Exam.Code:0907
Sub. Code: 6691

1078
B.E. (Bio-Technology)
Third Semester
BIO-311: Process Calculations

Time allowed: 3 Hours Max. Marks: 50

NOTE: Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Section. Use of Psychrometric chart and steam tables is allowed.

x-x-x

Q.1.a) The density of a material is 4 kg/m^3. Calculate its specific volume?

b) For an ideal gas the ratio of C_p to C_v is_____

c) 140 kg molecular hydrogen is fed into a reactor each hour. What is the molar flow rate of this stream in gram-moles/minute?

d) Molar average molecular weight of air is _____.

e) Standard heat of formation data are normally available at _____ temperature and _____ pressure.

f) At 100% relative humidity what is the relation between dry bulb temperature, wet bulb temperature and dew point temperature of air?

g) Define wet bulb temperature.

h) A wet pulp contains 75% water. After 100 kg of water is removed in dryer, it is found that the pulp is now containing 30% water. The mass of original pulp is _____

i) Sodium chloride weighing 600 kg is mixed with 200 kg Potassium chloride. Find the composition of the mixture in mass%.

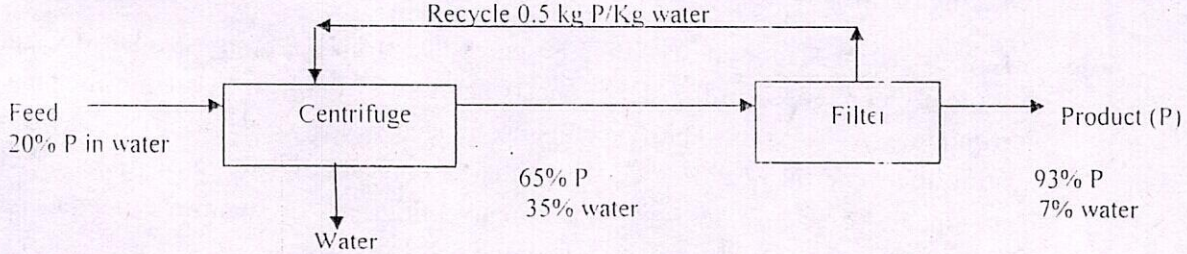
j) Explain single pass conversion and overall conversion. (10)

SECTION-A

Q.2a) The thermal conductivity k of a liquid metal is predicted via the empirical equation

$k = A\ exp\ (B/T)$ where k is in (J/smK) and A and B are constants. (i) What are the units of constants A and B? (ii) Derive a formula for k (BTU/hr m K).

b). 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. (5.5)



Q.3a). Iron reacts with steam according to the following reaction

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$

How many kilograms of iron and steam are required to produce 150 kg of hydrogen?

P.T.O.

b). 1200 kg/hr of a mixture containing equal parts by mass of methanol and water is distilled. Product streams leave the top and the bottom of the distillation column. The flow rate of the bottom stream is measured and found to be 670 kg/h, and the overhead stream is analyzed to contain 92 wt% methanol. Calculate the mass and mole fractions of methanol and the molar flow rates of methanol and water in the bottom product stream. (4.6)

Q.4. The fresh feed to an ammonia production process contains 24.25 mole % nitrogen, 74.75 mole% hydrogen, and the balance inerts (I). The feed is combined with a recycle stream containing the same species, and the combined stream is fed to a reactor in which a 25% single-pass conversion of nitrogen is achieved. The products pass through a condenser in which essentially all of the ammonia is removed, and the remaining gases are recycled. However, to prevent buildup of the inerts in the system, a purge stream must be taken off. The recycle stream contains 12.5 mole% inerts. Calculate the overall conversion of nitrogen, the ratio of moles of purge gas to the moles of gas leaving the condenser and the ratio of moles of fresh feed to the moles of mole fed to the reactor. (10)

SECTION-B

Q.5a). Calculate the heat required to heat 500 gms of carbon dioxide from 27°C to 527°C. The heat capacity for carbon dioxide, C_p in kJ/kmol K is given by

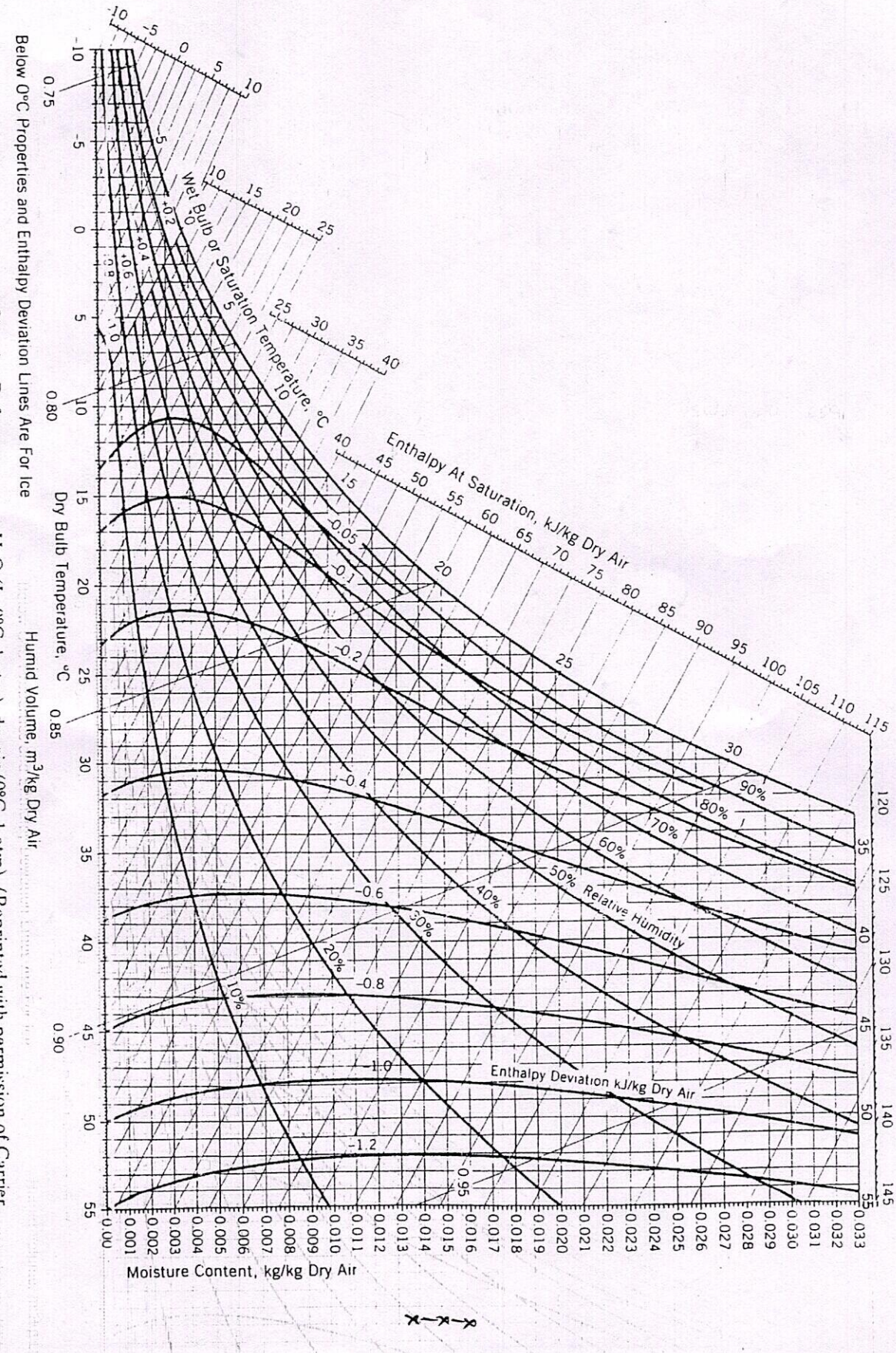
$$C_{pCO_2} = 26.540 + 42.454 \times 10^{-3}T - 14.298 \times 10^{-6}T^2$$

b). A turbine discharges 150 kg/h of saturated steam at 10 bar absolute. It is desired to generate steam at 250°C and 10 bar by mixing the turbine discharge with a second stream of superheated steam of 300°C and 10 bar. (a) If 300 kg/hr of the product steam is to be generated, how much heat must be added to the mixer? (b) If the mixing is carried out adiabatically, at what rate is the product steam generated? (5.5)

Q.6a) Air is at a dry bulb temperature of 21°C and 80% relative humidity. Find the absolute humidity, wet bulb temperature, dew point, enthalpy at saturation and humid volume using the psychrometric chart.

b) What is the mass of 3 m^3 of air at 27°C and a total pressure of 115 kPa absolute if the relative humidity of air is 65% ? (7.3)

Q.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= 3.26 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)



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

Psychrometric chart—SI units. Reference states: H_2O (L, 0°C, 1 atm), dry air (0°C, 1 atm). (Reprinted with permission of Carrier Corporation.)