Major Test in CHL604

Answer all questions

1.(a) Derive the t vs X relationship for a non-cat gas-solid reaction occurring in a slab type solid pellet. What are the usual assumptions made. The overall reaction is controlled by gas-film, ash layer diffusion and surface chemical reaction (1st order). (10)

(b) The following data was obtained under condition of $Sh \rightarrow \infty$ for a slab type pellet reacting with a gas. Determine the equation between t and X. (10)

(*i*) $t(\text{min})$ – 0.5 1 1.5 2 2.5 } *Pellet thickness*
X 0.1 0.2 0.3 0.4 0.5 } $0.05\,cm.$

(*ii*) $t(\text{min})$ – 1 2 3 4 5 } *Pellet thickness*
X 0.1 0.2 0.3 0.4 0.5 } *is* $0.1\,cm.$

(*iii*) $t(\text{min})$ – 15 60 130 240 } *Pellet thickness*
X 0.1 0.2 0.3 0.4 } $1\,cm.$

(*iv*) $t(\text{min})$ – 60 240 375 } *Pellet thickness*
X 0.1 0.2 0.3 } $2\,cm.$

2. For the non-cat. gas-solid reaction, the solid particle dia is 1 cm, porosity is 0.3 and the molar density of the reactant solid is 4.46 x 10^{-2} gm.mol/cm^3 and reactant gas is at 400°C and 1 atm pressure. The velocity of the gas around the solid particle is 105 cm/sec. (15)

Data given = D = 3.42 cm2/sec μ = 1.53 x 10^{-4} gm/sec.cm.
Sh = 2 + 0.6 $Re^{1/3}$ $Sc^{1/3}$ Sh no. is based on radius of the solid particle.

(a) For constant particle size and gas film resistance control conditions determine the time required for 50% and 100% conversions of the solid.

(b) For particle size reducing to zero with reaction and stagnant reactant gas around the solid and surface chemical reaction is not rate controlling determine the time for 50% and 100% conversions of the solid.

3. The following data was obtained from TG balance for $CaCO_3$ decomposition in air at 100°C/min. heating rate. The initial weight of the sample is 25 mg. and the reaction is chemical reaction controlled on the unreacted core of the solid particle.

Derive the governing equation and the activation energy and frequency factor for the reaction. (20)

$T(^oC)$ –	650	675	700	725	750	775	800	825
$wt\,con(mg)$ –	0.62	0.84	1.23	1.85	2.73	4.25	6.37	9.05

Given $\int_u^\alpha e^{-u}\,u^{-b}\,du = u^{1-b}\,e^{-u}\,\sum_{n=0}^{\alpha}(-1)^n\,(b)^n / u^{n+1}$

4. For the reaction $A \rightleftharpoons B$ occurring on a catalyst, derive the overall rate equation when adsorption of A is rate controlling (neglect diffusional and gas film resistances). (10)

5. The reaction $A \rightarrow 4B$ is carried out in a tubular reactor filled with catalyst. Determine the weight of the catalyst required for 35% conversion of A. The feed is pure A at 117°C and 3.2 atm pressure and enters the reactor at a rate of 1000 moles/hr. The rate constant is 9.6×10^{-2} m^3/hr. kg cat. Show derivation of the required equation separately. (15)