Autumn Examinations 2012 / 2013

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

External Examiner(s) Professor T. C. Gallagher
Internal Examiner(s) Dr. W. C. Carroll
*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 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 x 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) Methane burns completely in air
   (b) Lithium hydroxide reacts with sulphuric acid
   (c) Magnesium reacts with oxygen magnesium oxide

   **[12 Marks]**

   (ii) A compound contains 49.4% K, 20.3% S, and 30.3% O by mass. What is its empirical formula?

   **[8 Marks]**

   (iii) The combustion of ammonia in the presence of excess oxygen yields NO₂ and H₂O.

   \[4 \text{NH}_3 (g) + 7 \text{O}_2 (g) \rightarrow 4 \text{NO}_2 (g) + 6 \text{H}_2\text{O} (g)\]

   If 28.8 g of ammonia reacted, how much oxygen in grams is consumed?

   **[5 Marks]**

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

   (i) A sample of an ideal gas (3.00 L) in a closed container at 25.0°C and 76.0 torr is heated to 300°C. What is the pressure of the gas at this temperature? Express your answer in torr.

   **[10 Marks]**

   (ii) 50 mL of N₂ gas reacts with 150 mL of H₂ gas to form ammonia via the equation:

   \[\text{N}_2 (g) + 3 \text{H}_2 (g) \rightarrow 2\text{NH}_3 (g)\]

   How much ammonia (in mL) will be produced if the pressure and temperature are kept constant?

   **[8 Marks]**

   (iii) Draw a phase diagram showing what happens to the temperature of a sample of ice (starting at -10°C) as you put in energy to turn it first to liquid and then to gas. Explain what is happening.

   **[7 Marks]**
Section B

3. Answer each of the following:
   (i) Write out the electronic configuration of the following species:
       (a) Helium, (b) Lithium\textsuperscript{+}, (c) Cl\textsuperscript{-}, (d) Co\textsuperscript{2+}
       [1/2/2 Marks]

   (ii) Draw the Lewis structure for the following atoms, molecule and ion:
       (a) Lithium, (b) Argon, (c) Ammonia, (d) Ammonium
       [1/2/2 Marks]

   (iii) In each of the molecules below how would you classify the bonding (covalent, polar covalent or ionic) and why?
       H\textsubscript{2}O, CO\textsubscript{2} and LiF
       [9 Marks]

   (iv) Explain, using a diagram, what is meant by the term ‘self-ionization’ and give an example.
       [3 Marks]

4. Answer each of the following:

   (i) Write a balanced equation for the reaction of LiOH and HNO\textsubscript{3}.
       [5 Marks]

   (ii) A titration is performed to determine the concentration of a HNO\textsubscript{3} solution. 13.07 mL of a 0.1 M LiOH solution is used to neutralise 20 mL of the HNO\textsubscript{3} solution.

       (a) How would you make up the 0.1M LiOH solution provided you were given a flask that can hold 250 mL?
       (b) How many moles of LiOH are used in the titration?
       (c) What is the concentration of the HNO\textsubscript{3} solution?
       [10 Marks]

   (iii) Draw a typical titration curve between a strong acid and a strong base and label the endpoint in the graph.
       [5 Marks]

   (iv) What would you use to determine the endpoint in an acid-base titration?
       [5 Marks]
Section C

5. Answer each of the following:
   
   (i) Draw structural formulae showing all the atoms of both of the following: (a) hept-1-ene, (b) 4,5-dimethylhexan-2-ol  
   
   (ii) Name each molecule and indicate the functional group present in the following molecules (i)-(vi):

   
   (iii) Explain what is meant by the term optical isomers and briefly explain their effect on plane-polarized light.

6. Answer each of the following:

   (i) Calculate the pH of an aqueous solution at 25.0°C in which [H₃O⁺] is 0.0025 M.

   (ii) Calculate the pH of a solution made by mixing 25 mL of 0.1 M HCl with 25 mL 0.2 M NaOH.

   (iii) Consider the reaction below:

   2NO (g) \rightleftharpoons N₂ (g) + O₂ (g) + Heat

   (a) Write out an expression for K_{eq} for the reaction above.

   (b) What would the value of K_{eq} be if the equilibrium concentrations are 0.0035 M for NO, 0.025 M for N₂, and 0.025 M for O₂?
(v) What would be the effect on the position of equilibrium of the following changes in the reaction conditions?
   (a) Increased temperature
   (b) Removal of $O_2$ during the reaction

[2 x 3 Marks]

Section D

7. Write an essay on the chemistry involved in acid rain. The essay should discuss the chemistry of the subject and include structures of the chemicals involved and their role etc.
   [25 Marks]

8. Write an essay on the topic alternative fuels. The essay should discuss the chemistry of the subject and include structures of the chemicals involved and their role etc.
   [25 Marks]