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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

THIRD SEMESTER B. TECH DEGREE EXAMINATION (S), FEBRUARY 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : **20CHT203**

Course Name: **Chemical Process Principles**

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

Any missing data may be suitably assumed, Attested copy of Psychrometric chart can be permitted.

PART A

(Answer all questions. Each question carries 3 marks)

1. Differentiate between unit operations and unit processes. Give one example for each.
2. What do you understand by equation of state? Name any three equations of state proposed for real gases.
3. Give the use of Clapeyron equation. Write assumptions involved in the derivation of Clausius- Clapeyron equation from this.
4. Degree of unsaturation of air depends on the difference between dry bulb temperature and wet bub temperature. Explain.
5. Explain the need of purge operation.
6. Oxygen is mixed with air to produce oxygen rich air containing 60% oxygen by mole. In what ratio, oxygen and air are to be mixed?
7. Give the concept of conversion and selectivity in chemical reactions.
8. Comment on the statement: gross calorific value is greater than net calorific value of a fuel.
9. State Kopp's rule and give its use.
10. Define adiabatic flame temperature and theoretical flame temperature.

PART B

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

MODULE I

11. a) Calculate the pressure developed by 17 kg ammonia gas contained in a vessel of 0.6 m^3 capacity at a constant temperature of 473 K using Vander Waal's equation of state. The constants of equation are: $a = 0.423\ Nm^4/mol^2$ and $b = 3.73 \times 10^{-5}\ m^3/mol$. (7)

    b) An aqueous solution of acetic acid (CH_3COOH) contains 35% acid by weight and the solution has a density of 1.04 g/cc. Find the molarity and normality of the solution. (7)

OR

12. a) A gaseous mixture contains 67% Cl_2, 28% Br_2 and 5% O_2 (by weight). Assuming that the mixture obeys ideal gas law, find the composition of gas in volume %, density of the mixture at 25 ^0C and 740 mm Hg and average molecular weight. Take molecular weight as: Cl_2: 71, Br_2: 160 and O_2: 32. (14)

MODULE II

13. a) Explain the use of vapour pressure plots. (6)
    b) The vapour pressures of two pure liquids A and B are respectively 120 kPa and 70 kPa. The concentration of A in the vapour in equilibrium with a solution of A and B is found to be 50 mol%. Determine composition of the liquid. (8)

OR

14. a) Describe equilibrium diagram and boiling point diagram. (8)
    b) A gas containing 1 mol% ethane is in contact with water at 20 ^0C and 20 atm. Estimate the mole fraction of dissolved ethane. Henry's law constant for ethane in water at this temperature is 2.63 X 10^3 atm/molefraction. (6)

MODULE III

15. a) A tank of weak suphuric acid contains12.43% acid. If 200 kg of 77.7% H_2SO_4 is added to the tank and the final acid is 18.63%, determine the weight of weak acid obtained in kg. (5)
    b) A saturated solution of sodium sulphate is available at a temperature of 30 ^0C. Find out the weight of $Na_2SO_4.10H_2O$ crystallized, if 1000 kg of the solution is cooled to 10 ^0C. Solubility of sodium sulphate at 30 ^0C and 10 ^0C are 40.8 and 9 g Na_2SO_4/100 g water respectively. (9)

OR

16. a) Soyabean seeds are extracted with hexane in batch extractors. The flaked seeds contain 18.6% oil, 69% solids and 12.4% moisture. At the end of the extraction process, de-oiled cake (DOC) is separated from the hexane – oil mixture. DOC analysis yields 0.8 % oil, 87.7 % solids and 11.5 % moisture. Find the percentage recovery of oil. (10)
    b) A black liquor containing 8% solids enters an evaporator at the rate of 500 kg/hr. This is to be concentrated to 25% solids content in a single stage evaporator. Estimate the flow rate of thick liquor. (4)

MODULE IV

17. Formaldehyde is made by oxidation of methanol with air. The analysis of the exit gas from the reactor shows 64.49% N_2, 13.88% O_2, 5.31% H_2O, 11.02% CH_3OH, 4.08% HCHO and 1.22% HCOOH. Calculate the percent conversion of formaldehyde and ratio of air to (14)

methanol in the feed.

OR

18. a) A sample of flue gas has the following analysis by volume on dry basis: CO_2 – 11.3%, CO – 1.2%, O_2 – 7.7%. and N_2 – 79.8%. Compute percentage excess air used. (8)

    b) Write note on (i) proximate analysis (ii)ultimate analysis and (iii) ORSAT analysis (6)

MODULE V

19. a) Explain the procedure to estimate standard heat of reaction at any temperature T, if standard heat of reaction at 298 K and specific heats of components as a function of temperature are known. (8)

    b) Heat of combustion of CH_4, C and H_2 are -890.4 kJ/mol, -393.5 kJ/mol and -285.8 kJ/mol respectively. Calculate heat of formation of methane. (6)

OR

20. a) Calculate heat required to convert 100 kg of liquid benzene from 20 ^{0}C into saturated vapour at the normal boiling point of 80.1 ^{0}C. Latent heat of vaporization may be estimated using Kistyakowsky equation. Heat capacity of liquid benzene is given as Cp = 62.781 + 0.233 T, where T is in K and Cp in J/mol K. (8)

    b) Calculate heat of combustion of methane at 533 K, if standard heat of reaction is −191760 cal/mol. The mean molal heat capacities (cal/mol.K) in the temperature range, 298 K- 533 K are: CH_4 – 10; O_2 – 7.3; CO_2 – 9.9; H_2O – 8.2. (6)

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