MSK

Question Paper

Exam Date & Time: 16-Dec-2022 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

THIRD SEMESTER B.TECH END SEMESTER EXAMINATIONS, DEC 2022

CHEMICAL PROCESS CALCULATIONS [CHE 2152]

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

Answer all the questions.

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

1) (a) Convert the pressure 2 x 10^5 Pa(g) to inch Hg(a) (4)

A) (b) The superficial mass velocity is found to be 200 lb/(h-ft^2). Calculate the velocity in g/(sec-$inch^2$)

B) An alcohol-water solution contains 20% ethanol (C_2H_5OH) by volume at 300 K. If the densities of ethanol and water at 300 K are 0.798 g/mL and 0.998 g/mL respectively, calculate the mole fraction, and weight fraction of ethanol and the density of the final solution. (3)

C) A gas mixture contains 39.4% HCl, 47.8% N_2, and 12.6% O_2. Calculate the average molecular weight of the gas and its specific volume (m^3/kg) at 3 atm and 298 K. (3)

2) A benzene (C_6H_6) solution of an organic compound "A" analyses 10% of A. If the molality of the solution is 0.62, calculate the molecular weight of the compound A. (3)

A)

B) A flue gas containing 18% CO_2 enters an absorber at 120 kPa and 400 K. Only CO_2 is absorbed and the gas leaves the unit at 95 kPa and 310 K containing 2% CO_2. Calculate the volume of gas leaving in m^3 per 100 m^3 of gas entering and the weight of CO_2 absorbed in kg (4)

C) Oil is extracted from seeds by leaching with organic solvents. Soybean seeds containing 20% oil, 65% inert solids and 15% water are leached with hexane and after extraction the solid residue is removed from the solution of oil in hexane. The residue analyzed 1.0% oil, 88% inert cake and 11% water. Calculate the percent of oil recovered from seeds (3)

3) A batch of a 18.63% battery acid (aq. H_2SO_4) is to be prepared as follows. A tank of old weak battery acid solution contains 12.43% H_2SO_4 (remaining is water). If 200 kg of 77.7% H_2SO_4 is added to the tank and the final solution is to be 18.63% H_2SO_4, estimate the amount of battery acid to be made (3)

A)

B) At 101.3 kPa and 298 K, air is 55% saturated with water vapour. Calculate the following: (4)

(a) Absolute and molal humidity

(b) Partial pressure of water vapor

(c) % Relative saturation of the air

(d) If 90% of the water vapour is condensed by cooling the gas at 289 K and compressing at a certain pressure. Calculate the pressure. (The vapor pressure of water at 298 K is 3.101 kPa and at

289 K is 1.755 kPa

C) A 1000 m^3 of hot air having 10% humidity at 101.3 kPa and 355 K is used to dry a wet pulp containing moisture 70% moisture and remove 60% of the water present in the pulp. If air leaves the dryer at 50% humidity and 101.3 kPa, determine the water removed per 100 kg of a wet pulp and the temperature of the air leaving the dryer (3)

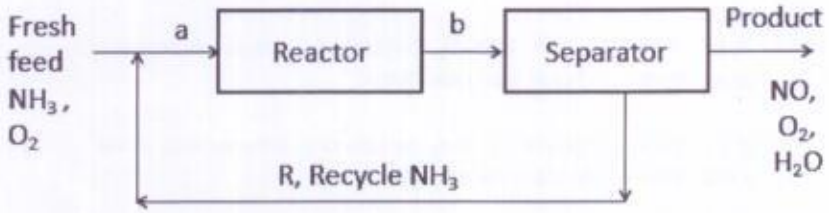
4) A gas containing only CH_4 and N_2 is completely burnt with air yielding a flue gas that has an Orsat analysis as 8.7% CO_2, 1% CO, 3.8% O_2, and 86.5% N_2. Evaluate the percent excess air used in (3)

A) combustion and the composition of the CH_4-N_2 mixture

B) In a process for concentrating 1000 kg of freshly extracted orange juice containing 15% solids, the juice is strained, yielding 750 kg of strained juice and 250 kg of pulpy juice. The strained juice is concentrated in a vacuum evaporator to give an evaporated juice of 60% solids. The 250 kg of pulpy juice is bypassed around the evaporator and mixed with the evaporated juice in a mixer to improve the flavor. The final concentrated juice contains 40% solids. Calculate (a) the mass of final concentrated juice, (b) the concentration of solids in the strained juice, and (c) the concentration of solids in the pulpy juice (3)

C) In an attempt to provide a means of generating NO cheaply, gaseous ammonia is burned with O_2. It is desired that oxygen entering the reactor is 20% in excess of that theoretically required. The reaction is 70% complete. The unreacted NH_3 is recycled and NO, O_2 and water are separated as product as shown in Figure below. (4)

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



Calculate the moles of NH_3 recycled and the ratio of moles of NH_3 to O_2 in the fresh feed

5) The heat capacity of silicon carbide is given by: (3)

A) $C_P = 37.221 + 1.22 \times 10^{-2} T - 1.189 \times 10^{5} T^{-2}$

where C_P is in kJ/kmol K and T is in K. Calculate the mean heat capacity of silicon carbide and its enthalpy change in the temperature range between 0 to 1000°C

B) Calculate the standard heat of reaction (ΔH°_{298}) for the reaction (3)

$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

The standard heat of formation of the compounds are as follows:

C_4H_{10} = - 30.04 kcal/mol, CO_2 = - 93.98 kcal/mol, and H_2O = - 68.27 kcal/mol

C) The gas leaving a pyrites roaster in a sulphuric acid plant has the following composition. SO_2= 7.00%, O_2= 10.50%, SO_3= 0.80%, N_2 = 81.70%. The heat capacity (C_P, kJ/kmol-K) of the gases varies with temperature (T, in K) is given below (4)

$O_2 = 25.74 + 12.98 \times 10^{-3} T - 3.864 \times 10^{-6} T^2$

$N_2 = 27.03 + 5.815 \times 10^{-3} T - 0.289 \times 10^{-6} T^2$

$SO_3 = 34.33 + 42.86 \times 10^{-3} T - 14.298 \times 10^{-6} T^2$

$SO_2 = 25.74 + 57.96 \times 10^{-3} T - 38.11 \times 10^{-6} T^2$

Calculate the enthalpy of the gas mixture at 750 K with reference to a base temperature of 298 K

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