Exam. Code: 0907
Sub. Code: 33351

2076
B.E. (Biotechnology) Third Semester
BIO-311: Process Calculations

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: ***Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section. Use of a Psychrometric chart is allowed.***

x-x-x

Q.1.a) A pipeline carries diesel fuel (density = 0.85 g/cm^3) at a volumetric flow rate of 1.5 L/min. Determine the mass flow rate in kg/h.

b) Calculate the heat required to raise the temperature of 15 kg of water from 25°C to 75°C. Take the specific heat of water as 4.18 kJ/kg°C.

c) A feed stream contains 120 kg of salt dissolved in 480 kg of water. If 150 kg of water is evaporated, determine the final concentration of salt in wt%.

d) A gas occupies 8.2 L at 2.5 atm and 320 K. Calculate the number of moles using the ideal gas equation.

e) A reactor is fed with 200 g mol/h of nitrogen. If 50 g mol/h reacts, calculate the single-pass conversion of nitrogen. (5*2=10)

SECTION-A

Q.2.a). A gas mixture has the following composition by mass : O_2 – 20%, N_2 -58%, CO_2- 22%. Calculate the mole fraction of each component in the mixture.

b). The concentration of a pollutant in a reactor is given by $C(g/L) = 5e^{-0.2t}$ where t is in minutes. Convert the equation so that C is expressed in kg/m^3, and t is expressed in hours. Also state the units of the constants 5 and 0.2. (5,5)

Q.3.a). A 600 kg/h mixture of methanol and water containing 40 wt% methanol is separated in a distillation column. The methanol flow rate in the distillate (top stream) is 210 kg/h, and the water flow rate in the bottoms is 330 kg/h. Assuming steady-state operation and no chemical reaction, Calculate (i) the mass flow rate of water in the distillate (kg/h) (ii) mass flow rate of methanol in the bottoms (kg/h) (iii) total mass flow rates of the distillate and bottoms streams.

b). An aqueous solution of hydrochloric acid (HCl) contains 25 wt% HCl. It is desired to prepare a 10 wt% HCl solution by mixing the 25 wt% HCl solution with pure water. Calculate (i) kg of water required per kg of feed solution (ii) kg product solution obtained per kg feed solution. (5,5)

P.T.O.

Q.4. Methanol is produced by the reaction $CO+2H_2 \rightarrow CH_3OH$. A feed to the reactor contains 20 mol% CO, 50 mol% H_2, and 30 mol% N_2 (inert). A fractional conversion of 40% of the limiting reactant is achieved. Taking 100 mol of feed as the basis, determine (i) the limiting reactant (ii) percentage by which the excess reactant is in excess (iii) molar composition of the product gas after the reaction. (Nitrogen does not take part in the reaction). (10)

SECTION-B

Q.5.a). Air is at a dry bulb temperature of 25°C and 50% relative humidity. Use the psychrometric chart to estimate (i) absolute humidity (ii) wet bulb temperature (iii) dew point and (iv) humid volume.

b). A liquid mixture containing 40 mol% acetonitrile (1) and 60 mol% nitromethane (2) is in vapor–liquid equilibrium at 348 K. Assuming that the liquid solution is ideal and the vapor phase behaves as an ideal gas, use Raoult's law to determine the equilibrium vapor-phase composition.

$$lnP_1^s(kPa) = 14.27 - \frac{2945.47}{T(K)-49.15} \qquad lnP_2^s(kPa) = 14.2 - \frac{2972.64}{T(K)-64.15}$$ (5,5)

Q.6.a). A mixer receives 100 kg/h of saturated steam at 8 bar pressure and has a specific enthalpy of 2770 kJ/kg. It is mixed with superheated steam at 250°C and 8 bar having a specific enthalpy of 2960 kJ/kg to produce 180 kg/h of steam at 220°C and 8 bar with a specific enthalpy of 2890 kJ/kg. Calculate the rate of heat transfer in the mixer (kJ/h). Assuming steady-state operation and negligible changes in kinetic and potential energy.

b). Steam flows through a turbine at a rate of 360 kg/h. The steam enters the turbine with a specific enthalpy of 3100 kJ/kg and leaves with a specific enthalpy of 2850 kJ/kg. The turbine loses 10 kW of heat to the surroundings. Calculate the shaft power developed by the turbine. Neglect changes in kinetic and potential energies. (5,5)

Q.7.a). Define enthalpy and explain its importance in energy balance calculations.

b). Saturated steam at 100°C is condensed completely in a heating coil to heat 100 kg of a liquid from 20°C to 60°C. The specific heat capacity of the liquid is 4 kJ/kg·K. The latent heat of condensation of steam at 100°C is 2257 kJ/kg. Calculate the mass of steam required to heat the liquid. Assume the condensate leaves the coil as saturated liquid at 100°C. Neglect any heat loss to the surroundings. (4,6)

x-x-x