Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree (S,FE) Examination December 2020

Course Code: CH201

Course Name: CHEMICAL PROCESS CALCULATIONS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two full questions, each carries 15 marks. Marks

Use of Psychrometric chart may be permitted

1 a) Differentiate unit operations and unit processes. Give two examples each. (3)

b) A solution of KCl has a concentration of 20 ppm. Find the concentration in (i) wt% and (ii) Molality. (4)

c) A gas mixture has the following composition by volume: (8)

CO_2 - 25 %, CO -10%, SO_2 - 15%, O_2 - 8%, N_2 - 42%

Calculate: (i) Average Molecular weight, (ii) Composition in weight % and (iii) density at standard conditions.

2 a) The specific gravity of an oil is 0.88 at 288.8 K. Determine the corresponding values in Baume and API scales. (3)

b) In a gas mixture consisting of hydrogen, nitrogen and carbon dioxide, the partial pressures are 25kPa, 35kPa, and 140kPa respectively. For $60m^3$ of gas, determine: (i) the number of moles of the mixture, (ii) number of moles and mole fraction of nitrogen and (iii) average molecular weight of the mixture. (7)

c) Given heat capacity of oxygen as a function of temperature, in the form (5)

$$Cp\ (kJ/kmol\ K) = a+bT+CT^2,$$

Where T is in Kelvin, a = 25.74, b = 12.987×10^{-3} and c = -3.864×10^{-6}. Change the equation into the form in which Cp is given in cal/(mol.^{0}C) and temperature in ^{0}C.

3 a) Define Compressibility factor and write the use of Compressibility factor charts. (3)

b) A solution of NaCl has a concentration of 20 wt%. Find: (i) Molarity, (ii) Molality and (iii) Normality. The density of the solution is 1.148 g/cm^3. (4)

c) 100 m^3/h of an ammonia - air mixture containing 20% ammonia by volume is admitted to an absorption column at 120 kPa and 300 K in order to recover ammonia by absorbing water. The gas leaves the column at 100 kPa and 280 K (8)

with a partial pressure of ammonia of 2 kPa. Determine: (i) the volume of gas leaving in one-hour (ii) kilograms of ammonia are recovered in one hour and (iii) percent recovery.

PART B

Answer any two full questions, each carries 15 marks.

4 a) The absolute humidity of a CO_2 - water vapour mixture at 310 K and 100 kPa is measured to be 0.022 kg water per kg dry CO_2. Calculate: (i) the molal humidity, (ii) the percent saturation and (iii) the percent relative saturation. The vapour pressure of water in kPa is approximated by the Antoine equation as (7)

$$lnP^s = 16.26205 - \frac{3799.887}{(T - 46.854)}$$

b) An evaporator is fed with 100 kg/h of a solution containing 10 % NaCl, 10% NaOH and the rest water. During evaporation, water is removed as vapour and NaCl crystallises and is removed. The mother liquor contains 50% NaOH and 2% NaCl. Calculate the amount of salt in kilograms, precipitated per hour. (4)

(c) Explain bypass and Recycle operation with the help of an example. (4)

5 a) Derive Clausius - Clapeyron equation. Write the major assumptions. (4)

b) An ideal solution containing 40% A and 60% B is in equilibrium with its vapour. The vapour pressures of pure liquids at the equilibrium temperature are 80 kPa and 40 kPa for A and B respectively. Calculate: (i) the vapour composition and (ii) total pressure. (3)

c) A distillation column separated a feed mixture containing 40% Propane, 40% Butane and remaining Pentane into an overhead containing 90% Propane, 8% Butane and remaining Pentane and the bottom product containing 4% Propane. The reflux ratio is 2 (ratio of recycle to top product). All the compositions given are on mole basis. On the basis of 1000 moles of feed per hour, Compute: (8)

i) The quantity the top and bottom product.

ii) Recovery of Propane in the top product and Pentane in the bottoms.

iii) Recycle ratio (defined as moles recycled to moles fed)

6 a) Define: (i) percent saturation, (ii) Dew point, (iii) Wet bulb temperature and (iv) Humid volume. (4)

b) The dry bulb temperature and due point of air are 343 K and 308 K respectively. Estimate the following using psychrometric chart. (4)

i) The absolute humidity

ii) The percent humidity

iii) Enthalpy of wet air

iv) Humid volume

c) A counter current extractor is employed to extract oil meal using ethyl ether as the solvent. The fresh meal is charged to the unit at a rate of 1000 kg/h and contains 25% oil. Pure solvent enters the bottom of the extractor. The overflow from the unit contains 60% oil. The underflow contains 0.25 kg of solvent per kg of oil free solids and the concentration of the oil in the underflow is 12%. Calculate: (i) the solvent requirement and (ii) the percentage of oil recovery. (7)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Define the terms: (i) conversion, (ii) yield and (iii) % excess. (3)

b) Flue gas produced by burning methane has following composition on dry basis: (7)

CO_2 - 10%, O_2 - 2.37 %, CO - 0.53%, N_2 - 87.1%

Calculate the composition of feed.

c) CO at 1000 K is burned with 90 % excess air at 800 K. The products of combustion leave the reaction chamber at 1250 K. Calculate the heat evolved in the reaction chamber per mol of CO burned. The standard heat of reaction at 298K is -282.99 kJ/mol CO. The mean specific heat applicable in the temperature range are 29.38, 49.91, 33.13 and 31.43 J/mol.K for CO, CO_2, O_2 and N_2 respectively. (10)

8 a) The fuel oil analyzing 85 % (weight) C and 15 % (weight) H is oxidised with 50 % excess air. For the oxidation of 100 kg of oil, calculate: (i) the air requirement in kilograms, ii) the composition of flue gas iii) the average Molecular weight of the gas. (7)

b) State Hess's law of constant heat summation. Give an example (3)

c) A gas mixture consisting of 20 % ethane and 80 % oxygen at 298 K is burned completely at 298 K. The mean heat capacities in J/mol K are 54.56 for CO_2, 43.02 for water vapour and 35.52 for oxygen. The standard heat of reaction is -1428 kJ/mol of ethane at 298 K. Determine the theoretical flame temperature (10)

9 a) When coal containing 74% C, 14.9% H and 11.1% ash is burned. It gives a flue gas containing 12.5% CO_2, 1% CO, 1.5% O_2 and 85% N_2 on dry basis. (10)

Determine: (i) the mass of coal fired in kg/ kmol of dry flue gas, (ii) the percent excess air used and (iii) the amount of air supplied per kg of coal.

b) Heat of combustion of methane at 298 K is -890.4 kJ/mol and the mean heat capacity in the temperature range of 298 to 800 K are 41.868 J/mol K, 30.563 J/mol K, 41.449 J/mol K and 34.332 J/mol K for methane, oxygen, carbon dioxide and water vapour respectively. Calculate the heat of combustion of methane at 800 K. (10)

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