

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

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**AUTUMN EXAMINATIONS 2002**

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**FIRST YEAR ENGINEERING**  
**CHEMISTRY 1 (CH105)**

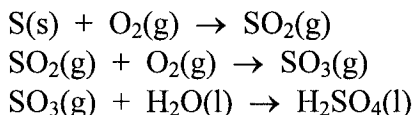
**Professor I. Fleming, FRS**  
**Professor R.N. Butler**  
**Dr. N.W.A. Geraghty**

**Time allowed: Two Hours**

**Answer four questions of which not more than two may be chosen from any one section. All questions carry equal marks.**

**Section A**

1. Sulfuric acid ( $\text{H}_2\text{SO}_4$ ) is the most heavily produced inorganic chemical worldwide. It is produced using the “contact process” which involves the following reaction:



- (a) Balance the above reaction equations where necessary. **[3 marks]**
- (b) What volume (at STP) of  $\text{SO}_2(\text{g})$  would be produced from 1 tonne (1000kg) of sulfur? **[6 marks]**
- (c) What weight of  $\text{H}_2\text{SO}_4(\text{l})$  would be produced from this weight of sulfur? **[5 marks]**
- (d) What **total** volume of  $\text{O}_2$  would be required to convert this weight of sulfur to  $\text{H}_2\text{SO}_4(\text{l})$ ? **[5 marks]**
- (e) What volume of  $\text{SO}_3$  (at  $20^\circ\text{C}$  and 2atm) would be formed from 1 tonne of sulfur? **[6 marks]**

[1 mole of gas at STP occupies 22.4 litres]

2. (i) Explain, using examples, what information is provided by each of the four quantum numbers. **[6 marks]**
- (ii) Describe the fundamental particles from which atoms are constructed and explain how any two of these were discovered. **[6 marks]**
- (iii) Outline Dalton's contribution to the development of atomic theory. **[6 marks]**
- (iv) Explain what is meant by ionization energy. The ionization energies (in  $\text{kJ mol}^{-1}$ ) of the elements in the first row of the Periodic Table are as follows:  
 Li, 519; Be, 900; B, 799; C, 1,090; N, 1,400; O, 1,310; Ne, 2,080.  
 Account for the overall trend and for any departures from this trend. **[7 marks]**

3. Global warming and ozone layer depletion are the most serious of the environmental problems currently affecting our planet. Discuss the chemical basis of these two problems, paying particular attention to the chemical reactions involved. **[25 marks]**

4. (i) Explain what is meant by an activation energy (transition state) diagram and use it to explain the effect of (a) temperature and (b) a catalyst on the rate of a chemical reaction. **[6 marks]**  
 Sulfuryl chloride,  $\text{SO}_2\text{Cl}_2$  is used in the manufacture of the antiseptic chlorophenol. The following data were collected for the decomposition of sulfuryl chloride at  $200^\circ\text{C}$ :

Time (min)	$[\text{SO}_2\text{Cl}_2]$ ( $\text{mol l}^{-1}$ )
0	0.1000
200	0.0768
400	0.0590
600	0.0453
800	0.0348

- (ii) Use the data to determine the order and rate constant for the reaction (graph paper is available). **[7 marks]**
- (iii) Is the half-life of the reaction constant? What is it? **[6 marks]**
- (iv) Determine the rate of the reaction when the concentration of  $\text{SO}_2\text{Cl}_2$  is  $0.4 \text{ mol l}^{-1}$ , and the time required for the concentration to drop from this value to  $0.1 \text{ mol l}^{-1}$ . **[6 marks]**

## Section B

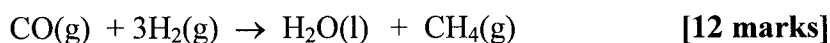
5. (i) Explain how gaseous diffusion can be used to produce “enriched” uranium for use as a nuclear fuel. [13 marks]
- (ii) A  $0.02\text{m}^3$  sample of gas at  $273\text{K}$  and  $2.00 \times 10^5 \text{ N m}^{-2}$  contains  $0.5$  moles of  $\text{N}_2$  and  $0.70$  moles of  $\text{Ar}$ .
- (a) What is the partial pressure of each gas? [6 marks]
- (b) Are there any other gases in the mixture? If so, calculate their combined partial pressures. [6 marks]
- $[R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$

6. (i) Explain, using an example, how a heterogeneous catalyst works. [7 marks]
- (ii) Explain how, and why, an atom of chlorine ( $\text{Cl}$ ) and an atom of lithium ( $\text{Li}$ ) would form a chemical bond with each other. [6 marks]
- (iii) Explain what is meant by electronegativity and how it can be used to determine the nature of a chemical bond. [6 marks]
- (iv) Write a note outlining what is meant by vapour pressure and explain how the concept is used to define the boiling point of a liquid. [6 marks]

7. Describe, in detail, the various types of *intermolecular* bonding. [15 marks]  
Explaining your answer, indicate what type of intermolecular bonding exists in each of the following:



8. Use the data below to determine  $\Delta H^\circ$ ,  $\Delta S^\circ$  and  $\Delta G^\circ$  for the following reaction:



Is the sign of  $\Delta S$  what you would expect for such a reaction? [6 marks]

How would you expect the spontaneity of the reaction to be affected by changes in the reaction temperature? [7 marks]

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

$$\Delta H^\circ_f \text{CO}(\text{g}) = -110.5 \text{ kJ mol}^{-1}$$

$$\Delta H^\circ_f \text{CH}_4(\text{g}) = -74.81 \text{ kJ mol}^{-1}$$