Department of Chemical Engineering

Minor II – CLL222/ CHL221 **CRE -II**

Time: 11-12 Noon Date: 8th Oct., 2015

M.M 20

1. (i) Develop an expression for packed bed reactor design if mass transfer from bulk gas to solid catalyst surface controls the rate of reaction.

(ii) A plant is removing a trace of hydrogen sulfide gas (H_2S) from a waste gas stream by passing it over a solid granular adsorbent in a tubular packed bed. At present, 63.2 % removal is being accomplished, but it is believed that higher removal could be achieved if the flow rate were doubled and the particle diameter were halved for the same packed bed. What percentage of H_2S gas would be removed under the scheme proposed? Assume that H_2S gas transferring to the adsorbent is removed by an instantaneous chemical reaction. Use the following correlation for the calculation of mass transfer coefficient:

$$\mathbf{Sh = (Re)^{1/2} (Sc)^{1/3}}$$ (3+4)

2. The gas phase cracking of atmospheric gas oil (A),

A (g) ---------→ P(g) + coke (s), is to be carried out in a straight through transport reactor containing a catalyst that decays due to coke deposition. The reaction is carried out at 500° C. The feed rate of gas oil is 10 mol/min at an entering concentration of 0.4 kmol /m^3. The feed gas and catalyst particles are moving in the bed at a velocity of 5.0 m/s. The first order kinetics of the reaction is given by

$$\mathbf{-r'_A = k' C_A a(t), \text{ with } k' = 0.05\ m^3/kg\ cat.s.}$$

At 500° C, the drop in the catalyst activity (a) for this reaction is given by a second order kinetics with $k_d = 7.5\ s^{-1}$. If the reactor is 8m long, calculate the conversion at the exit of the reactor. The bulk density of the catalyst in the bed is 60kg/m^3. (7)

3. The irreversible reaction A ----→ R, is done in a fixed bed reactor using a spherical catalyst with radius 0.21 cm and density 2.0 g/cm^3. The reaction is carried out at 100°C and 1 atm. 75% conversion was achieved at these experimental conditions. At a point in a reactor the observed reaction rate is 1.1×10^{-5} mol/s/gcat.,where the bulk concentration at the catalyst surface is 1.65×10^{-5} mol/cm^3. The mean effective diffusivity is 2×10^{-2} cm^2/s. Determine the effectiveness factor for the catalyst pellet if there is no external diffusion resistance. (6)