Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH DEGREE EXAMINATION(S), MAY 2019

Course Code: CH201

Course Name: CHEMICAL PROCESS CALCULATIONS

Max. Marks: 100 Duration: 3 Hours

(Attested copy of Humidity chart is permitted)

PART A

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

1 a) If the volumetric flow rate of a liquid of specific gravity 0.78 is 100 ft^3 / min, find the flow rate in kg/s**.** (3)

b) A solution of KCl in water contains 384g KCl per litre of the solution at 300 K. The specific gravity of the solution is 1.6. Determine the following. (i) The concentration in weight percent, (ii) molarity of the solution (iii) molality of the solution (iv) normality of the solution. (8)

c) Differentiate between unit operations and unit processes. Write examples. (4)

2 a) A flue gas contains CO_2 - 14%, SO_2 - 0.5%, CO - 2%, O_2 - 2.5% and rest N_2 by volume. Find (i) composition by weight (ii) average molecular weight of the gas mixture (iii) density of gas mixture at 320 K and 1.5 bar (iv) specific gravity of the gas mixture at 320 K and 1.5 bar. (9)

b) A compound whose molecular weight is 103, analyses C= 81.5%, H = 4.9% and N= 13.6%. Determine its molecular formula. (6)

3 a) 250 m^3 of 30 ^{0}API gas oil is blended with 1000 m^3 of 15 ^{0}API fuel oil. Determine the density of the resultant mixture in kg/m^3. The density of water at 288.5 K is 999 kg/m^3. Assume no volume change on mixing. (6)

b) For fluids in turbulent motion through tubes, the heat transfer coefficient is given by, (9)

$$h = a\left(\frac{C_p G^{0.8}}{D^{0.2}}\right)$$

The numerical value of the constant a = 10.1, when 'h' is measures in *Btu/(ft^2.h.^{o}F), C_p* is the specific heat of the fluid given in *Btu/(lb.^{o}F), G* is the mass velocity in *lb/(ft^2.s)* and the diameter is in *ft*. determine the value of 'a' when 'h' is measured in *W/(m^2.K),* Cp is the specific heat of the fluid given in *kJ/(kg.K), G* is the mass velocity in *kg/(m^2.s)* and the diameter in *m*.

PART B

Answer any two full questions, each carries 15 marks.

4 a) Define Humid heat and Humid volume. (3)

b) At 300 K, the vapour pressures of two pure liquids A and B are 80 kPa and 50 kPa respectively. The concentration of A in vapour in equilibrium with a solution of A and B is found to 35% in mole basis. Calculate (a) The composition of the liquid (b) The total pressure of the vapour. (5)

c) The percent saturation of a mixture of acetone vapour and nitrogen at 105 kPa and 300 K is found to be 80%. The vapour pressure of acetone is given by the Antoine equation with constants, A = 14.5463, B = 2940.46 and C = 49.19. Determine (i) molal humidity (ii) absolute humidity, (iii) partial pressure of acetone (iv) relative saturation and (v) dew point. (7)

5 a) What is steam distillation? Write its applications. (3)

b) An air-water vapour sample at 101.3 kPa has a dry bulb temperature of 333K and an absolute humidity of 0.01 kg water vapour per kg dry air. Using the Humidity chart, determine (i) Percent saturation (ii) partial pressure of water vapour (iii) Percent relative saturation (iv) dew point of the system (v) wet bulb temperature. (6)

c) Soya been seeds are extracted with n-hexane in batch extractor. The flaked seed contains 18.6% oil, 69% solids and 12.4% moisture. At the end of the extraction process, de-oiled cake (DOC) is separated from n-hexane –oil mixture. DOC analysis yields 0.8% oil, 87.7% solids and 11.5% moisture. Find the percentage recovery of oil. All percentages are by mass. (6)

6 a) 1000 kg of a 30% solution of Na_2CO_3 in water is cooled slowly to a temperature at which salt crystallizes out as $Na_2CO_3.10H_2O$. The solubility of anhydrous Na_2CO_3 in water at this temperature is 25kg/100 kg of water. During cooling, 20% of the water originally present is evaporated. Determine mass of $Na_2CO_3.10H_2O$ precipitated. (8)

b) 4000kg/hr caustic solution containing 10 wt% NaOH is evaporated in the first evaporator of a double effect evaporator, giving a 20 wt% NaOH solution. The solution is then fed into a second evaporator, which gives a product of 50% NaOH. Calculate (i) amount of water evaporated from each evaporators and (ii) amount of product in kg/hr. (7)

PART C

Answer any two full questions, each carries 20 marks.

7 a) Differentiate between the Proximate and Ultimate analysis of Coal (6)

b) The Orsat analysis of the flue gas resulting from the combustion of a hydrocarbon fuel is found to be 1% CO, 10.2% CO_2, 8.4% O_2 and 80.4% N_2. Determine the atomic ratio of H to C in the fuel. (6)

c) A solid fuel has the following analysis. H - 5%, S - 4%, C - 65%, O - 10% and rest inerts. The fuel is burned with 20% excess air. If only 80% of the carbon burned gets converted to CO_2, 15% is converted to CO and 5% left behind as soot, determine the composition of combustion gases. (8)

8 a) Develop energy balance equation for a flow steady state process. (6)

b) The molal heat capacity of CO_2 gas is given by (8)

$$C_p = 26.54 + 42.454 \times 10^{-3} T - 14.298 \times 10^{-6} T^2$$

where C_p is in kJ/(kmol.K) and T in K. Determine (i) The mean molal heat capacity between 500K and 1000K (ii) The heat required to raise the temperature of 200 m^3 per hour of CO_2 gas at STP from 500 to 1000K.

c) Pure CO is mixed with 100% excess air and completely burnt at constant pressure. The reactants are originally at 95 ^{0}C. Determine heat added or removed if the product temperature is 260 ^{0}C. (6)

Standard heat of reaction is -67600 cal/gmol.

C_{pm} data (cal/gmol.^{0}C) : CO= 6.95, O_2 = 7.1, N_2 = 6.95 and CO_2 = 9.9

9 a) Define theoretical flame temperature. (4)

b) Sulphur dioxide gas is oxidised in 100% excess air with 80% conversion to SO_3. The gases enter the converter at 673 K and leave at 723 K. The mean heat capacities of SO_2, SO_3, O_2 and N_2 are 45, 51, 32 and 31 J/(mol.K) respectively and the standard heat of reaction is -98.8 kJ/mol. Determine the amount of heat absorbed in the heat exchanger of the converter per kilo mole of SO_2 introduced. (8)

c) Dry methane is burned with dry air. Both reactants are at 298 K initially. The flame temperature is 1573 K. Determine the amount of air used, assuming complete combustion. Standard heat of reaction is -802.8 kJ/mol. Mean molal heat capacities of gases between 298K and 1573 K are 51.88 for CO_2, 34.01 for O_2, 40.45 for H_2O, and 32.21 for N_2. (8)

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