EX/ FTBE/ T / 326 /2017

B.FTBE. 3RD YEAR (2ND SEM.) EXAMINATIONS, 2017

CHEMICAL ENGINEERING KINETICS

Time: Three hours **Full Marks: 100**

Use separate Answer Script for each Part

PART-I (50 Marks)

(Answer any FIVE questions. All questions carry equal marks.)

1. a) What is called collision theory ?

b.) What would be the energy of activation in **kJ mol^{-1}**
if the rate of a reaction doubles when the temperature changes from 27°C to 37°C ?

2.How could you measure the order of reaction of the following equations ?

a) Dissociation of HI.
b) Dissociation of $COCl_2$
c) Saponification of ethyl acetate.
d) Reaction between NO and O_3.

3. a.) Calculate the frequency factor A (activation energy = 94.14 kJ mol^{-1}) if the value of rate constant at 313 K is 1.8 x 10^{-5}sec^{-1}.

b.) What is the role of catalyst in a chemical reaction is to change?

4. a.) Explain with a suitable example why the ionic reactions are very fast.

b.) What do you mean by reactions of high molecularity ?

5. a.) The three-fourth of a first order reaction is completed in 32 minutes. Find the half-life period of the reaction?

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[Turn over

6. The gas phase decomposition of dimethyl ether follows first order kinetics

$$CH_3\text{---}O\text{----}CH_3(\text{ gas}) \longrightarrow CH_4(\text{gas}) + H_2(\text{ gas}) + CO(\text{ gas}).$$

The reaction is carried out in a constant volume container at 500 C and has a half-life of 14.5 min. Initially only dimethyl ether is present at a pressure of 0.40 atm. What is the total pressure of the system after 12 min ? Assume ideal gas behavior.

7 a.) A first order reaction is 30% complete in 40 minutes. In what time will the reaction be 70% complete?

b.) What percentage of the reactant will be left behind after 80 minutes, if the half-life period of a first order reaction is 40 minutes?

8. The decomposition of N O according to the equation

$$2\,N_2O_5(\text{ gas}) \longrightarrow 4\,NO_2(\text{ gas}) + O_2(\text{ gas})$$

is a first order reaction. After 30 min from the start of the decomposition in a closed vessel , the total pressure developed is found to be 284.5 mm of Hg. On complete decomposition , the total pressure is 584.5 mm of Hg. Calculate the rate constant of the reaction.

9. a) For a n-th order reaction, deduce the integrated rate equation and the half life of the reactants .

b.) With a suitable example , explain what is called Consecutive -First Order Reaction .

PART - II (50 MARKS)

All notation carry their usual meaning.

Attempt ***any three*** questions :

10. a) Prove the following equation

$$Vr_{p_1} = Wr_{p_2} = Sr_{p_3} = V_S r_{p_4} = V_r r_{b_5}$$ 05

b) How may ways reactors can be classified ? 03

c) Write down the basic equation which fits for any type of reactor. 02

d) Prove the following equation with a neat sketch for a batch reactor

$$t = C_{Ao} \int_0^{x_A} \frac{dx_A}{(-r_A)}$$ 06

11. a) Considering the basic equation and with a neat sketch of a plug flow reactor, prove the following equation

$$\frac{V}{F_{A_o}} = \frac{y}{C_{A_o}} = \int_0^{x_{Af}} \frac{dx}{(-r_A)}$$ 08+1=09

b) The elementary liquid-phase reaction $A + 2B \underset{K_2}{\overset{K_1}{\rightleftharpoons}} R$ with rate equation

$$-r_A = \frac{1}{2} r_B = (12.5 \text{ Litre}^2/\text{mol}^2.\text{ min}) C_A C_B^2 - (1.5 \text{ min}^{-1}) C_R \left(\frac{\text{mol}}{\text{Litre. min}} \right)$$

is to take place in a 6-litre steady-state mixed flow reactor. Two feed streams, one containing 2·8 mol A/litre and the other containing 1·6 mol B/Litre are to be introduced at equal flow rate into the reactor, and 75% conversion of limiting component is desired. What should be the flow rate of each stream ? Assume a constant density throughout.

07

12. a) Mention the five steps (step 1 - step 5) generally needed for shrinking core Model for spherical particles of unchanging size. Mention the condition at which steps (4) and (5) do not contribute directly to the resistance to the reaction. 06+1=7

b) With a neat sketch, prove the following equation for Diffusion through Gas Film Control

$$\frac{t}{\tau} = X_B$$ 09

4. a) A feed containing

(30% of 50-μm radius particles ; 40% of 100 μm radius particles and 30% of 200μm radius) particles is to be fed continuously in a thin layer onto a moving grate cross-current to a flow of reactant gas. For the planned operating condition the time required for complete convcersion is 5, 10 and 20 min for the three sizes of particles. Find the conversion of solids on the grate for a residence time of 8 min in the reactor. 07

b) Considering diffusion-and reaction together, prove the following equation

$$200\ \mu m$$ 09