T.E- V Sem - Chem.

3/05/2016

# Chemical Reaction Engineering - I

(20)

TE/V/CBGS/CHEM./CRE-I

Q.P.Code: **31149**

Duration: 3 hours

Total Marks: 80

N. B. (i) Question number **one is compulsory.**

(ii) Answer any **three** questions from the rest.

(ii) Assume suitable data wherever necessary.

Q.1.a) Derive design equation of batch reactor. (05)

b) Explain differential method of analysis of rate data. (05)

c) What is Damkohler number? State its significance. Write down Damkohler number for first and second reaction. (05)

d) Experimental analysis shows that the homogeneous decomposition of ozone (05)

$2O_3 \rightarrow 2O_2$ proceeds with the rate $-r_{O_3} = k [O_3]^2 [O_2]^{-1}$

(i) Suggest a two-step mechanism to explain this rate.

(ii) What is the overall order of reaction?

Q.2.a) The decomposition of phosphine is irreversible and first order at 650°C. (10)

$$4\ PH_3\ (g) \rightarrow P_4\ (g) + 6H_2\ (g)$$

The rate constant in $(S)^{-1}$ is reported as

$$\log k = -(18963/T) + 2 \log T + 12.130$$

Where T in degree kelvin. In a closed vessel (constant volume) initially containing pure phosphine, the pressure is 1 atm. What will be the pressure after 50, 100 and 500 seconds? The temperature is maintained at 650°C.



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b) A zero order homogeneous gas phase reaction A→ rR takes place in a constant volume bomb, P = 1atm when t = 0 and P = 1.5 atm when t = 1 min. If the same reaction with the same feed composition and initial pressure takes place in a constant pressure apparatus, find V at t = 1 min if V = 1 lit at t =0 (10)

Q.3a) A homogeneous liquid phase reaction, with the stoichiometry and kinetics (12)

$$A \rightarrow S, -r_A = kC_A^2$$

takes place in a mixed flow reactor and results in 50% conversion.

i) Find the conversion if this reactor is replaced by another mixed flow reactor having volume 6 times that of the original reactor – all else remain unchanged.

ii) Find the conversion if the original reactor is replaced by plug flow reactor of the same size – all else remain unchanged.

b) Write a short note on Recycle reactor (08)

Q.4 a) Assuming a stoichiometry A → R for a first order gas phase reaction, the size (volume) of plug flow reactor required to achieve 99% conversion of a pure A is 32 lit. In fact, however, the stoichiometry of reaction A → 3R. For this corrected stoichiometry, find the required size of the same type reactor. (10)

b) A liquid reactant stream with $C_{Ao}$ = 4 mol/lit passes through a mixed flow reactor followed by a plug flow reactor. Find the concentration at the exit of the plug flow reactor if the concentration of A ($C_A$) in the mixed flow reactor is 1 mol/l. The reaction is second order with respect to A. The volume of plug flow reactor is three times that of mixed flow reactor. (10)

Q.5 a) For the elementary liquid phase reaction A ⇄ R construct a plot of equilibrium conversion as a function of temperature and from this plot, determine the adiabatic equilibrium temperature and conversion when pure A at a temperature of 27°C is fed to the reactor. (15)

Data:



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$\Delta H^0_{fA}$ = - 40000 cal/moi,

$\Delta H^0_{fR}$ = - 60000 cal/mol

$C_{pA}$ = 50 cal/(mol.K),

$C_{pR}$ = 50 cal/(mol.K)

$K$ = 100000 at 298 K

b) What is optimum temperature progression? Explain with example (05)

Q.6.a) A parallel liquid phase reaction (10)

$$A \overset{k_1}{\rightarrow} R \ , \quad A \overset{k_2}{\rightarrow} S$$

has the rate constants $k_1 = 5\ (h)^{-1}$ and $k_2 = 0.8\ (h)^{-1}$ Find the moles of R produced in 15 min. (Take $C_{Ao} = 8.5$ mol/lit, $C_{Ro} = C_{So} = 0$ )

b) 100 lit/h of radioactive fluid having a half life of 20 h is to be processed by passing it through two mixed flow reactors in series. The volume of each mixed flow reactor in series is 40000 lit. Find the decay in activity in passing the fluid through this reactor system. The reaction follows first order kinetics. (10)

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