JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
CLASS		EXAM INDEX NUMBER	

CHEMISTRY

9647/02

Paper 2 Structured Questions

12 September 2012

2 hours

Candidates answer on Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class 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.

Answer **all** questions.
A *Data Booklet* is provided. Do not write anything on the *Data Booklet*.

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	
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6	
Total	

1. Planning (P)

You are to plan an investigation into the thermal decomposition of caesium nitrate, $CsNO_3$.

You may make use the following data when planning your investigation.

Data:

Group I element	cation	Ionic radius / nm
lithium	Li^+	0.060
sodium	Na^+	0.095
potassium	K^+	0.133
rubidium	Rb^+	0.148
caesium	Cs^+	0.176

Equation for the thermal decomposition of lithium nitrate and sodium nitrate are given below:

1. $4LiNO_3(s) \rightarrow 2Li_2O(s) + 4NO_2(g) + O_2(g)$
2. $2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$

Nitrogen dioxide gas	Oxygen gas
NO_2	O_2
brown in colour	colourless
soluble in water	almost insoluble in water
poisonous	powerful oxidant

1 mol of any gas occupies a volume of approximately 24 dm^3 at room temperature and atmospheric pressure.

A_r: Cs, 133; N, 14.0; O, 16.0

(a) Predict which of the equations below will represent the thermal decomposition of caesium nitrate. Place a tick against the equation of your choice.

$4CsNO_3(s) \rightarrow 2Cs_2O(s) + 4NO_2(g) + O_2(g)$	
$2CsNO_3(s) \rightarrow 2CsNO_2(s) + O_2(g)$	

Use the data provided to explain your prediction.

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1. **(b)** You are to plan an experiment in which

- caesium nitrate is heated
- gas is collected
- the volume of gas collected is measured
- the experimental results are used to confirm or reject your prediction

(i) Draw a diagram of the apparatus you would use in this experiment.

Your apparatus should use only standard items found in college laboratory.

Label each piece of apparatus used, indicating its size or capacity and state the gas or gases collected on your diagram.

[3]

(ii) Calculate the volume of gas you would expect to collect at room temperature and atmospheric pressure if 1 mol of caesium nitrate completely decomposed according to your predicted equation in **(a)**.

[1]

1. **(c)** Use your answer to **(b)(ii)** and the capacity of the apparatus selected in **(b)(i)** to calculate the maximum mass of $CsNO_3$ that can be used in your experiment.

[1]

(d) Outline, in a series of numbered steps, the method to be used in the experiment.

Make certain that the steps you describe are in the correct order.
You need not explain how the apparatus is assembled.
Indicate clearly how you will know when decomposition is complete.

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[3]

1. **(e)** What should be done when decomposition is complete to ensure that the volume of the gas measured in the apparatus is the "correct" volume?

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(f) Identify a risk present in the method you have described and suggest how you would minimise this risk.

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[Total: 12]

2. **(a)** **(i)** Write an equation for the reaction between chlorine and cold aqueous sodium hydroxide and state the type of reaction that occurs.

Type of reaction: ……

(ii) The resultant solution obtained in **(a)(i)** is heated and a further reaction occurs. Write an equation for the overall reaction between chlorine and sodium hydroxide.

[3]

(b) Chlorine forms a variety of oxides and oxoanions. A series of standard reduction potentials involving the chlorine oxoanions, in alkaline medium, are given below.

half-equation	$E^{\ominus}$/V
$ClO^- + H_2O + 2e^- = Cl^- + 2OH^-$	−0.89
$ClO_2^- + H_2O + 2e^- = ClO^- + 2OH^-$	−0.67
$ClO_3^- + H_2O + 2e^- = ClO_2^- + 2OH^-$	−0.33
$ClO_4^- + H_2O + 2e^- = ClO_3^- + 2OH^-$	−0.35

Using the above data and information in the *Data Booklet*, predict the final product formed when excess zinc metal is added to an alkaline solution of chlorate(V), ClO_3^-. Support your answer with $E^{\ominus}_{cell}$ calculations.

[4]

2. **(c)** Chlorine dioxide, ClO_2, is a highly reactive gas that is used as a disinfectant to kill water-borne bacteria, viruses and fungi.

Draw a 'dot-and-cross' diagram to show the arrangement of valence electrons in the ClO_2 molecule. Hence suggest why chlorine dioxide is highly reactive.

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(d) Despite having similar relative molecular mass, the boiling point of chlorine is −34 ^oC and that of chlorine dioxide is 11 ^oC.

Give an explanation to account for this large difference in boiling points.

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[Total: 11]

3. **(a)** Aluminium is obtained by electrolysis of molten Al_2O_3 using inert electrodes.

(i) Give ion-electron equations, with state symbols, for the electrode processes:

at the cathode: ……

at the anode: ……

(ii) Calculate the mass of aluminium produced when a current of 8 A is passed for 100 minutes through the molten Al_2O_3.

[5]

3. (b) The enthalpy change of formation of Al_2O_3 can be calculated from a Born-Haber cycle.

Construct the Born-Haber cycle for the formation of Al_2O_3, using the following data and relevant data from the *Data Booklet*. Hence, calculate the enthalpy change of formation of Al_2O_3.

	ΔH / kJ mol^{-1}
Enthalpy change of atomisation of aluminium	+644
Sum of 1st and 2nd electron affinities of oxygen	+702
Lattice energy of Al_2O_3	–13311

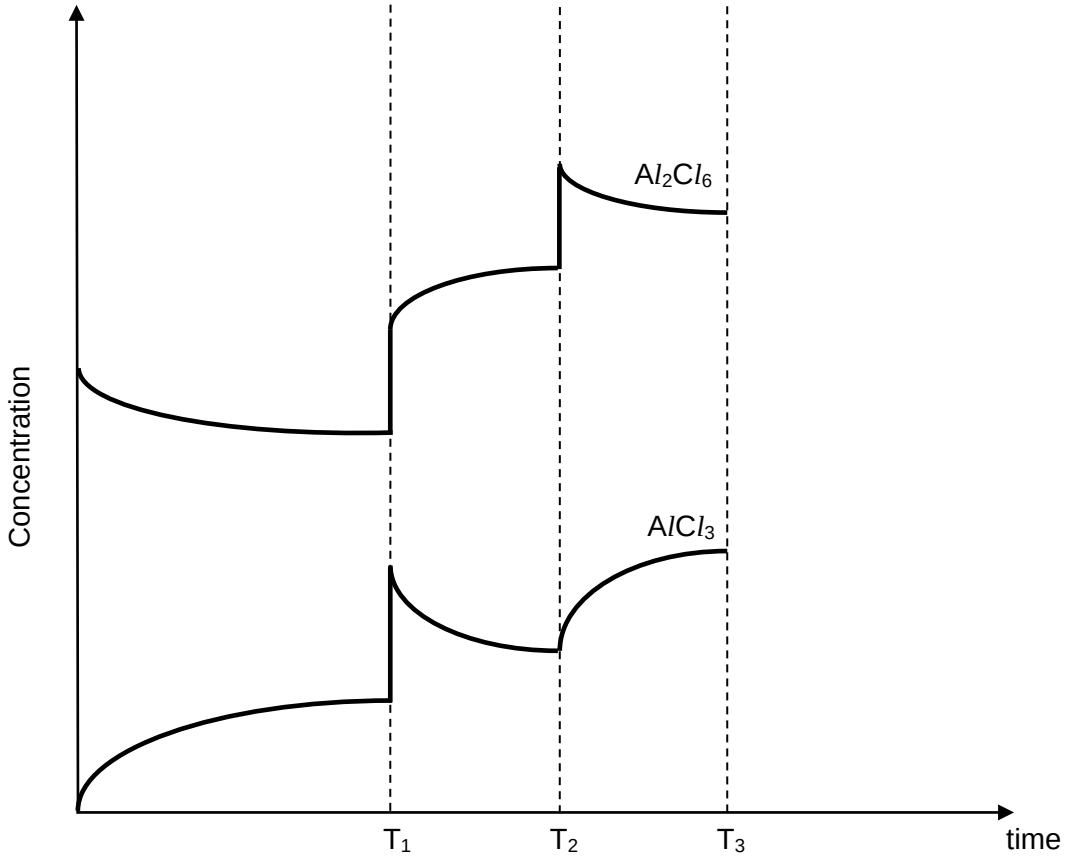
[5]

3. (c) Aluminium chloride exists in two different forms in the vapour state. When some Al_2Cl_6 was added into a reaction vessel, the following equilibrium is slowly set up.

$$Al_2Cl_6(g) = 2AlCl_3(g)$$

At different times during the experiment, changes were made to the conditions in the reaction vessel. At each time, there was only one change made to the condition in the reaction vessel.

The change in the concentrations in the equilibrium mixture with time is shown in the graph below.



(i) Suggest the changes that caused the equilibrium shifts at time:

T_1: ……

T_2: ……

(ii) Explain whether the conversion of Al_2Cl_6 to $AlCl_3$ is expected to be exothermic or endothermic.

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3. (c) (iii) Sketch on the same axes of the given graph on **page 9**, the changes in the concentration of Al_2Cl_6 and $AlCl_3$ when the mixture was cooled at time T_3.

Explain your answer with reference to your conclusion made in **(c)(ii)**.

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(iv) At a total pressure of 1 atm and 673 K, Al_2Cl_6 was 30% dissociated into $AlCl_3$.

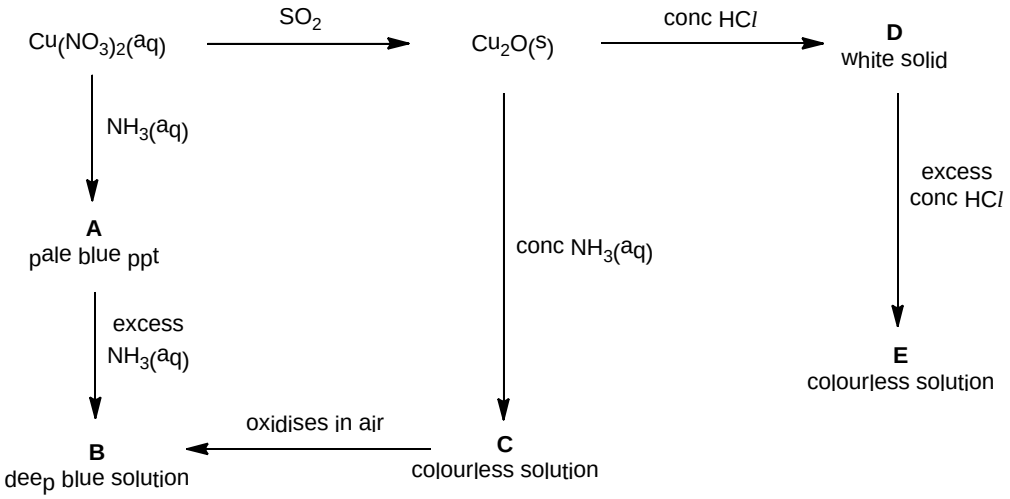
Calculate the equilibrium constant, K_p, including its units, at 673 K.

[9]

[Total: 19]

4. **(a)** Copper is a transition element that forms a rich variety of compounds with varying oxidation states.

$Cu(NO_3)_2(aq)$ is a blue solution which can undergo the following reactions.



B, **C** and **E** contain complex ions of copper.
Both compound **D** and complex ion **E** contain copper and chlorine only.
The oxidation number of copper in **C**, **D** and **E** are the same.

(i) What are the formulae of the compound **A** and of the cation present in **B**?

A: …… **B**: ……

(ii) Suggest a balanced equation for the formation of **B** from **A**.

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(iii) State the role of SO_2 in the conversion of $Cu(NO_3)_2$ to Cu_2O.

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(iv) The composition of complex ion **C** by mass is Cu, 65.1%, N, 28.7%, H, 6.2%.

Use the data to determine the empirical formula and identity of complex ion **C**.

4. **(a)** **(v)** Suggest the formulae of compound **D** and complex ion **E**, given that the coordination number of Cu in complex ion **E** is the same as that in **C**.

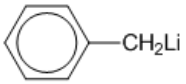
D: …… **E**: …… [8]

(b) Copper forms a very useful group of organic compounds known as Gilman reagents.

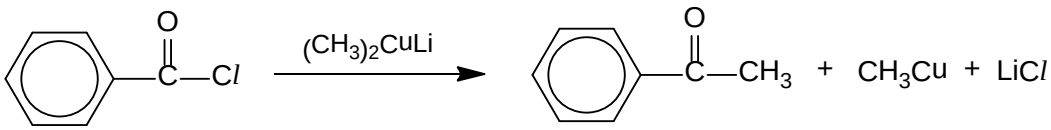
Gilman reagents can react with alkyl halides via nucleophilic substitution to form alkanes. An example is shown below:

Step 1: $2CH_3Li$ + CuI ⟶ $(CH_3)_2CuLi$ + LiI
methyllithium *Gilman reagent*

Step 2: CH_3CH_2Cl $\xrightarrow{(CH_3)_2CuLi}$ $CH_3CH_2CH_3$ + CH_3Cu + $LiCl$
chloroethane

(i) Suggest the structural formula of the final organic product formed when phenyllithium,  , and bromoethane are used in a similar two-step process.

(ii) Gilman reagents can also react with acyl chlorides to form ketones. An example is shown below:



It is observed that the reaction with acyl chlorides takes place much more readily than that with alkyl chlorides. Explain why this is so.

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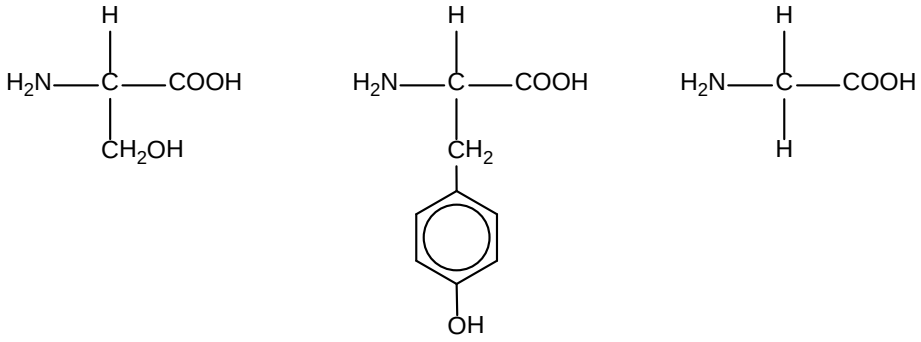
[Total: 11]

5. **(a)** The Green Fluorescent Protein (GFP) is a protein that can be isolated from the jellyfish, *Aequorea victoria*, and it can exhibit bright green fluorescence when exposed to ultraviolet light. The chromophore is the section of the GFP that fluoresces and contains the amino acid sequence *ser-tyr-gly*.



ser tyr gly

(i) Draw the structure of this section of the GFP at pH 14.

(ii) GFP has a beta barrel structure, consisting of one *b*-pleated sheet and *a*-helices running through the centre of the barrel structure.

Sketch a labelled diagram to show how the *β*-pleated sheet structure of proteins is stabilised, showing clearly the stabilising bonds involved.

[4]

5. **(b)** A venomous jellyfish has tentacles containing 'stinging cells' that inject venom into the skin of a victim. The venom is made up of a diverse variety of proteins and polypeptides capable of inflicting pain and swelling.

The most common first-aid treatment of jellyfish stings is to get the victim out of water, scrape off any attached tentacles with a hard object and rinse the affected area with hot seawater to deactivate the venom.

Explain how the application of heat is effective in treating jellyfish stings.

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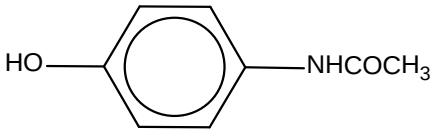
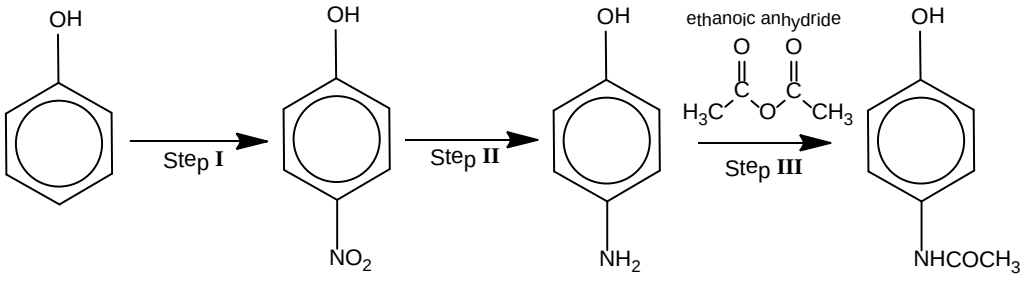
(c) Paracetamol is usually prescribed to the victim to reduce the pain from jellyfish stings.



Paracetamol

A student suggested that paracetamol can be synthesised from phenol, via a three-step reaction sequence as proposed below.



4-aminophenol paracetamol

(i) What types of reaction take place in Step **I**, **II** and **III**?

Step **I**: .....

Step **II**: .....

Step **III**: .....

5. **(c)** **(ii)** State the reagents and conditions needed for Step **I** and **II**.

Step **I**: .....

Step **II**: .....

(iii) In actual practice, 4-aminophenol is used instead as the starting material and only Step **III** is carried out.

Given that both phenol and 4-aminophenol are easily available, suggest a reason why phenol is not used as the starting material.

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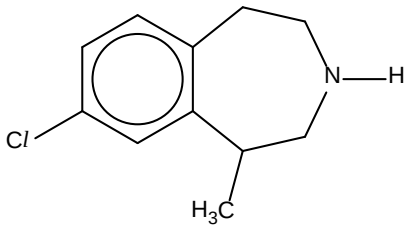
[Total: 13]

6. *Lorcaserin* (Trade name: Belviq®) is a weight-loss drug developed by Arena Pharmaceuticals in San Diego and is recently approved by the US Food and Drug Administration in June 2012 for use in the treatment of obesity for adults.



Lorcaserin

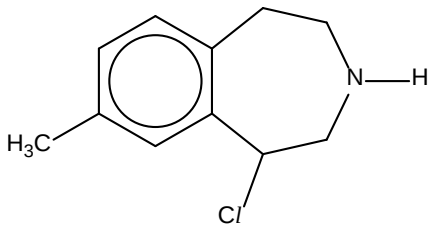
(a) Draw the structures of the organic compounds formed when *Lorcaserin* is treated with the following reagents.

(i) ethanoyl chloride

(ii) excess CH_3Cl

[2]

6. (b) An isomer of *Lorcaserin* (compound **Y**) is shown below.



compound **Y**

Suggest a chemical test that could be used to distinguish compound **Y** from *Lorcaserin*. You should state what you would observe for **each** compound in the test.

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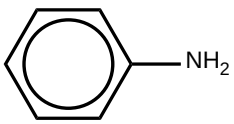
(c)



phenylamine

Explain how the basicity of *Lorcaserin* might compare with that of phenylamine.

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[Total: 6]