Class	Reg Number

Candidate Name _____

Meridian Junior College
JC2 Preliminary Examinations 2008

H1 Chemistry 8872
Paper 2

11 September 2008 **2 hours**

INSTRUCTION TO CANDIDATES

Write your name, class and register number in the spaces at the top of this page.
This booklet contains Section **A** and **B** of your paper.

Section A (Pg 1-11)

Answer **ALL** questions in Section A in the spaces provided on the question paper. You are advised to spend about **1 hour** on Section A.

Section B (Pg 12-17)

Answer **two** out of three questions in Section B on the foolscap paper. You are advised to spend about **1 hour** on Section B.

Begin each question on a ***fresh page*** of writing paper.

Fasten your answers for Section **B** behind Section **A**.

You are advised to spend about **30 min per question**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

Examiner's Use		
Paper 1	**MCQ**	**/ 30**
Paper 2 Section A	**Q1**	**/ 8**
	Q2	**/ 4**
	Q3	**/ 11**
	Q4	**/ 7**
	Q5	**/ 10**
Paper 2 Section B	**Q6**	**/ 20**
	Q7	**/ 20**
	Q8	**/ 20**
Total		**/ 110**

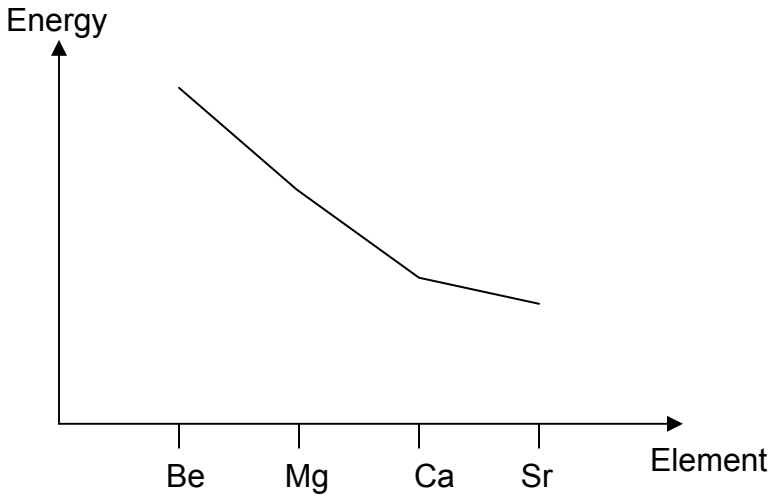
This question paper consists of *17 printed pages.*

SECTION A (40 marks)

Answer all questions in the space provided.

1(a) The graph below represents the first ionization energies from beryllium to strontium. Explain the general trend presented by the graph.

[2]



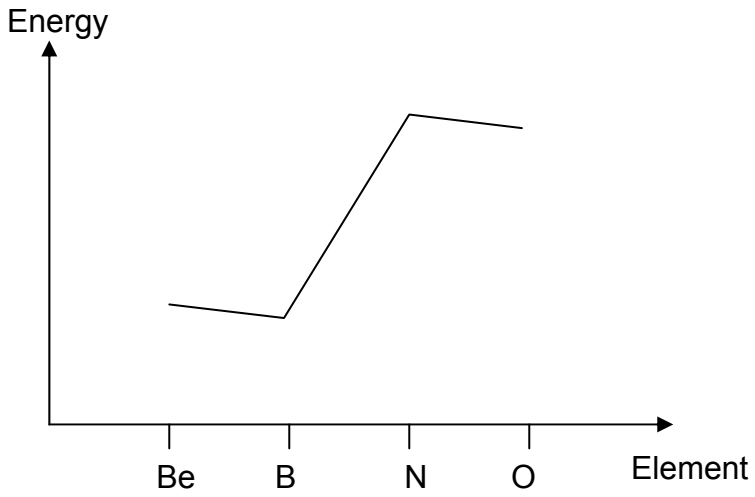
(b) Write the electronic configurations of chromium ion, Cr^{3+}.

[1]

(c) Between Cr^{3+} and F^-, state and explain which ion would be deflected the most when they are passed through an electric field?

[2]

(d) The first ionization energies of beryllium, boron, nitrogen and oxygen are presented in the graph below.



Explain the decrease in ionization energy from:

(i) Be to B

(ii) N to O

[3]

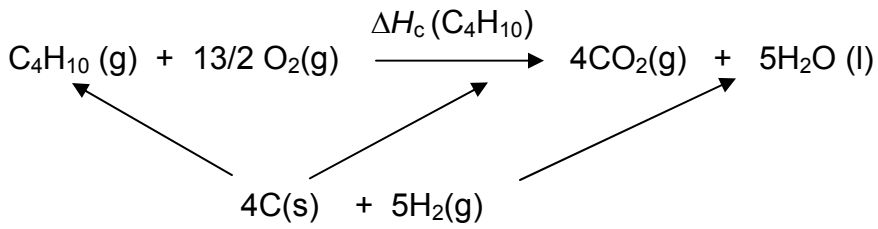
[Total: 8]

2 Certain enthalpy changes such as enthalpy change of formation cannot be found by direct experiment. Instead it can be found by applying Hess' Law to simple energy cycles.

(a) 500 cm^3 of water was heated in a calorimeter by burning a 1.30 g of butane, C_4H_{10}. The temperature rise of the water recorded was 30°C. Calculate the enthalpy change of combustion of butane.

[2]

(b) The energy cycle for the complete combustion of butane is shown below.



Using your answer in part (a) and the following enthalpy changes, calculate the enthalpy change of formation of butane.

ΔH_c (C) = - 393.5 kJ mol^{-1}
ΔH_c (H_2) = - 285.8 kJ mol^{-1}

[1]

(c) Chlorofluorocarbons, CFCs, are small alkane molecules where a few of the hydrogen atoms have been replaced by chlorine atoms and fluorine atoms. The use of CFCs in daily life products have been banned in many countries because CFCs are environmentally hazardous.

(i) State one use of CFCs.

(ii) Why is CFCs an environmental concern?

[1]

[Total: 4]

3(a) Explain what is meant by the *lattice energy* of an ionic compound.

[1]

(b) Based on their lattice energies, explain why MgO is preferably used as refractory lining for furnaces rather than $MgCl_2$,

[2]

(c) $MgCl_2$ is highly soluble in water and MgO is only sparingly soluble in water. Give an explanation for the observation.

[2]

(d) $MgCl_2$ and MgO are added to separate aqueous solutions, each containing a few drops of phenolphthalein. Predict, with reasoning, the expected observations. Support your answers with any relevant equations.

[3]

(e) Unlike magnesium chloride, aluminium chloride is a covalent compound. In the gaseous state, $AlCl_3$ has an apparent M_r of 267.0.

Draw a dot-and-cross diagram to illustrate the bonding of

(i) Magnesium chloride

(ii) Aluminium chloride in the gaseous state

[2]

(f) Unlike all other Group II oxides, beryllium oxide, BeO, is amphoteric in nature, like aluminium oxide, Al_2O_3. Suggest a reason for their similarity in chemical properties.

[1]

[Total: 11]

4(a) Certain chlorides and oxides of period 3 elements dissolve in water.

Elements **K**, **L** and **M** are in Period 3. Chlorides of **K** and **L** dissolve in water to form a neutral solution (pH = 7) and an acidic solution (pH ≈ 3) respectively. Oxide of element **M** is found to be insoluble in water, whereas its chloride forms a strongly acidic solution (pH ≈ 2).

(i) Suggest the identity of elements **K** and **L** and with the aid of equations, explain the above observations as fully as you can.

[5]

(ii) Identify element **M** and with the aid of an equation, explain why the chloride of **M** forms a strongly acidic solution.

[2]

[Total: 7]

5 Calcium hydroxide is a white solid which is only sparingly soluble in water. 1.85 g of $Ca(OH)_2$ will dissolve in 100 cm^3 of water. Ammonia is a pungent gas which is very soluble, 89.9 g of NH_3 dissolves in 100 cm^3 of water. The pH of saturated aqueous $Ca(OH)_2$ and NH_3 solution are 13.7 and 13.0 respectively.

Both compounds are useful for agricultural purposes. Calcium hydroxide can be used to control the pH level in soil while ammonia is reacted with nitric acid to produce ammonium nitrate for fertilizing uses.

In gardening, the pH level of the soil is very important. Soil pH is an important consideration for farmers and gardeners for several reasons, including the fact that many plants and soil life forms prefer either alkaline or acidic conditions. However, some diseases tend to thrive when the soil is too alkaline or acidic, and that the pH can affect the availability of nutrients in the soil.

Certain plants such as hydrangea will form flowers of different colours according to the pH of the soil. To encourage blue hydrangea flowers, the soil must have a pH of 5.0–5.2 and pH of 6.0–6.2 for pink blooms.

To raise the pH level of the soil, the gardener can adopt the liming method. The two common choice of lime is garden lime containing $CaCO_3$ and quicklime, CaO.

Quicklime is caustic and cannot be applied directly to the soil, instead it is spread around the land in heaps to absorb rain and form slaked lime ($Ca(OH)_2$), which is then spread on the soil. Their use is prohibited by the organic standards and while fast acting, the effect is short lived in comparison to the garden lime.

(a) Define the term pH.

[1]

(b) **(i)** Calculate the concentration in mol dm^{-3} of

I saturated calcium hydroxide solution

II saturated ammonia solution

[2]

(ii) Hence, explain whether calcium hydroxide is a strong or weak base.

[2]

(b) A blue hydrangea is planted in a plot of soil. The pH of the soil is 5.1 and the volume of water in the soil is 500 cm^3.

(i) Calculate the minimum concentration of H^+ ions required for the blue hydrangea to change to pink color.

(ii) Calculate the minimum volume of $4x10^{-5}$ mol dm^{-3} $Ca(OH)_2$ needed to change the color of the hydrangea to pink.
(*Ignore the contribution of H^+ and OH^- ions from the auto-ionisation of water*)

[3]

(c) Suggest why garden lime has a longer lasting effect than quicklime?

[1]

(d) A common advice given to aspiring gardeners is: “Never lime and fertilize at the same time”. Explain the rationale behind the advice.

[1]

[Total: 10]

Section B (40 Marks)

*Answer **two** of the three questions in this section.*
Begin each section on a fresh page.

6(a) A commonly used laboratory procedure to test for the presence of manganese (II), Mn^{2+} ions is to react them with a sodium salt, Na**R**O_n, where **R** is a period 6 element. A positive test for Mn^{2+} is indicated by the formation of a dark purple colour due to the presence of MnO_4^- ions in solution. It is found in an experiment that 30.00 cm^3 of 0.1 mol dm^{-3} of Mn^{2+} reacts with 15.00 cm^3 of 0.5 mol dm^{-3} of Na**R**O_n. In the process, aqueous $\mathbf{R}^{3+}$ ion is formed.

(i) Let **x** be the oxidation number of **R** in Na**R**O_n. Copy the half-equation as shown below onto your writing paper and complete the half-equation by filling in the blank.

$$\mathbf{R}^{x+} + \boxed{}\ \mathbf{e} \rightarrow \mathbf{R}^{3+}$$

(ii) Calculate the number of moles of Mn^{2+} required to react with 1 mole of Na**R**O_n.

(iii) Hence, deduce the oxidation number of **R** in Na**R**O_n and the value of **n**.

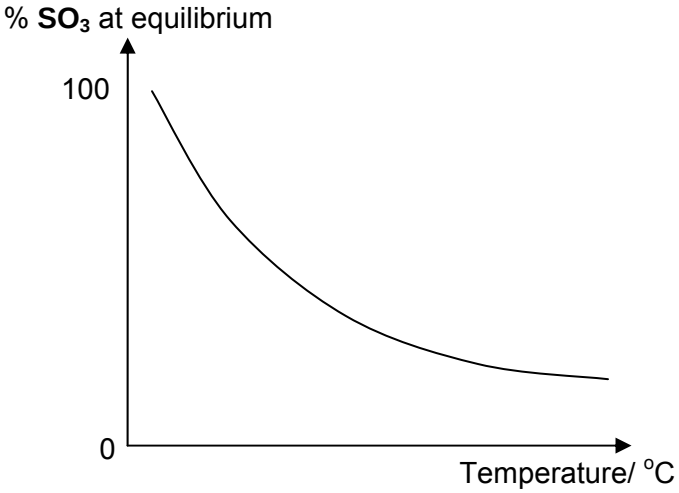
(iv) The formula mass of Na**R**O_n is 280.0. Determine the Ar of **R** and suggest the identity of **R**.

[7]

(b) For MnO_4^- ions to act as an oxidizing agent, it has to be acidified with sulphuric acid. Sulphuric acid is manufactured by the Contact Process which involves the following reaction:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The percentage of SO_3 obtainable at equilibrium is plotted against the operating temperature.



(i) Explain whether the formation of SO_3 is an exothermic or endothermic process.

(ii) Write an expression for the equilibrium constant, K_c.

(iii) Given that in a 3 dm^3 vessel, there are 0.2 moles of SO_2, 0.3 moles of O_2 and 4 moles of SO_3 at equilibrium. Calculate the K_c value.

[4]

(c) **(i)** Describe the shapes and state the bond angles of SO_2 and SO_3. Explain their shapes in terms of the numbers and types of electron pairs they contain.

(ii) Indicate whether the SO_2 and SO_3 are polar or non-polar.

(iii) Sulphur dioxide (SO_2) and sulphur trioxide (SO_3) have different boiling points as shown in the table below.

Compound	Boiling Point / °C
SO_2	-10
SO_3	45

With reference to the structure and bonding, explain why SO_2 and SO_3 have different boiling points.

[7]

(d) A few drops of sulphuric acid were added to a solution containing equal amounts of H_2CO_3 and $NaHCO_3$. With the aid of an equation, explain the change in pH of the solution.

[2]

[Total: 20]

7(a) Ethyl propanoate, an ester, is found naturally in apple juice, grapefruit peel and strawberries. Ethyl propanoate can be hydrolysed by aqueous NaOH.

$$C_2H_5OCOCH_2CH_3 + OH^- \rightarrow C_2H_5OH + {}^-OCOCH_2CH_3$$

The initial rate of the hydrolysis reaction between the ester and NaOH was measured in a series of experiments at a constant temperature. The results are obtained below:

Experiment	**Initial conc. of NaOH / mol dm^{-3}**	**Initial conc. of ester / mol dm^{-3}**	**Initial rate / mol dm^{-3} s^{-1}**
1	0.020	0.010	1.80×10^{-3}
2	0.020	0.015	2.70×10^{-3}
3	0.030	0.015	4.05×10^{-3}
4	0.060	0.020	–

(i) Use the data in the table to deduce the order of reaction with respect to the ester and the order of reaction with respect to OH^-.

(ii) Calculate the initial rate of reaction for Experiment **4** and the rate constant, **k**.

[5]

(b) Hydrolysis of the ester can also be carried out with water. However, this method is so slow that it is never used.

(i) Suggest a reason to explain why the hydrolysis is slow using water.

[1]

(ii) Ester hydrolysis can be catalyzed by dilute HCl. With the aid of a Maxwell-Boltzmann curve, explain the effect of catalyst on the rate of reaction.

[4]

(c) With reference to the structure of ethanoic acid, explain why sodium hydroxide will only react with ethanoic acid and not ethanol.

[2]

(d) Compound **P**, $C_6H_{10}O_3$, is a sweet smelling solid. When **P** is heated with dilute HCl, 2 isomeric compounds **Q** and **R** with the molecular formula of $C_3H_6O_2$ are formed. Compound **Q** is able to dissolve in $CaCO_3$ (aq) but not compound **R**. Compound **R** gives an orange precipitate with 2,4-dinitrophenylhdrazine but does not show any observable change with a mixture of ammonia and silver nitrate. Compound **R** gives a yellow precipitate with hot alkaline iodine. On reaction with PCl_5, **R** gives dense white fumes.

Deduce the identities for the compounds **P**, **Q** and **R** and explain the chemistry of the reactions involved.

[8]

[Total: 20]

8(a) Methylacetylene is an alkyne with the chemical formula $CH_3C{\equiv}CH$. It is a component of MAPP gas along with its isomer propadiene, which is commonly used in gas welding. Methylacetylene exists in equilibrium with its isomer, the mixture of methylacetylene and propadiene being called MAPD:

(i) Use the bond energies given in the *Data Booklet* to calculate the standard enthalpy change for the conversion of methylacetylene to propadiene.

(ii) Sketch and label an energy profile diagram for the reaction showing all relevant energy changes.

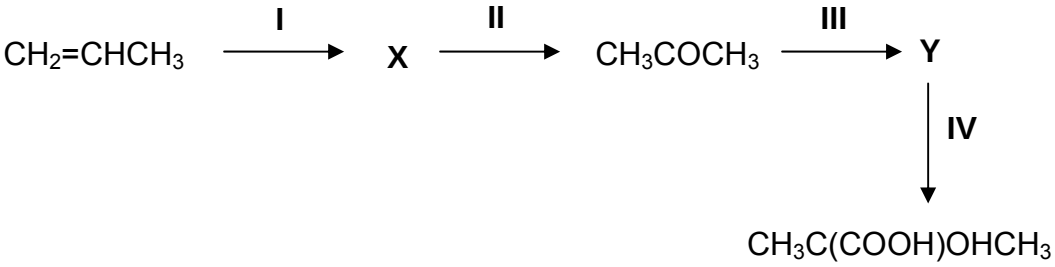
[4]

(b) **(i)** State the hybridisation, shape and number of sigma and pi bonds about C_1 and C_2 of propadiene.

(ii) Suggest whether propandiene is a planar or non-planar molecule.

[4]

(c) Propene is a major commodity in the petrochemical industry. It is used as an intermediate in the production of various chemicals. Below is reaction scheme of propene.



(i) Draw the displayed formulae of **X** and **Y**.

(ii) State the reagents and conditions of reactions **I** – **IV**

[6]

(d) Predict with explanation whether CH_3CH_2OH or CH_3OCH_3 has a higher boiling point.

[3]

(e) Suggest a 2-steps chemical tests to distinguish between CH_3COOH and CH_3CH_2COOH.

[3]
[Total: 20]