| Class | Reg Number |
|---|---|
| | |

**Candidate Name** _____

# Meridian Junior College
# JC2 Prelim Examination 2008
# H2 Chemistry 9746

**11 September 2008** **1 hr 30 min**

## Paper 2
## STRUCTURED QUESTIONS

**Additional Materials**
*Data Booklet*

**INSTRUCTION TO CANDIDATES**

Write your name, class and register number in the spaces provided at the top of this page.
Write in dark blue or black ink.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.
**All** working must be shown clearly.
You are reminded on the need for good English and clear presentation of your answers.

**INFORMATION FOR CANDIDATES**

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

| FOR EXAMINER'S USE | |
|---|---|
| Q1 | / 12 |
| Q2 | / 12 |
| Q3 | / 10 |
| Q4 | / 11 |
| Q5 | / 15 |
| Total | / 60 |

**This question paper consists of 19 printed pages.**

***Answer all the questions in the space provided.***

**1(a)** Phosgene gas, $COCl_2$, can be prepared by allowing gaseous chlorine and carbon monoxide to react under pressure. A scientist needed to prepare isotopically-labeled phosgene for use in an organic synthesis.

$$^{13}CO\ (g) + Cl_2\ (g) \rightleftharpoons {}^{13}COCl_2\ (g)$$

Some $Cl_2$ (g) and 5.00 atm of isotopically-labeled $^{13}CO$ (g) were pumped into a steel cylinder set at 25 °C which was then sealed. The cylinder was subsequently heated to 227 °C and the partial pressure of $Cl_2$ (g) was found to be 5.59 atm at 227 °C.

The cylinder was then maintained at 227 °C for an extended period of time to allow dynamic equilibrium to be reached. The new partial pressure of $Cl_2$ (g) was found to be 4.50 atm.

**(i)** Calculate the partial pressure of $^{13}CO$ (g) at 227 °C.

**[1]**

**(ii)** Write an expression for the equilibrium constant, $K_p$. Hence, or otherwise, calculate the $K_p$ value for the equilibrium at 227 °C, stating its units.

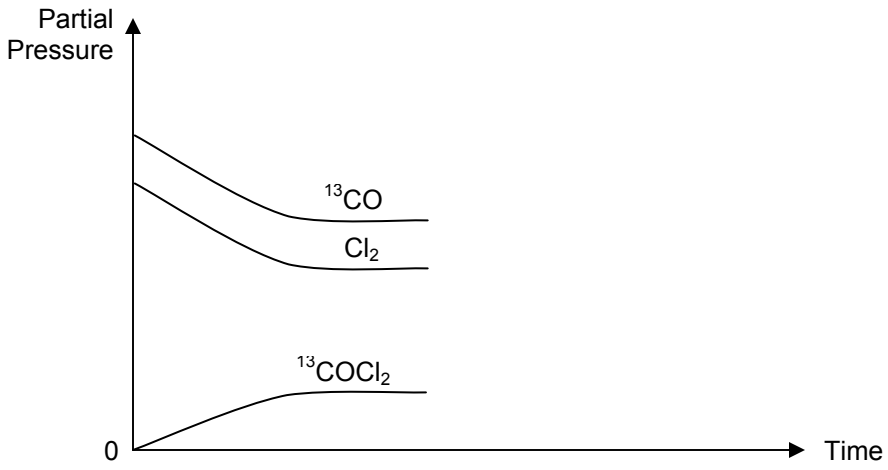
**[2]**

**(iii)** Calculate the average molecular mass of the gaseous mixture at equilibrium.
[$A_r$ of $^{13}C$: 13.0, O: 16.0, Cl: 35.5]

**[2]**

**(iv)** Sketch on the graph below to show what the scientist should expect to observe if additional $^{13}CO$ (g) was added at time t to the cylinder which was maintained at constant temperature of 227 °C. Label the graph extensions for each species till equilibrium is reached.

**[2]**



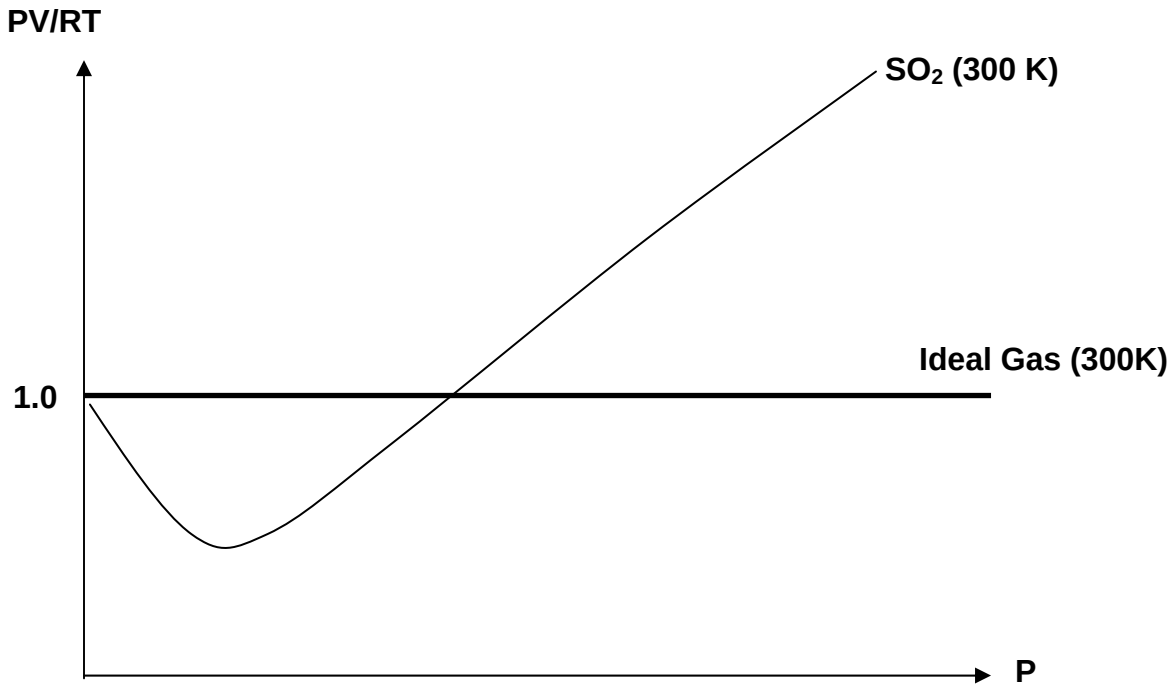

**(b)(i)** State **one** of the assumptions of the kinetic theory of gases.

**[1]**

**(ii)** The plots of PV/RT against P for one mole of an ideal gas and one mole of $SO_2$ at 300K are given below.

Show, on the same axes, how one mole of $CO_2$ will behave at the same temperature of 300K. Label your graph clearly.

**[1]**




**(iii)** Explain the difference in behaviour between carbon dioxide and sulphur dioxide at 300K.

**[1]**

**(iv)** Explain what happens when sulphur dioxide gas is cooled to 100K. Illustrate your answer clearly on the same axes in **b(ii).**

**[2]**
**[Total: 12]**

**2(a)** One method that is used to determine the concentration of ozone in the ozone layer is to pass air through acidified potassium iodide and to measure the amount of iodine liberated. In the process $O_2$ is also being liberated as one of the products.

The iodine liberated is measured using a platinum/ aqueous iodine/aqueous iodide electrode against a standard silver/aqueous silver nitrate reference electrode. The e.m.f. of the system, $\mathbf{E_{cell}}$, is given by the following equation.

$$E_{cell} = 0.32 + 0.029 \lg ([I_2])$$

To determine ozone in the atmosphere above New Zealand, a balloon was used to carry a sampling device. A 1.0 $dm^3$ sample of the air, at room temperature and 0.24 atm pressure, was passed through 15 $cm^3$ of acidified potassium iodide. When the iodine liberated was measured using the above cell, the e.m.f of the system was 0.21 V.

**(i)** Write a balanced equation for the reaction of ozone and iodide.

**[1]**

**(ii)** Calculate the percentage of ozone in this sample of air.

**[2]**

**(iii)** Draw a labeled cell diagram to show the set-up for measuring the e.m.f of the cell using silver/ aqueous silver nitrate and aqueous iodide/aqueous iodine half cells.

In your diagram, show clearly the polarity of the electrode and the direction of the electron flow in the external cell. Calculate the $E^{\theta}_{cell}$ for this set-up.

**[3]**

**(iv)** 20 $cm^3$ of 0.1 mol $dm^{-3}$ sodium iodide solution is added into the standard platinum/iodine/iodide electrode cell, describe what would happen to $E^{\theta}_{cell}$ value measured.

**[2]**

**(b)** Stratospheric ozone that protects the earth against harmful ultraviolet radiation is being depleted by the anthropogenic introduction of various gases into the atmosphere. The most destructive ozone depletion processes are catalytic cycles in which trace amounts of gases are able to destroy large quantities of ozone.

The overall reaction is shown below:

$$O_3\,(g) + O\,(g) \rightarrow 2\,O_2\,(g)$$

**(i)** Given the standard enthalpy change of formation of $O_3$ (g) is + 142.67 kJ $mol^{-1}$ and using relevant data from the Data Booklet, calculate the enthalpy change of the above reaction. **[2]**

**(ii)** The standard entropy change of the reaction between $O_3$ (g) and O (g) is +10.17 kJ $mol^{-1}$ $K^{-1}$. Use the data to decide if the reaction is spontaneous at -273 $^{o}$C, and predict how $\Delta G^{\theta}$ will change with increasing temperature.

**[2]**

**[Total: 12]**

**3(a)** The boiling points of three common chlorides are given in the following table.

| **Compound** | **Formula** | **Boiling Point/ $^{o}$C** |
|---|---|---|
| Magnesium chloride | $MgCl_2$ | 1412 |
| Aluminum chloride | $AlCl_3$ | 178 |
| Silicon tetrachloride | $SiCl_4$ | 58 |

**(i)** Briefly relate these boiling points to the structure of, and bonding in, each of these chlorides.

**[3]**

**(ii)** State the pH of the solution formed when the each of the chlorides compound dissolved in water. Hence, predict the expected observation when these chlorides were added separately to test-tubes containing sodium carbonate solution. Give reasons to support your answers.

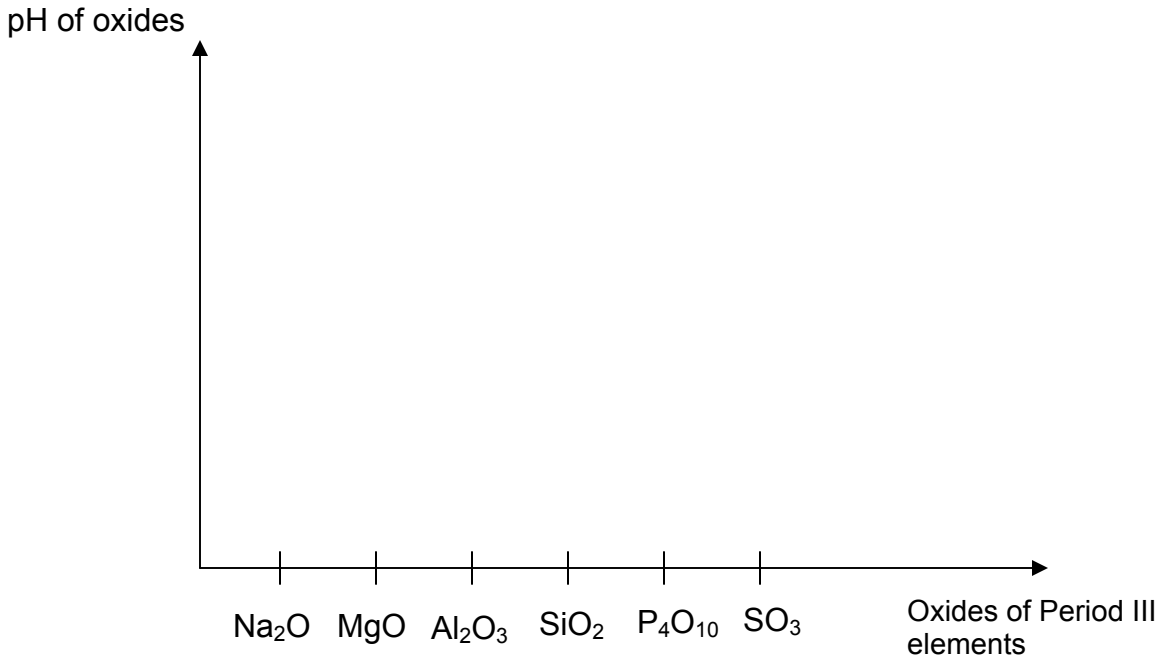
**[3]**

| **Compound** | **pH of solution when the compound dissolves in water** | **Observation on reaction of aqueous solution with $Na_2CO_3$** | **Reasons** |
|---|---|---|---|
| $MgCl_2$ | | | |
| $AlCl_3$ | | | |
| $SiCl_4$ | | | |

**(b)** The highest oxides of the Period 3 elements (from sodium to sulphur) are separately added to water.

**(i)** Using the grid provided below, sketch a graph to show the variation of pH of the resulting mixtures.

**[2]**




**(ii)** Describe and explain the trend of the graph you have drawn in **(b)(i).**

**[2]**

**[Total: 10]**

**4** In the analysis of drinking water, the method known as Mohr's titration is used to determine the chloride content present. Chloride ions present in a water sample is titrated against $AgNO_3$ (aq).

As $AgNO_3$ is slowly added, sparingly soluble AgCl precipitate is formed. The indicator used in the titration is yellow aqueous $K_2CrO_4$. The end-point of the titration is obtained when almost all the chloride present has been precipitated. Addition of $AgNO_3$ beyond this point causes the formation of a red-brown precipitate of $Ag_2CrO_4$.

This method can be used to determine the chloride ion concentration of water samples from many sources.

However, Mohr's titration should be carried out under conditions of pH 6.5 – 9. At higher pH, the $AgNO_3$ titrant added becomes ineffective, while at lower pH, the $K_2CrO_4$ indicator is affected. Chromate (VI) ions, $CrO_4^{2-}$, may be removed by an acid-base reaction to form hydrogen chromate ions ($HCrO_4^{2-}$) or dichromate ions ($Cr_2O_7^{2-}$), causing the end-point to be inaccurate.

The following are relevant $K_{sp}$ values in Mohr's titration:

| **Salt** | **$K_{sp}$** |
|---|---|
| AgCl | $1.8 \times 10^{-10}$ mol$^2$ dm$^{-6}$ |
| AgBr | $7.7 \times 10^{-13}$ mol$^2$ dm$^{-6}$ |
| AgI | $8.3 \times 10^{-17}$ mol$^2$ dm$^{-6}$ |
| $Ag_2CrO_4$ | $1.1 \times 10^{-12}$ mol$^3$ dm$^{-9}$ |

**(a)(i)** Calculate the concentration of $Cl^-$ (aq) ions at the end-point of the titration.

**[1]**

**(ii)** Explain what would be observe if excess aqueous ammonia is added to the resultant solution in **(a)(i)** at the end point. Support your answers with relevant equations.

**[3]**

**(b)(i)** In a 100 $cm^3$ sample of treated tap water, 6.95 $cm^3$ of 0.01 mol $dm^{-3}$ $AgNO_3$ was required for Mohr's titration. Calculate the concentration of $Cl^-$ (aq) ions in the treated water.

**[2]**

**(ii)** Determine the minimum concentration of $CrO_4^{2-}$ (aq) ions in the titration mixture that is required to precipitate only $Ag_2CrO_4$ immediately after the end-point.

**[1]**

**(iii)** Suggest a reason why the $AgNO_3$ titrant becomes ineffective at higher pH.

**[1]**

**(c)** An aqueous solution of chlorine can be used as a disinfectant, for example, in swimming pools. The disinfecting action is due to the presence of chloric (I) acid, HClO, formed by the reaction of chlorine with water:

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HClO(aq) + HCl(aq)$$

Chloric (I) acid ionizes as a weak acid:

$$HClO(aq) \rightleftharpoons H^+(aq) + ClO^-(aq)$$

In many swimming pools, chemicals other than chlorine gas are used to form the chloric (I) acid. This is partly because the use of chlorine gas causes much more corrosion of metal parts in the pool than does chloric (I) acid. Compounds used to chlorinate pool water in this way include calcium chlorate (I) and chlorine dioxide, $ClO_2$.

**(i)** Explain why chlorine in water causes more corrosion to the metal parts compared to pure chloric (I) acid.

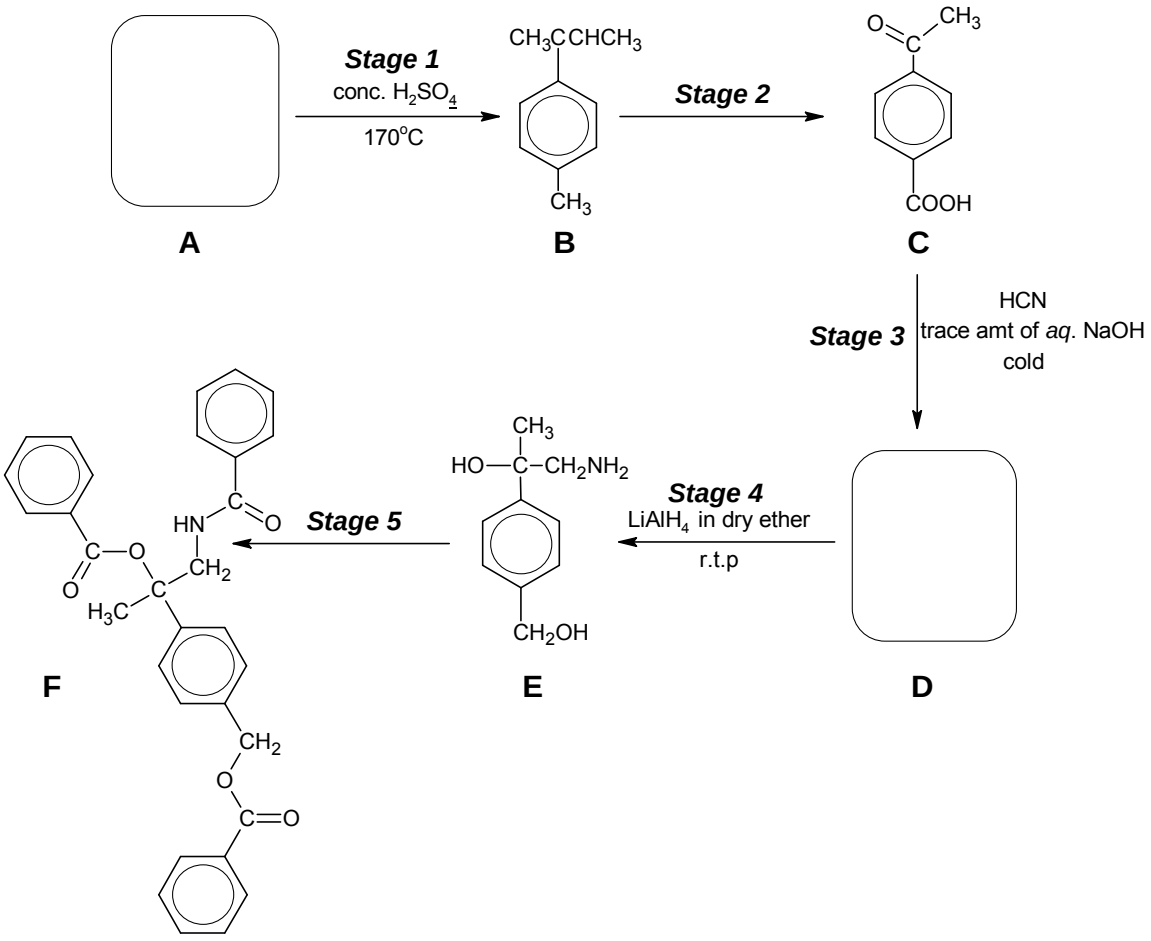
**[2]**

**(ii)** Chlorine dioxide undergoes a disproportionation reaction in water to give a mixture of chloric (I) acid and chloric (V) acid. Write a balanced equation, including state symbols, for this reaction.

**[1]**

**[Total: 11]**

**5** Compound **B** is an active ingredient used typically as a fungicide. Its low toxicity and well-known properties makes it ideal for agriculture.




**(a)(i)** Suggest the reagents and conditions for Stages **2** and **5**.

**[2]**

| | **Reagents** | **Conditions** |
|---|---|---|
| **Stage 2** | | |
| **Stage 5** | | |

**(ii)** Compound **A** is optically active. Draw the displayed formula of compound **A** in the box provided below.

**[1]**

| Compound **A** |
| --- |
| |

**(iii)** Compound **D** contains a chiral centre and it consists of a 50:50 mixture of two isomers. Draw structural formulae of these isomers of **D**.

**[1]**

**(b)(i)** Explain why traces amount of sodium hydroxide is required for ***Stage 3*** reaction to take place.

**[1]**

**(ii)** State and describe the mechanism for the reaction in ***Stage 3.***

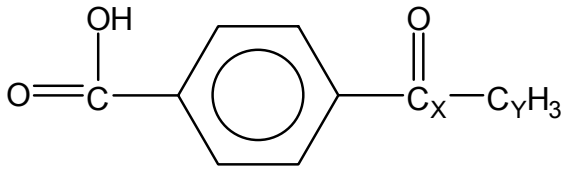
**[3]**

Mechanism: _____

**(iii)** However, a sample of **D** does not rotate the plane of polarized light. Based on the mechanism in **b(ii)**, suggest a possible reason for this occurrence.

**[1]**

**(c)** State and describe the types of hybridisation present in the carbon atoms labelled as $C_x$ and $C_y$ in Compound **C** as shown below.



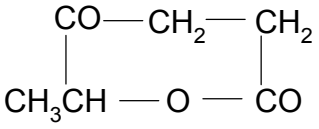

**[3]**

| **Carbon atom** | **$C_X$** |
|---|---|
| **Type of hybridisation** | |
| **Description of hybridisation** | |

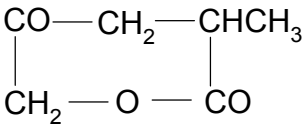
| **Carbon atom** | **$C_Y$** |
|---|---|
| **Type of hybridisation** | |
| **Description of hybridisation** | |

**(d)** Suggest a simple chemical test by which the compounds **G** and **H** could be distinguished from each other.

Write a balanced chemical equation for any reactions that has occurred.



**G**



**H**

**[3]**
**[Total: 15]**