# Deptt of Chemical Engg
## CH-029 Catalytic Processes (7th Sem)
## End-Semester Examination, 07/12/2006, 014:00-17:00Hrs

Time: 3 hr MM: 45

All questions are compulsory.

1 Explain the following statements: 10

a) Appreciable temperature gradients exist along the radial direction in a fixed bed catalytic reactor.

b) In a slurry reactor significant liquid-solid mass transfer resistance exists despite uniform mechanical mixing of the catalyst slurry.

c) In a fluidized bed reactor both internal and external resistance to mass transfer is negligible.

d) Surface area of Nickel catalyst determined using BET method was 500 $m^2$/gm but the area found by chemisorbing hydrogen gas on Nickel was only 150 $m^2$/gm.

e) The global reaction rate of a gas-solid catalytic reaction carried out in a fixed bed reactor increases with increase in the gas flow rate through the reactor and reaches a maximum value. Thereafter any increase in gas flow has no influence on the global rate of reaction.

2 Discuss the variation of heat transfer coefficient h along axial and radial position in a cylindrical fixed bed reactor using solid catalyst in pelleted form. The gaseous reactants enter one end and flows along the axis of the cylindrical reactor. 4

3 (a)Following data were obtained at for 70 degree C for the equilibrium adsorption of n-hexane on silica gel particles. 6 +4

| Partial pressure of $C_6H_{14}$ in gas x$10^3$,atm | 2 | 4 | 8 | 1.3 | 15.6 | 20.6 |
|---|---|---|---|---|---|---|
| $C_6H_{14}$ adsorbed x $10^5$ , gmol/(g gel) | 10.5 | 16 | 27.2 | 34.6 | 43 | 47.3 |

Determine how well the Langmuir isotherm fits these data. Also find $C_m$ and $K_C$

(b) Amount of a gas adsorbed per unit mass of a solid catalyst decreases as the temperature of the gas-solid system is increased and it reaches a **minimum** at around critical temperature of the adsorbing gas. As the temperature is **further** raised, the amount of gas adsorbed starts increasing with increase in temperature; reaches a **maximum** value and starts decreasing with further in temperature. Explain this observation with the help of chemisorption and physical adsorption.

4 (a) Two samples of silica alumina catalysts have particle densities of 1.126 and 0.962 gm/cm$^3$ respectively as determined by mercury displacement. The true density of solid material in each case is 2.37gm/cm$^3$.The surface area of the first sample is 467 m$^2$/gm and that of the second is 372 m$^2$/gm. Which sample has the larger mean pore radius? 4 +5

(b) Explain the basis, the range of applicability and procedure of mercury penetration method for pore –volume determination.

5 (a) Draw concentration profiles for a gaseous component A reacting at solid catalyst particle surface in a slurry reactor. 2 +3

(b) Estimate the maximum temperature difference $T_S - T_b$ for a gas-solid catalytic reaction for which $\Delta H$ = -20,000 cal/g mol; $C_p$ = 8 cal/g mole (K); $P_t$ = 2 atm; $T_b$ = 473 K. The mole fraction of reactant in the bulk gas is 0.25. If external diffusion resistance is not controlling, but $C_b - C_S = C_b/2$, what will be the value of $T_S - T_b$? +4 +3

(c) In isobutene-helium system, the diffusion rate of isobutane through a 1/8 inch long pelleted cylinder of alumina (dia = 1/8 inch). The measurements were at 750 mm Hg total pressure and 25degree Celsius and the diffusion direction was through the pellet parallel to the central axis. The following data are available: surface area $S_g$ =76 m$^2$/g, $\epsilon_M$ =0.18, $\epsilon_u$ =0.34, average macro pore radius = 4800 A$^0$; Avg micro pore size = 84 A$^0$
The mole fraction of isobutane is 1.0 on one face of the pellet and zero on the other face. The experimental results gave
$N_A R_g T \Delta r/( D_{AB} P_t(y_2-y_1) = -0.023$
where $N_A$ is the diffusion flux of isobutane
$D_{AB}$ is the bulk diffusivity of isobutane in the isobutane-helium system = 0.313 cm$^2$/s at 25 degree C and 1 atm pressure.
**Calculate** the experimental value of effective diffusivity. What macro pore tortuosity factor is indicated by the data AND by the random pore model?

(d) How does the external resistance to diffusion of gaseous reactant A to the surface of a catalyst pellet (where reactant A is converted to product R by first order reaction) affect the experimental determination of true activation energy of the reaction?