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

CANDIDATE NAME			
CLASS		INDEX NUMBER	

CHEMISTRY

9647/02

Paper 2 Structured Questions

14 September 2011

2 hour

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	/15
3	/12
4	/9
5	/13
6	/11
Significant figures	
Handwriting	
Total	/72

This document consists of **18** printed pages and **2** blank pages.

Answer ALL questions on the spaces provided.

For Examiner's Use

1 You are given a number of different acids to investigate how the enthalpy change of neutralisation, $\Delta H_{neutralisation}$, varies when the acids are neutralised with aqueous sodium hydroxide, NaOH.

(a) (i) Hydrochloric acid, nitric acid and sulfuric acid are all strong acids.

Predict how $\Delta H_{neutralisation}$ values for these acids would compare with each other.

.....

.....

(ii) Predict and explain how the expected $\Delta H_{neutralisation}$ for a weak acid, such as ethanoic acid or ethanedioic acid, compares with that for hydrochloric acid.

.....

.....

.....

[2]

(b) (i) Draw and label a diagram of the apparatus you would use to determine the temperature change, ΔT, when each of the acids reacts with 30.0 cm^3 of 2.0 mol dm^{-3} aqueous sodium hydroxide.

Any experimental method that is normally carried out in a college laboratory may be used.

For Examiner's Use

(ii) Identify **one** possible source of error in the experiment and state how you would minimise the effect.

.....

.....

.....

.....

[3]

(c) In each experiment, 30.0 cm^3 of 2.0 mol dm^{-3} aqueous NaOH is to be used. Suggest appropriate volumes for each of the acids to be used in the individual experiments.

Acid		Volume/ cm^3	Concentration/ mol dm^{-3}
Hydrochloric	HC*l*		2.0
Ethanedioic	$(CO_2H)_2$		1.0

[1]

(d) Ethanedioic acid is a hydrated crystalline solid, $(CO_2H)_2.2H_2O$.

Outline how you would prepare 100 cm^3 of 1 mol dm^{-3} solution of ethanedioic acid. In your answer, you should show how you determine the initial mass of ethanedioic acid to be used. [*A*r: C, 12.0; H, 1.0; O, 16.0]

[You are given more writing space on the following page]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

For Examiner's Use

.....

.....

.....

.....

.....

[4]

(e) Using the volume and concentration from **(c)** and ΔT to represent the temperature change, derive a mathematical expression for the enthalpy change of neutralisation of sodium hydroxide with hydrochloric acid.
[4.3 J of heat energy raise the temperature of 1 cm^3 of any solution by 1 °C]

[1]

(f) Suggest what modification you could make to your experimental procedure to ensure **complete neutralisation** of the acid.

.....

.....

[1]

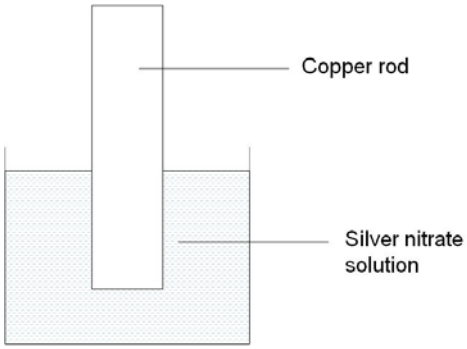
[Total: 12]

BLANK PAGE

For Examiner's Use

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

(a) The diagram below shows an experimental setup when a copper rod is dipped into a silver nitrate solution. After one hour, the copper rod is coated with a shiny substance and the solution turned slightly blue.



(i) Write an **ionic** equation, with state symbols, for the reaction that has occurred.

.....

(ii) Given that $\Delta G^{\theta} = -nFE^{\theta}$, where n is the number of moles of electrons transferred in the reaction, and E^{θ} is the electromotive force generated, calculate ΔG^{θ}, in kJ mol^{-1}, of the above reaction at standard conditions.

(iii) Suggest and explain if the above reaction has a positive or negative ΔS^{θ}.

.....

.....

[4]

For Examiner's Use

(b) In the laboratory, there are three bottles labelled **N**, **P** and **Q**. Each bottle contains one of the following reagents:

Cl_2(aq), NaI(aq) and KBr(aq)

Three tests were carried out using the reagents in the bottles. The results are summarised in the table below:

Test	Procedure	Observations
1	Mix reagent in bottle **N** with reagent in bottle **P**	No Change
2	Mix reagent in bottle **N** with reagent in bottle **Q**	Mixture turn brown
3	Mix reagent in bottle **P** with reagent in bottle **Q**	Mixture turn brown

(i) Deduce and explain which bottle contains Cl_2(aq). Write chemical equations with state symbols to support your reasoning.

……...

……....

……...

……....

……...

……....

(ii) To determine which bottle contains NaI(aq) and KBr(aq) respectively, tests 2 and 3 were repeated. Hexane was added to the resulting reaction mixture after the tests were conducted. The bottles were then shaken and allowed to stand.

State the observations which will help to identify which bottle contains NaI(aq) and KBr(aq) respectively.

……...

……....

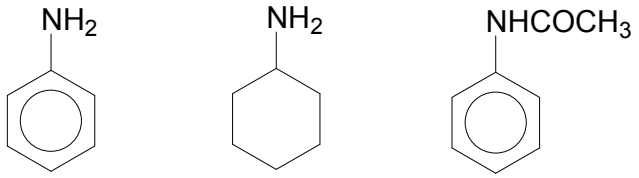
……...

……....

[5]

For Examiner's Use

(c) Arrange the following compounds in order of decreasing pK_b, giving reasons for your answer.



Highest pK_b	→	Lowest pK_b

……

……

……

……

……

……

……

[3]

(d) Magnesium hydroxide is an inorganic compound with the chemical formula $Mg(OH)_2$. A suspension of $Mg(OH)_2$ in water is often called 'milk of magnesia' because of its milk-like appearance. It is commonly used in laxatives.

(i) Write an expression for the K_{sp} of $Mg(OH)_2$.

……

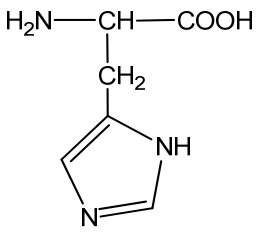
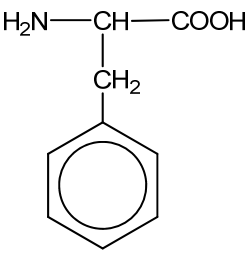
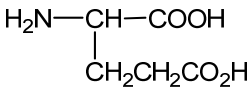
(ii) Calculate the concentration of $Mg^{2+}(aq)$ in a saturated solution of $Mg(OH)_2$, given that the pH of the solution is 9.25. You are given that K_{sp} of $Mg(OH)_2$ is 1.8×10^{-12} mol^3 dm^{-9}.

[3]

[Total: 15]

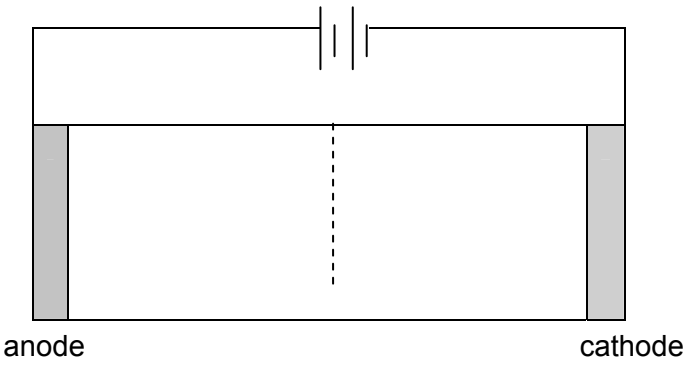
For Examiner's Use

3 **(a)** Keratin is a fibrous protein found in fingernails. A tripeptide, his-phe-glu, obtained from Keratin was further hydrolysed to obtain the individual amino acids.

Amino Acid			
	his	phe	glu
Isoelectric point	7.58	5.48	3.10

The individual amino acids were added to a buffer solution of pH 6.5 and placed at the centre of the gel electrophoresis plate. A potential difference was then applied across the plate.

(i) Indicate the relative positions of the amino acids on the diagram below. In your answer, use the labels "○**his**", "○**phe**" and "○**glu**" to represent the amino acids his, phe and glu respectively.



[2]

(ii) Draw the displayed formula of phe in the buffer solution at pH 6.5.

[1]

For Examiner's Use

(b) Explain why precipitation is seen when drops of dilute acid are added to Keratin.

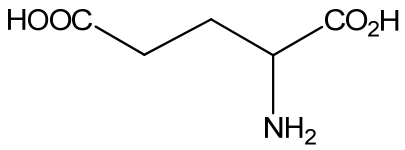
……

……

……

[2]

(c) The formation of GABA, an inhibitory neurotransmitter in the brain and retina, comes from the metabolism of glutamic acid.



glutamic acid

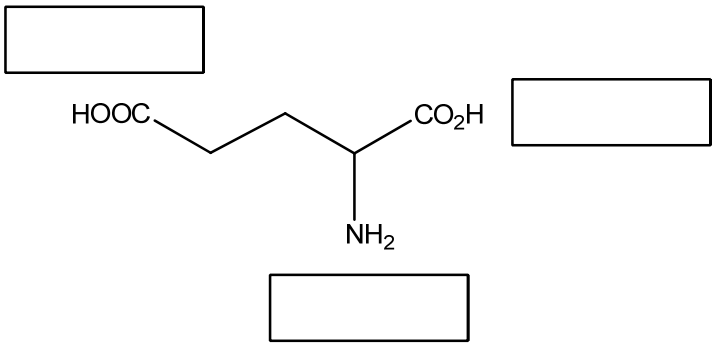
(i) Explain what is meant by the term pK_a as applied to a weak acid HA.

……

……

[1]

(ii) There are three pK_a values associated with glutamic acid: 2.2, 3.9 and 9.7. Assign the pK_a values to the appropriate functional groups present in glutamic acid.



[1]

For Examiner's Use

(iii) Make use of these pK_a values to suggest the major species present in solutions of glutamic acid with the following pH values.

At pH=3	At pH=11

[2]

(iv) Compound **R** can be used as a precursor of GABA.

$HO_2C–CH_2CH_2CH_2OH$

R

Both glutamic acid and **R** have similar relative molecular masses. Based on melting point analysis, it was found that glutamic acid has a much higher melting point than **R**. Explain the difference in their melting points.

……...

……...

……...

……...

……...

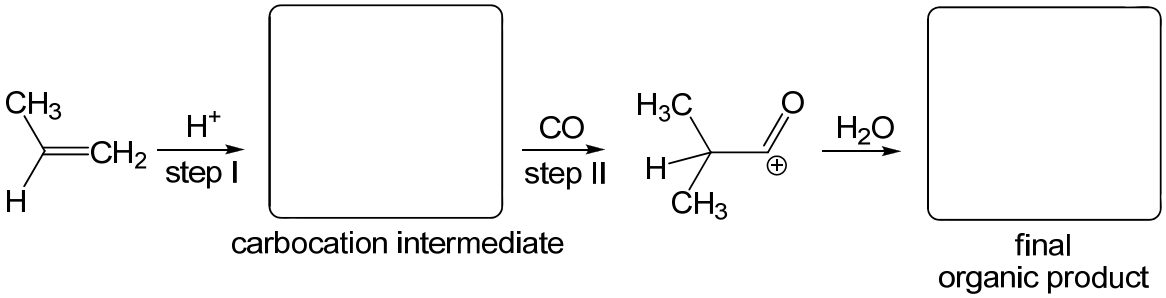
[3]

[Total: 12]

For Examiner's Use

4 Alkenes are very reactive due to the presence of unsaturation.

In the Koch reaction, alkenes can react with carbon monoxide and water to form carboxylic acids. The reaction scheme below shows propene undergoing the Koch reaction.



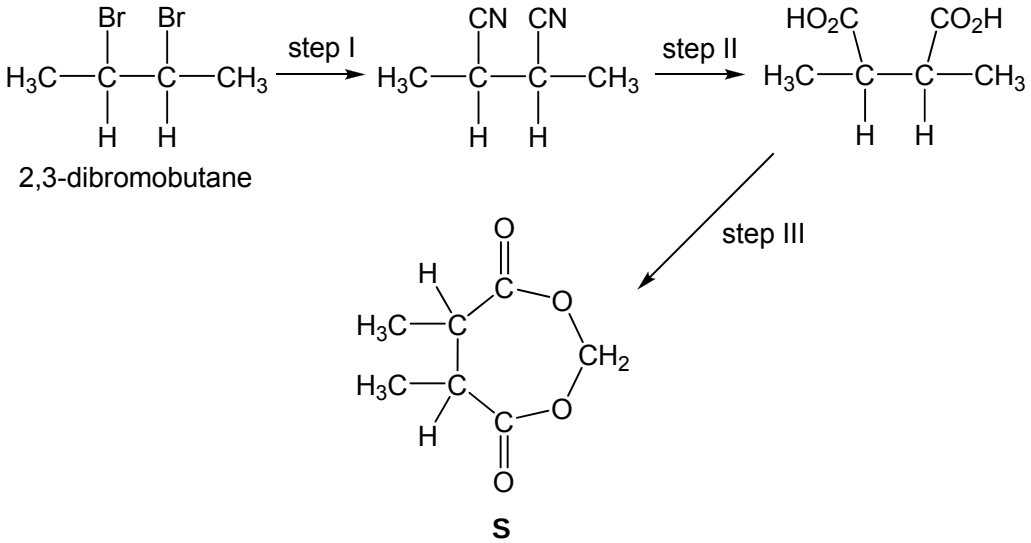
(a) **(i)** Alkenes undergo electrophilic addition in the presence of electrophiles such as H^+ due to the electron-rich π bond. Draw in the space provided above, the structure of the carbocation intermediate formed from propene.

(ii) Draw in the space provided above, the structure of the final organic product.

[2]

(b) **(i)** The reaction scheme below shows a three-step synthetic route to synthesise a dicarboxylic acid from 2,3-bromobutane, the product of which can react with a diol to form compound **S**, a cyclic diester.

Suggest the reagents and conditions at each step of the reaction.



S

For Examiner's Use

Step I:

Reagent(s): ……..……..

Condition(s): ….……..

Step II:

Reagent(s): ……..……..

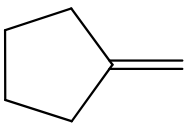
Condition(s): ….……..

Step III:

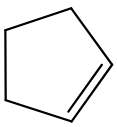
Reagent(s): ……..……..

Condition(s): ….……..

(ii) Suggest a simple chemical test you would use to distinguish between the two types of alkenes shown below.



methylenecyclopentane



cyclopentene

Reagent(s): ……..……..

Condition(s): ….……..

Observations for methylenecyclopentane:

……

……

Observations for cyclopentene:

……

……

[7]

[Total: 9]

For Examiner's Use

5 Hydrogen reacts with nitrogen monoxide to give nitrogen and steam as shown in the following equation.

$$2NO(g) + 2H_2(g) \longrightarrow N_2(g) + 2H_2O(g)$$

The following mechanism was proposed for the reaction between NO(g) and H_2(g).

Step I	$2NO \rightleftharpoons N_2O_2$	*fast*
Step II	$N_2O_2 + H_2 \longrightarrow N_2O + H_2O$	*slow*
Step III	$N_2O + H_2 \longrightarrow N_2 + H_2O$	*fast*

(a) (i) Draw dot-and-cross diagrams to show the electronic structures of NO and N_2O_2. Use your diagrams to explain why step I is a likely first step.

NO:	N_2O_2:

……...

……...

……...

(ii) The following kinetic experiments were carried out and the data recorded as shown below.

Experiment	Concentration / mol dm^{-3}		Initial rate / mol dm^{-3} s^{-1}
	NO (g)	H_2 (g)	
1	0.001	0.1	7.00×10^{-4}
2	0.001	0.2	1.40×10^{-3}
3	0.003	0.2	1.26×10^{-2}

Using these data, state the order of reaction with respect to NO and H_2 and write the rate equation for the reaction.

Order of reaction with respect to NO: ……..

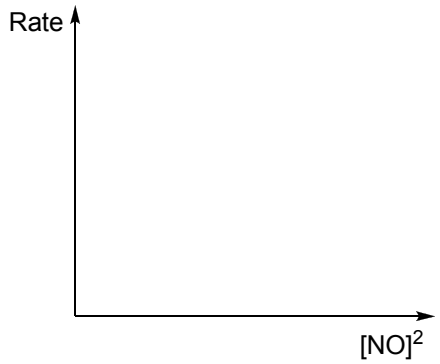
Order of reaction with respect to H_2: ……

Rate equation: ……..

For Examiner's Use

(iii) With reference to the above mechanism, prove that the rate equation you have derived in **a(ii)** is correct.

(iv) Sketch the graph of rate against $[NO]^2$.



(v) Explain, with the aid of a Maxwell-Boltzmann distribution curve, why the addition of a catalyst speeds up the rate of a chemical reaction.

……...

……...

……...

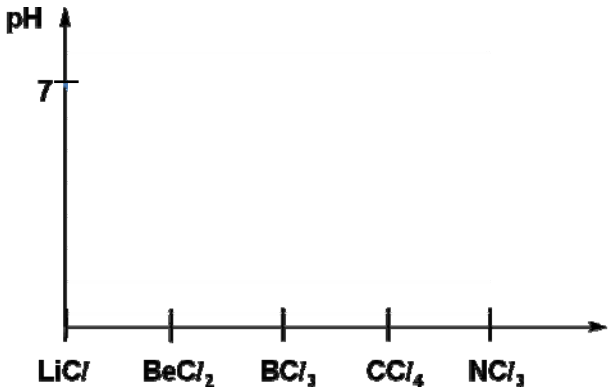
……...

……...

[11]

For Examiner's Use

(b) **(i)** The chlorides of Period 2 elements behave *similarly* to Period 3 elements. Based on your knowledge of Period 3 elements, sketch a graph of pH against the chlorides of lithium to nitrogen. In particular, the chloride of carbon forms an oily layer when mixed with water.



(ii) Write an equation with state symbols to account for the pH value of NCl_3 when dissolved in water. Aqueous HNO_2 is formed in the process.

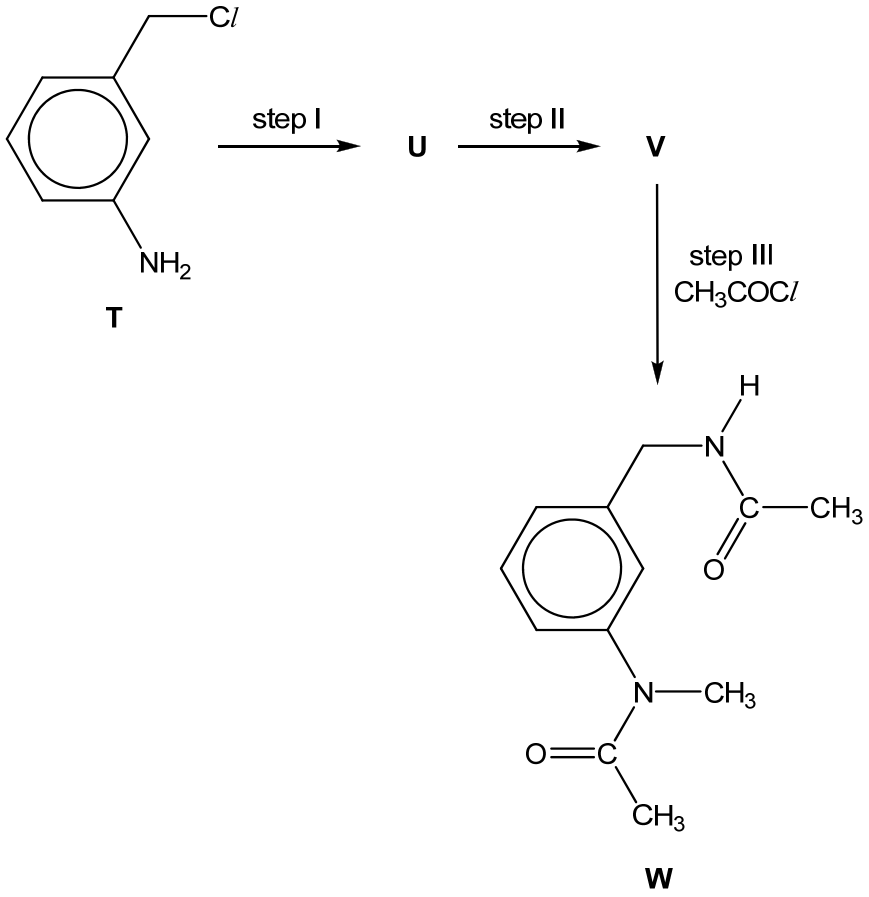
……...

[2]

[Total: 13]

For Examiner's Use

6 (a) Compound **W** can be synthesised from compound **T** via a series of steps.



(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 **U** and **V** in the boxes below.

U:	**V**:

For Examiner's Use

(iii) All 3 steps are the same type of reaction. State the type of reaction for step I to step III.

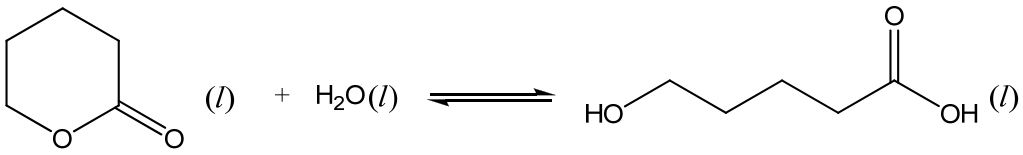
……...

(iv) A student incorrectly claimed that 5 g of Compound **V** will only require 2 m*l* of CH_3COCl to react completely. Determine the correct volume of CH_3COCl needed for the reaction.

You are given the following information:
M_r of Compound **V** = 136.0
Density of CH_3COCl = 1.104 g/m*l*

[7]

(b) 5-hydroxypentanoic acid is the product of the following hydrolysis, which exists in a *dynamic equilibrium*.



tetrahydro-2*H*-pyran-2-one 5-hydroxypentanoic acid

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

……...

……...

……...

For Examiner's Use

(ii) In an experiment, 2.0 mol of tetrahydro-*2H*-pyran-2one was allowed to undergo hydrolysis.

Given that 95% of tetrahydro-*2H*-pyran-2one remained at equilibrium and the total volume of the mixture remained constant at 2 dm^3, calculate the K_c for this reaction. You can assume that $[H_2O]$ = 55.5 mol dm^{-3} throughout.

[4]

[Total: 11]

BLANK PAGE