



NUI Galway
OÉ Gaillimh

Semester II Examinations 2010 / 2011

Exam Code(s) 0MB, 1BE, 1BG, 1BP, 1BO, 1BPM, 1BV
Exam(s) 1st Medicine, 1st Engineering, 1st Science

Module Code(s) CH111
Module(s) Engineering and Medical Chemistry

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INSTRUCTIONS: Answer five questions of which not more than two may be chosen from any one section.

Separate answers books for Sections A, B and C are not required

Duration 3 hrs
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.

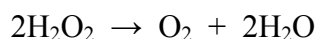
Section A

1. Answer all parts

Explain what is meant by an activation energy (transition state) diagram and use one to explain the effect of (a) temperature and (b) a catalyst on a chemical reaction.

[6 marks]

Under certain circumstances hydrogen peroxide (H_2O_2) breaks down to give oxygen and water:



The following data were obtained for this reaction:

t(s)	$[\text{H}_2\text{O}_2]$ (mol L ⁻¹)
0	2.32
300	1.86
600	1.49
1200	0.98
1800	0.62

- (i) Determine the order and rate constant of the reaction. [Graph paper is available] [6 marks]
- (ii) If the initial concentration of H_2O_2 is 0.5 mol L^{-1} , how long will it take for its concentration to drop to 0.125 mol L^{-1} ? [4 marks]
- (iii) Calculate the rate of the reaction at this concentration [4 marks]

2. Answer all parts

- (i) Draw a simple phase diagram for water and use it to explain how freeze drying works. [5 marks]
- (ii) Explain the difference between an orbit and an orbital, and how a $2p_x$ and a $3p_y$ orbital are related to each other. [5 marks]
- (iii) Explain briefly how magnetic resonance imaging (MRI) is used to investigate internal problems in the body. [5 marks]
- (iv) How would (i) a reduction in pressure and (ii) an increase in temperature affect the concentration of SO_3 in the following equilibrium reaction. Explain your answer.



[5 marks]

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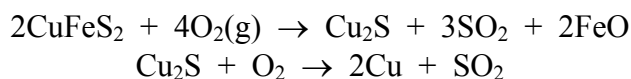
3. Answer all parts

Two liquids, A and B, have approximately the same molecular mass, but the boiling point of B is 82 °C higher.

- (i) Explain what this information tells us about the nature of the **intermolecular** bonds in A and B. **[5 marks]**
- (ii) In the gas state, which material will behave more like an ideal gas? Explain your answer. **[5 marks]**
- (iii) In which liquid, A or B, will NaCl be more soluble? Explain your answer. **[5 marks]**
- (iv) If 12 g of A occupies $5.2 \times 10^{-3} \text{ m}^3$ at $100,000 \text{ Nm}^{-2}$ and 25 °C, calculate its molecular mass ($R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$) **[5 marks]**

4. Answer all parts

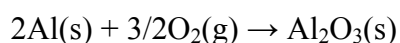
- (i) Copper pyrite (CuFeS_2) is one of the most important copper ores. The metal is obtained from this ore using a two-stage process:



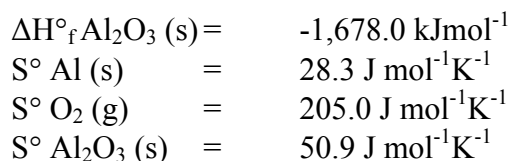
- (a) Calculate the mass of FeO formed from 1 tonne (1000 kg) of the ore. **[4 marks]**
- (b) Calculate the mass of copper metal that could be obtained from 1 tonne of the ore. **[3 marks]**
- (c) Calculate the **total volume** of SO_2 gas (STP) produced in processing 1 tonne of ore **[3 marks]**

[1 mole of gas at STP occupies 22.4 L]

- (ii) The inertness of the metal aluminium is due to the formation of a very thin layer of aluminium oxide (alumina, Al_2O_3) on its surface:



- (a) Use the data provided below to calculate ΔS° and ΔG° for this reaction. **[7 marks]**



- (b) Assuming ΔS and ΔH are independent of temperature, would you expect the reaction to be spontaneous at 400 °C? Explain your answer. **[3 marks]**

Please turn over

Section B

5. Hydrogen is the most abundant element in the Universe. Discuss this element under the following headings:
- (i) the common isotopes of hydrogen. [5 marks]
 - (ii) how the heavier elements are formed from hydrogen. [5 marks]
 - (iii) its basic chemical reactions. [5 marks]
 - (iv) the concept of a “hydrogen economy”. [5 marks]

[Balanced reaction equations must be provided where appropriate]

6. **Answer all parts**

- (i) Explain how hybridization accounts for the shape of CH₄. [5 marks]
- (ii) Explaining your answer, indicate what type of **intermolecular** bond exists in each of the following:
HF (liquid), H₂O (solid), CO₂ (gas), CO₂ (liquid) [5 marks]
- (iii) Explain briefly how the Brønsted-Lowry Theory explains the behaviour of acids and bases. Give two acid base reactions which clearly demonstrate the concepts involved. [5 marks]
- (iv) Explain how the molecular structure of diamond accounts for its physical properties. [5 marks]

7. **Answer all parts:**

The corrosion of iron is of enormous importance in terms of the use of this metal.

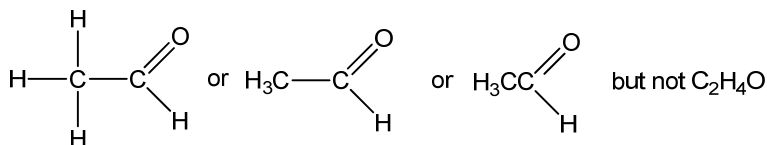
- (i) Explain in detail how corrosion occurs on the surface of a piece of iron. [7 marks]
- (ii) Describe any **two** methods that are currently used to control the corrosion of iron. [7 marks]
- (iii) In an industrial plant it is proposed to pump a solution of Mg²⁺ (magnesium) ions through a steel pipe. Write down the chemical reaction that could, in principle, occur and the cell description corresponding to the reaction. Calculate the EMF of this cell given the following SEPs: Fe²⁺/Fe = -0.45 V and Mg²⁺/Mg = -2.37 V. On the basis of the EMF value you obtain, would you advise the company to pump the solution through the steel pipe? Explain your answer. [6 marks]

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Section C

Structural formulae, and not molecular formulae, must be used in answering the questions in this section:

Example: ethanal



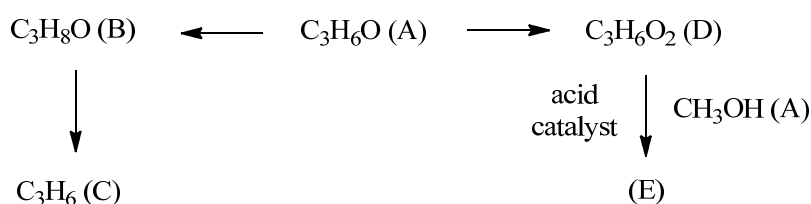
8. Answer all parts

- (i) Explain why ethanoic acid (acetic acid) is acidic. Is trifluoroacetic acid more or less acidic than ethanoic acid? Draw structures to explain your answers. **[5 marks]**
- (ii) Using examples, explain the difference between structural and geometrical (*cis/trans*) isomerism. **[5 marks]**
- (iii) Explain why it was difficult to work out a structure for benzene which would account for its properties and how this was eventually done using the resonance concept. **[5 marks]**
- (iv) Give any **two** examples of what you consider to be the most important type of reaction of alkenes. Provide a simple mechanism for one of the reactions you provide. **[5 marks]**

9. Discuss the chemistry of aldehydes and ketones under the following headings:

- (i) Structure and physical properties. **[7 marks]**
- (ii) Outline any 3 methods by which they may be prepared. **[6 marks]**
- (iii) Outline any 3 reactions of these molecules. **[7 marks]**

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



(A): contains a carbonyl group.

(D): turns blue litmus red.

(C): decolourises a solution of bromine in water

(E): has a pleasant smell

- (i) Provide structures for compounds (A) – (E). The functional group should be named and clearly labelled in each case. **[10 marks]**
- (ii) Provide a simple mechanism for the conversion of (B) to (C). **[4 marks]**
- (iii) List any two other reactions for (B) and give equations for them. **[6 marks]**