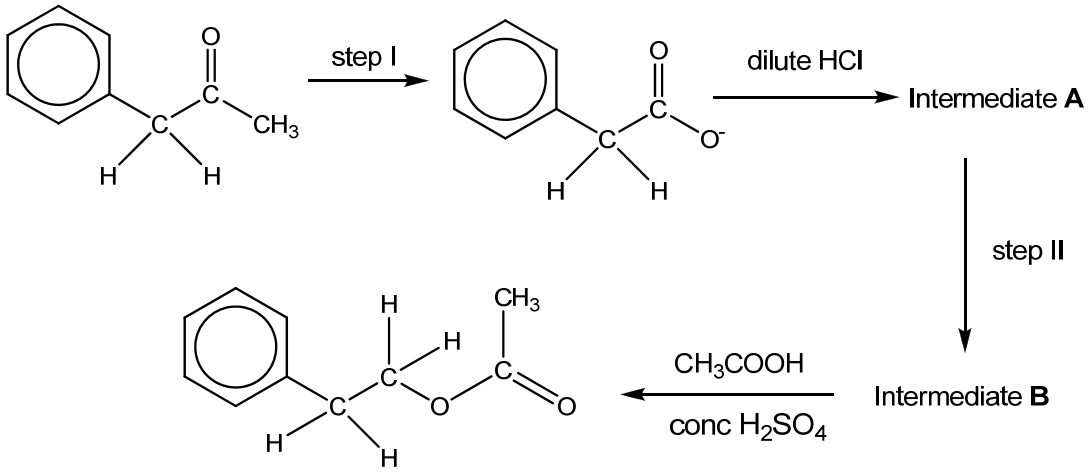
[2]

(c) Phenylacetone is used as an intermediate to produce pesticides and anticoagulants. It is also used as an intermediate to used in the clandestine synthesis of MDMA (3,4-methylenedioxymethamphetamine), commonly known as ecstasy.



Phenylacetone

Compound **W** can be synthesised from phenylacetone.



Compound **W**

Complete the synthesis route by giving the structures of Intermediates **A** and **B** as well as the reagents and conditions for steps I and II.

(i)

Intermediate **A**	Intermediate **B**

(ii) step I
Reagent(s) and Conditions:

……

step II
Reagent(s) and Conditions:

……

[4]
[Total: 8]

Section B

Answer <u>two</u> of the three questions on separate writing paper.

1 Iodine is poorly soluble in water. However, it dissolves in solutions containing iodide ions as the soluble I_3^- is formed.

The iodide ions and iodine molecules are in equilibrium with I_3^- (aq) ions as follows:
I_2 (aq) + I^- (aq) ⇌ I_3^-(aq)

0.080 mol of iodine and 0.058 mol of potassium iodide were dissolved in 500 cm^3 of water until equilibrium is reached.

(a) Write the K_c expression for the equilibrium above, stating its units. [1]

(b) If 0.0375 mol of iodine has reacted to reach equilibrium, find
(i) the amount of I_2, I^- ions and I_3^- ions at equilibrium, and
(ii) the equilibrium constant of the equilibrium obtained.
[3]

(c) The aqueous solution in part **(b)** is then shaken with 500 cm^3 of toluene (methylbenzene), and some of the iodine molecules present at equilibrium dissolves in the toluene layer.

A special type of equilibrium constant known as partition coefficient describes the way a solute is distributed between two immiscible solvents A and B. It is the proportion of the concentration of solute in the two immiscible solvents.

$$\text{Partition coefficient} = \frac{[\text{solute in solvent A}]_{organic}}{[\text{solute in solvent B}]_{aqueous}}$$

After some time, it is found that the concentration of iodine in the toluene (organic) layer is 0.084 mol dm^{-3}.

(i) Find the amount of iodine in the aqueous layer.

(ii) Hence, calculate the partition coefficient for iodine distributed between a layer of toluene and a layer of water at this temperature.
[3]

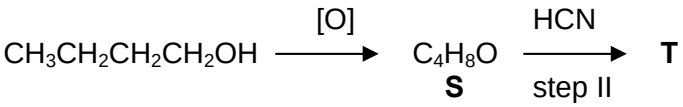
(d)
$$(CH_3)_2CHOH \xrightarrow{\text{step I}} (CH_3)_2CHBr \xrightarrow[\text{In ethanol}]{\text{KCN}} \mathbf{K} \xrightarrow{\text{heat with } H_2SO_4(aq)} \mathbf{L}$$

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

(ii) Identify the compounds **K** and **L** in the above reactions.

[3]

(e) **(i)** Identify **S** and **T**, the products of the following reactions.



(ii) State the type of reaction for step II.

[3]

(f) Compound **G**, C_7H_8O can be formed from Compound **F**, $C_6H_5CH_2Cl$.

(i) Suggest an identity for compound **G**.

(ii) Suggest reagent(s) and conditions for the conversion of compound **F** to compound **G** and state the type of reaction undergone.

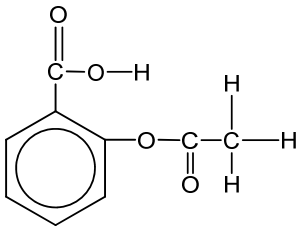
(iii) Draw the structural formula of the product when hot ethanolic KOH reacts with $C_6H_5CH_2CH_2Cl$ and state the type of reaction undergone.

(iv) Suggest simple test-tube reactions by which compound **F** and bromobenzene can be distinguished from each other. You should state the reagents and conditions for each test, and describe the observations.

[7]

[Total:20]

2 Aspirin, $C_8H_7O_2COOH$, is a salicylate drug, often used to relieve minor aches and pains and reduce fever. It is also used as an anti-inflammatory medication. It has been established that low doses of Aspirin may be given immediately after a heart attack to reduce the risk of another heart attack or of the death of cardiac tissue. Aspirin, $C_8H_7O_2COOH$ has the structural formula shown below:



Aspirin undergoes partial dissociation as follows:

$$C_8H_7O_2COOH \rightleftharpoons C_8H_7O_2COO^- + H^+$$

(a) **(i)** Define pH.

(ii) Calculate the $[H^+]$ that has dissociated from aspirin, $C_8H_7O_2COOH$ given that the percentage of dissociation is 5.62 % for 0.1 mol dm^{-3} of aspirin at 25 °C.

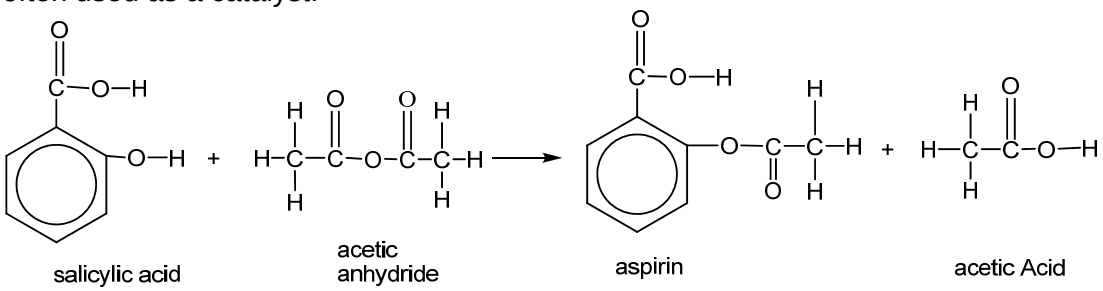
(iii) Write an expression for K_a and calculate its value.

(iv) When sodium hydroxide is reacted with excess aspirin, a buffer solution is formed. Write two equations to explain how the solution can control pH.

(v) Suggest a suitable indicator for the titration of aspirin and sodium hydroxide and explain the reason.

[9]

(b) The synthesis of aspirin is classified as an esterification reaction, where the alcohol group from the salicylic acid reacts with an acid derivative (acetic anhydride), yielding aspirin and acetic acid as a byproduct. Small amounts of sulfuric acid are often used as a catalyst.



(i) Calculate the mass of aspirin formed when 10 g of salicylic acid reacts with 20 g of acetic anhydride.

(ii) Why do formulations containing high concentrations of aspirin often smell like vinegar?

(iii) Suggest the type of reaction when aspirin reacts with sodium carbonate and draw the displayed formula of the organic product.

(iv) State the reagents and conditions to obtain salicylic acid from aspirin and write an equation.

[7]

(c) Gastric juice is a thin, acidic digestive fluid secreted by glands in the mucous membrane that lines the stomach. An average adult produces about 1 mole of gastric juice when pain is experienced. The gastric juice contains among other substances, 0.2 % hydrochloric acid.

An antacid is a substance which counteracts stomach acidity by raising the pH. One example is of Brand **A** antacid which contains 20 % magnesium carbonate. Brand **A** antacid is avaliable in 325 mg tablets.

(i) Write a balanced equation for the reaction of Brand **A** antacid with hydrochloric acid.

(ii) Calculate the number of tablets of Brand **A** antacid a person has to consume to remove the gastric juice.

[4]

[Total:20]

3 One of the methods of preparing esters is to react together an alcohol with a carboxylic acid. This process is reversible by the reaction called ester hydrolysis. An ester, RCOOR' is hydrolysed by dilute hydrochloric acid according to the equation:

$$RCOOR' + H_2O \overset{HCl}{\rightleftharpoons} RCOOH + R'OH$$

The table below lists the variation of the concentration of the ester with time for the two different experiments using different concentrations of hydrochloric acid at constant temperature.

Time/minute	[RCOOR'] / mol dm^{-3} when [HCl] = 0.20 mol dm^{-3}	[RCOOR'] / mol dm^{-3} when [HCl] = 0.40 mol dm^{-3}
0	0.160	0.160
25	0.120	0.090
50	0.090	0.054
75	0.070	0.030
100	0.054	0.018

(a) Plot these data on suitable axes.

(b) Use your graph to determine the order of reaction with respect to

(i) ester, RCOOR' using half-life method and

(ii) hydrochloric acid, HCl using initial rate method

(iii) Hence write the rate equation for the reaction and calculate the rate constant of the reaction, including units.

[8]

(c) Ethanol is the most important industrial chemical and is used as a solvent, fuel and an intermediate in large scale organic synthesis.

When 1.60 g of ethanol is burned, enough heat is produced to heat 250 g of water from 22.0 ºC to 67.0 ºC.

(i) Write a balance equation, with state symbols, which represents the standard enthalpy change of combustion of ethanol.

(ii) Use these data and values from the *Data Booklet* to calculate the enthalpy change of combustion of ethanol.

(iii) The standard enthalpy change of combustion of ethanol is –1371 kJ mol^{-1}. Suggest an explanation for the difference between this and your value calculated in (ii).

(iv) Use the bond energies in the *Data Booklet* to calculate a value of the standard enthalpy change of combustion of ethanol.

[6]

(d) The melting points of three oxides are given below.

Compound	Formula	Melting points / ºC
Sodium oxide	Na_2O	1275
Aluminium oxide	Al_2O_3	2072
Sulphur oxide	SO_3	17

(i) Briefly relate these melting points to the structure and bonding of each of these oxides.

(ii) Describe their solubilities in, and reaction with water. Give the approximate pH of any solution formed and write equations where appropriate.

[6]

[Total:20]

End of Paper