Name	Class: 2T

CATHOLIC JUNIOR COLLEGE

PRELIMINARY EXAMINATION 2008

CHEMISTRY **8872/02**
Higher 1
Paper 2 **26 August 2008**

2 hours

Candidates answer Section A on the Question Paper
and Section B on separate paper.
Additional Materials: Paper
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 paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

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	
Section A	
B5	
B6	
B7	
Total	

There are a total of 12 printed pages including this cover page.

SECTION A

Answer **all** the questions in this section in the spaces provided.

1 The equation for the decomposition of gaseous **X** at 373 K is shown below.

$$2\mathbf{X}\ (g) \rightleftharpoons \mathbf{Y}\ (g) + \mathbf{Z}\ (g)$$

The values for the initial rates of decrease in concentration of **X** at various initial concentrations have been determined. These are shown in the table below.

Initial concentration / mol dm^{-3}	1.67	3.34	5.01	6.68
Initial rate / mol dm^{-3} s^{-1}	0.41	1.64	3.69	6.56

(a) (i) Determine the order of reaction with respect to **X** and hence write the rate equation for this reaction.

(ii) Calculate the rate constant for this reaction, stating the units clearly.

[4]

(b) (i) At 373 K, the activation energy for the forward reaction is 130 kJ mol^{-1} and that for the reverse reaction is 72 kJ mol^{-1}. Sketch and label the energy profile diagram for this reaction.

(ii) Hence, determine the value of the enthalpy change of the decomposition reaction.

[3]

(c) What will be the effects of increasing pressure on the decomposition of **X**?

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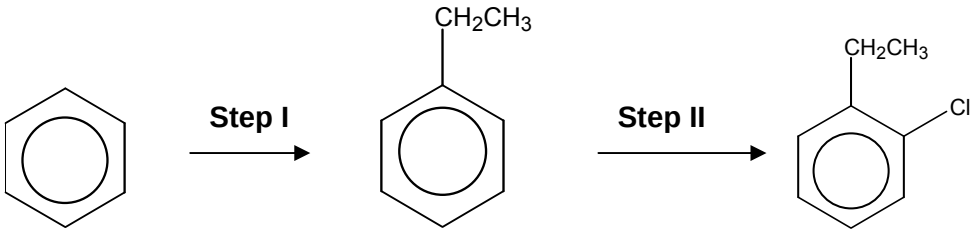
[2]

(d) In the presence of a catalyst, the activation energy of the reverse reaction is 43 kJ mol^{-1}. On the same axes in **(b)(i)**, draw the energy profile of the catalysed reaction and label it clearly.

[1]

[Total: 10]

2 2-chloroethylbenzene can be formed stepwise from benzene via the following reaction scheme.



(a) **Step I** shows how ethylbenzene is synthesised from benzene via a reaction known as Friedel-craft alkylation. The equation below represents the chemical reaction that occurs in **Step I**.

$$C_6H_6\ (l) + CH_3CH_2Cl\ (g) \rightarrow C_6H_5CH_2CH_3\ (l) + HCl\ (g)$$

(i) Use the following data to calculate the enthalpy change of the above Friedel-craft alkylation reaction.

$\Delta H^{\ominus}_f\ (C_6H_6)$	= +49.0 kJ mol^{-1}
$\Delta H^{\ominus}_f\ (CH_3CH_2Cl)$	= -109 kJ mol^{-1}
$\Delta H^{\ominus}_f\ (C_6H_5CH_2CH_3)$	= -12.5 kJ mol^{-1}
$\Delta H^{\ominus}_f\ (HCl)$	= -92.3 kJ mol^{-1}

[1]

(ii) Write an equation to represent the standard enthalpy change of combustion, $\Delta H^{\ominus}_c$ of ethylbenzene.

.....

(iii) Calculate the standard enthalpy change of combustion, $\Delta H^{\ominus}_c$ of ethylbenzene given the following data:

$\Delta H^{\ominus}_c$ (carbon) = -393 kJ mol^{-1}
$\Delta H^{\ominus}_c$ (hydrogen) = -286 kJ mol^{-1}

[3]

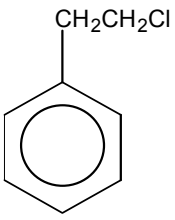
(b) **(i)** State the reagents and conditions used in **Step II**.

.....

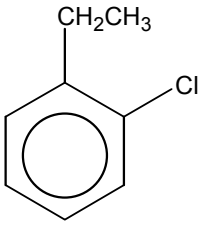
(ii) Draw the structure of another possible product that can be formed in **Step II** and briefly explain the formation of this product.

[3]

(c) Describe a simple chemical test that can be used to distinguish between 1-chloro-2-phenylethane and 2-chloroethylbenzene. State any observation made and write equation(s) where appropriate.



1-chloro-2-phenylethane



2-chloroethylbenzene

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[3]

.....

[3]
[Total: 10]

3 Physical properties of the oxides of some Period 3 elements **W, X, Y** and **Z** are given below.

Formula of oxide	Melting point / ^{o}C	Appearance at r.t.p.	Conductivity in molten state	Acidic/Basic nature of oxide
WO	1132	White solid	Good	Basic
$\mathbf{X}_2O_3$	2054	Solid (variable colour)	Good	Amphoteric
$\mathbf{Y}O_2$	1650	White solid	None	Acidic
$\mathbf{Z}O_2$	-72	Colourless gas	None	Acidic

(a) State the type(s) of particles present in the solid lattices of the four oxides above. In addition, identify **all** type(s) of bonds present in each oxide.

	WO	$\mathbf{X}_2O_3$	$\mathbf{Y}O_2$	$\mathbf{Z}O_2$
Type(s) of lattice particles				
Type(s) of bonds				

[4]

(b) Based on considerations of the properties of the respective oxides above,

(i) Draw and name the shape of the molecule of $\mathbf{Z}O_2$.

(ii) Suggest, with reasons, whether **W**O is soluble in water.

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.....

(iii) State the possible identity of $\mathbf{X}_2O_3$ and hence write down balanced equations to show the amphoteric nature of $\mathbf{X}_2O_3$.

.....

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[6]
[Total: 10]

4 Every year, Singapore celebrates its independence on the 9th of August with a large-scale celebratory event – the National Day Parade. During the Parade, the most highly anticipated item is the fireworks display, which has never failed to captivate the hearts of the audience.

To create these spectacular visual effects, chemistry is actually involved. In fact, each firework that is launched into the sky comprises of chemicals and fuels that are precisely formulated so as to produce different special effects.

The power needed to lift each firework into the air is provided by the highly exothermic combustion of the 'black powder', a slow-burning combination of 75 % potassium nitrate, 15 % charcoal (carbon), and 10 % sulphur. For a typical 1-kg firework, it contains approximately 500 g of black powder. This composition of the black powder was first used in China about 1000 years ago, and has undergone little change since then. When the black powder burns in open air, the heat and gases generated dissipate quickly. Hence, in order to successfully launch the firework high up into the atmosphere, the heat and gases generated during combustion need to be trapped at the bottom of the shell for enough pressure to build up prior to the launch.

When the black powder combusts, potassium nitrate in the powder will decompose according to the following equation:

$$2\ KNO_3(s) \rightarrow K_2O(s) + N_2(g) + \frac{5}{2}\ O_2(g)$$

The other two reagents in the black powder, sulphur and charcoal (carbon), will react with oxygen (from both air and potassium nitrate) to produce sulphur dioxide and carbon dioxide respectively:

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\quad\quad$ $\Delta H_c = -296.83\ kJ\ mol^{-1}$

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad\quad$ $\Delta H_c = \boldsymbol{x}\ kJ\ mol^{-1}$

The above combustions not only produce gases but also release a lot of heat energy. As such, the gases which are produced are simultaneously heated up and therefore rapidly expand. These rapidly expanding gases will become the explosive force of the reaction.

The colours of the fireworks are produced by heating the added metal salts, such as calcium chloride or sodium nitrate. Part of the heat energy which is produced from the combustions of sulphur and charcoal (carbon) will be absorbed by the atoms of the metal salts. As a result, the amount of unabsorbed energy released will be characteristic of the metal salts present.

The colours observed from the explosion of the fireworks are produced by the metal salts with the characteristic emissions listed in the table below:

Color	Compound	Wavelength (nm)	Energy released/ kJ mol^{-1}
red	strontium salts, lithium salts	652	183
orange	calcium salts	668	179
yellow	sodium salts	610-621	193
green	barium compounds + chlorine producer	589	203
blue	copper compounds + chlorine producer	505-535	224
purple	mixture of strontium (red) and copper (blue) compounds	420-460	260

(a) With reference to the oxidation states of nitrogen before and after the decomposition of potassium nitrate, describe its role in fireworks.

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.....

[1]

(b) (i) Define the term *bond dissociation energy*.

.....

.....

(ii) Given that enthalpy change of converting C(s) to C(g) is +715 kJ mol^{-1}, together with the use of relevant values in the ***Data Booklet***, calculate the enthalpy change of combustion of C(s).

(iii) Hence, calculate the energy released from ignition of a typical 1-kg firework.

[6]

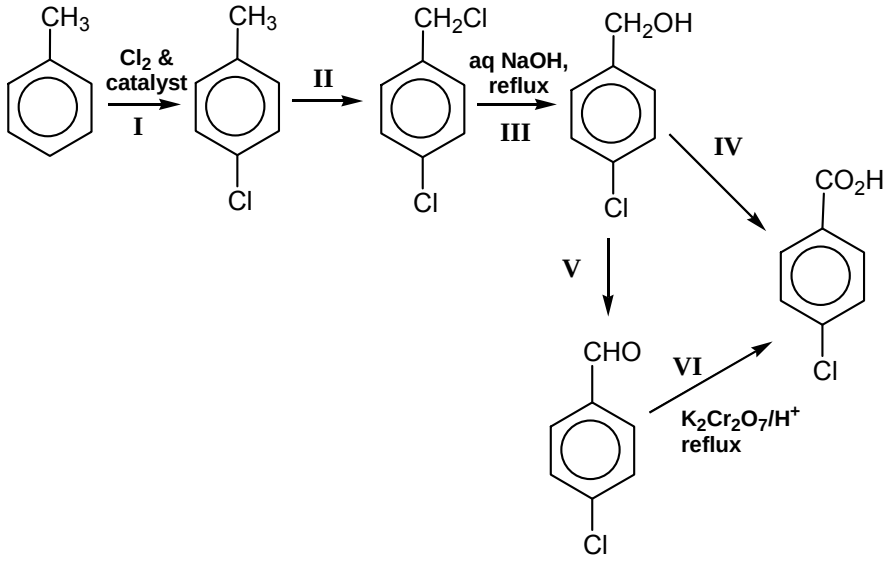
(c) Predict what would be the colour observed when approximately 71.9 % of the heat energy released in part **(b)(iii)** is absorbed by 3 mol of metal salts present in the firework.

[3]
[Total: 10]

SECTION B

Answer **two** of the following questions. Answer these questions on separate answer paper.

5

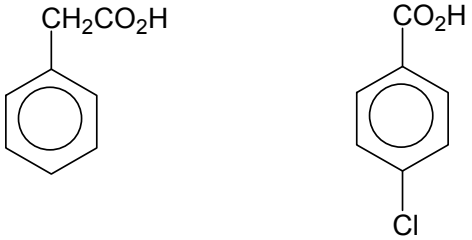


(a) (i) Suggest suitable reagents and conditions for steps **II, IV** and **V** of the reaction scheme above.

(ii) Explain briefly why the chloro- substituent group on the benzene ring does not get substituted during step **III** of the reaction.

[4]

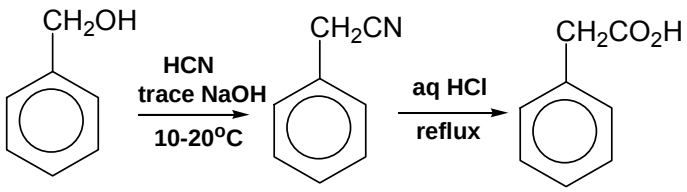
(b) 4-chlorobenzoic acid and phenylethanoic acid are two compounds containing benzene rings. Both compounds are not particularly soluble in water under room temperature conditions.



Phenylethanoic acid **4-Chloro-benzoic acid**

State and explain which of these two acids are relatively more acidic. [3]

(c) The following shows the proposed reaction scheme to synthesise phenylethanoic acid from phenylmethanol.



Identify, with explanations, the two errors that appeared in the suggested method above. [4]

(d) 1 mol of phenylmethanol, $C_6H_5CH_2OH$ and 1 mol of phenylethanoic acid, $C_6H_5CH_2CO_2H$ were mixed in a closed vessel and allowed to reach equilibrium at 25 ^oC.

$$C_6H_5CH_2CO_2H(l) + C_6H_5CH_2OH(l) \underset{\textbf{reflux}}{\overset{\textbf{c. } H_2SO_4}{\rightleftharpoons}} C_6H_5CH_2CO_2CH_2C_6H_5(l) + H_2O(l)$$

It was found that 60 % of $C_6H_5CH_2OH$ was converted at equilibrium.

(i) Write the equilibrium constant, K_c expression for the above reaction.

(ii) Calculate K_c at 25^{o}C.

(iii) Suggest what would happen to the rate and equilibrium position of the reaction system when concentrated H_2SO_4 is added.

[5]

(e) 30.0 cm^3 of excess NaOH solution of 1.00 mol dm^{-3}, was reacted with 5.70 g of an impure sample of ester, $C_6H_5CH_2CO_2CH_2C_6H_5$ formed from the earlier reaction in part **(d)**.

(i) Write an equation to show the reaction between NaOH and $C_6H_5CH_2CO_2CH_2C_6H_5$.

(ii) The remaining NaOH required 25.0 cm^3 of 0.100 mol dm^{-3} H_2SO_4 for neutralisation. Calculate the percentage purity of the ester in the sample.

[4]
[Total: 20]

6 (a) Phenol is a monoprotic acid commonly used as an active ingredient in household disinfectants. A solution of phenol in water containing 2.50 mol dm^{-3} has a pH of 4.8

(i) Explain, with the aid of appropriate calculations, whether phenol is a strong or weak acid.

(ii) Use the data given to calculate the value of K_a of phenol.

(ii) Suggest a suitable indicator for the titration of phenol with aqueous sodium hydroxide.

(iv) Phenol consists of 76.6% of C, 6.4% of H and 17.0% of O. Determine the empirical formula of phenol.

(v) A sample of phenol of mass 1.04 g was dissolved in water and titrated with 0.500 mol dm^{-3} sodium hydroxide solution. It was found that 22.2 cm^3 of hydroxide was required for neutralisation. Calculate the M_r of phenol.

(vi) Hence propose the structure of phenol.

[10]

(b) A solution containing phenol and its salt, sodium phenoxide acts as a buffer solution.

(i) What do you understand by the term *buffer solution*?

(ii) Write ionic equations to show how this solution reacts with

I added H^+ (aq) ions,

II added OH^- (aq) ions. [3]

(c) The melting points of four chlorides are given below.

Compound	Formula	m.p. / °C
Sodium chloride	NaCl	801
Aluminium chloride	$AlCl_3$	178
Carbon tetrachloride	CCl_4	-23
Silicon tetrachloride	$SiCl_4$	-70

(i) Briefly relate the melting points of NaCl, CCl_4 and $SiCl_4$ to the structure of, and bonding in, each of these chlorides.

(ii) Describe the reaction, if any, of each of the 4 chlorides above with water, stating the approximate pH of any solution formed. Write balanced equation(s) for any reaction that takes place and explain the differences in their reactivities.

[7]
[Total: 20]

7 Nitrogen exhibits a range of oxidation number in its compounds.

(a) Copy and complete the table below which refers to possible reduction products of nitric acid.

Formula of product	Oxidation number of nitrogen
NO_2 N_2O NH_2OH NH_4^+	

[2]

(b) Hydroxylamine, NH_2OH is oxidised by Fe^{3+} (aq) which itself is reduced to Fe^{2+} (aq). In an experiment, 25.0 cm^3 of 0.100 mol dm^{-3} NH_2OH required 25.0 cm^3 of 0.200 mol dm^{-3} Fe^{3+} for complete reaction.

(i) Determine the number of moles of Fe^{3+} that react with one mole of NH_2OH.

(ii) What change in oxidation number does the nitrogen in NH_2OH undergo?

(iii) Which formula from the table in **(a)** correspond to the nitrogen-containing product of this reaction?

(iv) Write a half-equation to illustrate the oxidation of NH_2OH.

(v) Construct an equation for the reaction of NH_2OH with Fe^{3+}. [6]

(c) Hydroxylamine, NH_2OH, dissolves readily in water. Explain the solubility of hydroxylamine in water with the aid of a diagram to illustrate the intermolecular forces of attraction between hydroxylamine molecules and water molecules.

[2]

(d) The following equation shows the partial dissociation of brown nitrogen tetraoxide gas, N_2O_4 to colourless nitrogen dioxide gas, NO_2 at ***T*** K.

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

(i) Draw the dot-and-cross diagrams of NO_2 and N_2O_4.

(ii) Identify the unique feature about the structure of NO_2.

(iii) State and explain whether the decomposition of N_2O_4 is exothermic or endothermic.

(iv) 0.5 mol of N_2O_4 is placed in a 1 dm^3 flask and allow to reach equilibrium. At equilibrium, 0.24 mol of N_2O_4 is left in the flask. Calculate the equilibrium constant, K_c at ***T*** K.

(v) A flask containing the N_2O_4 / NO_2 gas mixture is immersed into hot water. State the observation and indicate how the rate of decomposition and K_c will be affected.

[10]
[Total: 20]

----- End -----