Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

THIRD SEMESTERB.TECH DEGREE EXAMINATION (Regular), FEBRUARY 2022

CHEMICAL ENGINEERING

(2020 SCHEME)

Course Code: **20CHT203**

Course Name: **Chemical Process Principles**

Max. Marks: **100** **Duration: 3 Hours**

PART A

(Answer all questions. Each question carries 3 marks)

1. Describe unit operations and unit processes with one example each.
2. If 100 gmoles of ammonia-air mixture occupies 2.6 m^3, at 730 mm Hg and 30 °C, estimate its volume at 20 °C and 725 mm Hg. Assume the gas mixture is ideal.
3. State Raoult's law with mathematical expression. Give its use.
4. Differentiate between DBT and WBT.
5. Wet leather with moisture content 65% enters a drier and leaves with 7% moisture content. If the product leaves the drier at a rate of 490 kg/h, estimate the amount of water removed in the drier.
6. Explain the use of purge operation.
7. What is limiting reactant? Explain with one example.
8. What is orsat analysis?
9. State Hess's law of constant heat summation.
10. Heat capacity of a gas is expressed as a function of temperature as $C_p = 6 + 0.005T$ kcal/(kmol. K) and T is in K. What is mean heat capacity for the temperature range 25 °C to 100 °C?

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) A gaseous mixture contains 67% Cl_2, 28% Br_2 and 5% O_2 (percentage by weight). Assuming that the mixture obeys ideal gas law, estimate the composition by volume and density of the gas mixture at 25 °C and 740 mm Hg. Molecular weights for the components: Cl_2 - 71, Br_2 - 160, O_2 – 32. (10)

    b) If a bucket holds 2 lb of NaOH (molecular weight 40), calculate
    (i) how many pound moles of NaOH does it contain? (4)
    (ii) how many gram moles of NaOH does it contain?

OR

12. a) The effective heat capacity of a mixture of gases is given by $C_p = 15.2 + 2.68\,T,$ where, C_p is in J/(gmol.K) and T is in K. What are the units of constants in the equation? Change the equation into the form in which C_p in cal/(gmol • °F) and temperature in °F. (9)

b) A solution of caustic soda in water contains 20% NaOH by weight at 60 °C. Density of the solution is 1.196 g/cc. Determine molarity of the solution. (5)

MODULE II

13. a) With a neat sketch explain the T-x-y and P-x-y plots for a binary liquid vapor mixture. (8)

b) Vapour pressure of ethyl ether (molecular weight 74) at 0 °C is 185 mm Hg and its latent heat of vaporization is 4.185 x 10^5 J/kg. Estimate the vapour pressure of ethyl ether at 20 °C and 35 °C. (6)

OR

14. a) Antoine constants for n-heptane in the equation $\ln P = A - \frac{B}{T-C}$, are A = 13.86, B = 2911.32 and C = 56.56. Here P is in kPa and T is in K. Calculate (i) vapour pressure of n-heptane at 325 K and (ii) normal boiling point of n-heptane. (7)

b) Given the dry bulb and wet bulb temperature of an air - water vapor mixture explain how the following terms can be computed using a psychrometric chart: absolute humidity, absolute saturation humidity, percentage saturation, enthalpy of air and humid volume. (7)

MODULE III

15. a) 100 mol/h of 40% molal solution of ethylene dichloride in toluene, is fed to the middle of a distillation column. There is no net accumulation in the column. Total material leaves the column as two streams, overhead (distillate) and bottom (residue). The percentage (by mole) composition of ethylene dichloride in distillate and bottom stream are respectively 95% and 10%. Determine rate of flow of each stream. (8)

b) Write note on (i) recycle (ii) bypass and (iii) purge operations (6)

OR

16. a) Soybean seeds are extracted with hexane in batch extractor. The seeds contain 18.6% oil, 69% solids and 12.4% moisture. At the end of the extraction process, the residual cake is separated from hexane. The analysis of cake is 0.8% oil, 87.7% solids and 11.5% moisture. Calculate the percentage recovery of oil. (8)

b) Differentiate between steady and unsteady operations. Write general material balance for both steady and unsteady operations

(i) in the absence of chemical reaction

(ii) in the presence of chemical reaction (6)

MODULE IV

17. a) In the manufacture of chlorine by the oxidation of HCl gas, air used is 20% (10)

excess of that theoretically required. Oxidation of HCl is 75% complete. Calculate composition of gases leaving the oxidation chamber. Reaction is

$2HCl + \frac{1}{2} O_2 \rightarrow H_2O + Cl_2$

b) Write note on proximate and ultimate analysis of coal. (4)

OR

18. a) Define the terms (i) % yield (ii) % conversion, and (iii) selectivity. (9)

b) The gross calorific value of gaseous propane is 530.6 kcal/gmol at 25°C. Calculate its net heating value, if latent heat of vaporization of water at this temperature is 583.2 kcal/kg. (5)

MODULE V

19. a) What is heat of reaction? Give the steps to determine heat of reaction if standard heat of reaction and specific heat data of reactants and products are known. (7)

b) Calculate heat of combustion of methane at 533 K.
$CH_4 (g) + 2O_2 (g) \rightarrow CO_2 (g) + H_2O (l)$
Standard heat of reaction ΔH^0_R = -191760 cal/gmol. (7)
Mean molal heat capacity from 298 K – 533 K of CH_4: 10, O_2: 7.3, CO_2: 9.9, H_2O: 8.2 cal/molK

OR

20. a) Compute heat of reaction for the reaction
$C_2H_5OH (l) + CH_3COOH (l) \rightarrow C_2H_5COOCH_3 (l) + H_2O (l)$
Given heat of combustion of C_2H_5OH = -1366.91kJ/mol, CH_3COOH = -871.69 kJ/mol, $C_2H_5COOCH_3$ = -2274.48 kJ/mol (6)

b) Heat capacity of liquid benzene is given as $C_p = 62.78 + 0.233\ T$, C_p in J/molK and T in K. Calculate the heat required to convert 100 kg of liquid benzene from 20°C to saturated vapour at the normal boiling point of 80.1°C. Use Kistyakowsky equation for the estimation of latent heat of vaporization. (8)

****