

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 (5)  
 times as rapidly as at 1000 K. Find the activation energy for this decomposition.
- b) In case of a first order reaction, show that the time required for 75% conversion is (5)  
 double the time required for 50% conversion?
- c) Write design equation for batch reactor (5)
- d) Write short note on effect of temperature and pressure on equilibrium conversion (5)  
 and equilibrium constant.

- Q.2.a) For the gas phase decomposition of azomethane (10)  
 $(\text{CH}_3)_2\text{N}_2 \leftrightarrow \text{C}_2\text{H}_6 + \text{N}_2$   
 The rate expression is

$$r_{\text{N}_2} = \frac{k_1 C_{\text{Azomethane}}^2}{1 + k' C_{\text{Azomethane}}}$$

Where Azomethane =  $(\text{CH}_3)_2\text{N}_2$

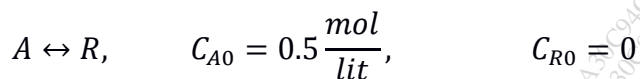
Devise a mechanism to explain this rate.

- Q.2b) Variation of the rate constant with temperature for the reaction (10)  
 $2\text{N}_2\text{O}_5 \longrightarrow 2\text{N}_2\text{O}_4 + \text{O}_2$  is given in the following table. Determine graphically  
 the activation energy for the reaction. Also write complete rate equation.

Temp. (K)	298	308	318	328	338
k (sec <sup>-1</sup> )	$1.74 \times 10^{-5}$	$6.61 \times 10^{-5}$	$2.51 \times 10^{-4}$	$7.59 \times 10^{-4}$	$2.40 \times 10^{-3}$

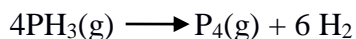
- Q.3 a) The gaseous reaction  $2\text{A} \longrightarrow \text{R} + 2\text{S}$  is second order w.r.t A. If pure A is (12)  
 introduced at 1 atm into a constant volume batch reactor, the pressure rises by  
 40% in 3 min. In case of a constant pressure batch reactor
- find the time required for the same conversion
  - The fractional change in volume at that time.

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



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)



proceeds at 649°C with the first-order rate

$$-r_{\text{PH}_3} = (10/\text{hr}) C_{\text{PH}_3}$$

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)



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

Q.5 a) The elementary irreversible liquid phase reaction  $A+B \rightarrow C$  is carried out in a (15)

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.

Data:  $\Delta H_r^0$  for

$$A = -20 \text{ kcal/mol, for } B = -15 \text{ kcal/mol and for } C = -41 \text{ kcal/mol}$$

$$C_{A0} = 0.10 \text{ kmol/m}^3$$

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

$$K = 0.01 \text{ (l/mol.sec) at } 300\text{K}, \quad E = 10000 \text{ cal/mol}$$

Q.5b) Compute  $K_y$  at 10 atm if  $K_p$  at this pressure is  $0.00381 \text{ atm}^{-1}$  for ammonia (05)

synthesis reaction from hydrogen and nitrogen at 500°C. Assume that the ideal gas law is applicable.

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

- Derive design equation of Recycle reactor
- What is Optimum Temperature Progression? Explain with examples
- Explain Half Life method of analysis of rate data

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