B.TECH/CHE/5TH SEM/CHEN 3141/2020

BIOPROCESS ENGINEERING
(CHEN 3141)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) When the rate of product formation is half the maximum forward velocity, the value of Michaelis-Menten constant equals
(a) half the substrate concentration (b) substrate concentration
(c) zero (d) square of substrate concentration.

(ii) The phase of microbial growth in which growth rate is independent of nutrient concentration is
(a) lag phase (b) exponential growth phase
(c) stationary phase (d) death phase

(iii) At high substrate concentration, rate of product formation according to Michaelis-Menten kinetics is
(a) First order (b) second order
(c) zero order (d) order half.

(iv) If Vm and Km are the maximum forward reaction velocity and the Michaelis-Menten constant under uninhibited conditions respectively, and Vm,app and Km,app are the corresponding values in case of enzyme inhibition, if Vm, app< Vm and Km,app=Km, the type of inhibition is
(a) un-competitive (b) competitive
(c) non-competitive (d) linear mixed.

(v) According to Hughmark, the ratio of power consumption by gassed and ungassed liquid is a function of
(a) Reynolds number (b) Aeration number
(c) Froude number (d) all of the above.

(vi) The expression for Reynolds number in an agitated vessel is
(a) $\rho D^2 N / \mu$ where D is the impeller diameter
(b) $\rho DN / \mu$ where D is the vessel diameter
(c) $\rho DN / \mu$ where D is the impeller diameter
(d) $\rho D^2 N / \mu$ where D is the vessel diameter.

(vii) In facilitated transport,
(a) molecules move from high to low concentration without the help of carrier
(b) molecules move from low to high concentration with the help of a carrier
(c) molecules move from high to low concentration with the help of a carrier
(d) molecules are chemically modified during transport.

(viii) If pressure drop through a membrane module is minimized, and solute mass transfer is optimized, the module satisfies the following criteria
(a) hydrodynamic (b) economic
(c) mechanical (d) both (a) and (c).

(ix) Aqueous two-phase extraction are carried out using
(a) two-water soluble polymers which are immiscible
(b) two water soluble polymers which are miscible
(c) one salt and one water soluble polymer which are immiscible
(d) both (a) and (c).

(x) The chromatographic technique which separates solutes based on size is termed
(a) adsorption chromatography
(b) liquid-liquid partition chromatography
(c) gel chromatography
(d) ion-exchange chromatography.

Group – B

2. (a) Derive the Michaelis-Menten rate equation using the quasi-steady state assumption. Give examples of coenzymes.

(b) During a test of kinetics of an enzyme-catalyzed reaction at 30 ºC temperature, the following data were recorded,

E_0 (g/l)	1.6	1.6	1.6	1.6	1.6	0.92	0.92	0.92	0.92	0.92	0.92
I(mmol/ml)	0	0	0	0	0	0	0	0	0.6	0.6	0.6
S(mmol/ml)	0.1	0.033	0.02	0.01	0.005	0.1	0.02	0.01	0.1	0.033	0.02
V(mmol/ml-min)	2.63	1.92	1.47	0.96	0.56	1.64	0.90	0.58	1.33	0.80	0.57

(i) Determine the Michaelis-Menten constant and maximum velocity of the uninhibited reaction for the two different enzyme concentration.
(ii) Determine the inhibition constant and comment on the type of inhibition.

(mm Graph paper required)

(3 + 1) + (4 + 4) = 12

3. (a) Explain the advantages of enzyme immobilization. Discuss the different methods of enzyme immobilization

(b) Enzyme urease is immobilized in calcium alginate beads 2 mm in diameter. When urea concentration in bulk liquid is 0.5 mM, the rate of urea hydrolysis is 10 mmol/l.h. Diffusivity of urea in calcium alginate is 1.5×10^{-5} cm^2/s and Michaelis-Menten constant is 0.2 mM. Assuming the urea concentration on the surface of beads is same as the bulk concentration, compute the maximum reaction velocity, Thiele modulus and effectiveness factor

(2 + 4) + 6 = 12

Group – C

4. (a) Describe the different steps of Krebs cycle with the help of a diagram, mentioning the energy balance in each step.

(b) Discuss the different factors affecting the microbial growth kinetics. What is the significance of critical oxygen concentration? Enumerate the different techniques used for k_La measurement.

6 + (3 + 2 + 1) = 12

5. (a) A simple batch fermentation of an aerobic bacterium growing on methanol gave the following results:

Time (h)	0	2	4	8	10	12	14	16	18
X (g/l)	0.2	0.211	0.305	0.98	1.77	3.2	5.6	6.15	6.2
S(g/l)	9.23	9.21	9.07	8.03	6.8	4.6	0.92	0.077	0

Calculate the maximum growth rate (μ_{max}), yield on substrate ($Y_{X/S}$), mass doubling time (t_d), saturation constant (K_s) and specific growth rate (μ_{net}) at 10 h.

(mm Graph paper required)

(b) Classify microbial products and briefly discuss each type mentioning their kinetics of formation. Give examples of each category of product.

7 + 5 = 12

Group – D

6. (a) Derive the expression for biomass concentration obtained from a chemostat if (i) extracellular product formation is negligible (ii) extracellular product formation is taken into account.

(b) Consider scale-up of a fermenter from a 5 litre to 5000 litre vessel. The small fermenter has a height to diameter ratio of 3. The impeller diameter is 40% of the tank diameter. Agitator speed is 500 rpm and three Rushton impellers are used. Determine the dimensions of the large fermenter and agitator speed for (i) Constant P/V, (ii) Constant Reynolds number, (iii) Constant impeller tip speed.

(3 + 4) + 5 = 12

7. (a) Explain the consequences of contamination of a fermentation medium. What is the significance of nabla factor in sterilization? Discuss the advantages of continuous sterilization of a medium over batch sterilization.

   (b) Classify sensors with respect to its application in process control. Explain the working principle of a dissolved oxygen electrode with a diagram.

(2 + 2 + 2) + (2 + 4) = 12

Group – E

8. (a) Discuss the different methods of cell lysis.

   (b) State one important application of centrifugal extractor. Explain the basic principle of aqueous two phase extraction.

6 + (1 + 5) = 12

9. (a) Explain the principle of chromatographic separation used for separating solutes from a liquid mixture. Discuss the important chromatographic methods used in bioseparation.

   (b) Describe the industrial process of production of ethanol in continuous mode with the aid of a flowsheet.

(2 + 5) + 5 = 12

Department & Section	Submission Link
CHE	https://classroom.google.com/c/MTIzNjM5MTYzMTYw/a/MjcxMjEzNzI1NDIx/details