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) Which of the following disinfectants act by disrupting microbial membranes?
(a) Cationic detergents (b) Halogens (c)Heavy metals (d) Aldehydes.

(ii) Which thermocouple can be used for measuring the temperature around 1400°C?
(a) Copper-constantan (b) Aluminium –chromel
(c) Platinum-platinum + rhodium (d) None of these.

(iii) The lowest temperature that kills all microorganisms in a liquid suspension in 10 minutes is known as the
(a) decimal reduction time (b)thermal death point
(c) thermal death temperature (d)thermal death time.

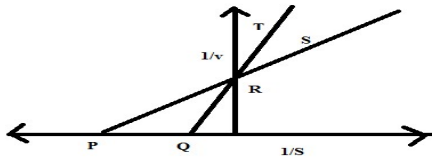
(iv) Which of the following is an undesirable dynamic characteristic of an instrument ?
(a)Reproducibility (b)Time lag (c)Dead zone (d)Static error.

(v) Working principle of radiation pyrometer is based on the
(a) Stafan-Boltzman law (b) Kirchoffs law
(c) Seebeck effect (d) Wien's law.

(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) The maximum specific growth rate of an organism depends on
(a) medium composition (b) temperature
(c) pH (d) All of these.

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



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

(ix) Which of the following is most suitable for measuring the temperature of a red hot furnace?
(a) Optical pyrometer (b) Platinum resistance thermometer
(c) Thermocouple (d) Bi-metallic thermometer

(x) 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.

Group - B

2. (a) What is immobilization of enzyme? What are the advantages of enzyme immobilization?

(b) An enzyme is immobilized on the surface of a non-porous spherical particle of 2 mm diameter. The immobilized enzyme is suspended in a solution having bulk substrate concentration of 10 mM. The enzyme follows first order kinetics with rate constant $10 s^{-1}$ and the external mass transfer coefficient is 1cm/s. Assume steady state condition wherein rate of enzyme reaction(mmol/L.s) at the surface is equal to mass transfer rate(mmol/L.s). Calculate the substrate concentration at the surface of the immobilized particle.

(2 + 3) + 7=12

3. 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 (mmol/mL.min)
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 1.6 g/L.

(iii) Determine K_i for the inhibitor at 30°C and decide what type of inhibitor is being used.

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Group - C

4. Pseudomonas sp has a mass doubling time of 2.4 h when grown on acetate. The saturation constant using this substrate is 1.3 g/L and cell yield on acetate is 0.46 gcell/g acetate. If we operate a chemostat on a feed stream containing 38 g/L acetate, find the following:
   (a) Cell concentration when the dilution rate is one-half of the maximum
   (b) Substrate concentration when the dilution rate is $0.8D_{max}$
   (c) Maximum dilution rate
   (d) Cell productivity at $0.8D_{max}$

12

5. A simple, batch fermentation of an aerobic bacterium growing on methanol gave the results shown in the table. Calculate:
   (a) Maximum growth rate(μ_{max})
   (b) Yield on substrate ($Y_{x/s}$)
   (c) Mass doubling time
   (d) Saturation constant
   (e) Specific growth rate at t=10h

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

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Group - D

6. (a) State three criteria for formulation of fermentation media.
   (b) Differentiate between Defined media and Technical media for microbial growth?
   (c) Describe the methods used for sterilization of media in industrial scale.

3 + 3 + 6= 12

7. Medium at a flow rate of 2 $m^3 hr^{-1}$ is to be sterilised by heat exchange with steam in a continuous steriliser. The liquid contains bacterial spores at a concentration of 5×10^{12} m^{-3}. The activation energy and Arrhenius constant for thermal destruction of these contaminants 283 KJ $gmol^{-1}$ and 5.7× 1039 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 kgm^{-3} and viscosity is 3.6 $kgm^{-1}hr^{-1}$. What sterilization temperature is required if Damkohler number (Da) corresponding to this system is taken as 42?

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Group - E

8. (a) What type of error may arise while using a manometer for measuring pressure?
   (b) Discuss the characteristics features of manometric fluid.

6 + 6 = 12

9. (a) Explain the working principle of thermocouple for measurement of temperature of fermentation broth in a fermenter.
   (b) Describe the method of design of a pH probe.

6 + 6 = 12