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) At 1100 K n-nonane thermally cracks (breaks down into smaller molecules) 20 times as rapidly as at 1000 K. Find the activation energy for this decomposition. (5)

b) In case of a first order reaction, show that the time required for 75% conversion is double the time required for 50% conversion? (5)

c) Write design equation for batch reactor (5)

d) Write short note on effect of temperature and pressure on equilibrium conversion and equilibrium constant. (5)

Q.2.a) For the gas phase decomposition of azomethane (10)

$(CH_3)_2N_2 \leftrightarrow C_2H_6 + N_2$

The rate expression is

$$r_{N_2} = \frac{k_1 C^2_{Azomethane}}{1 + k' C_{Azomethane}}$$

Where Azomethane= $(CH_3)_2N_2$

Devise a mechanism to explain this rate.

Q.2b) Variation of the rate constant with temperature for the reaction $2N_2O_5 \longrightarrow 2\,N_2O_4 + O_2$ is given in the following table. Determine graphically the activation energy for the reaction. Also write complete rate equation. (10)

Temp.(K)	298	308	318	328	338
k (sec^{-1})	$1.74x10^{-5}$	$6.61x10^{-5}$	$2.51\ x10^{-4}$	$7.59x10^{-4}$	$2.40x10^{-3}$

Q.3 a) The gaseous reaction $2A \longrightarrow R + 2S$ is second order w.r.t A. If pure A is introduced at 1 atm into a constant volume batch reactor, the pressure rises by 40% in 3 min. In case of a constant pressure batch reactor (12)

i) find the time required for the same conversion

ii) The fractional change in volume at that time.

Q.3b) The first-order reversible liquid reaction (08)

$$A \leftrightarrow R, \qquad C_{A0} = 0.5\frac{mol}{lit}, \qquad C_{R0} = 0$$

takes place in a batch reactor. After 8 minutes, conversion of A is 33.3% while equilibrium conversion is 66.7%. Find the rate equation for this reaction.

Q.4 a) The homogeneous gas decomposition of phosphine (08)

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

proceeds at 649^{O}C with the first-order rate

$-r_{PH_3} = (10/hr)\ C_{PH_3}$

What size of plug flow reactor operating at 649°C and 460 kPa can produce 80% conversion of a feed consisting of 40 mol of pure phosphine per hour?

Q.4b) For the elementary reaction in series in a batch reactor (12)

A→R→S, k1=k2, at t=0 ; $C_A=C_{A0}$; $C_{R0}=C_{S0}=0$

Find out the maximum concentration of R and when it is reached.

Q.5 a) The elementary irreversible liquid phase reaction A+B →C is carried out in a mixed Flow reactor. An equimolar feed in A and B enters the reactor at 300 K and the volumetric flow rate is 2 lit/s. Calculate the volume of reactor to achieve 85% conversion when the reaction is carried out adiabatically. (15)

Data: ΔH_f^0 for

A = -20 kcal/mol, for B= -15 kcal/mol and for C = - 41 kcal/mol

C_{A0}= 0.10 kmol/m^3

$C_{PA} = C_{PB}$=15 cal/(mol.K) , C_{PC} = 30 cal/(mol.K)

K=0.01 (l/mol.sec) at 300K E=10000 cal/mol

Q.5b) Compute K_y at 10 atm if K_p at this pressure is 0.00381 atm^{-1} for ammonia synthesis reaction from hydrogen and nitrogen at 500^{0}C. Assume that the ideal gas law is applicable. (05)

Q.6) Attempt **any two** of the following (20)

a) Derive design equation of Recycle reactor

b) What is Optimum Temperature Progression? Explain with examples

c) Explain Half Life method of analysis of rate data

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