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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

THIRD SEMESTERB.TECH DEGREE EXAMINATION (S), MAY 2022

CHEMICAL ENGINEERING

(2020 SCHEME)

Course Code: **20CHT203**

Course Name: **Chemical Process Principles**

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

Attested copy of psychrometric chart is permitted.
Assume any missing data

PART A

(Answer all questions. Each question carries 3 marks)

1. List any three chemical process industries in India
2. The flow rate of water through a pipe is reported as 15 ft^3/min. Taking density of water as 1 g/cm^3, calculate the mass flow rate in kg/s.
3. What are the general characteristics of an ideal solution?
4. Define the terms (i) wet bulb temperature (ii) adiabatic saturation temperature.
5. Which are the phases involved in the following unit operations:
   (i) Absorption
   (ii) Distillation
   (iii) Leaching
6. Define the terms (i) Tie component (ii) Recycling
7. Write the significance of ORSAT analysis.
8. Define the terms (i) % yield (ii) selectivity
9. Write any three methods used for estimation of heat of vaporization.
10. The vapour pressure of benzene at 273 K is 25 kPa and at 293 K is 63.5 kPa. Estimate the mean latent heat of vaporization of benzene in kJ/kg in this temperature range.

PART B

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

MODULE I

11. a) A saturated solution of salicylic acid (HOC_6H_4COOH) in methanol (CH_3OH) contains 64 kg salicylic acid per 100 kg methanol at 298 K. Find the composition of the solution in (i) weight % (ii) mole % and (iii) mole ratio of salicylic acid (6)

    b) A gas mixture contains 0.274 kmol of HCl, 0.337 kmol of N_2 and 0.089 kmol of O_2. Calculate (a) Average molecular weight of gas and (b) volume occupied by this mixture at 405.3 kPa and 303 K (8)

OR

12. a) A chemist is interested in preparing 500 ml of 1 normal, 1 molar and 1 molal (8)

solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.075 g/cm^3, calculate the amount of H_2SO_4 to be taken to prepare these solutions

b) A mixture of oxygen and sulphur dioxide has an average molecular weight of 44.8 at 200 kPa. Calculate (6)

(i) The composition of mixture in mole %

(ii) The composition of mixture in weight %

(iii) Partial pressure of oxygen in the mixture

MODULE II

13. a) An air-water vapor sample at 101.3 kPa has a dry bulb temperature of 328 K and is 10 % saturated with water vapor. Using the psychrometric chart determine the following: (8)

(i) The absolute humidity

(ii) The partial pressure of water vapor

(iii) The absolute saturation humidity

(iv) The vapor pressure of water

b) Derive the Calusius Clapeyron equation form the Clapeyron equation (6)

OR

14. a) Explain the procedure for determining the following from a psychrometric chart if the dry and wet bulb temperatures are given. (6)

(i) Absolute humidity

(ii) Humid volume

(iii) Adiabatic saturation temperature

b) The vapour pressure of acetone at 273 K is 8.52 kPa and that at 353 K is 194.9 kPa. Dry air initially at 101.3 kPa and 300 K is allowed to get saturated with the vapours of acetone at constant temperature and volume. Determine (8)

(i) The final pressure of the mixture

(ii) The mole percent of acetone in the final mixture

Assume that the Clausius-Clapeyron equation is applicable to acetone

MODULE III

15. a) Differentiate between drying and evaporation (4)

b) A batch of leather leaving a drier weighs 1000 kg and contains 5% moisture. During drying the leather, it loses 50% of its original weight. Determine the following: (10)

(i) The moisture content of the leather entering the drier on a dry basis

(ii) The amount of water removed as percent of the original water present

OR

16. a) Explain the significance of bypass and purge operations (4)

b) A mixture of benzene and toluene containing 10 % by mole benzene is continuously distilled at a rate of 1000 kmol/h in a distillation column. 95% of the benzene in the feed is recovered as distillate product which contains 98% benzene and 2% toluene. Calculate the following (10)

(i) The moles of bottom product

(ii) The composition of the bottom product

MODULE IV

17. a) A gas containing 25% CO, 5% CO_2, 2% O_2 and the rest N_2 is burnt with 20% excess air. If the combustion is 80% complete, Calculate the composition by volume of the flue gases considering the given compositions of gas to be on mole basis. (10)

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

OR

18. A fuel containing 74.1% C, 8.9% H and 17% ash by weight is burned with air and the resulting flue gas contains 12.4% CO_2, 1.2% CO, 4% O_2 and 82.4% N_2 by volume on a dry basis. Calculate: (14)
   (i) The amount (in kilogram) of coal fired per 100 kmol of flue gas
   (ii) The percent excess air used
   (iii) The kg of air used per kg of coal

MODULE V

19. a) State Hess's law of constant heat summation. (4)

b) Obtain an empirical expression relating the heat of reaction and the temperature of the reaction for the following: (10)

SO_2 (g) + ½ O_2 (g) → SO_3 (g)

Using the same expression, calculate the heat of reaction at 773 K

Data:

Component	ΔH^0_f, kJ/kmol
SO_3 (g)	-395720
SO_2 (g)	-296810

$C^0_P = a + bT + cT^2 + dT^3$, kJ/kmol K

Component	a	b x 10^3	c x 10^6	c x 10^9
SO_3	22.036	121.624	-91.867	24.369
SO_2	24.771	62.948	-44.258	11.122
O_2	26.026	11.755	-2.343	-0.562

OR

20. a) State and explain (i) Kopp's rule and (ii) Trouton's rule (4)

b) Calculate the standard heat of the following reaction at 298 K. (10)

C_5H_{12} (g) + 8O_2 (g) → 5CO_2 (g) + 6H_2O (l)

The standard heat of formation of the components are:

Component	ΔH^0_f, kJ/mol
CO_2 (g)	-393.509
H_2O (g)	-241.818
C_5H_{12} (g)	-146.76

The latent heat of vaporization of water at 298 K is 43.967 kJ/mol

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