

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third semester B.Tech examinations (S) September 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

- 1 a) Convert the following empirical equation into SI units. (10)

$$h = \frac{0.026G^{0.8}k^{0.67}C_p^{0.5}}{D^{0.2}\mu^{0.47}}$$

where h is heat transfer coefficient in Btu/hr ft² °F

G is mass velocity of liquids in lb/ft²s

k is thermal conductivity in Btu/ft.hr. °F

C_p is specific heat in Btu/lb °F

D is diameter of tube in ft

μ is viscosity of liquid in lb/ft s

- b) An aq. solution of K₂CO₃ is prepared by dissolving 43 kg K₂CO₃ in 100 kg water (5)
at 293 K. The density of the solution is 1.3 kg/L. Find the molarity, normality and molality of the solution.
- 2 a) A gas mixture at 1 atm and 273 K has the following composition by volume. (10)
Ethylene – 30.6 %, Benzene – 24.5 %, Oxygen – 1.3 %, Methane – 15.5 %, Ethane – 25 %, Nitrogen – 3.1 %. Find the average molecular weight, density and composition by weight of the gas mixture.
- b) State and explain Soave Redlich-Kwong equation of state. (5)
- 3 a) Write a note on specific gravity scales. (5)
- b) State and prove Amagat's law. (5)
- c) State and explain Kay's rule. Write its application. (5)

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

- 4 a) Derive Clausius-Clapeyron equation. Write its significance. (7)
- b) A distillation column separates 10,000 kg/hr of 50% benzene - 50 % toluene (8)
mixture. The product recovered from the top contains 95% benzene while the

bottom product contains 96% toluene. The stream entering the condenser from the top of the column is 8000 kg/hr. Find the reflux ratio.

- 5 a) A hot solution of $\text{Ba}(\text{NO}_3)_2$ from an evaporator contains 30.6 kg of $\text{Ba}(\text{NO}_3)_2$ per 100 kg of water and goes to a crystallizer where the solution is cooled and $\text{Ba}(\text{NO}_3)_2$ crystallizes. On cooling 10% of the original water present evaporates. For a feed solution of 100 kg, calculate the yield of crystals and water evaporated if the solution is cooled to 290 K. Solubility of $\text{Ba}(\text{NO}_3)_2$ is 8.6 kg per 100 kg total water at 290 K. (8)
- b) Ammonia is recovered from a gas mixture containing 25% (volume) CO_2 and 75% (volume) NH_3 by scrubbing with water. Assuming that CO_2 is insoluble in water, determine the percent of ammonia in the entering gas that is absorbed if the gas leaving the scrubber analyses 35% NH_3 . (7)
- 6 a) An air- water vapour sample at 1 atm has a dry bulb temperature of 328 K and is 10% saturated with water vapour. Using psychrometric chart, determine (i) the absolute humidity, (ii) partial pressure of water vapour, (iii) absolute saturation humidity at 328 K, (iv) the vapour pressure of water at 328 K, (v) percent relative saturation and (vi) dew point of the system. (15)

PART C

Answer any two full questions, each carries 20 marks.

- 7 a) Pure propane is burnt in an excess of air to give the following analysis of combustion products in volume percent: CO_2 – 5%, CO – 3.5%, H_2O – 11.4%, O_2 – 7%, N_2 – 73.1%. Calculate the percentage excess air and find the Orsat analysis. (15)
- b) State and explain Hess's law of constant heat summation. (5)
- 8 a) Coal is burnt to a gas of the following composition by mole: CO_2 – 9.2, CO – 1.5, O_2 – 7.3, N_2 – 82%. Compute the enthalpy difference for this gas between the bottom and the top of the stack if the temperature at the bottom is 550 K and at the top is 200 K. (10)
- Cp of CO_2 is $8.448 + 5.757 \times 10^{-3} T - 21.59 \times 10^{-7} T^2 + 3 \times 10^{-10} T^3$ J/mol K
- Cp of CO is $6.865 + 0.8024 \times 10^{-3} T - 0.736 \times 10^{-7} T^2$ J/mol K
- Cp of N_2 is $6.895 + 0.7624 \times 10^{-3} T - 0.7 \times 10^{-7} T^2$ J/mol K
- Cp of O_2 is $7.104 + 0.7851 \times 10^{-3} T - 0.5528 \times 10^{-7} T^2$ J/mol K
- b) Explain recycle, bypass and purge operations with examples. (10)
- 9 a) CO and hydrogen reacts to give methanol. The conversion of CO entering the (20)

reactor is only 20%. A feed stream consisting of 33% CO, 66.5% H₂ and 0.5% CH₄ are mixed with a recycle stream and sent to a reactor. The methanol leaving the reactor is separated and the unconverted gases are recycled. A portion of the recycle stream is blown off to prevent the accumulation of CH₄ and to keep its concentration in the recycle stream at 3%. For 100 moles of fresh feed, determine: (i) the moles of recycle and purge stream, (ii) composition of purge stream and (iii) the moles of methanol.

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