Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

III SEMESTER B.TECH. (BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS, NOV/DEC 2016
SUBJECT: BIOPROCESS CALCULATIONS [BIO 2104]
REVISED CREDIT SYSTEM
(02/12/2016)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A.	Your responsibility is to develop a complete bioprocess for the commercial manufacture of a new rDNA derived product. Elaborate the sequence of steps and explain the each step:	**5**
1B.	The heat capacity of CO gas is given by $C_P = 26.586 + 7.582 * 10^{-3} T - 1.12 * 10^{-6} T^2$, where C_P is in kJ/(kmol K) and temperature is in K. Obtain the equations which will express a. Cp in cal/mol °C and T in °C b. Cp in Btu/lb-mol °F and T in °F	**5**
2A.	Roots of the Begonia rex plant are cultivated in an air-driven bioreactor in medium containing glucose and two nitrogen sources, ammonia and nitrate. The root biomass can be represented stoichiometrically using the formula $CH_{1.63}O_{0.8}N_{0.13}$. A simplified reaction equation for growth of the roots is: $C_6H_{12}O_6 + 3.4O_2 + 0.15NH_3 + 0.18HNO_3 \rightarrow 2.5CH_{1.63}O_{0.8}N_{0.13} + 3.5CO_2 + 4.3H_2O$ a. If the medium contains 30g/L glucose, what minimum concentration of nitrate (in molarity) is required to achieve complete conversion of the sugar? b. If the bioreactor holds 50 L of medium and there is complete conversion of the glucose, what mass of roots will be generated? c. For the conditions described in (b), what minimum volume of air at 20°C and 1 atm pressure must be provided to the bioreactor during growth?	**6**
2B.	Fresh orange juice contains 12.0 wt% solids and the balance water, and the concentrated orange juice contains 42.0 wt% solids. Initially a single evaporation process was used for the concentration, but volatile constituents of the juice escaped with the water, leaving the concentrate with a flat taste. The current process overcomes this problem by bypassing the evaporator with a fraction of the fresh juice. The juice is concentrated to 58 wt% solids, and the evaporator product stream is mixed with the bypassed fresh juice to achieve the desired final concentration. Calculate the amount of product (42% concentrate) produced per 100 kg fresh juice fed to the process and the fraction of the feed that bypasses the evaporator.	**4**
3A.	Formaldehyde is produced by the gas phase oxidation of methanol with air over a catalyst: $CH_3OH + \frac{1}{2}O_2 \rightarrow HCHO + H_2O$. 100 m^3 of methanol vapor at $1.013*10^5$ N/m^2 and 550 K is to be treated. If 10% excess air is supplied and the reaction is only 80% complete, calculate a. The composition of the product gas b. The volume of product gases at $1.5*10^5$ N/m^2 and 800 K.	**4+1**

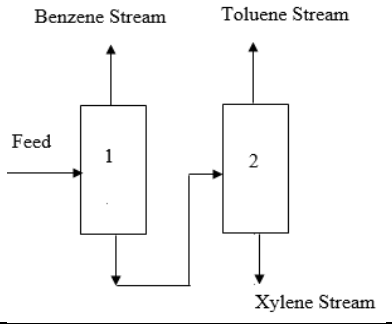
3B. Aerobic degradation of an organic compound by a mixed culture of organisms in waste water can be represented by the following reaction: $C_3H_6O_3 + aO_2 + bNH_3 \rightarrow cC_5H_7NO_2 + dH_2O + eCO_2$. Determine a, b, c, d, and e, if Y_{XS}=0.4 g X / g S **5**

4A. Corn-steep liquor contains 2.5 % invert sugars and 50% water; the rest can be considered solids. Beet molasses containing 50% sucrose, 1% invert sugars, 18% water and the remainder solids, is mixed with corn-steep liquor in a mixing tank. Water is added to produce a diluted sugar mixture containing 2% invert sugars. 125 kg corn-steep liquor and 45 kg molasses are fed into the tank. **3+2**

a. How much water is required?

b. What is the concentration of sucrose in the final mixture?

4B. A feed mixture containing 40% benzene, 30% toluene and 30% xylene is being separated into three product streams using two distillation columns. All the compositions are expressed as wt%. Benzene stream consists of 99.5% benzene and 0.5% toluene. Toluene stream consists of 97% toluene and 2% benzene and 1% xylene while the xylene stream contains 95% xylene and 5% toluene. Determine the recovery of each feed component in its own product stream and the composition of intermediate stream: **5**



5A. *S.cerevisiae* is grown anaerobically in continuous culture at 30°C. Glucose is used as carbon source; ammonia is the nitrogen source. A mixture of glycerol and ethanol is produced. Mass flows to and from the reactor at steady state are as follows: Estimate the cooling requirements: **5**

Compound	$C_6H_{12}O_6$ in	NH_3 in	Cells out	$C_3H_8O_3$ out	C_2H_5OH out	CO_2 out	H_2O out
Amount (kg/h)	36	0.4	2.81	7.94	11.9	13.6	0.15
Standard heat of combustion	– 2805.5 kJ/mol	– 382.6 kJ/mol	– 21.2 kJ/g	– 1655.4 kJ/mol	– 1366.8 kJ/mol	--	--

5B. The mutation rate of *E. coli* increases with temperature. The following data were obtained by measuring the frequency of mutation of *his*$^-$ cells to produce *his*$^+$ colonies: **5**

Temperature (°C)	15	20	25	30	35
Relative mutation frequency, α	4.4×10^{-15}	2.0×10^{-14}	8.6×10^{-14}	3.5×10^{-13}	1.4×10^{-12}

The relative mutation frequency, α is expected to obey an Arrhenius-type equation:
$\alpha = \alpha_o \, EXP\,(-E/RT)$, where α_o is the mutation rate parameter, E is activation energy, R is the ideal gas constant, and T is the absolute temperature.

a. What is the activation energy for the mutation reaction?

b. What is the value of α_0?