Autumn Examinations 2012-2013

Paper 2

Exam Code(s) 1BO, 0MB, 1BPM, 1BMS, 1BY, 1EH, 1EV, 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.
Section A

1. **Answer all parts**
   
   (a) Explain why many reactions start off rapidly, but then slow down and eventually stop with considerable amounts of reactants still unreacted.  
   
   **[8 marks]**

   (b) A mixture of the three gases N₂, H₂ and NH₃ is at equilibrium at 300 °C and has the following composition:
   
   \[ [N₂] = 0.25 \text{ mol L}^{-1}; [H₂] = 0.15 \text{ mol L}^{-1}; [NH₃] = 0.09 \text{ mol L}^{-1} \]
   
   Calculate the equilibrium constant, K, at 300 °C for the reaction:
   
   \[ 3H₂ + N₂ \rightleftharpoons 2NH₃ \]
   
   **[9 marks]**

   (c) The reaction is catalysed by iron oxide (FeO) which is a solid. What effect would the addition of FeO have on a mixture of the three gases which is at equilibrium? Explain your answer using an activation energy (transition state) diagram.
   
   **[8 marks]**

2. **Answer all parts**

   Sodium metal can be manufactured by the electrolysis at 900°C of molten sodium chloride

   (a) Draw a simple diagram showing how the electrolysis might be carried out.
   
   **[5 marks]**

   (b) Label the cathode and the anode on this diagram. Write down the reaction equation for each electrode and for the overall process.
   
   **[7 marks]**

   (c) Calculate the mass of sodium that would be produced by a current of 8 A flowing for 40 min (1 F = 96,500 C).
   
   **[7 marks]**

   (d) Explain why sodium is not produced when the electrolysis involves a solution of sodium chloride in water, rather than molten sodium chloride.
   
   **[6 marks]**

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3. **Answer all parts**

(a) Which of the following are acid-base reactions?

\[
\begin{align*}
\text{NH}_3 + \text{H}_2\text{O} & \rightarrow \text{NH}_4^+ + \text{OH}^- \\
\text{HPO}_4^{2-} + \text{SO}_3^{2-} & \rightarrow \text{PO}_4^{3-} + \text{HSO}_3^- \\
\text{H}_2\text{O} + \text{H}_2\text{O} & \rightarrow \text{H}_3\text{O}^+ + \text{OH}^- \\
2\text{NO} + \text{H}_2 & \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}
\end{align*}
\]

For those which are acid base reactions, indicate which reactant is the acid and which is the base. [7 marks]

(b) Explain the difference between the strength and the concentration of an acid. [6 marks]

(c) Calculate the pH of the following solutions:

(i) 0.01 M HCl; (ii) 0.10 M LiOH; (iii) 0.03 M H\textsubscript{2}SO\textsubscript{4} [6 marks]

(d) In terms of acids and bases, explain what is meant by a “neutral” solution and why its pH = 7. [6 marks]

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4. **Answer all parts**

(a) In terms of the structure of a crystal, explain what is meant by the term “unit cell”. Draw diagrams showing the three cubic unit cells. [6 marks]

(b) Explain, in detail and using appropriate diagrams, how hybridization accounts for the shape of CH\textsubscript{4}. [7 marks]

(c) The solubility of a substance in a liquid can be predicted on the basis of the “like dissolves like” principle. Outline the molecular basis of this principle using water (solvent) and oil (solute) as an example. [6 marks]

(d) Explain in detail what happens when sodium chloride (NaCl) dissolves in water. How can the process you describe explain why sodium chloride (Na\textsuperscript{+}Cl\textsuperscript{-}) dissolves in water whereas silver chloride (Ag\textsuperscript{+}Cl\textsuperscript{-}) does not (only energy need be considered in your answer). [6 marks]
Section B

Structural formulae, and not molecular formulae, must be used in answering Questions 5, 6 and 7.

Example

\[
\begin{align*}
\text{H} & \quad \text{C} \quad \text{C} \quad \text{O} \\
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{O} \\
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H}
\end{align*}
\]

or

\[
\begin{align*}
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{C} \quad \text{C} \quad \text{O} \\
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H}
\end{align*}
\]

but not \( \text{C}_2\text{H}_4\text{O} \) or \( \text{CH}_3\text{CHO} \)

5. **Answer all parts**

Describe the **chemistry of alkenes** under the following headings:

(a) Basic physical properties [4 marks]

(b) The electronic structure of the carbon-carbon double bond [6 marks]

(c) How isomerism arises in alkenes [6 marks]

(d) Basic reactions, including a reaction mechanism for one of the reactions discussed. Reaction equations, based on simple structural formulae, must be provided for any reaction discussed. [9 marks]

6. **Answer all parts**

(a) Explain why it was difficult to work out a structure for benzene which would account for its properties and how this was eventually achieved using the resonance concept. [7 marks]

(b) (i) Explain why ethanoic acid (acetic acid) is acidic.

(ii) Is trifluoroacetic acid more or less acidic than ethanoic acid? Explain your answer.

Appropriate structures must be used in both (i) and (ii). [6 marks]

(c) Explain what is meant by “cracking” and “reforming” in the context of the petrochemical industry. [6 marks]

(d) Using two examples, outline the basic IUPAC rules for systematically naming an alkane. [6 marks]

more on next page
7. **Answer all parts**

The following scheme outlines a series of reactions involving compounds (A) to (E):

![Chemical reaction scheme](image)

(A): contains a carbonyl group  
(D): turns blue litmus red  
(C): decolourises a solution of bromine in water  
(E): has a pleasant smell

(a) Provide structures for compounds (A) – (E). The functional group should be named and clearly labelled in each case.  

(b) Provide a simple mechanism for the conversion of (B) to (C).  

(c) List any two other reactions for (B) and give equations for them.  

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8. **Answer all parts**

The oxides of nitrogen, sulphur and carbon are gases which play an important role in determining the quality of the air we breathe. Outline the role played by the oxides of any two of these elements in air pollution; in the case of carbon, only carbon monoxide should be considered. The origin of the gases involved and the role they play in the atmosphere should be considered.  

[2 x 12½ marks]

[Balanced reaction equations must be provided where appropriate]