MANIPAL INSTITUTE OF TECHNOLOGY
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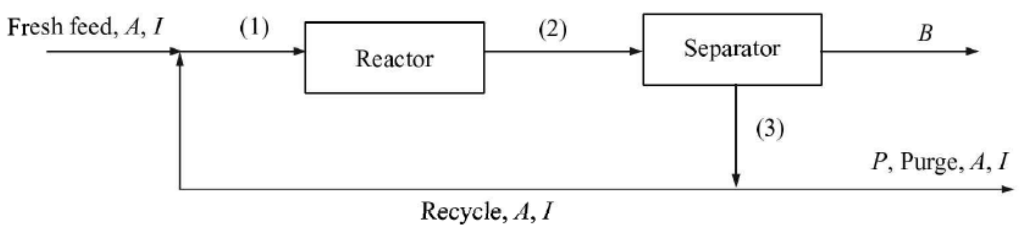
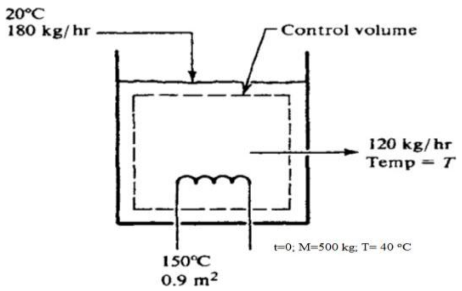
I SEMESTER M.TECH. (INDUSTRIAL BIOTECHNOLOGY)
END-SEMESTER EXAMINATION, 30/11/2023 (09:30 AM-12:30 PM)
SUBJECT: ADVANCED BIOPROCESS ENGINEERING (BIO 5111)
REVISED CREDIT SYSTEM
ANSWER ALL QUESTIONS

TIME: 3 HOURS **MAX. MARKS: 50**

Q. NO	QUESTIONS	M	CO	PO	BTL
1A	For the reaction A--→ B, the process flow diagram is shown in Figure. The fresh feed of A contains 0.5 % of inerts by volume. 60% conversion of A per pass is obtained. The concentration of inerts going into the reactor at (1) must be held at 2 % by volume. All streams are ideal gases and the process is at steady state. How many moles need to be recycled per mole of total feed to the reactor at (1)?  	**3**	**1**	**1,3,4**	**3**
1B	Develop an overall energy balance equation for the heating process shown in figure below:  	**2**	**1**	**1,3,4**	**3**
1C	What is the significance of K_La in gas-liquid mass transfer? Elucidate the method for measuring k_La based on oxygen balance technique.	**5**	**2**	**1,3,4**	**4**
2A	Define the following: i. Internal mass transfer ii. External master transfer iii. Effectiveness factor iv. Critical Radius	**4**	**3**	**1,3,4**	**6**
2B	Gel immobilized cells of *Papaver somniferum* (opium poppy) can make codeine from codeinone. The rate of codeinone uptake is FIRST order with a rate constant	**4**	**3**	**1,3,4**	**4**

	of 3.3x10^{-8} L/g dry wt cells-sec. The diffusivity of codeinone in the gel is 0.2x10^{-9} m^2/sec. For a gel particle of 4mm diameter with a 25 % volume loading of cells (95 % water), what will be the effectiveness factor? Assume that the specific gravity of wet of cells is1.05.				
2C	*A. niger* cells are observed to form aggregates of average diameter 5 mm. the effective diffusivity of oxygen in the aggregates is 1.75x10^{-9} m^2/s. In a fixed-bed reactor, the oxygen consumption rate at a bulk oxygen concentration of 8x10^{-3} is 8.7x10^{-5} kg/s m^3 biomass. The liquid-solid mass transfer coefficient is 3.8x10^{-5} m/s. Is oxygen uptake affected by external mass transfer?	**2**	**3**	**1,3,4**	**3**
3A	To ensure turbulent conditions and minimum mixing time during agitation with a turbine impeller, the Reynolds number must be atleast 10^4. i. A stirred laboratory-scale fermenter with a turbine impeller 5 cm in diameter is operated at 800 rpm. If the density of broth being stirred is close to that of water, what is the upper limit of viscosity of the suspension if adequate mixing is to be maintained? ii. The mixing system is scaled up so the tank and impeller are 15 times the diameter of the laboratory equipment. The stirrer in the large vessel is operated so that the stirrer tip speed ($tip\ speed = \pi N_i D_i$) is the same as in the laboratory-appartus. How does scale-up affect the maximum viscosity allowable for maintainance of turbulent mixing conditions?	**4**	**4**	**1,3,4**	**4**
3B	You are being asked to design a batch bioreactor to produce 200 kg of recombinant *Picha pastoris* at a concentration of 25 g/L (the actual product is intracellular). Your microbiology support group has determined an appropriate medium formulation for cultivating this organism at bench scale and has been able to find experimental kinetic and other parameters for this organism, including that this yeast grows according to Monod kinetics: μ_m = 0.11 h^{-1}; K_s =3.8 g/L; Y_{xs} = 1.2 g/g; C_{crit} = 0.9 mg/L; x_o = 1.5 g/L; T = 30 °C; μ = 25 cP; and ρ = 1010 kg/m^3. Determine the initial substrate concentration required. Determine the duration of fermentation by assuming no lag phase. Determine the oxygen demand (Kg/h) when the fermentation is 60 % complete (based on time).	**6**	**4**	**1,3,4**	**6**
4A	A bioreactor has a diameter of 1.22 m, and is filled with culture medium to a height equal to its diameter. There are 4 baffle plates mounted vertically around the circumference of the tank. Mixing is provided by two 6-blade turbine, with an overall diameter of 0.36 m. The turbine operates at 2.8 rps. Air is sparged through an open-ended tube mounted directly below the turbine impeller, at an aeration rate of 0.00416 m^3/s. The tank pressure is 1.08 atm and temperature is 25°C. Take the viscosity and density of water at 25°C is 8.904 x 10^{-4} kg/m s and 997.08 kg/m^3 respectively. For highly turbulent flow, the power number is approximately is equal to 6. i. Determine the power required to mix the non-aerated tank ii. Determine power required to mix the gassed reactor	**5**	**4**	**1,3,4**	**5**

	$$\frac{P_{gassed}}{P_{ungassed}} = 2.99\times10^3 N_A^4 - 1\times10^3 N_A^3 + 1.25\times10^2 N_A^2 - 10.2N_A + 1.012$$ Where, N_A represents flow number				
4B	Under substrate-limited conditions, a microorganism exhibits the following net specific growth rate, μ_{net}, and yield coefficient, $Y_{x/s}$. μ_{net} (h^{-1}) = 0.7 S / (0.1 + S), with ‘S’ in g/L; $Y_{x/s}$ (g DCW / g) = 0.4. The available growth medium contains 10 g/L substrate. When a batch bioreactor containing 100 L of the growth medium is inoculated with 1.0 g DCW of biomass, estimate the maximum cell density achieved, and the approximate time required to achieve it, after exponential growth is initiated.	**3**	**5**	**1,3,4**	**4**
4C	For an *E.coli* culture in the exponential phase of growth, optical density (OD) at 540 nm is 0.3 at 2 h and 0.6 at 4 h. Assuming that the measured OD is linearly proportional to the number of *E.coli* cells, find the growth rate for this culture.	**2**	**5**	**1,3,4**	**4**
5A	Nicotiana tabacum cells are cultured to high density for production of polysaccharide gum. The reactor used is a stirred tank, containing initially 100 L medium. The maximum specific growth rate of the culture is 0.18 d-1 and the yield of biomass from substrate is 0.5 g/g. the concentration of growth-limiting substrate in the medium is 3 % (w/v). the reactor is inoculated with 1.5 g/L cells and operated in batch until the substrate is virtually exhausted; medium flow is then started at a rate of 4 L/d. Fed-batch operation occurs under quasi-steady state condition. i. Estimate the batch culture time and final biomass concentration. ii. Fed-batch operation is carried out for 40 d. What is the final mass of cells in the reactor?	**5**	**5**	**1,3,4**	**5**
5B	A Two stage chemostat system is used for production of secondary metabolite. The volume of each reactor is 0.5 m^3, the flow rate of feed is 50 L/h. Mycelial growth occurs in the first reactor, the second reactor is used for product synthesis. The concentration of substrate in the feed is 10 g/L. Kinetic and yield parameters for the organism are: Y_{xs} = 0.5 kg/kg; K_s = 1.0 Kg/m^3; μ_m = 0.12 h^{-1}; m_s = 0.025 kg/kg.h; q_p = 0.16 kg/kg.h; and Y_{ps} = 0.85 kg/kg. Assume that product synthesis is negligible in the first reactor and growth is negligible in the second reactor. i. What is the overall substrate conversion? ii. What is the final concentration of product?	**5**	**5**	**1,3,4**	**5**
	CO: Course Outcome; BLOOM TAXONOMY LEVEL: 1-Remember, 2-Understanding, 3-Application, 4-Analyzis, 5-Evaluation, 6-Creation				