

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

AUTUMN EXAMINATIONS 2002

FIRST YEAR ENGINEERING
CHEMISTRY 1/2 (CH106)

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Time allowed: Three Hours

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

Section A

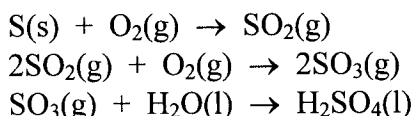
1. (i) Explain what is meant by an activation energy (transition state) diagram and use it to explain the effect of (a) temperature and (b) a catalyst on the rate of a chemical reaction. **[6 marks]**
 Sulfuryl chloride, SO_2Cl_2 is used in the manufacture of the antiseptic chlorophenol. The following data were collected for the decomposition of sulfuryl chloride at 200°C :

Time (min)	$[\text{SO}_2\text{Cl}_2]$ (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). **[6 marks]**
- (iii) Is the half-life of the reaction constant? What is it? **[4 marks]**
- (iv) Determine the rate of the reaction when the concentration of SO_2Cl_2 is 0.4 mol l^{-1} , and the time required for the concentration to drop from this value to 0.1 mol l^{-1} . **[4 marks]**

- (i) Explain how gaseous diffusion can be used to produce “enriched” uranium for use as a nuclear fuel. **[8 marks]**
- (ii) A 0.02m^3 sample of gas at 273K and $2.00 \times 10^5 \text{ N m}^{-2}$ contains 0.5 moles of N_2 and 0.70 moles of 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 [$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$]. **[6 marks]**

3. (i) Sulfuric acid (H_2SO_4) is the most heavily produced inorganic chemical worldwide. It is produced using the “contact process” which involves the following reaction:



- (a) What volume (at STP) $\text{SO}_2(\text{g})$ would be produced from 1 tonne (1000kg) of sulfur? **[4 marks]**
- (b) What weight of $\text{H}_2\text{SO}_4(\text{l})$ would be produced from this weight of sulfur? **[3 marks]**
- (c) What **total** volume of O_2 would be required to convert this weight of sulfur to $\text{H}_2\text{SO}_4(\text{l})$? **[3 marks]**

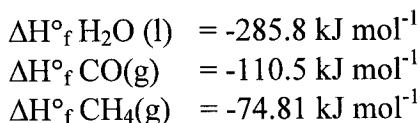
[1 mole of gas at STP occupies 22.4 litres]

- (ii) Use the data below to determine ΔH° for the following reaction:



What would you expect the sign of ΔS to be for this reaction? Explain your answer. **[3 marks]**

How would you expect the spontaneity of the reaction to be affected by changes in the reaction temperature? **[3 marks]**



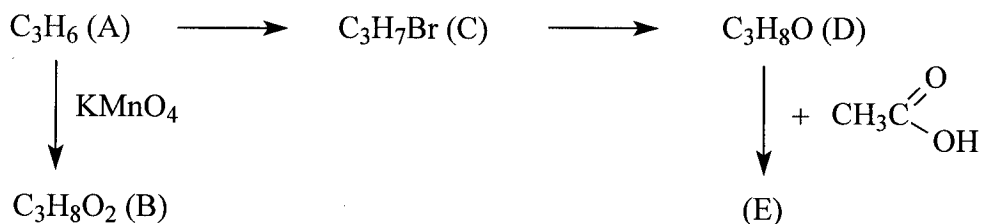
4. (i) Explain, using an example, how a heterogeneous catalyst works. **[5 marks]**
- (ii) Outline the basic features of the Bohr Theory of Atomic Structure. **[5 marks]**
- (iii) Explain what is meant by an “orbital”, and how a $2p_x$ and a $3p_y$ orbital are related to each other. **[5 marks]**
- (iv) Explain why sodium chloride (NaCl) dissolves in water and, in detail, how it occurs. **[5 marks]**

Section B

5. 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. **[2 x 10 marks]**
6. The electron pair repulsion theory (EPRT) can be used to predict the shapes of molecules of type AB_n .
- (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 structure and indicate the size of the bond angle(s) in each case. **[6 marks]**
 - (c) Use the EPRT theory to assign shapes to BF_3 and BF_4^- . **[4 marks]**
 - (d) Explain how the shape of the molecule $O=C=O$ can be determined. **[4 marks]**
7. Describe in detail what happens when a current of electricity is passed (a) through a solution of sodium chloride ($NaCl$) in water and (b) through fused (molten) sodium chloride. **[2 x 6 marks]**
- In the case of (b) determine the mass of sodium and the volume of chlorine gas (Cl_2) (at STP) which is produced by a current of 20A flowing for 25 minutes. ($1F = 96,500C/mol$). **[2 x 4 marks]**

Section C

8. Discuss the chemistry of carboxylic acids under the following headings:
- (a) Structure and basic physical properties. **[7 marks]**
 - (b) Acidity: explain why they are acidic and how the acidity of bromoethanoic acid compares to that of ethanoic acid. **[6 marks]**
 - (c) Important chemical reactions. Chemical equations should be provided for all reactions discussed. **[7 marks]**
- 9.
- (i) Explain, in the context of the petrochemical industry, what is meant by cracking and reforming, and how they are carried out. **[5 marks]**
 - (ii) Explain what is meant by an addition reaction and provide a simple mechanism for any addition reaction of your choice. **[5 marks]**
 - (iii) Using examples, explain the difference between structural and geometrical (cis/trans) isomerism. **[5 marks]**
 - (iv) Explain, using an example, what is meant by a Grignard reaction. **[5 marks]**



- (A): This also reacts readily with Br_2
 (B), (D): Both compounds react with sodium metal to give bubbles of H_2 gas.
 (E): This has a pleasant, fruity smell

- (i) Provide structure for compounds (A) – (E). The functional group should be named and clearly labeled in each case. **[5 x 2 marks]**
- (ii) Suggest suitable reagents for the conversion of (A) to (C), and (C) to (D). **[2 x 2 marks]**
- (iii) Outline two other reactions for compound (A) and provide reaction equations for them. **[2 x 3 marks]**