Exam Date & Time: 08-Jan-2024 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

THIRD SEMESTER B.TECH END SEMESTER EXAMINATIONS, JAN 2024

BIOPROCESS CALCULATIONS [BIO 2125]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions. Section Duration: 180 mins

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Write a short note on bioprocess development and role of process engineer. (4)

A)

B) In the SI system, thermal conductivity has the unit w/(m.k). The thermal conductivity of solid material can be calculated as **k = (X Q)/(A ΔT)**, where Q is the rate of heat transfer, X is the thickness of solid, A is the area of heat transfer and ΔT is the temperature across the solid. The following values were obtained experimentally. Q = 10,000 kJ/h, A = 1 m^2, X = 100 mm, and ΔT = 800 K. (4)

(a) Calculate the thermal conductivity of the solid in w/(m.k).

(b) If thermal conductivity of a second material is 0.15 Btu/(h.ft. ^oF)Which one will make a better thermal insulator ?

C) Briefly explain the principles of homogeneity of dimensions. (2)

2) In the carbonation of a soft drink, the total quantity of carbon dioxide required is the equivalent of 3 volumes of gas to one volume of water at 0 °C and atmospheric pressure. Calculate (a) the mass fraction and (b) the mole fraction of the CO_2 in the drink, ignoring all components other than CO_2 (3)

A) and water. (Mol wt of CO_2 = 44).

B) A solution of $ZnBr_2$ in water contains 150 g salt per 100 mL solution at 293 K. The specific gravity of the solution is 2. Calculate the following: (Mol Wt, Zn:65 Br: 80)

(a) The concentration of $ZnBr_2$ in mole percent

(b) The concentration of $ZnBr_2$ in weight percent (3)

(c) The molality

C) Uric acid is degraded by uricase enzyme immobilized in porous Ca- alginate beads. The following data were obtained at different bulk uric acid concentrations. (4)

S(mg/L)	10	25	50	100	200	250
V(mg/(L*h))	10	20	30	40	45	46

Plot the graph and calculate K_m and V_{max}. The data follows MM Kinetics.

$$\mathbf{v} = \frac{v_{max} * [S]}{K_m + [S]}$$

3) Production of single-cell protein from hexadecane is described by the following reaction

A) $C_{16}H_{34} + aO_2 + bNH_3 \text{ ----------> } cCH_{1.66}O_{0.27}N_{0.20} + dCO_2 + eH_2O$ (4)

Where $CH_{1.66}O_{0.27}N_{0.20}$ represents the biomass. If RQ=0.43, Determine the stoichiometric coefficients of the reaction.

B) 4000 kg/h of fresh juice containing 10 wt % pulp is evaporated in the first evaporator giving a 20% pulp solution. This is then fed in to a second evaporator, which gives a product of 50% pulp. Calculate the following.

(a) The amount of water removed from each evaporator.

(b) The feed to the second evaporator in kg/hr. (3)

(c) The amount of product in kg/hr.

C) A cellulose solution containing 5% cellulose by weight in water. It is to be diluted to 4% using 1% solution of cellulose in water. Determine the kilograms of 1% solution required to dilute 100 kg of the 5% solution. (3)

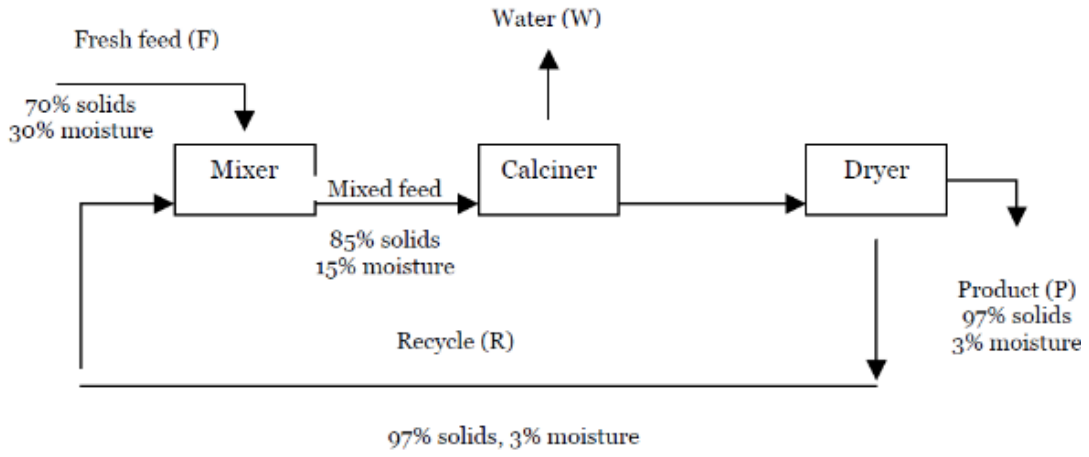
4) A) A single cell protein product from yeast is to be dried in hot air and the moisture content reduced from 20% to 2%. Fresh air contains 0.02 kg water per kg of dry air. Find the volume of fresh air required if 1000 kg of the dried yeast is to be produced. The exit air contains 0.09 kg of water per kg of dry air. Air enters at 300 K and one atm pressure. (4)

B) A distillation column is charged with aqueous solution of ethanol containing 35% ethanol by weight. The concentrated alcohol is withdrawn as the distillate containing 85% ethanol. The bottom product contains 5% ethanol. Determine the following:

(a) The mass of distillate per 100 kg of feed. (3)

(b) The ratio of the mass of the distillate to mass of the residue.

C) In a particular drying operation, it is necessary to hold the moisture content of feed to a calciner to 15% (W/W) to prevent lumping and sticking. This is accomplishing by mixing the feed having 30% moisture (w/w) with recycle steam of dried material having 3% moisture (w/w). The dryer operation is shown in fig below. What fraction of the dried product must be recycled. (3)



5) A) A furnace shell has to be cooled from 90 °C to 55 °C. The mass of the furnace shell is 2 tonnes, the specific heat of furnace shell is 0.2 kCal/kg °C. Water is available at 29 °C. The maximum allowed increase in water temperature is 5 °C. Calculate the quantity of water required to cool the furnace. Specific heat of water is 1 kCal/kg °C. Neglect heat loss. (2)

B) Xanthan gum is produced using Xanthomonas campestris in batch culture. Laboratory experiments have shown that for each gram of glucose utilised by the bacteria, 0.23 g oxygen and 0.01 g ammonia are consumed, while 0.75 g gum, 0.09 g cells, 0.27 g gaseous CO2 and 0.13 g H2O are formed. Medium containing glucose and ammonia dissolved in 20, 000 litres water is pumped into a stirred fermenter and inoculated with X. campestris. Air is sparged into the fermenter; the total amount of off-gas recovered during the entire batch culture is 1250 kg. Because of the high viscosity and difficulty in handling xanthan-gum solutions, the final gum concentration should not be allowed to exceed 3.5 wt%. Assume complete conversion of glucose and Ammonia (4)

(a) How much glucose and ammonia are required?

(b) Calculate wt% of components in off gas

C) An electric heating coil is immersed in a stirred tank. Solvent at 15 ^{o}C with heat capacity 2.1 kj/kg. ^{o}C is fed into the tank at a rate of 15 kg/h. Heated solvent is discharged at the same flow rate. The tank is filled initially with 125 kg cold solvent at 10 ^{o}C. The rate of heating by the electric coil is 800 W. Calculate the time required for the temperature of the solvent to reach 60 ^{o}C. Assume that heat capacity is independent of temperature (4)

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