**Exam. Code: 0907**
**Sub. Code: 6291**

**2123**

**B.E. (Biotechnology) Third Semester**

**BIO-311: Process Calculations**

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

***NOTE: Attempt <u>five</u> questions in all, including Question No. I which is compulsory and selecting two questions from each Section. Use of a psychometric chart and steam table is allowed.***

*x-x-x*

1.a) The available nitrogen in a urea sample is 45% by mass. Find the actual urea content in the sample. (molar mass of $NH_2CONH_2$ is 60)

b) The thermal conductivity of a metal is predicted using the equation $k = A\ exp\ (B/T)$. Here k is in (W/m K) and A and B are constants. What are the units of constants A and B?

c) How is the dry bulb temperature related to wet bulb temperature and dew point temperature at 100% relative humidity for air?

d) 1000 kg/hr of a mixture containing equal parts by mass of benzene and toluene is distilled. Product streams leave the top and the bottom of the distillation column. The mass flow rate of benzene in the top stream is 540 kg/hr and that of toluene in the bottom stream is 460 kg/hr. Calculate the unknown flow rate of toluene and benzene in the product stream.

e) 100 g of Nitrogen is stored in a container at 296 K and 6.9 kPa. Assuming ideal gas behavior, calculate the volume of the container.

(10)

**SECTION-A**

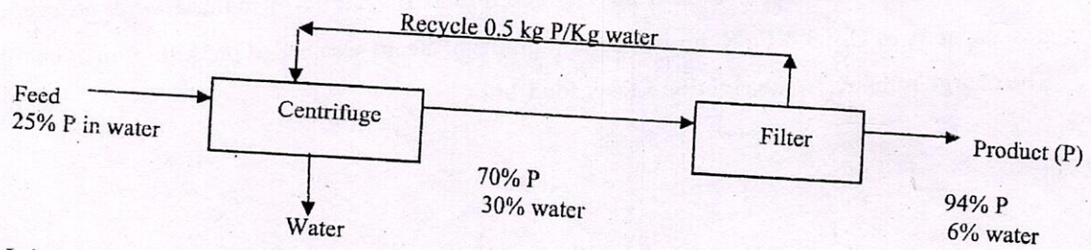
2a). An aqueous sample of ethanol contains 20% ethanol by volume. Assuming the densities of ethanol and water to be 0.79 kg/L and 1 kg/L respectively, find the mass% of ethanol.

b). A mixture of gases has following composition by mass. Calculate the molar composition.

$O_2 = 16\%,\ CO = 4\%,\ CO_2 = 17\%,\ N_2 = 63\%$

(4,6)

3a). The process for the manufacture of certain product (P) requires centrifugation and filtration of as shown in the figure. For 100 kg/hr of fresh feed charged determine the flow rate of the recycle stream in kg/hr.




b). It is required to make 1000 kg of mixed acid containing 62% $H_2SO_4$, 30% $HNO_3$ and 8% water by blending (i) spent acid containing 12.2 % $HNO_3$, 42.5% $H_2SO_4$ and 45.3 % $H_2O$, (ii) aqueous 90% $HNO_3$, (iii) aqueous 98% $H_2SO_4$. All percentages are by mass. Calculate the quantities of each of the three acids required for blending.

(5,5)

P.T.O.

4. The reaction between ethylene and hydrogen bromide to form ethyl bromide is carried out in a continuous reactor.

$$C_2H_4 + HBr \Longrightarrow C_2H_5Br$$

The product stream is analyzed and found to contain 51.7 mole% $C_2H_5Br$ and 17.3% HBr. The feed to the reactor contains only ethylene and hydrogen bromide. Calculate the fractional conversion of the limiting reactant and the percentage by which the other reactant is in excess. If the molar flow rate of the feed stream is 165 mol/s, what is the extent of reaction? (10)

## SECTION-B

5a). 1.1 kg of carbon dioxide occupies a volume of 33 L at 27°C. Using the van der Waals equation of state, calculate the pressure.

Given for $CO_2$ : $a = 3.6\, m^5\, kPa/kmol^2$ and $b = 4.3 \times 10^{-2}\, m^3/kmol$

b). Steam at 260°C and 7 bar absolute is expanded through a nozzle to 200°C and 4 bar. Negligible heat is transferred from the nozzle to its surroundings. The approach velocity of the steam is negligible. The specific enthalpy of steam is 2974 kJ/kg at 260°C and 7 bar and 2860 kJ/kg at 200°C and 4 bar. Use the open system energy balance to calculate the exit steam velocity. (5,5)

6a). Find the enthalpy of formation of liquid ethanol from the following data:

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ $\quad \Delta H = -1367.8\, kJ$

$C\,(graphite) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H = -393.5\, kJ$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\quad \Delta H = -571.6\, kJ$

b) Air is at a dry bulb temperature of 41°C and 10% relative humidity. Use the psychrometric chart to estimate the absolute humidity, wet bulb temperature, humid volume and, dew point. Calculate the amount of water in 150 $m^3$ of air at these conditions. (3,7)

7. Steam enters the steam chest, which is segregated from the biomass, at 250°C saturated, and is completely condensed in the steam chest. The rate of the heat loss from the steam chest to the surroundings is 1.5 kJ/s. The reactants are placed in the vessel at 20°C and at the end of the heating the material is at 100°C. If the charge consists of 150 kg of material with an average heat capacity of $C_p$= 3.3 J/g K, how many kilograms of steam are needed per kilogram of charge? The charge remains in the reaction vessel for 1 hr. (10)

*x-x-xx*