Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER II (NEW) – • EXAMINATION – SUMMER 2016

Subject Code: 2721609 Date: 25/05/2016

Subject Name: Advanced Kinetics and Reaction Engineering (AKRE)

Time:10:30 am to 01:00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q-1(a) What is Hatta number, E and Ei? Discuss the Enhancement factor for fluid-fluid reactions as a function of M_H and Ei. **(07)**

(b) Derive the equation for time required to completely react particle of size R_0, when the movement of the particle is in stokes Regime and Diffusion through Gas film controls the overall rate. **(07)**

Q-2(a) A batch of solids (60 kg A and 40 Kg B) is fluidized. The air velocity used is rather high and the solids blown from the bed are trapped in cyclone and are immediately returned to the bed. At steady state 36 kg A/ hr and 8 Kg B/hr are blown out and returned. It is planned to have continuous operation where this A-B mixture (100 kg/hr) is fed continuously to a bed containing 100 kg. Solids, the air velocity is kept identical to the batch run and entrained soids are not returned to the bed. Find the mean residence time of solids A and B in the continuous flow fluidized bed. **(07)**

(b) Silicon particles of size 10 µm diameter are to be converted to Tetrachloro silane($Sicl_4$) by reacting them with Cl_2 gas at 300^0C in a fluidized bed reactor. Assuming that the process is mass transfer limited with S_{hd} =2.0, how long will it be required to react completely? Partial pressure of Cl_2 is 0.02 atm. The density of silicon is 2330 kg/m^3 and its atomic weight is 32.Assume diffusivity, D_{sicl4} = 0.1cm^2/sec. If a fluidized bed is to be designed to treat 1 Ton/hr of solid with stoichiometric feed rate of A, fed at C_{A0} , find the weight of solids in the reactor if gas is assumed to be in mixed flow. **(07)**

OR

(b) It is desired to lower the concentration of B in the liquid (V_l =1.62 m^3,C_U = 55,555.6 mol/m^3)of an agitated tank reactor by bubbling gas (F_g = 9000 mol/hr, P = 10^5 Pa)containing A(p_{Ain} = 1000Pa) through it. A and B react as follows. **(07)**

$$A(g) + B(l) \longrightarrow \text{product(l)}, \text{ with } -r_A' = kC_AC_B$$

How long must we bubble gas through the vessel to lower the concentration fromC_{B0} = 555.6 mol/$m^3$to C_{Bf} = 55.6 mol/m^3 ?

Data.

$k_{Ag}a$ = 0.72 mol/hr.m^3.Pa f_l =0.9 m^3liquid/m^3 total

$k_{Al}a$ =1.44 hr^{-1} $D_A = D_B$ =3.6× 10^{-6} m^2/hr, a = 100 m^2/m^3

H_A = 103 Pa.m3/mol k = 2.6 × 10^5 m^3/mol hr

Q-3 (a) For enzymatic fermentation discuss the Michaelis-Menten equation. **(07)**

(b) Substrate A and enzyme E flow through a CSTR(V=6lit.).From the entering and leaving concentration and flow rate, find a rate equation to represent the action of enzyme on substrate. **(07)**

DATA:-

C_{EO} mol/lit	$C_{A}o$ mol/lit	C_A mol/lit	V, lit/hr
0.02	0.2	0.04	3.0
0.01	0.3	0.15	4.0
0.001	0.69	0.60	1.2

OR

Q-3 (a) For microbial fermentation reaction viscous various phases of cell growth with appropriate equation. **(07)**

(b) Enzymatic Batch reactor, urea was converted to ammonia and carbon dioxide, with the initial concentration of urea 0.1 mol/lit, and the urease concentration 0.001 gm/lit. Following experimental results were available.

A= urea

C_A kmol/m^3	$-r_A$ (kmol/m^3s)
0.20	1.08
0.02	0.55
0.01	0.38
0.005	0.20
0.002	0.09

Now the reaction is to be carried out under same condition, but with urease concentration of 5gm/lit. Determine the time needed to convert 80% urea to ammonia and carbon dioxide

Q-4 (a) Explain with neat sketch about working of Gas induction type agitated reactor with spiral baffled jacket and also write about its advantages over conventional type agitated vessel gas-liquid reactors. **(07)**

(b) Explain with neat sketch about working of Jet Loop Reactor and also write about its advantages over agitated type gas-liquid reactors. **(07)**

OR

Q-4 (a) Discuss about various factors affecting on the performance of bubble column reactor. **(07)**

(b) Explain with neat sketch about working of Quench bed Reactor and also write about other design of fixed bed catalytic reactors. **(07)**

Q-5 Butyl acetate formation is carried out in a batch reactor at 90°C with sulphuric acid as a homogeneous catalyst. The feed contained 4.97 moles of *n*-butanol per mole of acetic acid and the catalyst concentration is 0.032% by mass as H_2SO_4. **(14)**

Rate equation for this reaction is $-r_A = kC_A^2$

where, C_A = Concentration of acetic acid in mol/cm^3

k = 17.4 cm3/(mol min). Density of the reaction mixture at 90°C can be assumed constant and equal to 0.75 g/cm^3. Molecular weights of butyl acetate, butanol and acetic acid are 116, 74 and 60 respectively.

(a) Calculate the time required to obtain conversion of 50%.
(b) Determine the size of reactor and the mass of reactants that must be charged to the reactor in order to produce ester at the average rate of 100 kg/h. Conversion is 50%. Reactor will be shut down for 30 min between batches for removal of product, cleaning and start-up. Assume that batch reactor is ideal. Also decide height and diameter of the reactor.

OR

Q-5 In the continuous process for the manufacturing of monochloroacetic acid (MCA) conversion of acetic acid is restricted to 50% to avoid the formation of dichloroacetic acid. Reaction is carried out in a bubble column reactor. **(14)**

Determine the following:
(a) Working volume of reactor
(b) Diameter of reactor
(c) Height of liquid inside the reactor during reaction
(d) Calculate heat must be removed by cooling water circulated through jacket if heat duty of overhead condenser is 43.7 kW.

Data

(i) Reaction: $CH_3COOH(l) + Cl_2(g) === CH_2ClCOOH(l) + HCl(g)$
(ii) Heat of reaction at reaction temperature, i.e., at 100°C
ΔHr = –87.92 kJ/mol (Exothermic)
(iii) Chlorine supply rate is 20% higher than that consumed in reaction.
(iv) Cooling water is available in plant at 32°C.
(v) Mass transfer coefficient data
For superficial velocity of gas, Sg = 1 to 30 cm/s K_{La} = 0.25 x 10^{-2} to 0.4 s^{-1}
(vi) Rate of chemical reaction
$-r_A = kC_A$, k = 2.777 x 10^{-5} s^{-1}
Density of acetic acid, ρ = 1048 kg/m^3
(vii) Production rate of monochloroacetic acid = 1 t/h
(viii) Operating pressure in reactor = 0.1 atm g

Specifi c Heat of Gases/Vapours and Liquids at 70°C

Component	C_{pi}, **kJ/(kg . °C)** (gas/vapour)	C_{Li}, **kJ/(kg . °C)** (Liquid)
Chlorine	0.5024	– –
Hydrogen chloride	0.7955	—
Acetic acid	1.2267	2.22
MCA	1.0467	1.9

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