the reactor pressure is 0.025kmol/m^3. The internal diffusion controls the rate as compared to liquid solid mass transfer. Mass transfer coefficient for gas absorption, is 0.22 s^{-1} and the specific combined resistance to internal diffusion and chemical reaction, calculated **for 60μm** particles is, 18.0 s.kg/m^3. State clearly other assumptions made if any. 6

4. The irreversible gas phase reaction (**2P ------> P_2**) is carried out at 10 atm in a stirred reactor containing solid catalyst to which only pure A is fed. There is 200 g of spherical catalyst pellet (dia. 2 cm) in the reactor. The following experiments were carried out at 237^{0}C.

Total inlet molar feed rate, (g mole/minute)	2.0	4.0	7.0	12.0	20.0
Mole fraction of P at the exit	0.20	0.48	0.62	0.72	0.82

i. Calculate apparent and true reaction order for the reaction. 5

ii. Calculate the catalyst effectiveness factor. What diameter of the pellets should be used to make catalyst more effective? 4

5. (a) Define Hatta number and Enhancement factor for a gas liquid reaction along with their importance in selection and design of a gas liquid reactor. 3

(b Spherical particles of Zinc blend of radius R=1.5 mm are roasted in an 10% oxygen stream at 800^0 C. and 1 atm. The stoichiometry of the reaction is :

$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$.

Assuming that reaction proceed by the shrinking core model calculate the time required for complete conversion of a particle and the relative resistance of ash layer diffusion during this operation. Neglect the gas film resistance.

Data: Density of solid particles = 0.03 mol/cm^3

Surface reaction rate constant ,ks = 1.0cm/s

Diffusion coefficient for gases in ZnO layer, De= 0.09 cm^2/sec 5

$\frac{dx}{dt} = R_A = k C_A^n (1-X)^n$

Chemical Reaction Engineering –II (CHL 221)

Major Exam 2014 **Date: 23/11/2014**

M.M : 40 **Time: 1-3 pm**

1. A first order reaction is taking place on the walls of a cylindrical pore of length L. A catalyst poison also entered the reactor together with the reactant in one run. To estimate the effect of poisoning assume that the poison strongly chemisorbs the catalyst pore wall near the pore mouth up to a distance x_1, so that no reaction takes place on the walls in this entry region (pore mouth poisoning).

   (i) Derive an expression for concentration profile in the poisoned section of the pore.

   (ii) Develop the new expression for effectiveness factor for the poisoned pore in terms of the effectiveness factor and thiele modulus of the fresh catalyst pore. 4+4

2. Experimental data for the gas-phase catalytic reaction, **A + B ------→ C**, is shown below. The limiting step in the reaction is known to be irreversible, so that the overall reaction is irreversible. The reaction was carried out in a differential reactor to which reactants A, B, and C, all were fed.

Run No.	1	2	3	4	5	6	7
P_A (atm.)	1	1	10	1	1	20	0.1
P_B (atm.)	1	10	1	20	20	1	1
P_C (atm.)	2	2	2	2	10	2	2
Reaction Rate mol/g cat. s	0.114	1.140	0.180	2.273	0.926	0.186	0.024

(a) Develop a rate expression consistent with the experimental data. 4

(b) Evaluate the parameters of the rate law expression. 5

3. An unsaturated hydrocarbon oil is to be converted to saturated hydrocarbon oil by hydrogenation in a slurry bubble reactor of size 1 m^3 in which hydrogen gas is bubbled up through the liquid and catalyst. The reaction is pseudo first order with respect to hydrogen concentration. The molar feed rate of oil fed to the reactor is 0.1 kmol/s. The partial pressure of hydrogen is 10 atm and the reactor is well mixed. Calculate the percent contribution of each resistance and catalyst loading necessary to achieve 40 % conversion of the feed. The catalyst particle size is **80 μm** and solubility of hydrogen at