Reg No.:_____ Name:_____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

**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) Convert Btu/(ft.hr.$^0$F) to Kcal/(m.hr.$^0$C) (2)

b) A solution of KOH in water has a molarity of 7.0 and a KOH content of 30.2% (weight). Determine the density of the solution? (4)

c) Find the specific gravity of a hydrocarbon oil at 288.8 K with a rating of $30^0$ API (2)

d) A flue gas sample has the following composition by volume: $CH_4$ - 30 %, $C_2H_4$ - 20%, $O_2$ - 10 % and the rest $N_2$. Calculate: (7)

i) Composition in weight %

ii) Average molecular weight

iii) Density at standard conditions

2 a) Distinguish between unit operations and unit processes with the help of examples (2)

b) Pure water and alcohol are mixed together to get a 50% alcohol solution. The density in g/ml of water, alcohol and solution may be taken as 0.998, 0.780 and 0.914 respectively. Determine: i) molarity ii) molality and iii) volume percent of alcohol in solution. (6)

c) A mixture of oxygen and sulphur dioxide has an average molecular weight of 44.8 at 200 kPa. Calculate: i) the composition of mixture in mole %, ii) composition in weight % and iii) partial pressure of oxygen in the mixture (7)

3 a) An aqueous solution of 2.45% by weight $H_2SO_4$ has a specific gravity of 1.011. Find the normality of the solution (4)

b) Simplified equation for heat transfer from a pipe to air is $h = 0.026\frac{G^{0.6}}{D^{0.4}}$ where h is heat transfer coefficient in $\frac{Btu}{hr.ft^{2}{}^0{}_F}$ , G is the mass flow rate in $\frac{lb}{hr.ft^2}$ and D, the outside diameter of the pipe in *ft*. Find the new constant in the place of 0.026 so that h is in $\frac{cal}{\min(cm^2)0_C}$ , G is in $\frac{g}{min(cm^2)}$ and D in *cm*. (6)

c) Define compressibility factor. Explain the use of compressibility factor charts to represent the behaviour of real gases (5)

## PART B

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

4 a) State and derive Clausius- Clapeyron equation. Write all the assumptions used. (4)

b) Air at temperature of 20 $^0$C and 750 mmHg pressure has a relative humidity of 80 %. Find the percentage humidity, vapour pressure of water at 20$^0$C is 17.5 mm Hg (4)

c) A benzene- toluene solution containing 40 % (weight) benzene is fed into the distillation column. The distillate contains 97 % (weight) benzene and the bottom product contains 95 % toluene. Determine i) the composition of the feed, distillate and the bottom product in mole percent ii) the moles of distillate and bottom product obtained by separating 100 moles/hour of feed. (7)

5 a) A liquid mixture of benzene and toluene is in equilibrium with its vapour at 101 kPa and 373 K. The vapour pressure of benzene and toluene at 373 K respectively are 156 and 63 kPa. Find the composition of liquid and vapour phases (4)

b) Define i) wet bulb temperature ii) adiabatic saturation temperature iii) dew point (3)

c) $Na_2SO_4.10H_2O$ crystals are formed by cooling 100 kg of 30% by weight aqueous solution. The final concentration of the solution is 10 %. Calculate the weight of the crystals formed. (5)

d) Explain the systems with i) Bypass ii) Recycle (3)

6 a) The dry bulb temperature and dew point of an air sample are 328 K and 308 K respectively at 101.3 kPa. Determine the following using psychrometric chart: ( 7)

i) the absolute humidity
ii) molal humidity
iii) percent saturation
iv) wet bulb temperature
v) humid volume

b) An evaporator is fed with 100 kg/h of a solution which contains 10 % NaCl, 10 % NaOH and the rest water. During evaporation water is removed as vapour and NaCl crystallizes and is settled and removed. The mother liquor contains 50 % NaOH and 2% NaCl. Calculate (i) kilograms of salt precipitated per hour and (6)

ii) the weight of concentrated liquor leaving per hour.

c) Define key component in a material balance problem. Give two examples (2)

## PART C

***Answer any two full questions, each carries 20 marks.***

7 a) 6 g of carbon is burnt with an amount of air containing 18 g oxygen. The product contains 16.5 g $CO_2$ and 2.8 g CO besides other constituents. Determine the degree of conversion on the basis of disappearance of the limiting reactant. (6)

b) Write the significance of proximate and ultimate analysis of coal (4)

c) CO at 1000 K is burned with 90 percent 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 kmol of CO burned. The standard heat of reaction at 298 K is -282.99 kJ/mol CO. The mean specific heats 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) A gas containing $CH_4$ and $N_2$ is burned with air to form a flue gas that has an Orsat analysis of $CO_2$ - 8.7%, CO - 1.0%, $O_2$ - 2.0% and rest nitrogen. (7)

Calculate:

(i) the percent composition of fuel

(ii) the percent excess air used

b) Write any three methods used for estimation of heat of vaporization. (3)

c) Pure CO is mixed with 200 percent excess air and completely burned. The reactants are at 400 K and products leave at 600 K. The standard heat of reaction at 298 K is 282.99 kJ/mol CO burned. The mean specific heats applicable are 29.10, 29.70, 29.10 and 41.45 J/mol.K respectively for CO, $O_2$, $N_2$ and $CO_2$. Determine the heat added or removed. (10)

9 a) A solid fuel has the following analysis: H - 5.0 %, S - 4.0%, C -65%, O -10 % and inerts - 16 %. The fuel is burned with 20 % excess air. Only 80 % of the carbon burned gets converted to $CO_2$, 15 % converted to CO and 5 % is left behind as soot. Determine the composition of gases formed by combustion. (10)

b) Calculate the theoretical flame temperature when CO is burned with 100% excess air. Both reactants are at 373 K. The heat capacities (J/mol.K) may be assumed constant at 29.23 for CO, 34.83 for $O_2$, 33.03 for $N_2$ and 53.59 for $CO_2$. The standard heat of combustion at 298 K is -282.99 kJ/mol CO (10)

*****