**Semester 1 2013 / 2014**

Exam Code(s) 1HF, 1MR, 1EV  
Exam(s) 1st Science  
Module Code(s) CP102  
Module(s) Fundamentals of Chemistry

External Examiner(s) Professor Tim Gallagher  
Internal Examiner(s) Professor P.V. Murphy  
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**INSTRUCTIONS:** Answer **Four** questions: one question must be attempted from each section (A, B, C and D)  
Separate Answer Books are not required for each section.  
All questions carry 25 Marks distributed as shown.  
Leave the front page of the Answer Book blank and clearly list on it the numbers of the questions attempted.

**Duration** 2hrs  
**No. of Pages** 6 (including this front page)  
**Department(s)** Chemistry

**Requirements** None

All questions carry equal Marks.  
Molar volume at STP= 22.4 dm$^3$, Avogadro’s Number $6.02 \times 10^{23}$,  
R=$0.08206$ dm$^3$ atm/mol K
Section A

1. **Answer each of the following:**

   (i) Write balanced chemical equations for the following reaction descriptions:
   (a) Propane burns completely in air
   (b) Magnesium hydroxide reacts with sulphuric acid
   (c) Copper(I)chloride reacts with silver(I)nitrate to give silver(I) chloride and copper(I)nitrate

   **[12 Marks]**

   (ii) A commercial solid deodorant was analysed for chemical constitution. It was found to contain: 8.24% potassium, 5.69% aluminium, 13.53% sulfur, 67.43% oxygen and 5.11% hydrogen. What is the formula of the compound?

   **[8 Marks]**

   (iii) In an experiment butane was burnt in the presence of oxygen to form carbon dioxide and water. It was measured that 880g of carbon dioxide was formed in the reaction. Calculate how many grams of butane were used in the combustion reaction.

   **[5 Marks]**

2. **Answer each of the following:**

   (i) The universal gas equation can be written as \( PV = nRT \). Explain each of the terms in the equation.

   **[4 Marks]**

   (ii) Suppose you want to fill a pressurised tank (volume = 100 litres) with oxygen enriched air for use by a deep-sea diver and you want the tank to contain 50.0g of O\(_2\) and 100.0g of N\(_2\). What will the total pressure be at 21°C?

   **[10 Marks]**

   (iii) What will be the pressure of a balloon that occupies 1L at 15°C if the pressure is 0.5 atm at a volume of 0.5L at 25°C?

   **[8 Marks]**

   (iv) Of the following substances, which compound has London dispersion forces as the **only** intermolecular force? Explain your answer.

   (a) CH\(_3\)OH
   (b) Ar
   (c) HCl

   **[3 Marks]**
Section B

3. **Answer each of the following:**

   (i) Write out the electronic configuration of the following species.
       (a) Carbon,
       (b) Phosphorous
       (c) O^{2-}
       (d) Fe^{3+}  
       **[8 marks]**

   (ii) Use Lewis symbols to explain the compound formed when boron reacts completely with sulphur.  
       **[6 Marks]**

   (iii) List and explain three types of **intramolecular bonding** and provide an example for each type.  
       **[6 Marks]**

   (iv) Arrange the following molecules according to their boiling points. Explain your answer.
       CH₃OH, C₂H₆, HOCH₂CH₂OH  
       **[5 Marks]**

4. **Answer each of the following:**

   (i) Work out the two possible Lewis structures for sulphur dioxide (SO₂). Determine the preferred structure and justify your choice.  
       **[7 Marks]**

   (ii) A student wishes to measure the concentration of a NaOH solution. They use a 13.07 mL of a 0.1 M H₃PO₄ solution to neutralise 25 mL of the NaOH solution. Calculate the following.

       (a) How many moles of H₃PO₄ are used.
       (b) What is the concentration of the KOH solution?  
       **[8 Marks]**

   (iii) Explain, using a diagram, the **band theory of solids**. In your explanation, discuss why a conductor conducts electricity but an insulator does not.  
       **[5 Marks]**

   (iv) List the two main differences of graphite and carbon. Explain, using a diagram, the different properties based on the structures of graphite and carbon.  
       **[5 Marks]**
Section C

5. Answer each of the following:

(i) Draw structural formulae showing all the atoms of both of the following:
   (a) 1-chloro-1-methylcyclopentane
   (b) ethyl 2-methylpentanoate.  
       [6 Marks]

(ii) Name each molecule and indicate the functional group present in the following molecules (i)-(vi) by drawing a circle around it:

   ![Structural formulae](image)

   (a)  
   (b)  
   (c)  
   (d)  
   (e)  
   (f)  

       [2 x 6 Marks]

(iii) Explain what is meant by the term ‘enantiomer’ and draw two molecules that are enantiomers of each other.  
       [3 Marks]

(iv) Draw and name one alcohol and ether with the empirical formula \( \text{C}_x\text{H}_{10}\text{O} \).  
       [4 Marks]
6. **Answer each of the following:**

   (i) The Haber Bosch process is an industrial process for making ammonia. In this chemical process heat is generated as a by-product:

   \[ \text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3 + \text{heat} \]

   Explain the Le Chatelier’s principle as it applies to the Haber Bosch process. In doing so outline the effect on the equilibrium if you do any of the following:

   (a) Increase the temperature
   (b) Increase the pressure
   (c) Add \( \text{H}_2 \)

   [3 x 4 Marks]

   (ii) Draw a hypothetical energy level diagram for the Haber Bosch and label the following:

   (a) Average energy of the reactants.
   (b) Average energy of the products.
   (c) Activation energy.
   (d) Energy change in the reaction.

   [4 x 2 Marks]

   (iii) Show in your diagram above how the use of a catalyst would change the energy level diagram.

   [5 Marks]

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**Section D**

7. **Write an essay on the topic: acid rain – its origin, chemistry and effects.**

   [25 Marks]

8. **Write an essay methane as a greenhouse gas (the essay should discuss the chemistry of the subject and include structures of the chemicals involved and their role etc)**

   [25 marks]