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INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

II SEMESTER B.S. DEGREE EXAMINATION – APRIL/ MAY 2017

SUBJECT: PROCESS AND BIOPROCESS CALCUALTION (BT 121)

(BRANCH: INDUSTRIAL BIOTECHNOLOGY)

Wednesday, 26 April 2017

Time: 3 Hours **Max. Marks: 100**

- ✓ **Answer ANY FIVE full Questions.**
- ✓ **Missing data, if any, may be suitably assumed**

1A. The average molecular weight of a flue gas sample containing carbon dioxide, oxygen and nitrogen is calculated by an engineer and a biologist. The biologist used the correct molecular weight of nitrogen and determined the average molecular weight of the flue gas to be 30.6. The engineer used the atomic weight of nitrogen as the molecular weight and calculated the average molecular weight to be 19.4. Compute the composition of the flue gas. **(5)**

1B. Do the following conversions:

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 **(5 X 3 = 15)**

2A. 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. **(10)**

2B. A gas mixture has the following composition by mole %: Benzene 23.2 %, Methane 15.8 %, Oxygen 12.7 %, Nitrogen 8.7 %, Carbon dioxide 32.7 %, Sulphur dioxide 7.9 %. Find

a) The average molecular mass of the gas mixture
b) The composition of mass
c) The density of the mixture at 975 mm of Hg and 39°C
d) The specific gravity **(10)**

3A. Sample of Light Diesel Oil (LDO) from a refinery is found to contain 0.75% (by mass) of Sulphur. The density of LDO is 0.85 kg/L at 303.15 K. Convert the impurity into ppm (mg/L). **(5)**

3B. A liquid mixture contains n-butane, 1-butene and furfural. It is boiled at 338 K and 570.46 kPa gauge pressure. The mole fraction of n-butane in the ternary vapour mixture in equilibrium with the liquid is found to be 0.491. Assuming ideal behaviour of the liquid and vapour mixture, estimate the composition of the vapour mixture.
Data: Vapor pressure of furfural = 3.293 kPa at 338 K
Mole fraction of furfural in the liquid mixture = 0.7734
Apply Dalton's law of partial pressure. **(10)**

3C. A mixture of nitrogen and carbon di oxide at 298 K and 101.325 kPa has an average molecular weight of 31. What is the partial pressure of nitrogen? **(5)**

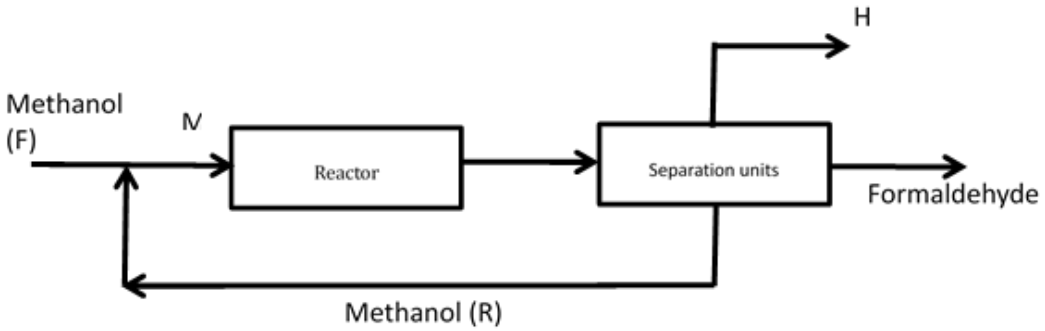
4A. It is desired to have a mixed acid containing 40 % HNO_3, 43 % H_2SO_4 and 17 % H_2O by weight. Sulfuric acid of 98 % by weight is readily available. Calculate (a) the strength of nitric acid and (b) the weight ratio of sulfuric acid to nitric acid. **(10)**

4B. An evaporator system concentrating a weak liquor from 5 % to 50 % solids handles 100 kg of solids per hor. 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)**

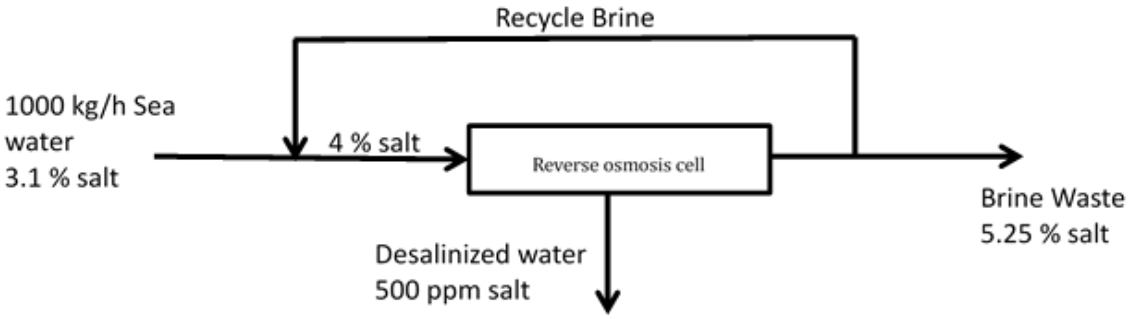
5. Sulphur dioxide reacts with oxygen producing Sulphur trioxide. In order to ensure complete reaction 100 % excess oxygen is supplied than that required theoretically. However only 75 % conversion is obtained. The pressure was 75 psi and temperature 750 K. 100 kg of Sulphur dioxide is charged to the converter. Determine the following

a) The volume of pure oxygen supplied at 2.5 bar and 350 K **(5)**
b) The volume of Sulphur trioxide produced **(5)**
c) The volume of gases leaving the converter **(5)**
d) The composition of gases leaving the converter **(3)**
e) The average molecular weight of the gas leaving the converter. **(2)**

6A. 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)**



6B. 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)**



7A. 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	**$\Delta H°_f$, kJ/mol**
$NH_3(g)$	-49.94
$NH_4OH(l)$	-361.20
$H_2O(l)$	-285.83

7B. 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 $mol^{-1}K^{-1}$

7C. 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. Production of single-cell protein from hexadecane is described by the following reaction equation:

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

a) Determine a, b, c, d, and e if RQ = 0.75
b) Determine the yield coefficients, $Y_{X/S}$ and $Y_{X/O2}$

Determine degree of reduction for the substrate and bacteria **(20)**