Question Paper

Exam Date & Time: 25-Apr-2018 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
II SEMESTER B.Sc (APPLIED SCIENCES)
END - SEMESTER THEORY EXAMINATIONS APRIL - 2018
DATE: 25 APRIL 2018
TIME: 9:30 AM TO 12:30 PM

Bioprocess Calculations [IBT 121]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.

1) A) The diameter and height of a vertical cylindrical tank are 5' and 6' 6'' inch respectively. It is filled up to 75% height with thick liquor the density of which is 1.8 kg/lit. Find the mass in kilogram. (4)

B) The solubility of sodium chloride in water at 270 K is 35.8 kg/ 100 kg of water. Express the solubility as the following. (6)
a) Mass fraction and mass percent of NaCl.
b) Mole fraction and mole percent of NaCl.
c) Kmol NaCl per 1000 kg of water.

C) Do the following conversions: (10)
a) 294 g/L H_2SO_4 to normality.
b) 5 normality H_3PO_4 to g/L.
c) 54.75 g/L HCl to molarity.
d) 3 molarity K_2SO_4 to g/L.
e) 4.8 mg/mL $CaCl_2$ to normality

2) A) Calculate the equivalent weights of the following compounds: (a) H_3PO_4 (b) $CaCl_2$ (c) $FeCl_3$ (d) $Al_2(SO_4)_3$ (e) $KMnO_4$. Atomic weights: K = 39, Ca = 40, P = 31, Al = 27, S = 32, Cl = 35.5, Fe = 56, Mn = 55. (5)

B) Natural gas is piped from the wall at 300 K and 400 kPa. The gas is found to contain 93 % methane, 4.5 % ethane and the rest nitrogen. Calculate the following: (15)
a) The partial pressure of nitrogen
b) The pure component volume of ethane in 10 m^3 of the gas
c) The density at standard conditions in kg/ m^3
d) The density of the gas as piped in kg/ m^3
e) The composition in weight percent

3) A) The vapour pressure of chloroform is given by the Antoine equation (8)

$$\ln P^s = 13.9582 - \frac{2696.79}{T - 46.16}$$

when the pressure is in kPa and the temperature in K. Determine
a) The boiling point of chloroform at 50 kPa
b) The vapour pressure at 300 K

B) A solution contains 50 % Benzene (Molecular mass 78), 30% Toluene (Molecular mass 92), and 20 % Xylene (Molecular mass 106) by weight at a temperature of 100Â°C. The vapours are in contact with the solution. Calculate the total pressure and the molar % composition of the liquid and the vapour. The vapour pressures of benzene, toluene and xylene are 1340, 560 and 210 mm of Hg respectively. (12)

4) It is desired to have a mixed acid containing 40 % HNO_3, 43 % H_2SO_4 and 17 % H_2O by weight. Sulfuric acid of 98 % by weight is readily available. Calculate (a) the strength of nitric acid and (b) the weight ratio of sulfuric acid to nitric acid. (10)

A)

B) An evaporator system concentrating a weak liquor from 5 % to 50 % solids handles 100 kg of solids per hour. If the same system is to concentrate a weak liquor from 4 % to 35 %, find the capacity of the system in terms of solids that can be handled per hour assuming water evaporation capacity to be the same in both the cases. (10)

5) 300 kg N_2, 75 kg H_2 are brought together and allowed to react at 823 K, 300 atm pressure. It is found to that 38 kmol of gases present at equilibrium. How many kmol of N_2, H_2 and NH_3 are present at equilibrium. Which is the limiting reactant? What is excess % of excess reactant? What is the conversion % of H_2 to NH_3? (8)

A)

B) Commercial nitric acid is produced by the catalytic air oxidation of ammonia, according to the following equation (12)

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

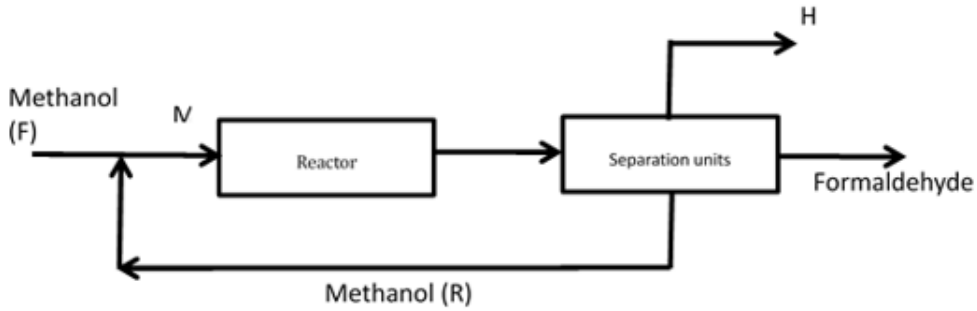
This reaction goes to 95 % completion. It is followed by the reaction,

$$4NO + 3O_2 + 2H_2O \rightarrow 4HNO_3$$

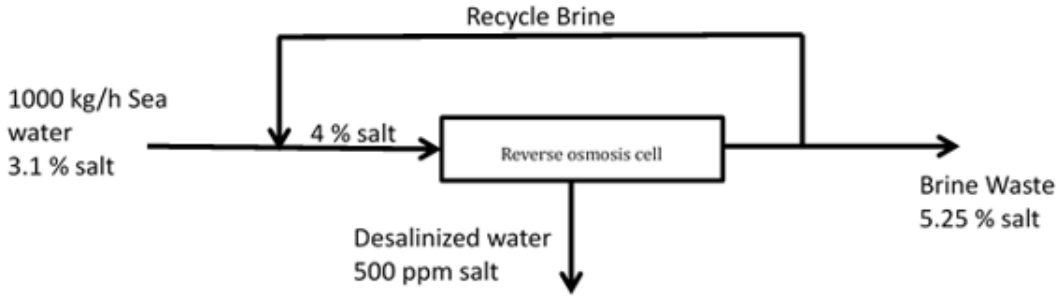
This reaction goes to 98 % completion. Calculate the amount of ammonia and water required for producing 1000 kg of 65 % nitric acid.

6) Formaldehyde is produced by dehydrogenation of methanol. $CH_3OH \rightarrow HCHO + H_2$. The per pass conversion is 67 %. The product leaving the reactor is fed to a separation unit battery where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to the reactor. If the production rate of formaldehyde is 1000 kg/h, Calculate (a) the combined feed ration and (b) the flow rate of methanol required to the process (as fresh feed). (10)

A)



B) Sea water is to be desalinized by reverse osmosis using the scheme shown in figure. Using the data mentioned in figure, calculate (a) the rate of waste brine removal (b) the rate of production of desalinized water and (c) the fraction of the brine leaving the reverse osmosis cell that is recycled. (10)



7) A) Calculate the standard heat of reaction at 298.15 K when gaseous ammonia is dissolved in water to form 2 % by weight ammonia solution. (7)

Component	ΔH°_f, kJ/mol
$NH_3(g)$	-49.94
$NH_4OH(l)$	-361.20
$H_2O(l)$	-285.83

B) A stream of nitrogen flowing at a rate of 100 kmol/h is heated from 303 K to 373 K. Calculate the heat that must be transferred. (6)

C_P for nitrogen = $29.59 - 5.141 \times 10^{-3} T + 11.189 \times 10^{-6} T^2 - 4.968 \times 10^{-9} T^3$ cal $mol^{-1}K^{-1}$

C) When liquid benzene is completely burned to carbon dioxide and liquid water, the standard heat of combustion is -3267.6 kJ/mol. The standard heat of combustion of hydrogen to liquid water is -285.83 kJ/mol and that of carbon to CO_2 gas is -393.51 kJ/mol. Calculate the standard heat of formation of liquid benzene (7)

8) A) Production of single-cell protein from hexadecane is described by the following reaction equation: (12)

$$C_{16}H_{34} + aO_2 + bNH_3 \longrightarrow cCH_{1.66}O_{0.27}N_{0.20} + dCO_2 + eH_2O.$$

a) Determine a, b, c, d, and e if RQ = 0.75

b) Determine the yield coefficients, $Y_{X/S}$ and $Y_{X/O2}$

c) Determine degree of reduction for the substrate and bacteria

B) Prove that mole % = pressure % = volume % for gases. (8)

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