

**Ollscoil na hÉireann, Gaillimh**  
**National University of Ireland, Galway**

**Semester 1 2001**

**FIRST YEAR ENGINEERING**

**Chemistry I**

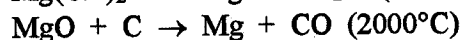
**Professor R.N. Butler**  
**Dr. N.W.A. Geraghty**

**Time allowed: Two Hours**  
**Answer Four questions**

**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 weight of MgO would be obtained from 1 tonne of  $\text{Mg(OH)}_2$ ? [7 marks]
  - (b) What volume of gaseous water would be produced from 1 tonne of  $\text{Mg(OH)}_2$  at the reaction temperature of  $500^\circ\text{C}$  and 1 atm? [6 marks]
  - (c) What weight of Mg metal would be produced from 1 tonne of  $\text{Mg(OH)}_2$ ? [6 marks]
  - (d) What weight of carbon would be required to process this amount of  $\text{Mg(OH)}_2$ ? [6 marks]
- 2.
- (a) Describe the basic features of the Bohr model of the atom. [7 marks]
  - (b) Write down the electronic configuration of the fluorine atom, and give an account of the rules you use to do this. [6 marks]
  - (c) Explain what is meant by the term "orbital" and draw a diagram showing how a  $2p_x$  and a  $3p_y$  orbital are related to each other. [6 marks]
  - (d) Explain how and why the size of an atom varies as we go across a row and down a group in the Periodic Table. [6 marks]

**More on next page 1**

3. Give an account of how steel is manufactured paying particular attention to the chemical reactions involved. **[25 marks]**
4. (a) Briefly outline the factors that can affect the rate of a chemical reaction. **[6 marks]**
- (b) The following data were obtained for the reaction of NO(g) and Cl<sub>2</sub>(g):  

$$2\text{NO(g)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NOCl(g)}$$

Experiment	Initial [NO] (mol.l <sup>-1</sup> )	Initial [Cl <sub>2</sub> ] (mol.l <sup>-1</sup> )	Initial rate (mol.l <sup>-1</sup> .s <sup>-1</sup> )
1	0.10	0.10	0.117
2	0.20	0.10	0.468
3	0.30	0.10	1.054
4	0.30	0.20	2.108

- (i) Determine the order of the reaction. **[7 marks]**
- (ii) Calculate the rate constant, k. **[6 marks]**
- (iii) Calculate the rate when the concentration of both reactions is 0.5 mol.l<sup>-1</sup> **[6 marks]**

### Section B

5. Explain how a gas and a solid differ at a molecular level. **[8 marks]**

A mixture of O<sub>2</sub>, N<sub>2</sub> and CO<sub>2</sub> exerts a pressure of 93,300N.m<sup>-2</sup> in a 0.01m<sup>3</sup> container at 30°C. Analysis shows that the partial pressure (p) of O<sub>2</sub> is 26,700Nm<sup>-2</sup> and that 5.0g of CO<sub>2</sub> are present.

Calculate:

- (i) p(CO<sub>2</sub>) in the container **[6 marks]**
- (ii) p(N<sub>2</sub>) in the container **[6 marks]**
- (iii) the number of moles of O<sub>2</sub> in the container **[5 marks]**

$$[R = 8.314\text{J.K}^{-1}\text{mol}^{-1}]$$

6. (a) A-B and C-D are both gases. The electronegativity values are as follows;

A: 2.5; B: 2.9; C: 1.7; D:3.1

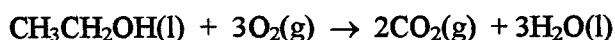
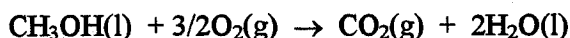
What information about the two molecules can be obtained from these electronegativity values? If the gases have approximately the same molecular weight which would you expect to have the lower boiling point? Explain your answer. **[7 marks]**

- (b) Explain how the bonding present in sodium metal accounts for its electrical and mechanical properties. [6 marks]
- (c) Describe any one type of **intramolecular** bond in detail, using an example to illustrate your answer. [6 marks]
- (d) Explain the idea behind the Band Theory of Solids and use it to explain the difference between an insulator and a conductor. [6 marks]

7. The Electron Pair Repulsion Theory (EPRT) can be used to predict the shape of molecules of type AB<sub>n</sub>.

- (a) Explain how the number of electron pairs involved in bonding is determined for a molecule of this type. [6 marks]
- (b) Draw diagrams of the shapes adopted by molecules which have (i) 3, (ii) 4, (iii) 5 and (iv) 6 electron pairs. Name the structures and indicate the size of the bond angles in each case. [7 marks]
- (c) Use the EPRT theory to compare the shapes of NH<sub>4</sub><sup>+</sup> and NH<sub>3</sub>. [6 marks]
- (d) Explain how the shape of the molecule O=SCl<sub>2</sub> can be determined. [6 marks]

8. (a) Explain what is meant by the terms entropy, enthalpy and free energy. [6 marks]
- (b) Methanol (CH<sub>3</sub>OH) and ethanol (CH<sub>3</sub>CH<sub>2</sub>OH) are both possible alternatives to hydrocarbon fuels. They react with oxygen as follows:



- (i) Using the data below calculate
  - (a) the value of ΔH° for each reaction. [4 marks]
  - (b) the calorific values of both fuels. [4 marks]

$$\Delta H^\circ_f \text{CH}_3\text{OH(l)} = -238.7 \text{ kJ.mol}^{-1}$$

$$\Delta H^\circ_f \text{CH}_3\text{CH}_2\text{OH(l)} = -277.6 \text{ kJ.mol}^{-1}$$

$$\Delta H^\circ_f \text{CO}_2\text{(g)} = -393.5 \text{ kJ.mol}^{-1}$$

$$\Delta H^\circ_f \text{H}_2\text{O(l)} = -285.8 \text{ kJ.mol}^{-1}$$

- (ii) If the cost of producing 1 kg of ethanol and methanol is £0.30 and £0.50, respectively, which fuel represents the best value for money? [5 marks]
- (iii) Explain briefly how the calorific value of either fuel might be determined. [6 marks]