(b) *Pseudomonas sp* has a mass doubling time of 2.4h when grown on acetate. The saturation constant using this substrate is 1.3g/L and cell yield on acetate is 0.46gcell/g acetate. If we operate a chemostat on a feed stream containing 38g/L acetate, find the following:

i. Cell concentration when the dilution rate is one-half of the maximum.
ii. Substrate concentration when the dilution rate is $0.8D_{max}$.
iii. Maximum dilution rate.
iv. Cell productivity at $0.8D_{max}$.

6 + 6 = 12

7. In cultivation of baker's yeast in a stirred and aerated tank, lethal agents are added to the fermentation medium to kill the organisms immediately. Increase in dissolved oxygen (DO) concentration upon addition of lethal agents is followed with the aid of a DO analyzer and a recorder. Using the following data, determine the oxygen transfer coefficient (k_la) for the reactor. Saturation DO concentration is C* = 9mg/L.

Time(min)	1	2	2.5	3	4	5
DO(mg/L)	1	3	4	5	6.5	7.2

12

Group - E

8 (a) State the basic principle of Resistance Temperature Detector (RTD) for temperature measurement.

(b) Explain with diagram that how the redox potential of culture liquid is measured by Redox electrode.

6 + 6 = 12

9 (a) State the principle and application of paramagnetic oxygen analyser in biochemical processes.

(b) Write short note on Bourdon tube.

6 + 6 = 12

BIOPROCESS AND 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) For the enzyme substrate reaction, the rate of disappearance of substrate is given by $-r_A = \frac{1760[A][E_0]}{6+[A]}$, mol/m³.s. What are the units of the two constants?
(a) s^{-1}, mol/m^3 (b) mol/L, s^{-1}
(c) $mol/m^3.s$, mol/m^3 (d) none.

(ii) When the inhibitor factor affects the maximum forward velocity in an enzyme substrate reaction, the resulting inhibition is
(a) competitive (b) non-competitive
(c) uncompetitive (d) substrate inhibition.

(iii) Leudeking-Piret equation is applicable to
(a) cell productivity
(b) product productivity
(c) mixed growth associated product formation rate
(d) primary metabolite production rate.

(iv) The growth of cells become oxygen limited when the dissolved oxygen concentration becomes
(a) more than critical oxygen concentration in medium
(b) less than critical oxygen concentration in medium
(c) more than saturated oxygen concentration in medium
(d) less than saturated oxygen concentration in medium.

(v) The dilution rate, D is defined as(where F = volumetric flow rate, V_R = total volume of culture in the reactor and μ= specific growth rate)
(a) F/V_R (b) V_R/F (c) μ/F (d) F/μ.

(vi) Which of the following influences heat sterilization of media?
(a) Number of organisms (b) Kind of organisms
(c) Type of media (d) All of the above.

(vii) Which of the following is not true at steady state
(a) OTR=OUR (b) $D=\mu_g$ (c) $D=\mu_{net}$ (d) $F_{in} \neq F_{out.}$

(viii) Continuous sterilization is better over batch sterilization due to
(a) protection of nutrient value (b) easier automatic control
(c) decrease in sterilization time (d) all of the above.

(ix) Radiation pyrometer is used to measure
(a) absorbance of cell suspension (b) DO
(c) temperature (d) pressure.

(x) Thermistor is a
(a) semiconductor whose resistance decreases with temperature rise
(b) metal whose temperature increases linearly with temperature rise
(c) metal whose resistance does not vary with temperature
(d) device for measuring nuclear radiation.

Group - B

2. At room temperature sucrose is hydrolyzed by the enzyme sucrase as follows:
sucrose + sucrase → products + sucrase.
Starting with sucrose (S_0 = 1mol/m^3) and sucrase (E_0 = 0.01mol/m^3) the following data are obtained in a batch reactor.

S, mol/m^3	0.68	0.16	0.006
t, h	2	6	10

Find the kinetic constants involved in the enzyme reaction.

6 + 6 = 12

3. Decarboxylation of glyoxalate(S) by mitochondria is inhibited by malonate(I). Using the following data obtained in batch experiments, determine the following:

S, mM		0.25	0.33	0.4	0.5	0.6	0.75	1.00
V, mM/h	I=0	1.02	1.39	1.67	1.89	2.08	2.44	2.5
V, mM/h	I=1.26mM	0.73	0.87	1.09	1.3	1.41	1.82	2.17
V, mM/h	I=1.95mM	0.56	0.75	0.85	1	1.28	1.39	1.82

i. What type of inhibition is this?
ii. Determine the constants V_{max}, K_m' and K_I .

2 + 10 = 12

Group - C

4. The values of thermal death constants for *Bacillus subtilis* at different temperatures are given below:

Temp. (K)	Thermal death constant (K_d)
358	0.012
369	0.0925
383	1.177
393	9.61

(i) Determine the activation energy for the thermal death of *Bacillus subtilis*.
(ii) What is the specific death constant at 100°C
(iii) Estimate the time required to kill 90% of spore.

8 + 2 + 2 = 12

5. The following experimental values were obtained for the inactivation rate constants for *Clostridium botulinum* and thiamine at 60° C and 120° C.

Temperature/° C	Inactivation rate constant, k_d (s^{-1})	
	C. botulinum	Thiamine
60	$2.42 * 10^{-7}$	$2.760 * 10^{-7}$
120	$2.42 * 10^{-1}$	$4.070 * 10^{-6}$

Using this data, determine the time needed for a 12D reduction of thiamine activity at 135° C, where D is decimal reduction time. What will be the level of inactivation of thiamine after the sterilization?

9 + 3 = 12

Group - D

6 (a) *E.coli* have a maximum respiration rate, q_{o2max}, of about 240mgO_2/gX.h. It is desired to achieve a cell mass of 20gX/L. The $k_l a$ is 120h^{-1} in a 1000L bioreactor. A gas stream enriched in oxygen is used which gives a value of C*= 28mg/L. If oxygen becomes limiting, growth and respiration slow and follow:

$$q_{o2} = \frac{q_{o2max}}{\frac{0.2mg}{L} + C_L} C_L$$

Where C_L is the dissolved oxygen concentration in the fermenter. What is the C_L when the cell mass is at 20g/L?