

- (iii)  $Y_{x/s}$ , mg cells/mg glycerol  
 (iv)  $m_s$ , mg glycerol/mg cells.h.

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7. A simple, batch fermentation of an aerobic bacterium growing on methanol gave the results shown in the table. Calculate:

- (i) Maximum growth rate ( $\mu_{max}$ )  
 (ii) Yield on substrate ( $Y_{x/s}$ )  
 (iii) Mass doubling time  
 (iv) Specific growth rate at  $t=10$  h.

Time, h	0	2	4	8	10	12	14	16	18
X, g/L 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

$$6 + 2 + 2 + 2 = 12$$

### Group - E

8. (a) Explain with a diagram the working principle of pH meter.  
 (b) Discuss the characteristics features of manometric fluid.
- 6 + 6 = 12**
9. (a) Explain the working principle of thermister.  
 (b) Describe the working strategy of oxidation-reduction potential measuring instruments.
- 6 + 6 = 12**

## BIOPROCESS & PROCESS INSTRUMENTATION (BIOT 4143)

Time Allotted : 3 hrs

Full Marks : 70

*Figures out of the right margin indicate full marks.*

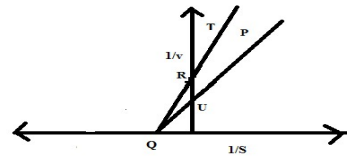
*Candidates are required to answer Group A and  
any 5 (five) from Group B to E, taking at least one from each group.*

*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) The thermocouple circuit which is used to measure temperature works on \_\_\_\_  
 (a) Seebeck effect (b) Peltier effect  
 (c) Thomson effect (d) none of (a), (b) and (c).
- (ii) What do you mean by "Axenic culture"?  
 (a) Containing single type of organism  
 (b) Containing two types of organism  
 (c) Containing multiple types of organism  
 (d) Not containing any type of organism.
- (iii) Which of the following influence Heat sterilization of media  
 (a) Number of organisms (b) Kind of organisms  
 (c) Type of media (d) All of (a), (b) and (c).
- (iv) What is the recommended unit of enzyme activity?  
 (a) Katal (b) mM  
 (c) mM/h (d) All of (a), (b) and (c).
- (v) Enzyme catalytic efficiency is given by  
 (a)  $K_m/k_{cat}$  (b)  $k_{cat}/K_m$   
 (c)  $k_{cat} \cdot [E_T]$  (d)  $k_{cat}/[E_T]$ .
- (vi) The phenomenon in which substrates are used in a sequential manner is known as  
 (a) trans-substrate genesis (b) dialism  
 (c) diauxic (d) multiplicity.
- (vii) Mixed growth associated product production is quantified using  
 (a) Luedeking Piret equation (b) Michaelis Menten equation  
 (c) Monod equation (d) none of (a), (b) and (c).

(viii) Identify Q, R, U, P and T respectively from the graph below.



- (a)  $-1/K_m, -1/V_{m,app}, 1/V_{max}, [I]=0, [I]>0$
- (b)  $-1/K_{m,app}, -1/K_m, 1/V_{max}, [I]=0, [I]>0$
- (c)  $-1/K_{m,app}, -1/K_m, 1/V_{max}, [I]>0, [I]=0$
- (d)  $1/V_{max}, 1/V_{m,app}, -1/K_m, [I]=0, [I]>0$

- (ix) Wash out in steady state fermentation occurs when
  - (a) dilution rate is less than maximum specific growth rate
  - (b) dilution rate is higher than the maximum specific growth rate
  - (c) cell concentration reaches the maximum
  - (d) specific growth rate is maximum.
- (x) An example of an unsteady state reactor is
  - (a) fed batch reactor
  - (b) continuous reactor
  - (c) batch reactor
  - (d) all of (a), (b) and (c).

**Group - B**

2. During a test of kinetics of an enzyme catalyzed reaction the following data were recorded:

$E_0$ (g/L)	T (°C)	I (mmol/mL)	S (mmol/mL)	V
1.6	30	0	0.1	2.63
1.6	30	0	0.033	1.92
1.6	30	0	0.02	1.47
1.6	30	0	0.01	0.96
1.6	30	0	0.005	0.56
1.6	49.6	0	0.1	5.13
1.6	49.6	0	0.033	3.7
1.6	49.6	0	0.01	1.89
1.6	49.6	0	0.0067	1.43
1.6	49.6	0	0.005	1.11
0.92	30	0	0.1	1.64
0.92	30	0	0.02	0.90
0.92	30	0	0.01	0.58
0.92	30	0.6	0.1	1.33
0.92	30	0.6	0.033	0.80
0.92	30	0.6	0.02	0.57

- (i) Determine the Michaelis-Menten constant for the reaction with no inhibitor present at 30°C and 49.6°C.
  - (ii) Determine the maximum velocity of the uninhibited reaction at 30°C and an enzyme concentration of 1.6g/L.
- Determine  $K_i$  for the inhibitor at 30°C and decide what type of inhibitor is being used.

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3. The following data were obtained from enzymatic oxidation of phenol by phenol oxidase at different phenol concentrations.

S, mg/L	10	20	30	50	60	80	90	110	130	140	150
v, mg/(L.h)	5	7.5	10	12.5	13.7	15	15	12.5	9.5	7.5	5.7

- (i) What type of inhibition is this?
- (ii) Determine the constants  $V_m, K_m$  and  $K_{Si}$ .
- (iii) Determine the oxidation rate at  $[S]= 70\text{mg/L}$ .

1 + 8 + 3 = 12

**Group - C**

4. Medium at a flow rate of  $2 \text{ m}^3 \text{ hr}^{-1}$  is to be sterilised by heat exchange with steam in a continuous steriliser. The liquid contains bacterial spores at a concentration of  $5 \times 10^{12} \text{ m}^{-3}$ . The activation energy and Arrhenius constant for thermal destruction of these contaminants are  $283 \text{ KJ gmol}^{-1}$  and  $5.7 \times 10^{39} \text{ hr}^{-1}$ , respectively. A contamination risk of one organism surviving every 60 days' operation is considered acceptable. The steriliser pipe has an inner diameter of 0.1 m, the length of holding section is 24 m. The density of medium is  $1000 \text{ kgm}^{-3}$  and viscosity is  $3.6 \text{ kgm}^{-1}\text{hr}^{-1}$ . What sterilization temperature is required if Damkohler number (Da) corresponding to this system is taken as 42?

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- 5. (a) State the advantages of (i) batch sterilization (ii) continuous sterilization.
- (b) Describe the sterilization methods of air for aerobic fermentation.

(3 + 3) + 6 = 12

**Group - D**

6. The following data were obtained in a chemostat for the growth of *E. aerogenes* on a glycerol limited growth medium.

D, h <sup>-1</sup>	S, mg/mL	X, mg/mL
0.05	0.012	3.2
0.1	0.028	3.7
0.2	0.05	4.0
0.4	0.1	4.4
0.6	0.15	4.75
0.7	0.176	4.9
0.8	0.8	4.5
0.84	9.0	0.5

$S_0 = 10 \text{ mg/mL}$ . For this system, estimate the values of:

- (i)  $K_s$ , mg glycerol/mL
- (ii)  $\mu_m, \text{h}^{-1}$