

Time allowed: 3 Hours

Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Section. State clearly your assumptions.

x-x-x

Q. 1) Write briefly:

- Define enzyme activity and specific enzyme activity?
- Define extracellular and intracellular enzyme with examples?
- Define V_{max} and K_m ? What is the turnover number.
- Define effectiveness factor for immobilized enzyme? What do you mean by the total effectiveness factor for the system is close to unity.
- Derive a performance equation for plug flow reactor. (5x2)

SECTION - A

Q. 2. a) The K_m value of an enzyme is known to be 0.01 mol/L. To measure the V_{max} , the initial rate of reaction was measured and it was found that 10% of the substrate was consumed in 5 minutes. The initial substrate concentration is 0.00034 mol/L. Assuming that reaction can be expressed by the M-M kinetics;

Determine (i) V_{max} (ii) Concentration of substrate after 15min?

b) An enzyme is used to produce a compound that is further used to manufacture sunscreen lotion. V_{max} for enzyme 2.5 mol/m³-s, $K_m = 8.9$ mM. The initial concentration of substrate is 12 mM. If the reaction is being carried out under isothermal conditions, what batch reaction time is required for 90% substrate conversion and if the enzyme used in deactivates with half life of 4.4 hr, what is the batch reaction time required to achieve 90% substrate conversion?

c) Find out degree of inhibition caused by competitive enzyme inhibition when $[S] = K_m$ and $[I] = \frac{1}{2} K_I$ (4,4,2)

Q.3. a) An enzymatic reaction has a simple Michaelis-Menten mechanism:



K_1 and K_{-1} are very fast, $K_2 = 100$ 1/sec and $K_M = 10^{-4}$ M at 280 K while $K_2 = 200$ 1/sec, and $K_M = 1.5 \times 10^{-4}$ M at 300 K. **(i)** For $[S] = 0.1$ M and $[E_0] = 10^{-5}$ M, what is v_0 at 280 K? **(ii)** Calculate the activation energy for K_2 . **(iii)** What is K_{eq} at 280 K for E binding to S?

b) The velocity of enzymatic reaction at 35 °C is twice as great as the velocity at 25 °C. Calculate activation energy (E_a)

c) Explain effect of substrate and enzyme concentration on enzyme activity. (6,2,2)

(2)

- Q. 4. a)** Describe the type of enzyme inhibitions and compare V_{max} and K_m with controlled enzyme.
- b)** Discuss the effect of V_{max} and K_m if Enzyme follows deactivation kinetics with controlled enzyme.
- c)** Derive a rate of expression (V) for substrate inhibition kinetics by King-Altman's method and show that at maximum reaction rate of substrate concentration is

$$S_{max} = \sqrt{K_m \times K_S} \quad (3,3,4)$$

SECTION - B

- Q. 5. a)** A carbohydrate (S) decomposes in the presence of an enzyme (E). The reaction follows MM kinetics. The Michaelis-Menten kinetic parameters for this reaction are $K_m = 200 \text{ mol m}^{-3}$ and $V_{max} = 100 \text{ mol m}^{-3} \text{ min}^{-1}$. The initial concentration of substrate $[S_0] = 300 \text{ mol m}^{-3}$.
- i)** If the reaction is run in a batch reactor, calculate how long the reaction has to be carried out to achieve a final substrate concentration that is 50% of the initial concentration.
- ii)** If the same reaction is run in a CSTR, calculate the size of reactor if volumetric flow rate is $100 \text{ m}^3 \text{ min}^{-1}$.
- b)** The isomerisation of $5 \times 10^{-2} \text{ mol} \cdot \text{dm}^{-1}$ bulk concentration of glucose to fructose is conducted at 313°K in a batch reactor using immobilised glucose isomerase. The reaction exhibits reversible Michaelis-Menten kinetics and is characterised by K_m value of $2 \times 10^{-3} \text{ mol} \cdot \text{dm}^{-1}$. The determined effectiveness factor η of 0.7 reveals an appreciable contribution of mass transport to the measured reaction rate. Calculate the substrate concentration at the solid-liquid interface under these conditions. (5, 5)
- Q. 6)** Name the various methods in Block diagram. Discuss the entrapment method in details. Write advantages and disadvantages of entrapment method. How will you eliminate the enzyme leakage and diffusion problem during immobilization? (10)
- Q. 7. a)** Immobilized lactose is used to hydrolyze lactose in dairy waste to glucose and galactose. Enzyme is immobilized in resin particles and packed into at 0.05 m^3 Plug – flow column. The total effectiveness factor for the system is close to unity; K_m for the immobilized enzyme is 1.32 kg m^{-3} ; V_{max} is $45 \text{ kg m}^{-3} \text{ h}^{-1}$. The lactose concentration in the feed stream is 9.5 kg m^{-3} ; a substrate conversion is 98% is required. At what flow rate should the reactor be operated?
- b)** Derive the equation for effectiveness of an immobilized enzyme, assume that rate of substrate consumption can be expressed as zero order kinetics. (5,5)