JURONG JUNIOR COLLEGE
2015 JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME	
CLASS	**15S**

CHEMISTRY

9647/02

Paper 2 Structured Questions

28 August 2015
2 hours

Candidates answer on the Question Paper.
Additional Materials: 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.

Answer **all** the questions.
The use of an approved scientific calculator is expected, where appropriate.
A *Data Booklet* is provided.

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	**12**
2	**13**
3	**10**
4	**11**
5	**13**
6	**13**
Penalty (delete accordingly)	
Lack **3sf** in final ans	**–1 / NA**
Missing/wrong **units** in final ans	**–1 / NA**
Incorrect Bond linkages	**–1 / NA**
Total	**72**

Answer **all** the questions.

For Examiner's Use

1 Planning (P)

Calcium hydroxide is an ionic solid that dissolves sparingly in water to form ions.

$$Ca(OH)_2\,(s) = Ca^{2+}\,(aq) + 2OH^-\,(aq)$$

It is possible to determine the solubility product of calcium hydroxide by measuring the concentration of Ca^{2+} in a saturated calcium hydroxide solution using *atomic absorption spectroscopy*. Atomic absorption spectrometry is an analytical technique which allows you to measure the concentration of a specific ion in the sample.

For this experiment, a sample containing Ca^{2+} is placed into the atomic absorption spectrophotometer. In the machine, a specific wavelength which corresponds to calcium is shone onto the sample and the amount of radiation absorbed is measured. The amount of radiation absorbed is expressed as an absorbance value. The higher the concentration of Ca^{2+} in the sample, the higher the absorbance value.

To determine the concentration of Ca^{2+} in a saturated calcium hydroxide solution, a series of known, but different, concentrations of Ca^{2+} solutions is prepared. The atomic absorption spectrophotometer is used to measure the absorbance value of Ca^{2+} in each solution. A graph of absorbance value against concentration of Ca^{2+} is then plotted. This graph is known as a calibration line, which can be used to determine the concentration of Ca^{2+} in unknown solutions.

The experiment is then repeated using a saturated solution of calcium hydroxide. By comparing the absorbance of this solution with the calibration line, the concentration of calcium hydroxide in the saturated solution can be determined.

(a) Using the information given above, you are required to write a plan to determine the concentration of Ca^{2+} in a saturated calcium hydroxide solution at 25°C.

You may assume that you are provided with:

- 0.0500 mol dm^{-3} Ca^{2+} stock solution which should be diluted before the absorbance is measured.
- solid calcium hydroxide, $Ca(OH)_2$;
- an atomic absorption spectrophotometer and instructions for its use;
- graph paper;
- the apparatus and chemicals normally found in a school or college laboratory.

Your plan should include details of:

- the preparation of a suggested number of diluted Ca^{2+} solutions of accurate concentrations from 0.00500 mol dm^{-3} to 0.0250 mol dm^{-3} using 25.0 cm^3 graduated flasks;
- an outline of how you will obtain the results needed to plot the calibration line;
- a sketch of the calibration line you would expect to obtain;
- the preparation of a saturated solution of calcium hydroxide;
- how the calibration line would be used to determine the concentration of Ca^{2+} in the prepared saturated calcium hydroxide solution.

For Examiner's Use

1 (a)

For Examiner's Use

1 (a) ……

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…… [10]

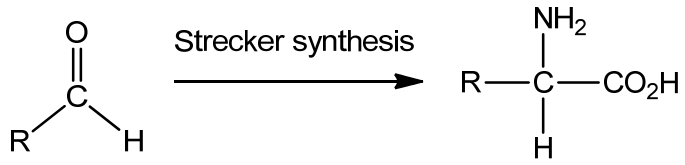
(b) Assuming the concentration of Ca^{2+} in the prepared saturated calcium hydroxide solution obtained in **(a)** is x mol dm^{-3}, calculate the solubility product of calcium hydroxide, stating its units.

[2]

[Total: 12]

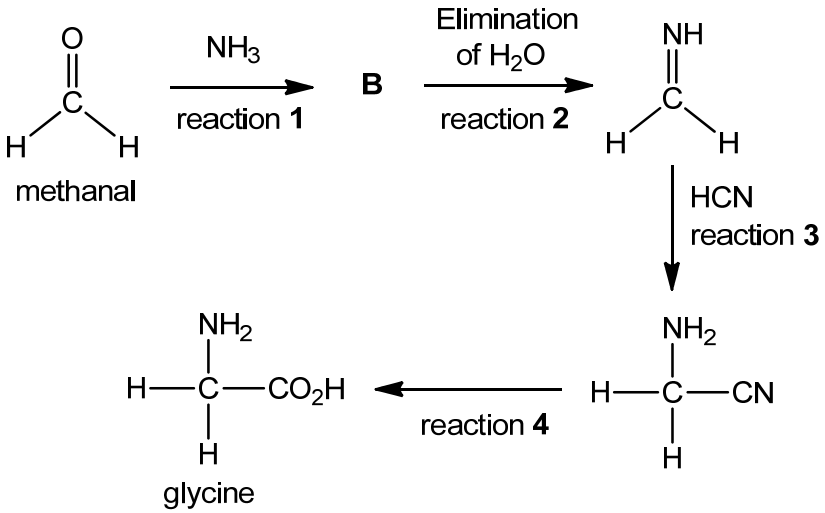
For Examiner's Use

2 The Strecker synthesis is a route to prepare amino acids.



Glycine, 2-aminoethanoic acid, can be prepared from methanal in this way.

The reaction is thought to proceed through the following stages.



(a) On the structure of methanal given above, circle the atom that is attacked by the ammonia molecule. [1]

(b) State the role of ammonia in reaction **1**.

……. [1]

(c) Suggest the structure of compound **B**.

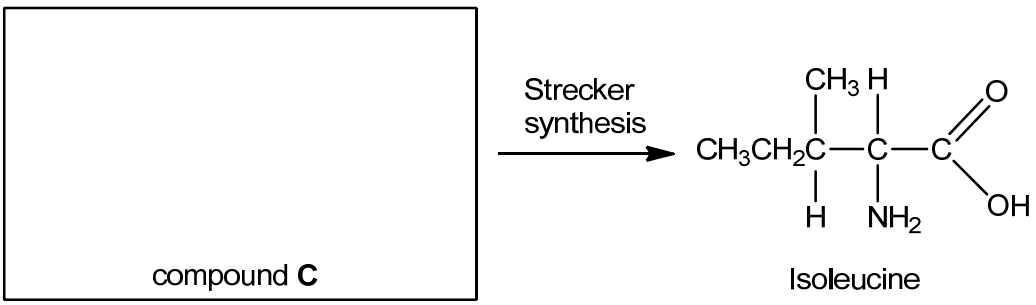
[1]

(d) State the type of mechanism that occurs in reaction **3**.

……. [1]

(e) Isoleucine can be produced from compound **C** using Strecker synthesis.

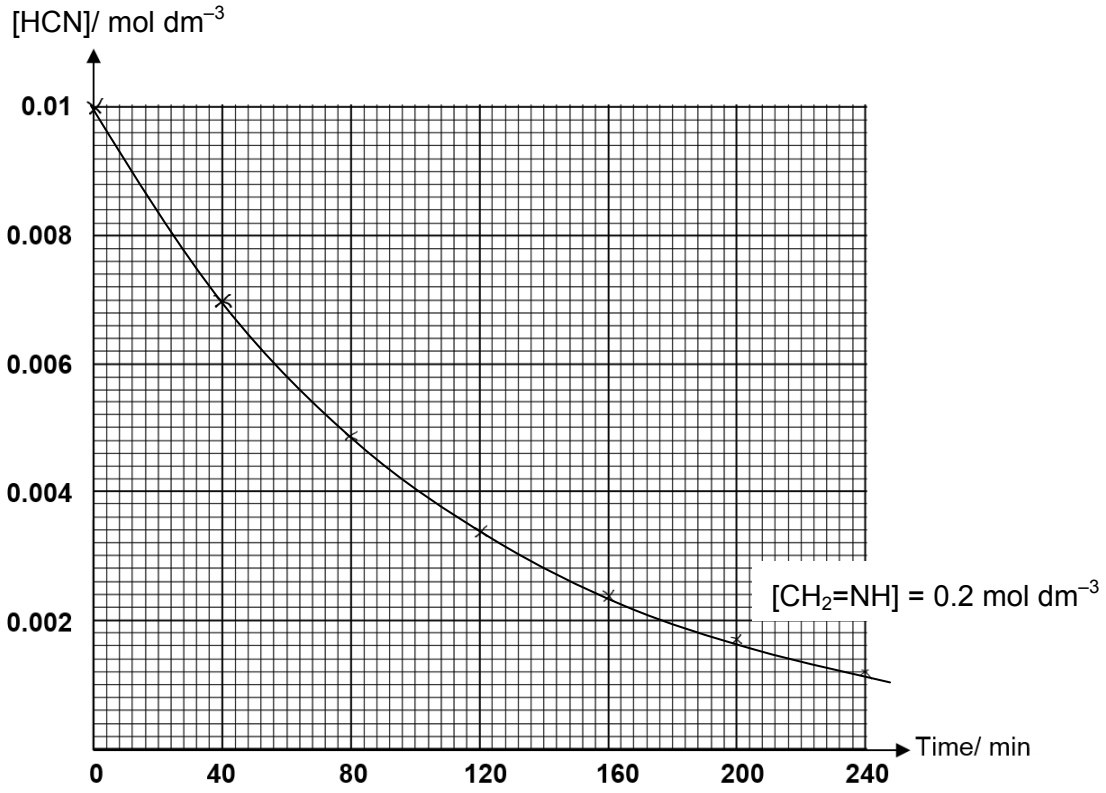
Suggest the structure of compound **C**.



[1]

For Examiner's Use

2 (f) Reaction **3** in the Strecker synthesis involves the reaction between HCN and CH_2=NH. The kinetics of this reaction was determined by monitoring the change in the [HCN] with time using initial concentrations of 0.01 mol dm^{-3} HCN and 0.2 mol dm^{-3} CH_2=NH. The following graph was obtained.



(i) Use the graph above to show that the reaction is first order with respect to [HCN].

…...……...

…...……... [1]

(ii) The experiments were repeated at the same temperature using 0.01 mol dm^{-3} HCN and 0.1 mol dm^{-3} CH_2=NH and a similar graph was plotted. The gradient at each point was halved that obtained from the graph above.

What is the order of reaction with respect to [CH_2=NH]? Explain your answer.

…...……...

…...……...

…...……... [2]

(iii) Construct the rate equation for reaction **3**.

…… [1]

For Examiner's Use

2 (f) (iv) Calculate the value of rate constant and give its units.

[3]

(v) Predict the half life of HCN if the experiment was repeated at the same temperature with 0.02 mol dm^{-3} HCN and 0.2 mol dm^{-3} CH_2=NH.

…… [1]

[Total: 13]

For Examiner's Use

3 The reaction between lead metal and Cr^{3+} ions is an equilibrium reaction.

$$Pb(s) + 2Cr^{3+}(aq) \rightleftharpoons Pb^{2+}(aq) + 2Cr^{2+}(aq)$$

(a) Write the expression for K_c of this reaction, and state its units.

[2]

(b) Some lead metal and a solution of $Cr^{3+}(aq)$ were mixed together, and allowed to reach equilibrium.

The concentrations at equilibrium of $Cr^{3+}(aq)$ and $Cr^{2+}(aq)$ were as follows.

$$[Cr^{3+}(aq)] = 0.200 \text{ mol dm}^{-3}$$

$$[Cr^{2+}(aq)] = 2.96 \times 10^{-4} \text{ mol dm}^{-3}$$

(i) Calculate the concentration of $Pb^{2+}(aq)$ at equilibrium.

[1]

(ii) Hence, calculate the value of K_c for this reaction.

[1]

(iii) Suggest what is the significance of the magnitude of your answer in **(b)(ii)**.

…...……...

…...……...

…...……... [1]

3 **(c)** When aqueous sodium sulfate was added to the reaction mixture at equilibrium, a white precipitate was produced.

(i) State the identity of the white precipitate that was produced.

…..……..……..…… [1]

(ii) State and explain how the addition of aqueous sodium sulfate will affect the equilibrium position and the value of K_c for this reaction.

…..……...

…..……...

…..……...

…..……...

…..……...

…..……... [4]

[Total: 10]

4 **(a)** Compound **D**, $CH(OH)=CHCO_2H$, exists as a pair of geometrical isomers.

(i) Draw the structures of the two geometrical isomers in the table provided.

	cis isomer	*trans* isomer
Structure		
Boiling point/ °C	240	262

[2]

(ii) Explain why the *cis* isomer has a lower boiling point.

……....

……....

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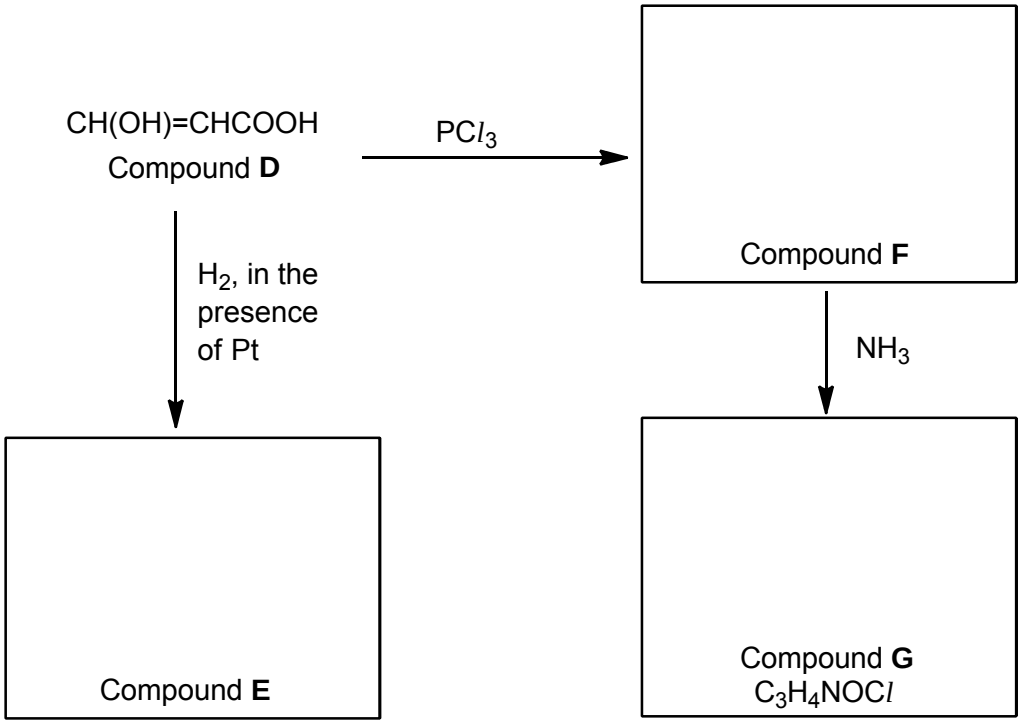
…….... [2]

For Examiner's Use

4 (b) Compound **D** undergoes reactions with the following reagents in the scheme provided below.



Draw the structural formulae of **E**, **F** and **G** in the boxes provided. [3]

(c) Compound **D** reacts with sodium bromide in the presence of concentrated sulfuric acid to form compound **H**, $C_3H_5O_3Br$.

(i) The reaction occurs in two stages, the first between inorganic reagents only and the second involving compound **D**.

Write an equation for each of these stages, showing the structural formula of compound **H** clearly in your equation.

Stage I: ……..

Stage II: ……. [2]

(ii) When concentrated sulfuric acid is added in this reaction, cooling is necessary. If the temperature is not controlled carefully, an inorganic by-product that also reacts with compound **D** may be produced.

Give the identity of this inorganic by-product and write an equation to show how it is formed.

Inorganic by-product: …….

Equation: …….. [2]

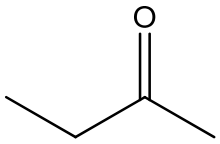
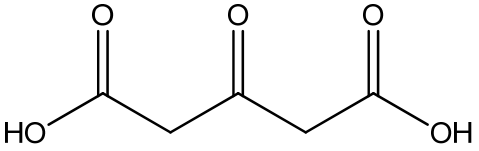
[Total: 11]

For Examiner's Use

5 **P** and **Q** are compounds containing the same functional groups.

Both compounds

- readily decolourise bromine in the dark
- liberate a gas with sodium metal
- do not have O atom bonded to an unsaturated carbon atom
- react with hot concentrated, acidified potassium manganate(VII) to give the products as shown in the table below.

Compound	Products of oxidation
P ($C_6H_{12}O$)	 and CO_2
Q (C_5H_8O)	

(a) Considering the molecular formulae of the two compounds together with the information given above, name the two functional groups that are present in compounds **P** and **Q**.

Functional groups present: …….. and …… [2]

(b) Suggest the structures of compounds **P** and **Q**.

Compound **P**	Compound **Q**
P ($C_6H_{12}O$)	**Q** (C_5H_8O)

[2]

5 (c) **R** and **S** have the same two functional groups as **P** and **Q**. Upon strong oxidation, the following products are obtained as shown in the table.

Compound	**Products of oxidation**
R ($C_5H_{10}O$)	**T** ($C_3H_4O_3$) and CH_3CO_2H
S ($C_7H_{14}O$)	**U** ($C_6H_{12}O_2$) and CO_2

The following four reagents were used to test compounds **R**, **S**, **T** and **U** and the results are shown in the table below.

Test reagent	**Result of test with**			
	Compound **R**	Compound **S**	Compound **T**	Compound **U**
Na(s)	fizzes	fizzes	fizzes	fizzes
$NaHCO_3$(aq)	No reaction	No reaction	fizzes	No reaction
I_2(aq) + OH^-(aq)	Yellow ppt	No reaction	Yellow ppt	No reaction
2,4-DNPH	No reaction	No reaction	Orange ppt	Orange ppt

(i) By considering the test results with Na(s) and $NaHCO_3$(aq), name the functional group that is present in **T** and **U**.

Functional group present in **T**: ……..

Functional group present in **U**: …….. [1]

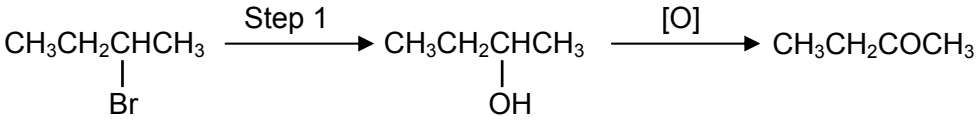
(ii) Suggest the structures of compounds **R**, **S**, **T** and **U**.

Compound **R**	Compound **S**
R ($C_5H_{10}O$)	**S** ($C_7H_{14}O$)
Compound **T**	Compound **U**
T ($C_3H_4O_3$)	**U** ($C_6H_{12}O_2$)

[4]

For Examiner's Use

5 **(d)** $CH_3CH_2COCH_3$, one of the products of the oxidation of **P,** can be synthesised from 2-bromobutane in two steps.



2-bromobutane

(i) State the reagents and conditions required and the type of reaction undergone for Step 1.

Reagents and condition: ……..……..

Type of reaction: ……..…… [2]

(ii) The reaction in Step 1 is followed in a polarimeter, which measures the angle of rotation caused by passing polarised light through an optically active molecule.

When 2-bromobutane undergoes the reaction in Step 1, the optical activity is observed to change gradually from −23.1° to +13.5°, showing that the stereochemistry of the molecule has been inverted.

Describe the mechanism for the reaction that is taking place in Step 1.

[2]

[Total: 13]

For Examiner's Use

6 **(a)** **(i)** Complete the electronic configuration for

Cu^+ ion: $1s^2 2s^2 2p^6 3s^2 3p^6$……

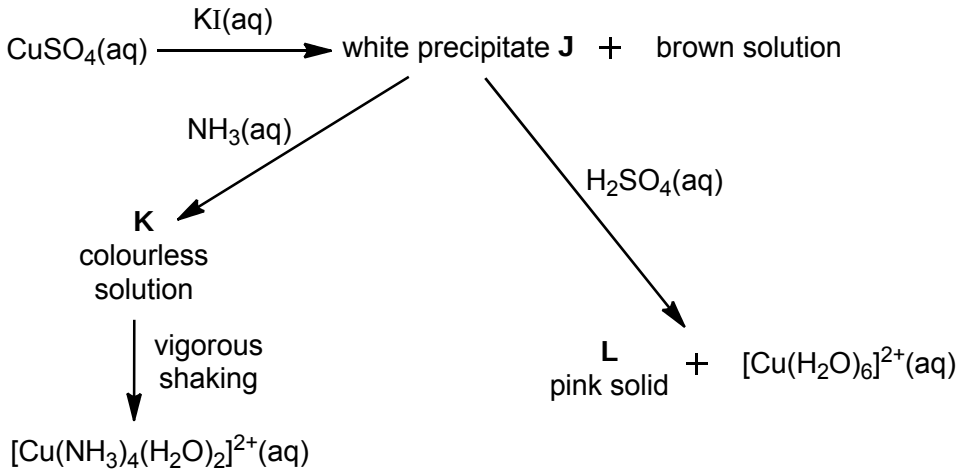
Cu^{2+} ion: $1s^2 2s^2 2p^6 3s^2 3p^6$…… [2]

(ii) State the colours of the following complex ions.

$[Cu(H_2O)_6]^{2+}$: ……..……..

$[Cu(NH_3)_4(H_2O)_2]^{2+}$: …… [1]

(b) Copper(II) sulfate can undergo a series of reactions as shown in the reaction scheme below.



(i) Identify the white precipitate **J** and write a balanced ionic equation, including state symbols, for its formation.

White precipitate **J**: …….

Equation: ……..……. [2]

(ii) When concentrated ammonia solution is added to the white precipitate **J**, a colourless solution of a copper complex is obtained. Complex **K** is linear in shape. Suggest the formula of **K**.

Formula of **K**: …… [1]

(iii) Suggest why **K** changes into $[Cu(NH_3)_4(H_2O)_2]^{2+}$ on shaking.

……..……... [1]

(iv) When aqueous sulfuric acid is added to the white precipitate **J**, a pink solid, **L**, and $[Cu(H_2O)_6]^{2+}$ are obtained. Suggest the identity of solid **L** and state the type of reaction that has occurred in this reaction.

Solid **L**: ……..……

Type of reaction: ……. [2]

6 (c) (i) $Cu(NO_3)_2$ decomposes in the same manner as Group II nitrates.

Write an equation for the reaction that occurs when a solid sample of anhydrous $Cu(NO_3)_2$ is strongly heated.

……..……..……..…… [1]

(ii) Using suitable data from the *Data Booklet*, compare the thermal stabilities of $Cu(NO_3)_2$ and $Ca(NO_3)_2$. Explain your answer.

……..……..……..……

……..……..……..……

……..……..……..……

……..……..……..……

……..……..……..…… [2]

(iii) The decomposition temperatures for the following metal nitrates are shown in the table below.

Metal nitrates	**Decomposition Temperature / °C**
$Mg(NO_3)_2$	330
$Ca(NO_3)_2$	561
$Sr(NO_3)_2$	570
$Ba(NO_3)_2$	592

Using the data given in the table and suitable data from the *Data Booklet*, suggest a likely decomposition temperature for $Cu(NO_3)_2$.

Decomposition temperature for $Cu(NO_3)_2$ = ……. °C [1]

[Total: 13]

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