Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VI SEMESTER B.TECH (BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS, MAY 2017
SUBJECT: BIOPROCESS EQUIPMENT DESIGN [BIO 3202]
REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A.	You have been given responsibility to design the closures for a reactor. The pressure to be maintained inside the reactor is 15 bar. You have four options: Flat plate / Ellipsoidal head / Hemispherical / Torispherical head. Which one do you select? Justify your selection:	**5**
1B.	A jacketed vessel is to be used as a fermentor. The vessel has an internal diameter of 2m and is fitted with a jacket over a straight section 1.5m long. Both the vessel and jacket walls are 25mm thick. The spacing between the vessel and jacket is 75mm. The vessel and jacket are made of carbon steel. The vessel will operate at atmospheric pressure and the jacket will be supplied with steam at 20bar. Check if the thickness of the vessel and the jacket is adequate for this duty. Take the allowable design stress as 100 N/mm^2 at the design temperature of 400°C.	**5**
2A	After graduation, you go to work for a medium-sized pharmaceutical company in their Cell Culture Manufacturing group, which is in-charge of process design for large-scale animal cell culture. You have been asked to investigate the production of a recombinant protein by CHO cells. Two choices are open to you: an air lift reactor and a stirred tank reactor. Which one do you choose? Justify your selection:	**5**
2B	After graduation you accept a position in a biotech company, where your first assignment is to scale up the cultivation of plant cells from the well-characterized 50 L pilot scale to the 1,500 L process scale. You discuss the problem with another recently hired chemical engineer. He says, "That's easy. Just maintain the same impeller Reynolds number." But your boss says, "No, No, Just maintain same k_La". Which of these criteria do you choose? Or do you propose a new criteria for this situation? Discuss:	**5**
3A	Elaborate the process of inoculation of a plant fermentor using a seed fermentor with usual notations.	**5**
3B	Determine the required k_La to operate an 18000L (working volume) sterile feed CSTR at 80% of the washout dilution rate. Assume that cell line follows Monod kinetics. Use the following data: $\mu_m = 0.28\ h^{-1}$; $K_s = 1.8$ g/L; $Y_{XS} = 0.36$; $Y_{O2X} = 0.65$; $C_{crit} = 0.7$ mg/L; C_{AL}^*(mg/L) = 468 / (31.6 + T°C); $S_o = 50$g/L; T = 36°C	**5**

4

A decision has been made to use a STHE with one shell and two tube passes in a biochemical industry for the purpose of cooling methanol from 95°C to 40°C at a rate of 27.8 kg/s using river water available at 25°C and leaving at 40°C. Determine the available overall heat transfer coefficient and check whether the design criteria is satisfied or not? Use the following information: Correction factor F_T=0.836, ¾ inch on 1 inch triangular pitch 16 BWG (OD=20 mm, ID=16 mm) with length 4.88m. Shell diameter = 889 mm. $r_H = \{[(0.43P_T^2)-(\pi d_o^2/8)]/[\pi d_o/2]\}$

Property	**Water**	**Methanol**
Density (kg/m^3)	995	750
Viscosity (kg/m-sec)	$0.8x10^{-3}$	$0.34x10^{-3}$
Heat capacity (kJ/kg K)	4.2	2.84
Thermal conductivity (W/m K)	0.59	0.19

Overall heat transfer coefficient (W/m^2 K)	600
Dirt factor (W/m^2 K)	5000 (Methanol) 3000 (River water)
Individual Heat transfer coefficients	$Nu = 0.36\ Re^{0.55}Pr^{0.33}$ (Shell side) $Nu = 0.027\ Re^{0.8}Pr^{0.33}$(Tube side)

10

5A

You are given with a hot feed which has to be concentrated with multiple effect evaporation system. Which one do you prefer forward-feed or backward-feed? Justify with usual notations used in the evaporation systems:

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5B

An aqueous solution of a solute is concentrated form 5% to 20% (mass basis) in a single effect short tube evaporator. The feed enters the evaporator at a rate of 10kg/sec and at a temperature of 300K. Steam is available at a saturation pressure of 1.3 bar. The pressure in the vapor space of the evaporator is 0.13 bar and the corresponding saturation temperature of steam is 320 K. If the overall heat transfer coefficient is 5000 W/m^2 K. Calculate the steam economy and heat transfer area:

	Enthalpy (kJ/kg)	Heat of vaporization (kJ/Kg)
Saturated steam (1.3 bar; 380 K)	---	2000
Saturated steam (0.13 bar; 320 K)	2200	---
Feed (5%; 300K)	80	---
Concentrated liquor (20%; 320K)	400	---

5