H

CATHOLIC JUNIOR COLLEGE
Preliminary Examination 2009
Higher 2

CANDIDATE NAME	
CLASS	2 T

CHEMISTRY

9746/02

Paper 2 Structured Questions

4 September 2009
1 hour 30 minutes

Candidates answer on the 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.

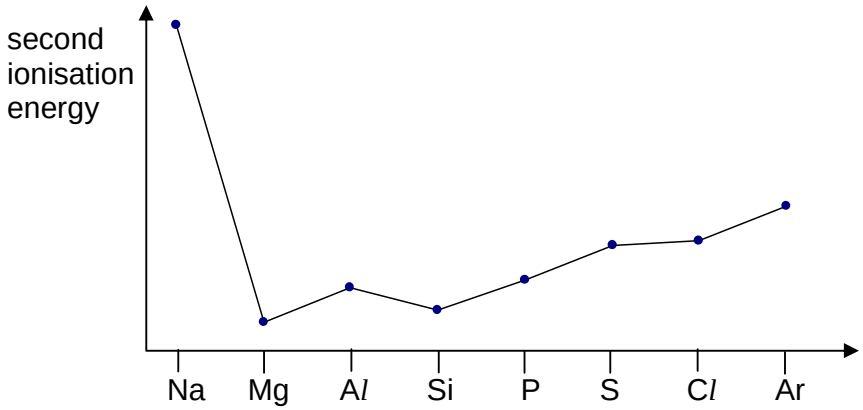
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
Total	

This document consists of **11** printed pages and **1** blank page.

CJC Chemistry Department

1 **(a)** The **second ionisation energies** of the elements in Period 3 are given in the graph below.



(i) Define, by means of an equation, what is meant by the **second ionisation energy** of magnesium.

……

(ii) Explain why the **second ionisation energy** of silicon is lower than that of aluminium.

……

……

……

[2]

(b) Orange street lamps contain sodium metal with a small amount of neon gas. The light is produced when gaseous atoms are ionised in an electric field. When first turned on, the lamps emit a red glow characteristic of neon but, after a time, the orange glow of sodium predominates.

Suggest a brief explanation of this phenomenon.

……

……

……

……

[2]

(c) The behaviours of the oxides and chlorides of aluminium and silicon with water are similar, but for different reasons.

Explain as fully as you can, giving balanced equations where relevant, why

(i) aluminium oxide and silicon dioxide are both insoluble in water, and

……

……

……

(ii) aluminium chloride and silicon tetrachloride both react with water to give acidic solutions.

……

……

……

……

……

[4]

(d) (i) Lithium and magnesium show a diagonal relationship, which indicates similarities in their physical and chemical properties.

Predict how the solubility and basicity of lithium oxide, Li_2O, will compare with that of barium oxide, BaO.

……

……

……

(ii) Lithium peroxide, Li_2O_2, is commonly used in spaceship cabins as an air purifier to absorb carbon dioxide and release oxygen:

$$Li_2O_2(s) + CO_2(g) \rightarrow Li_2CO_3(s) + ½\ O_2(g)$$

Calculate the percentage change in the mass of a sample of lithium peroxide when it has been fully used up.

[4]

[Total: 12]

2 **(a)** Ammonium nitrate is commonly used in agriculture as a high-nitrogen fertiliser, and it has also been used as an oxidising agent in explosives, including improvised explosive devices.

By making use of the data below, determine the enthalpy change of the following process.

$$NH_4NO_3(l) + aq \rightarrow NH_4NO_3(aq)$$

Given:

	kJ mol^{-1}
$NH_4NO_3(l) \rightarrow NH_3(g) + HNO_3(g)$	+71
ΔH (neutralization) of $NH_3(aq)$ and $HNO_3(aq)$	-50
ΔH (solution) of $NH_3(g)$	-31
ΔH (solution) of $HNO_3(g)$	+37

[3]

(b) Gibbs free energy is dependent on the enthalpy and entropy changes.

Comment on the following with reference to the above statement:

When $NaHCO_3(aq)$ is added to HC*l*(aq) at room temperature, the temperature of the reaction mixture drops. Despite this, the reaction is spontaneous.

……

……

……

……

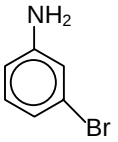
……

[2]

(c) The molecule of benzene is a regular hexagon in which the π electrons are described as being delocalised which gives benzene its stable structure.

(i) Give one chemical property which arises due to this structure.

……

(ii) 3-bromophenylamine, 

can be synthesised from benzene.
Give the necessary reagents, conditions and any intermediates formed for this synthesis.

[5]
[Total: 10]

3 (a) Chromium is a typical transition metal element. It forms different coloured compounds.

Give the electronic configurations of Cr and Cr^{3+}.

Cr: ……

Cr^{3+}: …… [2]

(b) When aqueous ammonium dichromate(VI), $(NH_4)_2Cr_2O_7$, is added gradually to molten ammonium thiocyanate, NH_4SCN, an ammonium salt known as Reinecke's salt, **A**, is formed. **A** has the formula $NH_4[Cr(SCN)_x(NH_3)_y]$, and analysis produced the following composition by mass:

Cr, 15.5 %; S, 38.1 %; N, 29.2 %

(i) Calculate the values of ***x*** and ***y*** in the above formula.

x : …… ***y*** : ……

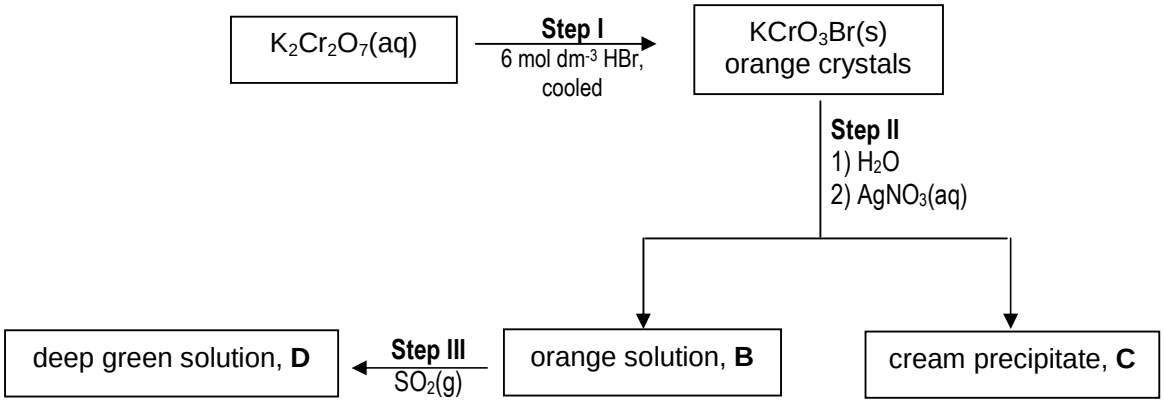
(ii) State the oxidation state of chromium in the complex, **A**.

……

(iii) Draw the structure of the complex anion, showing clearly its shape.

[7]

(c) Potassium dichromate(VI) undergoes the following reactions.



(i) Write the equation for the reaction involved in **Step I**.

……

(ii) Is the reaction in **Step I** a redox one? Give your reasoning.

……

……

……

(iii) Using relevant $E^{\ominus}$ data for the reaction in **Step I**, suggest what you might have expected the products to be instead of $KCrO_3Br$.

(iv) Suggest a reason why the reaction does not go in the way $E^{\ominus}$ data indicate.

……

……

(v) Identify compound **C**.

C: ……

(vi) Explain the type of reaction that occurred in **Step III**.

……

……

……

[7]

[Total: 16]

4 **(a)** One common iron ore is magnetite, Fe_3O_4. It can be obtained by heating iron with steam.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

A mixture containing 0.1 mol of iron and 0.1 mol of steam was allowed to come to equilibrium in a closed vessel at 600 ^oC and 1.5 atm pressure. At equilibrium, 0.055 mol of hydrogen gas was present. Calculate K_p for the reaction at 600 ^oC.

[3]

(b) A catalyst such as iron is used in the synthesis of ammonia (Haber process):

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g); \quad \Delta H = -92\ kJ\ mol^{-1}$$

but not in the synthesis of nitrogen dioxide: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta H = +57\ kJ\ mol^{-1}$. Explain the observation as fully as you can.

……

……

……

……

……

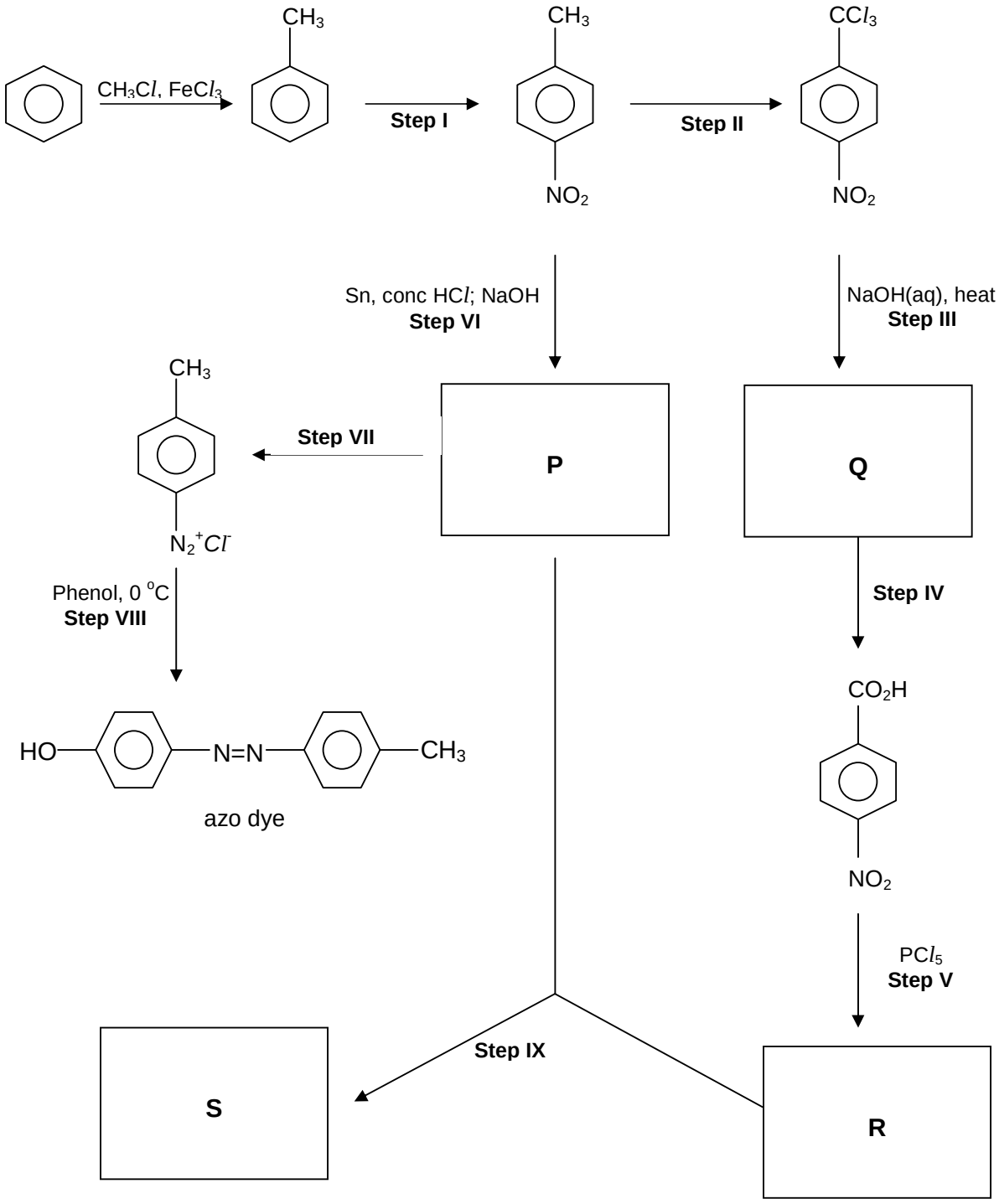
……

……

……

[3]

(c) $FeCl_3$ is used as a catalyst in the presence of CH_3Cl to yield methylbenzene. This is referred to as the alkylation of benzene. A series of reactions involving methylbenzene is shown below. You are required to answer questions that follow.



(i) What reagents and conditions are required in each of the following steps?

Step	Reagents and conditions
I	
II	

(ii) What type of reaction takes place in each of the following steps?

Step IV: ……..

Step VIII: ……

(iii) In the boxes below, give the full structural formulae (displayed formulae) of compounds **P**, **Q**, **R** and **S**. Note that compound **S** is obtained from the reaction of **P** with **R**.

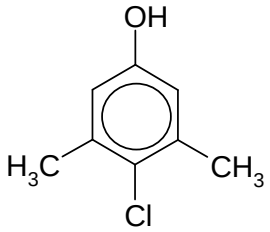
P:	**Q:**
R:	**S:**

[6]

[**Total: 12**]

5 Parachlorometaxylenol, also known as Dettol, is a common household antiseptic manufactured by Reckitt Benckiser.

The key ingredient which provides Dettol with its unique antiseptic property is an aromatic chemical compound, **chloroxylenol**. This makes up 4.8 % of Dettol's total composition, with the rest comprising of pine oil, isopropanol, castol oil soap, caramel and water. As several ingredients are insoluble in water, Dettol produces a white emulsion of oil droplets when diluted during use.



chloroxylenol

(a) (i) **Chloroxylenol** reacts with hot potassium manganate(VII) in sulfuric acid to form **W**. One mole of **W** formed was found to react with three moles of sodium hydroxide. Account for this reaction ratio with the use of relevant equation(s).

……

……

……

……

……

……

(ii) **W** reacts with phosphorus pentachloride to form compound **X**. Identify the organic compound **X**.

X:

(iii) Describe **one** simple chemical test that can distinguish **chloroxylenol** from 4-chlorophenol. Clearly state the observation expected.

……

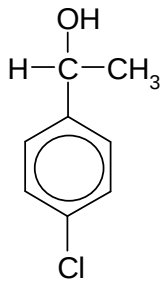
……

……

……

[5]

(b) (i) **Y**, with a structure as shown below, is an isomer of **chloroxylenol**.



Y

Heavier isotopes like deuterium, D, which is an isotope of hydrogen, are often used in the determination of organic reaction mechanisms.

Complete the table to provide the type of reaction and the organic products formed when **Y** reacts under the following reagents and conditions.

Reagents & Conditions	**Type of reaction**	**Organic products**
concentrated D_2SO_4, heat		
I_2, NaOD, D_2O		

(ii) Oxidation of **Y** with hot potassium manganate(VII) in sulfuric acid produces an organic compound **Z**. Explain what you will observe when **Z** is heated with 2,4-dinitrophenylhydrazine solution.

……

……

……

……

[5]

[Total:10]