Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

A Constituent Institution of Manipal University

VI SEMESTER B.TECH (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, APR/MAY 2018

SUBJECT: BIOPROCESS EQUIPMENT DESIGN [BIO 3202]

REVISED CREDIT SYSTEM (20/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A.	Write a note on various types of closures used in process vessels. Highlight the pressure limits:	**5**
1B.	You have been given responsibility to design an evaporator (1.2 m diameter & 46 m height) to concentrate a fruit pulp. The pressure inside the evaporator is full vacuum. The design temperature is 450°C and the allowable yield stress of the material used at this temperature is 1.84 kN/m^2. Use fully radiographed weldings. Your boss proposes that the wall thickness of this evaporator be 12mm. Check whether this thickness is sufficient or not?	**5**
2A	You have been given responsibility to culture high cell density of *Catharanthus roseus* which produces ajmalicine, an alkaloid used in the treatment of hypertension. Which one of the following reactor type do you choose: Stirred tank reactor or air-lift reactor? Compare and discuss:	**5**
2B	Assuming dynamic similarity, can you determine the power consumption and impeller speed of a 1000 L fermenter, based on the findings of the optimum conditions from a geometrically similar 1 L vessel? If not, can you scale-up by using a different fluid system?	**5**
3A	Your responsibility is to design a sterile feed chemostat (18,000 L) that has to be operated at 80% of washout dilution rate. The kinetic and other parameters are given below and it can be assumed that cells follow Monod kinetics. S_o = 50g/L; μ_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); T = 36°C; μ=25cp, ρ=1010kg/m^3 ,You can choose the following design parameters: N=215 RPM, D_T =2.5m, D_i =1 m, v_g=120 m/h; Flooding: $Q_g < 0.6\ (D_i^5N^2/D_T^{1.5})$; Gas hold-up $\varphi = 1.8\ P_m^{0.14}v_g^{0.75}$; $N_P = 6+1/Re_i$; $P_g/P = 2.99\times10^3\ N_A^4 - 1\times10^3\ N_A^3 + 1.25\times10^2\ N_A^2 - 10.2N_A+1.012$; $k_La = (0.0333/D_T^4)(P_g/V)^{0.541}Q_g^{\ (0.541/\sqrt{D_T})}$ a. Design the chemostat based on k_La method, accounting for hold up and head space. b. Will a jacket provide sufficient heat transfer area to keep the system isothermal at 35°C? It can be assumed that cooling fluid is available at 10 °C and is not to exceed 25°C and average overall heat transfer coefficient of 680 W/m^{2}K applies in this case.	**10**

4A	Your responsibility is to cool an organic solvent from 368 K to 313 K at a rate of 27.8 kg/s using a coolant available at 298 K and leaving at 313 K. You can choose 1 – 2 STHE. Determine the available overall heat transfer coefficient and check whether the design criteria are satisfied or not? Use the following information: Correction factor F_T=0.836, ¾ inch on 1inch triangular pitch 16 BWG (OD=20 mm, ID=16 mm) with length 4.88m. Shell diameter = 889 mm. $r_H = \{[(0.43P_T^2)-(\pi d^2_o/8)]/[\pi d_o/2]\}$	**10**

Property	**Coolant**	**Organic solvent**
Density (kg/m^3)	995	750
Viscosity (kg/m-sec)	0.8×10^{-3}	0.34×10^{-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 (Organic solvent) 3000 (Coolant)
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)

5A	A triple effect evaporator is concentrating a liquid that has no appreciable elevation in boiling point. The temperature of the steam to the first effect is 381 K, the boiling point of the solution in the last effect is 325 K. The overall heat transfer coefficients, in W/m^{2}°C, are 2500 in the first effect, 2000 in the second and 1000 in the third effect. At what temperatures will the liquid boil in the first and second effects?	**5**
5B	A sugar solution has to be concentrated from 5% to 20% in a single effect evaporator. The feed solution enters the evaporator at a rate of 36 tons/h and at a temperature of 300K. Steam is available at a saturation pressure of 2.3 bar. The pressure in the vapor space of the evaporator is 0.18 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:	**5**

	Enthalpy (kJ/kg)	Heat of vaporization (kJ/Kg)
Saturated steam (2.3 bar; 380 K)	---	2000
Saturated steam (0.18 bar; 320 K)	2200	---
Feed (5%; 300K)	80	---
Concentrated liquor (20%; 320K)	400	---