**Seat No.: _____** **Enrolment No._____**

# GUJARAT TECHNOLOGICAL UNIVERSITY

## ME Semester –I Examination Feb. - 2012

**Subject code: 713001N** **Date: 11/02/2012**
**Subject Name: Advance Reactor Design**
**Time: 10.30 am – 01.00 pm** **Total Marks: 70**

## Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

**Q.1** **(a)** Derive the design equation for exothermic reaction in batch reactor. **07**

**(b)** Give industrial examples of reactions in parallel and reactions in series. **07**

**Q.2** **(a)** Following parallel reactions take place. Kinetic data for each reaction is given: **07**

$A \longrightarrow R$ $r_R = 1$ gmmol/ltr-sec

$A \longrightarrow S$ $r_S = 2C_A$ gmmol/ltr-sec

$A \longrightarrow T$ $r_T = C_A^2$ gmmol/ltr-sec

For $C_{Ao}$ = 2 moles/ltr, find the maximum expected $C_S$ for the isothermal operation (S is the desired product). It is planned to provide separator after reactor to separate unconverted A, return to reactor and mix with feed stream. For conversion of 120 tons of A per day, find the size of the reactor.

Molecular weight of A, R, S and T is 30.

**(b)** A series reaction $A \longrightarrow B \longrightarrow C$, takes place in a continuous stirred tank reactor at v = 4 ltr/min, with $C_{Ao}$ = 2 moles/ltr. Both reactions are first order and irreversible with rate constant $k_1$ = 0.5 $min^{-1}$ and $k_2$ = 0.1 $min^{-1}$. For maximum yield of B, find what the size of the reactor is? **07**

**OR**

**(b)** Derive the equation for maximum yield of B in CSTR for the reaction system, $A \longrightarrow B \longrightarrow C$ with the following rate equation. **07**

For $A \longrightarrow B$ $-r_1 = k_1C_A$ and

For $B \longrightarrow C$ $-r_2 = k_2C_B$

**Q.3** For the elementary solid-catalyzed liquid phase reaction $A \longleftrightarrow B$, make a plot of equilibrium conversion as a function of temperature. Determine the adiabatic equilibrium temperature and conversion, when pure A is fed to the reactor at a temperature of 300 K. **14**

Data:

$H^o_A$ (298 K) = -40000 cal/mol

$H^o_B$ (298 K) = -60000 cal/mol

$C_{pA}$ = 50 cal/mol K

$C_{pB}$ = 50 cal/mol K

$K_e$ = 100000 at 298 K

**OR**

**Q.3** **(a)** Discuss the construction and working of LPCVD. **07**

**(b)** Silicon particles are to be grown on silicon seed crystals by chemical vapor deposition (CVD) of silane ($SiH_4$) with a rate $r'' = k''C_{SiH4}$. If T = 200°C, $p_{SiH4}$ = 0.1 atm and k'' = 10 cm/min. Calculate the time necessary to grow silicon particles from 1 to 10 μm, assuming that the particles are spherical and the reaction is reaction limited. The density of Si = 2.33 gm/cm$^3$ and molecular weight of Si = 32. **07**

**Q.4** **(a)** Calculate the heat of reaction for the synthesis of ammonia from $H_2$ and $N_2$ at 150°C in kcal/mol of $N_2$ reacted. **07**

Data:

Heat of formation of $NH_3$ = -11020 cal/mol at 298 K

$C_{pH2}$ = 6.992 cal/(mol of $H_2$)(K)

$C_{pN2}$ = 6.984 cal/(mol of $N_2$)(K)

$C_{pNH3}$ = 8.92 cal/(mol of $NH_3$)(K)

**(b)** Derive the rate equation for slurry reactor. **07**

**OR**

**Q.4** If pyrite ore is having 60% concentration of ZnS, find the time needed for complete conversion and size of reactor to produce 65 tons/day of ZnO. **14**

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

Data:

Particle size = 1 mm

Concentration of $O_2$ in air = 8% at 900°C and 1 atm

Density of solid $\rho_B$ = 4.13 gm/cm$^3$ = 0.0425 mol/cm$^3$

Reaction rate constant = 2 cm/sec

For gases in the ZnO layer, $D_e$ = 0.08 cm$^2$/sec

Reaction is controlled by diffusional resistance.

Bulk density of ZnS particles of 1 mm size = 2500 kg/m$^3$

Porosity = 30%

Assume that reaction follows shrinking core model.

**Q.5** **(a)** With reference to multiple-steady state encountered in exothermic reaction, discuss ignition-extinction curve. **07**

**(b)** With reference to the plot of temperature vs. heat removed term R(T) and heat generation term G(T), discuss the runaway reaction in a CSTR. **07**

**OR**

**Q.5** **(a)** Discuss different models for fluidized bed reactor. **07**

**(b)** Write a short note on: Monolithic Reactors **07**

**********