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GIET UNIVERSITY, GUNUPUR – 765022

B. Tech (Third Semester - Regular) Examinations, December – 2022

21BCHPC23003 - Chemical Process Calculations

(Chemical Engineering)

Time: 3 hrs

Maximum: 70 Marks

Answer ALL questions

(The figures in the right hand margin indicate marks)

PART – A

(2 x 5 = 10 Marks)

Q.1. Answer <i>ALL</i> questions	CO #	Blooms Level
a. The specific gravity of hydrocarbon oil is 0.88 at 288 K. Calculate its value in Baume and API scale.	CO2	3
b. Differentiate heat of mixing and heat of solution	CO2	3
c. What is the use of Kistyakwosky rule?	CO2	3
d. What are the assumptions of Clausius- Clapeyron equation?	CO2	1
e. If the partial pressure and total pressure of an air-water vapour mixture is 15 kPa and 100 kPa respectively, calculate the absolute humidity of mixture	CO2	3

PART – B

(15 x 4 = 60 Marks)

Answer ALL questions

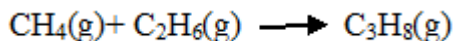
	Marks	CO #	Blooms Level
2. a. The average molecular weight of a gas mixture of oxygen and sulphur dioxide is found to be 44.8. For 5 kg of of this mixture at 298 K and 200 kPa calculate	8	CO2	4
i. The partial pressure of oxygen			
ii. The volume of the mixture.			
iii. The density at standard conditions			
b. Define the terms partial pressure and pure component volume in a gas mixture. Derive the relation mole fraction = pressure fraction = volume fraction from Dalton's law of partial pressure and Amagot's law of pure component volume.	7	CO2	4
(OR)			
c. An aqueous solution of NaCl contains 20% NaCl. Te density of the solution is 1.16 g/ml. 500 ml of water of density 1 g/ml is added to 1 litre of solution. What will be the molality and molarity of the resulting solution?	8	CO2	3
d. A liquid mixture contains three components A (MW=72), B (MW= 58) and C (MW=56) in which A and B are present in the mole ratio of 1.5:1 and the weight % of B is 25%. A sample of mixture is found to contain 10 kg of C. Calculate the total number of moles of the mixture	7	CO2	3
3.a. Moist air contains 0.025 kg water vapour per cubic metre of mixture at 313K and 103.15 kPa. Calculate the following:	8	CO2	3
i. The relative saturation			
ii. The absolute humidity of the air			
iii. The percent saturation			
iv. The temperature to which the mixture be heated so that its percent saturation becomes 10%.			

The vapour pressure of water (in kPa) is approximated by the Antoine equation

as

$$\ln P^S = 16.262 - \frac{3799.887}{T - 46.854}$$

- b. What are the characteristics of an ideal solution? How Raoult's law is related with ideal solution? Write its application. 7 CO3 2
- (OR)
- c. An aqueous solution of acetaldehyde contains 2% acetaldehyde by weight. The partial pressure of acetaldehyde over the solution is found to be 41.4 kPa at 367 K. What will be the partial pressure over a 0.1 molal solution at the same temperature? 8 CO2 3
- d. Derive the expression relating vapour pressure and temperature from Clausius-Clapeyron equation. What is its application? 7 CO3 2
- 4.a. The spent acid from a nitrating process contains 33% H₂SO₄, 36% HNO₃ and 31% water by weight. This acid is to be strengthened by the addition of concentrated sulphuric acid containing 95% H₂SO₄ and concentrated nitric acid containing 78% HNO₃. The strengthened mixed acid is to contain 40% H₂SO₄ and 43% HNO₃. Calculate the quantities of spent and concentrated acids that should be mixed together to yield 1500 kg of the desired mixed acid. 8 CO2 3
- b. Propane is burned with excess air to ensure complete combustion. If 55 kg of CO₂ and 15 kg of CO are obtained when propane is completely burned with 500 kg air, determine: the mass of propane burnt in kg and the percent excess air. 7 CO2 4
- (OR)
- c. A drier is fed with wet solid to reduce the moisture content from 80% to 15%. The product leaving the drier is admitted to an oven which further brings down the moisture to 2%. If the drier can handle 1000 kg of wet solid per hour, calculate:
 (i) The weight of water evaporated in the drier and in the oven per hour.
 (ii) The percentage of original water that is removed in the drier and the oven. 8 CO2 3
- d. A synthesis gas analyzing 6% CO₂, 0.5% O₂, 40% CO, 50% H₂ and rest is N₂ is burned with 50% excess air. What is the composition of the flue gas? 7 CO2 4
- 5.a. Obtain the empirical equation for calculating the heat of reaction at any temperature T (K) for the following reaction: 8 CO2 3



Data: Standard heat of reaction at 298 k = -82.66 kJ/mol,

Sp. Heat = a + bT + cT², kJ/(mol.K)

Component	a	bx10 ³	C x10 ⁶
CH ₄	19.2494	52.1135	11.973
C ₂ H ₆	4.1261	155.0213	81.5455
C ₃ H ₈	4.2227	306.264	158.6316

Using the same expression, calculate the heat of reaction at 600 0C

- b. . Calculate the std heat of formation of ethane gas at 25 0C using the following data. 7 CO3 2

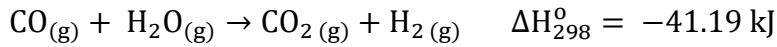
Heat of formation of CO₂(g) = -393.5 kJ/mol

Heat of formation of $\text{H}_2\text{O}(l) = -285.8 \text{ kJ/mol}$

Heat of combustion of $\text{C}_2\text{H}_6(g) = -1560.7 \text{ kJ/mol}$

(OR)

- c. Carbon monoxide reacts with water vapour to form CO_2 and H_2 . 8 CO2 3



The reactants are at 298 K. 75% of CO is converted in the reaction. The products leave the reaction chamber at 800 K.

$$C_{\text{pm,CO}} = 30.35 \frac{\text{J}}{\text{mol.K}}$$

$$C_{\text{pm,H}_2\text{O}(g)} = 36 \frac{\text{J}}{\text{mol.K}}$$

$$C_{\text{pm,CO}_2(g)} = 45.64 \frac{\text{J}}{\text{mol.K}}$$

$$C_{\text{pm,H}_2(g)} = 29.3 \frac{\text{J}}{\text{mol.K}}$$

Determine the quantity of heat to be added or removed in the reaction chamber per 1000 kg of H_2 produced.

- d. Derive the expression for effect of temperature on standard heat of reaction 7 CO2 3

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