

**Autumn 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  
*Dr. J. Würmel*

**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** 7 (including this front page)  
**Department(s)** Chemistry  

**Requirements** None

All questions carry equal Marks.  
Molar volume at STP= 22.4 dm³, Avogadro’s Number $6.02 \times 10^{23}$,  
R=$0.08206$ dm³ atm/mol K
Section A
1. Answer each of the following:

(i) Write balanced chemical equations for the following reaction descriptions:
   (a) Butane burns completely in air
   (b) Calcium hydroxide reacts with sulphuric acid
   (c) Magnesium reacts with oxygen to form magnesium oxide
   [12 Marks]

(ii) A commercial body lotion was analysed for chemical constitution. It was found to contain: 4.12% potassium, 2.9% aluminium, 6.8% sulfur, 33.7% oxygen and 3.1% hydrogen. What is the formula of the compound?
   [8 Marks]

(iii) In an experiment propane was burnt in the presence of oxygen to form carbon dioxide and water.
     The unbalanced equation for this reaction is:
     \[ \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

     It was measured that 1452g of carbon dioxide was formed in the reaction. Calculate the following:

     (a) how many grams of propane were used in the combustion reaction.

     (b) how many grams of water were formed in the combustion reaction.

     [5 Marks]
2. **Answer each** of the following:

(i) Using a plot of Charles's law, explain the term ‘absolute temperature’. [4 Marks]

(ii) State Boyle's gas law. [4 Marks]

(iii) State the *ideal gas law* and explain each term. [5 Marks]

(iv) Explain, using a diagram, the term: ‘vapour pressure of liquids’. [6 Marks]

(v) The diagram below shows the possible transformations from one state to another.

(a) Name each of the six transformations.

(b) For each transformation indicate if heat is gained or lost. [6 Marks]
Section B
3. Answer each of the following:
   (i) Write out the electronic configuration of the following species.
       (a) Nitrogen
       (b) Argon
       (c) S^{2-}
       (d) Mn^{7+}
       [8 marks]

   (ii) Draw the Lewis structure of the following molecules:
       (a) H_{2}
       (b) CO_{2}
       (c) CCl_{4}
       [6 Marks]

   (iii) Using the Valence Shell Electron Pair Repulsion Theory, determine the shape of the following molecules:
       (a) H_{2}O
       (b) CO_{2}
       (c) [NH_{4}]^{+}
       [8 Marks]

   (iv) Explain, using two different examples, the term hydrogen bonding.
       [3 Marks]

4. Answer each of the following:
   (i) A student is setting up a titration experiment to determine the concentration of HCl solution using a standard solution of KOH.

       (a) Firstly they need to make up a 0.1M standard solution of KOH in a 250mL flask. Explain how they would do this.
       [3 Marks]

       (b) They then carry out the titration. They use 10mL of HCl and get the following titration volumes of KOH: 8.9mL, 7.2mL, 7.3mL and 7.25mL. Using the information provided determine the concentration of the HCl solution.
       [7 Marks]

   (ii) Explain why a solution of sugar does not conduct electricity while a salt solution does.
       [5 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) Name 3 properties of an acid and 3 properties of a base. Give one example of an acid and one of a base.
       [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-3,3-dimethylpentane
       (b) bromobenzene [6 Marks]

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

   ![Molecules Diagram]

   [6 x 2 Marks]

   (iii) Explain what is meant by the term ‘chirality’ and draw a chiral molecule of your choice. [3 Marks]

   (iv) Explain what is meant by the term ‘optical isomers’ and briefly explain their effect on plane-polarized light. [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:

\[
N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{heat}
\]

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) Decrease the temperature
(b) Increase the pressure
(c) Add nitrogen  

[3 x 4 Marks]

(ii) Write the *Equilibrium Constant Expression* for the chemical reaction of the Haber Bosch process shown above.

[5 Marks]

(iii) Draw an energy level diagram for an *exothermic reaction* 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]

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**Section D**

7. Write an essay discussing: *Hydrogen – is it the fuel of the future?* and include the chemicals involved and their role.

[25 Marks]

8. Write an essay discussing *The chemistry of the greenhouse effect* and include the chemicals involved and their roles.

[25 Marks]