**B.E. METALLURGICAL ENGINEERING**
**THIRD YEAR**
**FIRST SEMESTER EXAM 2025**

**CHEMICAL KINETICS AND MASS TRANSFER**

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

**Answer question 1 and any two from each of part A and part B**
**Assume any missing data**
**Notations have their usual significance**

| Q. NO | | QUESTION | MARKS |
|---|---|---|---|
| Q1 | a) | Half-life is the time required to achieve 50% conversion. For a first order liquid phase reaction half-life depends on initial concentration/ rate constant/ initial concentration and rate constant/ none of these. | 2x10=20 |
| | b) | For the reaction in gas phase 3A+30%inert → 2P+Q+inert, the volume expansion coefficient € is (a) 4/5 (b) 1/3 (c)2.5 (d) none of these. | |
| | c) | For n-th order liquid phase chemical reaction order maybe obtained using log log graph paper/ semi log graph paper/ triangular graph paper | |
| | d) | For a zero order chemical reaction, rate of the reaction is proportional to concentration/ inverse of concentration/ rate constant. | |
| | e) | In an ideal plug flow reactor, there is no mixing in the longitudinal direction/ mixing takes place in the radial direction/ uniform velocity across the radius/ all of the above. | |
| | f) | What is the unit of diffusivity?<br>i) m/s<br>ii) $m^3/s$<br>iii) $m^2/s$<br>iv) $m/s^2$ | |
| | g) | What causes the concentration at the interphase to be unequal, according to Lewis and Whitman theory?<br>i) Moderate mass transfer rate<br>ii) Low mass transfer rates<br>iii) High mass transfer rates<br>iv) None of the mentioned | |
| | h) | Which type of mass transfer involves the transfer of mass across a phase boundary?<br>i) Molecular diffusion<br>ii) Interphase mass transfer<br>iii) Diffusion<br>iv) None of the mentioned | |
| | i) | What does the term “steady-state diffusion” imply?<br>i) No diffusion occurs<br>ii) Diffusion rate is zero<br>iii) Concentration remains constant with time<br>iv) Concentration changes over time | |
| | j) | What are the similarities between surface renewal theory and penetration model<br>In both cases molecular diffusion is assumed/ steady state diffusion is assumed/ unsteady state mass transfer is assumed/ non uniform bulk concentration is assumed | |
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| | | **PART A** | |
| **Q2** | | **In order to study kinetics of a liquid phase reaction A → B following data were obtained:**<br>**Time (min) 10 20 30 40 50 60**<br>**$C_A$ gmole/$m^3$ 2.45 1.74 1.23 0.88 0.62 0.44**<br>**Determine order of reaction and the rate constant** | **20** |
| **Q3** | | **A liquid phase reaction A + B → C is carried out in a stirred tank reactor to produce 5000 kilograms per day of product whose molecular weight is 60 . The aqueous solution of A and B (molecular wt is 60) are continuously fed to reactor separately containing 2 kilomole per meter cube of A along with aqueous solution of B of same concentration and same volumetric flow rate. Calculate the volume of reactor needed to achieve 85% conversion of A and space time required . The $2^{nd}$ order rate constant is 0.1 meter cube per kilo mole per second.** | **20** |
| **Q4** | | **An elementary $2^{nd}$ order liquid phase reaction is carried out in a plug flow reactor. The feed stream contents 10 K mole per meter cube of A and 50 kilo mole per meter cube of B. The volumetric flow rate of reactant mixture is 0.002 meter cube per second. The rate constant of the reaction is 0.0005 meter cube per kilo mole second per. Calculate the volume of plug flow reactor to obtain 80% conversion of the limiting reactant.** | **20** |
| | | **PART B** | |
| **Q5** | | **Draw a schematic for interface mass transfer according to film theory. Show that the mass transfer coefficient as predicted by film theory is proportional to the diffusivity. Compare advantage and limitations of film theory, penetration theory, and surface renewal theory.** | **20** |
| **Q6** | | **Imagine a cube of dimension 1m in a multi component flow containing 3 moles of A, 5 moles of B 10 moles of C at steady state . Molecular weights of A , B, and C are 3, 2 and 1 respectively. Diffusion rate of A in the x direction is 1 mole per second and that of B and C in the opposite direction is 3 mole per second. if the cube is convected at a velocity of 2m per second, calculate molar average velocity and fluxes relative to molar average velocity. Draw the schematic of the problem.** | **20** |
| **Q7** | | **What is the significance of diffusion velocity? State Fick's first law of diffusion. Consider a hollow cylinder of two meter long. The inside surface of the cylinder is coated with a dye of concentration 1g per cc. The inner diameter the cylinder is 10 centimeter and the outer diameter is 20 centimeter. The dye diffuses through the wall of the cylinder. The diffusivity of dye through the cylindrical wall is $1x10^{-7}$ $cm^2/s$. Derive an expression for concentration distribution of dye across the cylindrical wall and calculate the molar flux through the cylindrical wall.** | **20** |