Ref. no. Ex/Met/BS/B/T/315/2024(S)

B. E. METALLURGICAL AND MATERIAL ENGINEERING

THIRD YEAR SUPPLEMENTARY EXAMINATION – 2024

CHEMICAL KINETICS AND MASS TRANSFER

Full marks 100 Time- 3 hours

Group A (Chemical kinetics)

50 marks

Answer any two questions. All questions carry equal marks

1) a) What is an elementary reaction? Give example. Why more than third order chemical reaction is not found in nature? What do you mean by molecularity of chemical reaction? How it is different from order of chemical reaction? What is meant by limiting reactant. **10**

b) With suitable diagram discuss transition state theory for exothermic and endothermic reaction. **10**

c) What are different methods of analysis of kinetic data? **5**

2) Consider a constant density reaction A →P is carried out in a batch reactor. Data obtained from batch reactor are as follows:

Time(s)	0	30	60	90	120	150	180	600
Concentration A ($kmol/m^3$)	1	0.74	0.55	0.42	0.29	0.24	0.16	0.0025

Calculate order and rate constant of the reaction and also calculate time for 50% conversion. **25**

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3) a) The 2nd order liquid phase reaction 2A→P is carried out in an isothermal batch reactor operating at 75°C. Density of pure A is 10 Kmol/m^3. The charge contains 30% of inert fluid. The reaction is continued to achieve 90% conversion of A. Calculate the reaction time if the rate constant for reaction is 0.000714 m^3/kmol.s **10**

b) a petroleum fraction contains an impurity A whose concentration is 1.1 more percent. The acceptable limit of impurity is 0.02 mole. The impurity is reduced by treating the petroleum product with the catalyst in a CSTR. Mediation is a first order with respect to A and the rate constant is 0.003 per second. What size of CSTR is needed if the feed rate is 0.0005 m^3/s **15**

Group B (Mass transfer)

50 marks

Answer any two questions. All questions carry equal marks

4) a) Explain mass average velocity and molar average velocity. Write respective mathematical expression. What is diffusion velocity? **10**

b) imagine a cube of dimension 1m in a multi component flow containing 3 moles of a, 5 moles of B, and 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 X direction is 1 mole per second and that of B in the opposite direction is 3 mole per second. If that cube is convicted at a velocity of 1m per second, calculate molar average velocity add fluxes relative to molar average velocity. Draw suitable schematic for the problem. **15**

5) a) Derive the equation for molar flux N_A in the X direction in a binary mixture of A and B. **10**

b) In a binary gaseous mixture of A and B component A is diffusing where B is non diffusing. Derive an expression for steady flux of A. Calculate the flux when diffusivity is 0.1 cm2/s, total pressure P=1.0 atm, R = 82.06 cm3.atm/gmol.K, T = 273K, partial pressures Pa1 =0.1atm, Pa2=0.05 atm, and diffusion length = 0.5 cm. **15**

6) a) Gaseous reactant A is reacting on the solid surface of B to produce gaseous products C and D according to the following reaction.

A(g) + B(s) → 2C(g) + D(g)

Derive an expression for molar flux of A at the solid surface. **15**

b) Derive the expression for mass transfer coefficient according to film theory and discuss advantage and limitations of this theory. Compare this theory with penetration model. **10**