Semester 1 Examinations 2012-2013

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
External Examiner(s) Prof. Paul Seakins
Internal Examiner(s) Professor Paul V. Murphy
*Dr. Niall W.A. Geraghty

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 4 (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. The metal lead (Pb) is produced from its oxide (PbO) by a two step process which involves roasting the ore (PbS, galena) and the subsequent reduction of the lead oxide (PbO) thus formed:

\[
PbS + \frac{3}{2}O_2 \rightarrow PbO + SO_2
\]

\[
PbO + CO \rightarrow Pb + CO_2
\]

(a) What mass of PbO is obtained from 1 tonne of the ore? [5 marks]

(b) What volume of SO\textsubscript{2} is produced in processing this amount of ore? [5 marks]

(c) What mass of lead is obtained from 1 tonne of the ore? [5 marks]

(d) What volume of CO\textsubscript{2} is produced in processing 1 tonne of the ore? [5 marks]

(e) What volume of CO at STP is required to process 1 tonne of the ore? [5 marks]

[1 tonne = 1000kg; 1 mole of a gas occupies 22.4 L at STP]

2. Briefly outline the factors that affect the rate of a chemical reaction. [6 marks]

It is believed that the reaction between nitrogen dioxide (NO\textsubscript{2}) and ozone (O\textsubscript{3}) may be having a negative effect on the Ozone Layer:

\[
NO_2 + O_3 \rightarrow \text{Products}
\]

The reaction is first order in both NO\textsubscript{2} and O\textsubscript{3}.

(a) Write down the rate equation for the reaction. [5 marks]

(b) If the rate of the reaction is 6.30 mol L\textsuperscript{-1} s\textsuperscript{-1} when [NO\textsubscript{2}] = 0.21 mol L\textsuperscript{-1} and [O\textsubscript{3}] = 0.70 mol L\textsuperscript{-1}, calculate the rate constant, k. What are the units of k? [5 marks]

(c) Sketch a rough concentration vs. time plot for the reaction. [5 marks]

(d) Would you expect the reaction half-life to be constant? Explain your answer. [4 marks]

3. (a) Outline how the electrons are organized in the energy levels within an oxygen (O) atom and list the rules that determine how this comes about. [7 marks]

(b) Outline the information that is provided by each of the four quantum numbers and explain how a 2p\textsubscript{x} and a 3p\textsubscript{y} orbital are related to each other. [6 marks]

(c) Explain what is meant by ionization energy and account for the variations shown in the ionization energies (kJ mol\textsuperscript{-1}) of the elements in the first row of the Periodic Table:

\[
\text{Li, 519; Be, 900; B, 799; C, 1090; N, 1400; O, 1310; F, 1680; Ne, 2080}
\]

[6 marks]

(d) Outline the contribution of John Dalton to the development of our understanding of the structure of matter. [6 marks]
4. It has been said that the Ozone Layer is “the shield which makes life on the surface of the earth possible”. Discuss the chemistry of the ozone layer under the following headings:

(a) the formation of the Ozone Layer and how it normally functions [12 marks]

(b) CFCs and their interaction with the Ozone Layer [13 marks]

Reaction equations must be provided where appropriate

Section B

5. (a) Explain what is meant by vapour pressure and how the concept can be used (i) to define the boiling point of a liquid and (ii) to account for the process of evaporation. [12 marks]

(b) 35 L of oxygen at 85 °C and 92,000 N m⁻² is added to a 40 L stainless steel cylinder containing carbon dioxide at 40 °C and 70,000 N m⁻². Calculate the final pressure in the cylinder if after the addition the final temperature is 55 °C. [13 marks]

6. (a) List, giving one example in each case, the various types of intramolecular and intermolecular bonding. [9 marks]

(b) In the case of intramolecular bonding, explain how we can determine the nature of a particular bond in a molecule. [8 marks]

(c) Explaining your answer, indicate what kind of intramolecular bonding exists in each of the following:

NaCl, NH₃, SiH₄, I₂ [8 marks]

7. (a) Describe the bonding that occurs in metals and how it accounts for their mechanical properties. [6 marks]

(b) Explain briefly what is involved in magnetic resonance imaging (MRI) and how is used to investigate internal problems in the body [7 marks]

(c) Explain how the Electron Pair Repulsion Theory (EPRT) accounts for the shape of BF₃ and NH₄⁺ [6 marks]

(d) Using the molecule O=SCl₂ as an example, explain how the EPRT accounts for the shape of a molecule containing a double bond. [6 marks]
8. (a) Explain what is meant by the term entropy (S). Give examples (one chemical and one non-chemical in each case) of processes which involve (a) an increase in entropy and (b) a decrease in entropy. [6 marks]

(b) Using the data given below, calculate the standard entropy change (ΔS°) for the following reaction:

\[
\text{CaO(s) + SO}_3\text{(g) } \rightarrow \text{CaSO}_4\text{(s)}
\]

[9 marks]

(c) Explain why you consider the sign of the calculated entropy change to be appropriate for this reaction. [5 marks]

(d) Estimate the temperature at which the reaction changes from being spontaneous to being non-spontaneous and explain what assumptions are involved in making this estimate. [5 marks]

<table>
<thead>
<tr>
<th></th>
<th>( \Delta H^\circ_f \text{ (kJ mol}^{-1})</th>
<th>( \Delta G^\circ_f \text{ (kJ mol}^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaSO_4\text{(s)}</td>
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<td>-1320.3</td>
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<tr>
<td>CaO\text{(s)}</td>
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<td>-604.2</td>
</tr>
<tr>
<td>SO_3\text{(g)}</td>
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