NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

MASTER OF ENGINEERING DEGREE IN CHEMICAL AND ENVIRONMENTAL PROCESS ENGINEERING

Reactor Technology

TCE 7102

Final Examination Paper

December 2024

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

INSTRUCTIONS

1. Answer all questions in **Section A** and any other **three (3)** questions in **Section B**
2. Each question carries 25 marks
3. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.A	**25**
1.B	**25**
2.B	**25**
3.B	**25**
4.B	**25**
TOTAL ATTAINABLE	**100**

SECTION A

Answer all questions

QUESTION A1

a) State the Langmuir Adsorption Isotherm assumptions and derive and expression for Langmuir Adsorption Isotherm for any simple system. **[6]**

b) Discuss the importance of catalysis in petrochemical industry, in energy production and in the protection of the environment. **[8]**

c) Discuss the significance of these terms; Thiele Modulus, effectiveness factor and Weisz Modulus. **[6]**

d) With the aid of a diagram, describe pore diffusion resistance in porous catalysts or materials, and show how it interacts with external mass transfer resistance. **[4]**

SECTION B

Answer any 3 questions

QUESTION B1

a) What are the steps that take place in heterogeneous catalysis reactions? **[4]**

b) Typically a catalyst is composed of a support, an active material and a promoter(s). Discuss the role and nature of each catalyst component and give practical examples. **[12]**

c) Describe any 3 characterization techniques that can be used for a catalyst and explain which characteristics and how they are measured by these techniques. **[9]**

QUESTION B2

a) Differentiate between the Langmuir and the Freundlich adsorption isotherm. **[5]**

b) The oxidation of SO_2 on platinum is believed to occur according to the following steps;

$$O_2 + 2S \leftrightarrow 2O.S$$

$$SO_2 + O.S \rightarrow SO_3.S$$

$$SO_3.S \leftrightarrow SO_3 + S$$

When surface reaction is rate-controlling show that the kinetics can be expressed as below:

$$r = \frac{kK_A{}^{0.5}(O)^{0.5}\,(SO_2)}{1 + K_A{}^{0.5}\,(O)^{0.5} + K_C(SO_3)} \qquad k = k_s C_T$$

Postulate a series of elementary steps that will yield this rate expression. **[20]**

QUESTION B3

a) With an aid of a block diagram describe a catalyst preparation method, relate the catalyst preparation method to the desired catalyst properties or function. **[5]**

b) The following N2 adsorption-desorption data were obtained at 77 K for a commercial FCC catalyst. Using this data: (i) plot the full isotherm and identify the important points on the plot and the information that can be obtained; (ii) determine V_m and S_{BET}.

$\frac{x}{V(1-x)} = \frac{1}{CV_m} + \frac{(c-1)x}{CV_m}$ (Assume N_2 molecule occupies an area of 214.2066m2/g) **[20]**

p/p_o	$v = m^3$
0.01	31
0.02	34.4
0.031	36.6
0.04	38.2
0.049	39.7

0.079	43.6
0.109	47.1
0.138	50.2
0.168	53.2
0.198	56.3
0.243	61
0.283	65.5
0.327	70.7
0.369	76.4
0.414	83.3

QUESTION B4

a) State five criteria that may be applied for selecting a multiphase reactor for a given application. **[5]**

b) Based on the reaction characteristics, different types of multiphase reactors are used in industrial practice. Discuss where the following reactors are most appropriate:

i) Trickle bed

ii) Stirred tank reactor

iii) Venturi loop reactor

iv) Sparged reactors **[20]**

(END OF PAPER)