Autumn Examinations 2013-2014

Paper 2

Exam Code(s) 1BO, 0MB, 1BPM, 1BMS, 1BY, 1EH, 1BPP
Exam(s) Foundation Medicine, 1st Science
Module Code(s) CH120, CH130
Module(s) Chemistry: molecular science
Chemistry: world of the molecule
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Instructions: Answer four questions of which not more than two may be chosen from any one section. Separate answers books for Sections A and B are not required.

Duration 2 hr
Number of pages 5 (including this front page)
School Chemistry

Requirements Graph paper, mathematical tables
Marks All questions carry equal marks; breakdown of marks is as shown.
1. **Answer all parts**

(a) Explain how the Principle of Le Chatelier can be used to predict the effect of (i) a change in pressure, (ii) a change in temperature or (iii) a change in the concentration of the products or reactants, on a gas phase reaction which is at equilibrium. [8 marks]

(b) How would (i) a reduction in pressure and (ii) an increase in temperature effect the concentration of SO₃ in the following equilibrium? Explain your answer.

\[
3\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3 \quad \Delta H = -70.9 \text{ kJmol}^{-1}
\] [9 marks]

(c) If more O₂ was added to the above equilibrium, what would be the effect on the concentration of SO₂ and SO₃? Explain your answer. [8 marks]

2. **Answer all parts**

(a) Assign oxidation numbers to each atom in the following:

\[
\text{AlCl}_3, \quad \text{SF}_6, \quad \text{PO}_4^{3-}, \quad \text{Cr}_2\text{O}_3
\] [6 marks]

(b) Explaining your answer, indicate which of the following are redox reactions:

(i) \( \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \)

(ii) \( \text{Cd} + \text{H}_2\text{O} + \text{Ni}_2\text{O}_3 \rightarrow \text{Cd(OH)}_2 + 2\text{NiO} \)

(iii) \( 2\text{H}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{SO}_2 + 2\text{H}_2\text{O} \)

In the case of those which are redox reactions, identify the atoms which have been oxidized and reduced. Explain your answer. [6 marks]

(c) (i) Draw a diagram of the cell and write down the cell reaction corresponding to the following cell description:

\[
\text{Fe} \mid \text{Fe}^{2+} \mid \mid \text{Sn}^{2+} \mid \text{Sn}
\] [6 marks]

(ii) How many Faradays of charge are transferred when 5 g of iron (Fe) reacts? [3 marks]

(iii) The standard electrode potentials (SEPs) of iron (Fe) and tin (Sn) are as follows:

\[
\text{Fe}^{2+} \mid \text{Fe} = -0.440 \text{ V}; \quad \text{Sn}^{2+} \mid \text{Sn} = -0.126 \text{ V}
\]

Calculate the EMF of the cell. [4 marks]

More on next page
3. **Answer all parts**

(a) Using an example, explain what is meant by a weak acid and, using the acid you choose, how its “strength” is evaluated. **[7 marks]**

(b) In terms of the equilibrium involved, explain in detail why the pH of water is 7. **[6 marks]**

(c) Calculate the pH of the following solutions:

   (i) 0.005 M HCl; (ii) 0.05 M LiOH; (iii) 0.1 M H₂SO₄ **[6 marks]**

(d) In biologically important water based solutions such as blood, it is important that the pH remains relatively constant even if acids and bases are added. Using an example, explain how this is achieved. **[6 marks]**

4. **Answer all parts**

(a) Using appropriate diagrams explain why the liquid hydrocarbon pentane is not soluble in water

![Pentane molecule](image)

**pentane**

**[6 marks]**

(b) Using appropriate diagrams, explain how hybridization can be used to account for the structure of diamond. Explain how this structure accounts for the mechanical and electrical properties of diamond. **[6 marks]**

(c) (i) Draw a phase diagram for water (triple point: 0.01 °C, 0.0006 atm), and for a substances (X) whose triple point occurs at 6 atm and 3 °C, but whose phase diagram is otherwise very similar to that of water. **[5 marks]**

(ii) Use the phase diagram for water to outline the changes that occur when ice at -30 °C and 0.6 atm is heated to 150 °C. Provide as much information about these changes as possible. **[4 marks]**

(iii) Use the phase diagram for X to outline what happens when a gaseous sample of X is cooled at 1 atm? **[4 marks]**
5. **Answer all parts**

Discuss the chemistry of alcohols under the following headings:

(a) Functional group, classes of alcohol and physical properties. [9 marks]

(b) Methods of making alcohols: at least three different methods should be discussed. [8 marks]

(c) Typical reactions of alcohols: at least three different reactions should be discussed [8 marks]

Structural formulae (see above), and chemical reactions based on structural formulae, must be used in answering (a) – (c).

6. **Answer all parts**

(a) Draw structures for all the structural isomers of hexane and provide an IUPAC name for any one of them. [7 marks]

(b) Explain what is meant by a reaction mechanism and draw, in detail, any reaction mechanism of your choice. [6 marks]

(c) **Using examples**, explain the difference between geometrical and optical isomerism. Explain why the isomerism arises in each of the examples you provide. [6 marks]

(d) Draw the structure of any ketone and, using an appropriate reaction as an example, explain why it would react with a nucleophile. [6 marks]
7. **Answer all parts**

In the context of the transformations shown below, and of the additional information provided, answer (a), (b) and (c):

\[
\begin{align*}
\text{C}_3\text{H}_6 \ (A) & \quad \rightarrow \quad \text{C}_3\text{H}_7\text{Br} \ (C) & \quad \rightarrow \quad \text{C}_3\text{H}_8\text{O} \ (D) \\
\text{KMnO}_4 & \quad \rightarrow \quad \text{C}_3\text{H}_8\text{O}_2 \ (B) & \quad + \quad \text{H}_3\text{C} = \text{C} \quad \text{OH} & \quad \rightarrow \quad \text{C}_5\text{H}_{10}\text{O}_2 \ (E)
\end{align*}
\]

(A): This reacts readily with Br₂
(B), (D): Both compounds react with sodium metal to give bubbles of H₂ gas.
(E): This has a pleasant, fruity smell

(a) Provide structures for compounds (A) – (E). The functional group should be named and clearly labelled in each case. [5 x 3 marks]

(b) Suggest suitable reagents for the conversion of (A) to (C), and (C) to (D). [2 x 2½ marks]

(c) Outline two other reactions for compound (A) and provide reaction equations based on structural formulae for them. [2 x 2½ marks]

8. **Answer all parts**

Soaps and detergents are important materials in the modern world.

(a) Describe the general structure of soap and detergent molecules. [4 marks]

(b) What are surfactants? Explain why soaps and detergents are typical surfactants. [4 marks]

(c) Discuss some of the problems that arise as a result of the fact that oil does not dissolve in water. [4 marks]

(d) Explain in detail how a soap or detergent solubilises oil in water through the formation of micelles. [5 marks]

(e) Why is “solubilise” better than “dissolve” as a term to describe the role played by soap/detergents in the oil/water issue [4 marks]

(f) What is the difference between a soap and a detergent in terms of how they function [4 marks]