JURONG JUNIOR COLLEGE
2016 JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
CLASS	**16S**	EXAM INDEX NUMBER	

CHEMISTRY

9647/02

Paper 2 Structured Questions

29 August 2016
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.
You may use a HB pencil for any diagrams or graphs.
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	**/ 14**
3	**/ 10**
4	**/ 10**
5	**/ 18**
6	**/ 8**
Penalty (delete accordingly)	
Lack **3sf** in final ans	**–1 / NA**
Missing/wrong **units** in final ans	**–1 / NA**
Bond linkages	**–1 / NA**
Total	

Answer **all** the questions.

For Examiner's Use

1 Planning (P)

When iodine is mixed with propanone in the presence of dilute sulfuric acid, one of the hydrogen atoms in propanone is replaced by an iodine atom and hydroiodic acid, HI, is produced.

The rate equation for the reaction is determined to be

$$\text{rate} = k\,[CH_3COCH_3][H^+]$$

Initially the reaction mixture is brown due to the iodine that is present. The reaction is complete when all the iodine has reacted and the solution becomes colourless.

A teacher demonstrates this experiment as follows.

She prepares two separate solutions, **X** and **Y**.

Solution **X** contains 5.00 g dm^{-3} iodine solution.

Solution **Y** is a mixture of 50 cm^3 of 1.0 mol dm^{-3} propanone and 50 cm^3 of 1.0 mol dm^{-3} dilute sulfuric acid.

She mixes 10 cm^3 of solution **X** with 10 cm^3 of solution **Y** at room temperature of 25 ^oC and, after about 40 seconds, the mixture decolourises.

Data: Boiling point of propanone is 56 ^oC.

(a) Construct a balanced chemical equation for this reaction.

…….... [1]

(b) Consider the description of the experiment given above.

Write a plan to determine how the rate of this reaction changes with temperature.

You may find it useful to use 1/**t** to represent the reaction rate, where **t** is the time taken for the reaction mixture to decolourise.

In your plan, you should use the same volumes of solution **X** and solution **Y** described above.

Your plan should include <u>five</u> experiments. Ensure that at least one of your experiments would be expected to take more than 40 seconds.

You may assume that you are provided with the following:

- solution **X** containing 5.00 g of iodine in 1.0 dm^3 of water
- 1.0 mol dm^{-3} dilute sulfuric acid
- 5.0 mol dm^{-3} propanone solution
- deionised water, hot water and crushed ice
- boiling tubes and other apparatus normally found in a school or college laboratory

Your plan should contain the following:

- details for the preparation of 1.0 mol dm^{-3} propanone solution from the propanone solution provided
- details for the preparation of solution **Y**
- the temperatures at which the five experiments would be carried out
- all measurements you would make
- all essential experimental details to ensure accurate results

1 (b) .....

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For Examiner's Use

For Examiner's Use

1 (b) ....

[6]

For Examiner's Use

1 **(c)** Identify one potential safety hazard in this experiment and state how you would minimise this risk.

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[1]

(d) The activation energy, E_a, for the reaction can be determined from the following *Arrhenius* equation:

$$k = Ae^{-\frac{E_a}{RT}}$$, where k is the rate constant,
A is the *Arrhenius* constant,
E_a is the activation energy,
R is the molar gas constant, and
T is the temperature in Kelvins.

The *Arrhenius* equation may also be expressed in the following linear form:

$$\ln k = \ln A - \frac{E_a}{RT}$$

(i) State the relationship between k and **t**, the time taken for the reaction mixture to decolourise.

……... [1]

(ii) Outline how the data collected in your experiment would be used to determine the activation energy, E_a, for the reaction.

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[1]

(e) What is the effect on **t**, the time taken for the reaction mixture to decolourise, if the concentration of iodine solution used is halved? Explain your answer.

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[2]

[Total: 12]

For Examiner's Use

2 This question is about chromium compounds and the following data are relevant.

salt	*Colour*	K_{sp} *value at 25 °C*
$BaCr_2O_7$	orange	Soluble in water
$BaCrO_4$	yellow	1.2×10^{-10}
Ag_2CrO_4	red	1.1×10^{-12}

ions	$Cr_2O_7^{2-}(aq)$	$CrO_4^{2-}(aq)$	$Cr^{3+}(aq)$	$Cr^{2+}(aq)$
Colour	orange	yellow	green	blue

(a) **(i)** Write an expression for K_{sp} of Ag_2CrO_4, stating its units.

[2]

(ii) Calculate the solubility of Ag_2CrO_4 in g dm^{-3}.

[2]

(iii) State the expected observations when 50 cm^3 of 2.0×10^{-4} mol dm^{-3} of K_2CrO_4 solution is mixed with 50 cm^3 of an aqueous solution containing 8.0×10^{-5} mol dm^{-3} of $AgNO_3$ and 8.0×10^{-5} mol dm^{-3} of $Ba(NO_3)_2$.

Justify your answer with relevant calculations.

[3]

For Examiner's Use

2 **(b)** In aqueous solution, $Cr_2O_7^{2-}$ ions exist in equilibrium with CrO_4^{2-} ions.

$$Cr_2O_7^{2-}(aq) + H_2O(l) = 2CrO_4^{2-}(aq) + 2H^+(aq)$$

Predict, and explain, the effect of adding aqueous barium chloride to an equilibrium mixture of $Cr_2O_7^{2-}$ and CrO_4^{2-} ions in terms of equilibrium position and pH.

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[3]

(c) When granulated zinc is added to an acidified solution of aqueous chromium(III) solution, the solution turns from green to blue.

When the excess zinc is filtered off and the blue filtrate is left to stand for several hours in the absence of air, it slowly turned back to green and a colourless gas is evolved.

Using the given information and relevant $E^\ominus$ values from the *Data Booklet*, explain the above observations.

Write balanced equations for any reactions that occur.

[4]

[Total: 14]

For Examiner's Use

3 This question is about Period 2 and 3 elements and their compounds.

(a) Both magnesium and lithium give oxides, MgO and Li_2O respectively, whereas sodium gives a mixture of oxide and peroxide, Na_2O and Na_2O_2, when burned in oxygen.

Explain why lithium does not give Li_2O_2 when burned in oxygen.

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[1]

(b) **X**, **Y** and **Z**, in no particular order, are MgO, SiO_2 and P_4O_6.

Some information regarding these three oxides are listed below.

oxide	melting point / K	resulting pH when mixed with water
X	297	2
Y	1986	7
Z	3125	9

(i) Suggest the identities of **X**, **Y** and **Z**.

X: …… **Y:** …….. **Z:** …….. [1]

(ii) With reference to the structure and bonding, explain why the resulting pH is 7 when **Y** is mixed with water.

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…….. [1]

(iii) Write equations to account for the difference in pH when **X** and **Z** are mixed with water.

[2]

(iv) Two of these three oxides are acidic in nature. Write equations to show how these two oxides act as an acid.

[2]

For Examiner's Use

3 (c) Some enthalpy changes are listed below.

Lattice energy of $Ca(OH)_2$	= −2506 kJ mol^{-1}
Enthalpy change of hydration of Ca^{2+}	= −1579 kJ mol^{-1}
Enthalpy change of hydration of OH^-	= −460 kJ mol^{-1}
Enthalpy change of formation of $H_2O(l)$	= −286 kJ mol^{-1}
Enthalpy change of formation of $Ca(OH)_2(s)$	= −987 kJ mol^{-1}

(i) Using relevant data from the above, calculate the enthalpy change of solution of $Ca(OH)_2$.

[1]

(ii) Calcium reacts with water to form aqueous calcium hydroxide and hydrogen gas.

$$Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g) \quad \Delta H_r$$

Using relevant data from the above and your answer in **(c)(i)**, draw an energy cycle and use it to determine ΔH_r.

[2]

[Total: 10]

4 (a) Nitrogen monoxide and fluorine undergo the following gaseous reaction to form nitrosyl fluoride, ONF.

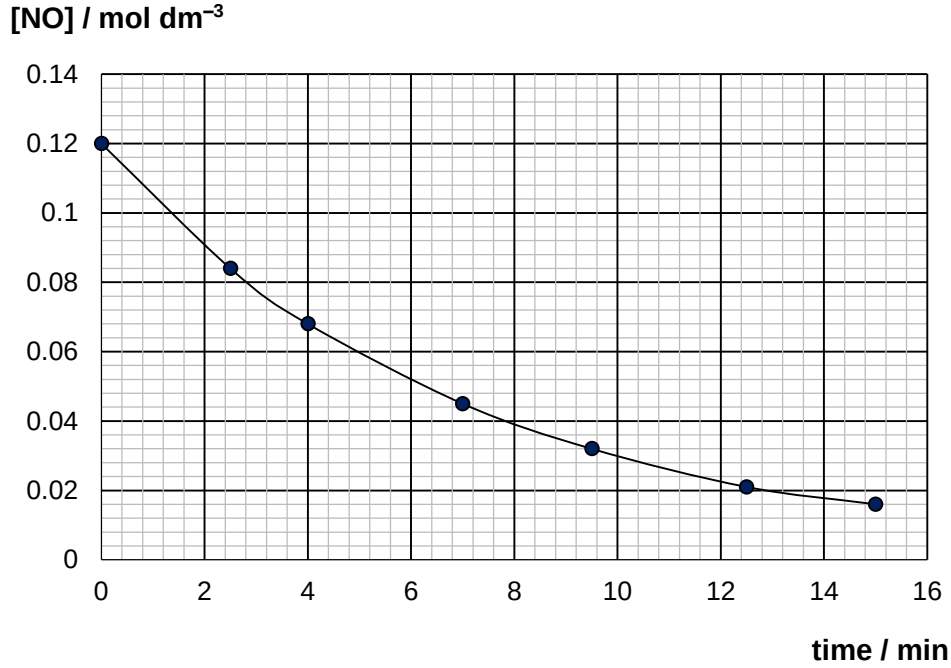
$$2NO(g) + F_2(g) \rightarrow 2ONF(g)$$

The reaction was followed **twice** with different concentrations of F_2. In each experiment, the overall concentration of F_2 remained virtually constant.

The following results were obtained from *Experiment 1* when the concentration of F_2 is 1.5 mol dm^{-3}.

Time / min	[NO] / mol dm^{-3}
0.0	0.120
2.5	0.084
4.0	0.068
7.0	0.045
9.5	0.032
12.5	0.021
15.0	0.016

The data in the table above was plotted on suitable axes and the graph below was obtained.



(i) Using the graph above, determine the order of reaction with respect to NO.

[2]

For Examiner's Use

4 (a) (ii) The concentration of F_2 for *Experiment 2* is 1.0 mol dm^{-3}. The time taken for the concentration of NO to drop to half of its original concentration in *Experiment 2* is 7.5 min.

Using this information and suitable data from the graph, determine the order of reaction with respect to F_2.

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[2]

(iii) Hence determine the rate equation for this reaction.

[1]

(iv) The mechanism has two steps, one of which produces ONF and the free radical F• in equimolar amounts. Suggest equations for the two steps of the mechanism, indicating clearly the slow step.

[2]

(b) Nitrogen dioxide and carbon dioxide gases behave like ideal gases under high temperature and low pressure.

(i) Draw dot-and-cross diagrams for NO_2 and CO_2 molecules.

NO_2	CO_2

[2]

(ii) Suggest a reason why NO_2 gas is expected to deviate more from the ideal gas behaviour than CO_2 gas.

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[1]

[Total: 10]

For Examiner's Use

5 Gasoline is a mixture of C5 to C10 alkanes. When treated with bromine under free radical conditions, it produces a mixture of brominated compounds.

(a) Compound **A**, $C_5H_{11}Br$, is one of the brominated compounds.

When **A** is heated with aqueous potassium hydroxide, compound **B** is formed. **B** does not react with hot acidified potassium dichromate(VI).

(i) State the functional group present in **B**.

…….. [1]

(ii) Draw the displayed formula of **A** and **B**.

A	**B**

[2]

(iii) Describe the mechanism to show how compound **A** is formed from its corresponding alkane, showing structural formula of all species.

[3]

For Examiner's Use

5 (b) Compound **C**, $C_8H_{15}Br_3$, is another brominated compound.

When **C** undergoes dehydrobromination, compound **D**, C_8H_{12}, is produced.

1 mol of **D** reacts with hot acidified $KMnO_4$ to give 2 mol of CO_2, 1 mol of propanedioic acid, $HO_2CCH_2CO_2H$, and 1 mol of compound **E**, $C_3H_4O_3$.

Compound **E** shows a positive test with alkaline aqueous iodine and 2,4-dinitrophenylhydrazine respectively.

(i) State the functional groups positively identified by

- alkaline aqueous iodine

  ……..

- 2,4-dinitrophenylhydrazine

  …… [2]

(ii) Identify compound **E**, and hence deduce the structure of **D**.

E	**D**

[2]

For Examiner's Use

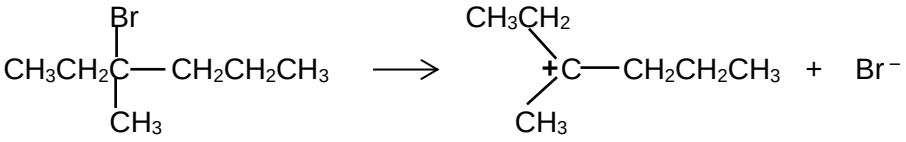
5 (c) 3-bromo-3-methylhexane is another brominated compound.

Under suitable conditions, it reacts with potassium ethoxide, $CH_3CH_2O^-K^+$, to give 3-methylhex-3-ene.

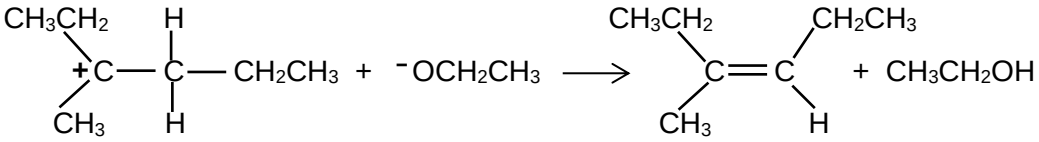
(i) The following shows a possible mechanism for the formation of 3-methylhex-3-ene.

Complete the mechanism by drawing any missing lone pair, partial charges and curly arrows.

Step 1:



Step 2:



[2]

(ii) Following the same mechanism, two other structural isomers of 3-methylhex-3-ene were formed. This explains why the yield of 3-methylhex-3-ene is poor.

Give the structural formulae of these two structural isomers.

[2]

(iii) An unintended organic product, compound **F**, may be formed from a different mechanism.

Suggest the structural formula of compound **F** and state the type of reaction involved.

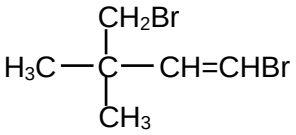
F

Type of reaction: ……..

[2]

For Examiner's Use

5 (c) (iv) Another brominated compound undergoes a similar reaction to give compound **G**.



G

When compound **G** is heated with concentrated NH_3, compound **H** with molecular formula $C_6H_{12}BrN$ is formed.

Give the structural formula of compound **H** and explain why only one of the bromine atoms in compound **G** reacts with NH_3.

H

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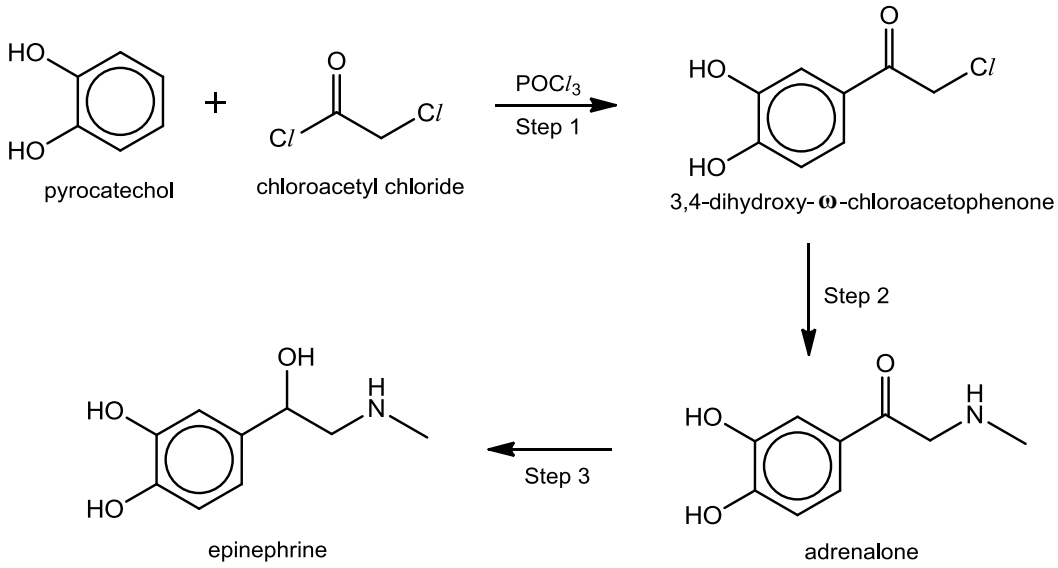
[2]

[Total: 18]

For Examiner's Use

6 **(a)** Epinephrine, also known as adrenaline, is primarily a medication and hormone.

The following synthesis of epinephrine was first performed by Freidrich Stolz in 1904.



(i) Step 1 must be carried out under dry conditions. Explain why it is so.

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…… [1]

(ii) Suggest the reagents and conditions used in Step 2.

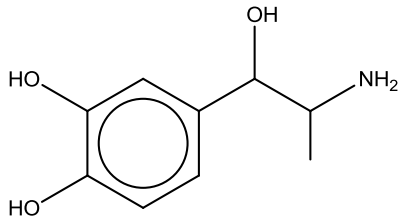
…….. [1]

(iii) State the type of reaction involved in Step 3.

…… [1]

For Examiner's Use

6 **(b)** Cordabrine, a nasal congestant drug, is an isomer of epinephrine.



cordabrine

Is epinephrine expected to be a stronger or weaker base than cordabrine? Explain your answer.

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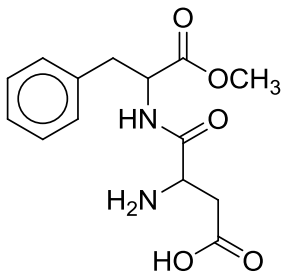
[2]

(c) Epinephrine is an important neurotransmitter that was converted from phenylalanine found in aspartame, an artificial sweetener. An aspartame overdose can cause problems in the physiology of the brain and psychiatric disorders.



aspartame

Draw the structural formulae of the products formed when aspartame is heated with HC*l*(aq).

[3]

[Total: 8]

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