

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester 1 2005/2006

FIRST YEAR ENGINEERING

Chemistry I (CH105)

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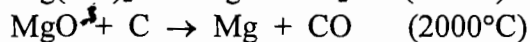
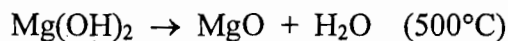
Time allowed: two hours

Answer four questions

No more than two questions may be taken from either section

Section A

1. The metal magnesium (Mg) can be produced industrially by a process which involves the following reactions:



- (a) What mass of MgO would be obtained from 1 tonne of Mg(OH)_2 ? [7 marks]
- (b) What volume of gaseous water would be produced from 1 tonne of Mg(OH)_2 ? [6 marks]
- (c) What mass of Mg would be produced from 1 tonne of Mg(OH)_2 ? [6 marks]
- (d) What mass of carbon would be required to process this amount of Mg(OH)_2 ? [6 marks]

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

[Please turn over]

2. What is a catalyst? Use an activation energy diagram to explain how a catalyst works. [6 marks]

Use the following data to determine the order and the rate constant for the reaction:



Time (s)	0	200	400	600
[A] (mol l ⁻¹)	0.600	0.400	0.267	0.178

[13 marks]

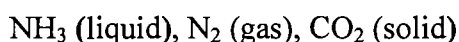
Calculate the rate of the reaction when $[A] = 0.291 \text{ mol l}^{-1}$. [6 marks]

- 3.
- (a) Explain how the Periodic Table is constructed and how it can be used to show variations in the metallic character of the elements. [7 marks]
- (b) Describe Rutherford's "gold foil" experiment and the conclusions that were drawn on the basis of the results obtained from it [6 marks]
- (c) Explain, using examples, what information is provided by the four quantum numbers. [6 marks]
- (d) Explain what is meant by an orbital and how a $2p_x$ and a $3p_z$ orbital are related to each other. [6 marks]
4. Discuss the chemistry involved in the conversion of iron ore into steel. Balanced chemical reaction equations should be provided where appropriate. [25 marks]

Section B

5. Describe, in detail, the three types of **intermolecular** bonding. [15 marks]

Explaining your answer, indicate what type of intermolecular bond exists in each of the following:



[10 marks]

- 6.
- (a) Explain what is meant by Charles's Law and how it can be used to define the absolute scale of temperature. [13 marks]
- (b) A 0.20 m^3 sample of gas at 300 K and $2.00 \times 10^5 \text{ Nm}^{-2}$ contains 0.50 moles of O_2 and 0.70 moles of Ne
- (i) Calculate the partial pressure of each gas. [6 marks]
- (ii) Are there any other gases present in the mixture? If so, calculate their combined partial pressure. [6 marks]

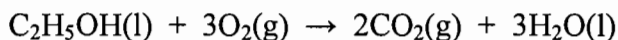
$$[R=8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

- 7.
- (a) The electronegativity of the element A is 1.9 and that of B is 2.3 . Explain what this tells us about the gaseous molecule AB and whether it would behave like an ideal gas. [7 marks]
- (b) Give an example of a molecule that has at least one non-bonded (lone) pair of electrons and explain how the Electron Pair Repulsion Theory accounts for its shape. [6 marks]
- (c) Explain what is meant by superconductivity and how it can be measured. Why is it important to have materials which are superconducting above 77 K ? [6 marks]
- (d) Explain in general terms how the structures of gases, liquids and solids differ at a molecular level. [6 marks]
8. Explain the significance of each of the terms in the following equation:

$$\Delta G = \Delta H - T\Delta S$$

[6 marks]

Ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) can be obtained from sugar cane or sugar beet by fermentation and as it can be used in an internal combustion engine it is often described as a biofuel. Ethanol reacts with oxygen as follows:



- (a) Use the data given below to calculate:
- (i) ΔH°_f for the reaction [6 marks]
- (ii) the calorific value of ethanol [5 marks]
- $$\Delta H^\circ_f \text{CH}_3\text{CH}_2\text{OH}(\text{l}) = -277.6 \text{ kJ mol}^{-1}$$
- $$\Delta H^\circ_f \text{H}_2\text{O}(\text{g}) = -285.8 \text{ kJ mol}^{-1}$$
- $$\Delta H^\circ_f \text{CO}_2(\text{g}) = -395.5 \text{ kJ mol}^{-1}$$
- (b) Is the entropy change for this reaction positive or negative? Explain your answer. [4 marks]
- (c) Explain briefly how the calorific value of ethanol might be determined experimentally. [4 marks]