GANDHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, ODISHA, GUNUPUR (GIET UNIVERSITY)

B. Tech (Third Semester - Regular) Examinations, November – 2024

23BCHPC23003 - Chemical Process Calculation

(Chemical Engineering)

Time: 3 hrs Maximum: 60 Marks

Answer ALL questions

(The figures in the right hand margin indicate marks)

PART – A **(2 x 5 = 10 Marks)**

Q.1. Answer ***ALL*** questions		CO #	Blooms Level
a.	Calculate the weight of $CaCl_2$ required for making 2 lit 0.2N aq. solutions.	CO2	K3
b.	Why is the vapour pressure over a solution of a component with other component less than that of its pure form of liquid?	CO1	K4
c.	Write the objective of bypass in unit operation.	CO1	K1
d.	Identify the limiting reactant with reason in the reaction of 500 g of sulphur reacts with 400 g of oxygen to produce sulphur dioxide.	CO3	K3
e.	Differentiate heat of mixing and heat of solution.	CO1	K2

PART – B **(10 x 5 = 50 Marks)**

Answer ***ALL*** the questions		Marks	CO #	Blooms Level
2. a.	10 kg of liquid A of specific gravity 1.2 is mixed with 3 kg of liquid B of sp. Gravity of 0.8. Assuming there is no volume change on mixing, what is the specific gravity of the mixture?	5	CO2	K3
b.	Prove that mole fraction = pressure fraction = volume fraction	5	CO1	K2
	(OR)			
c.	The flue gas has the following percent composition by volume CO_2=14%, SO_2=0.5%, CO=2%, O_2= 2.5% N_2= 81% Determine (a) The average molecular weight of the gas mixture (b) The composition of gas in weight percent (c) The density of the gas at 320 K and 1.5 bar	5	CO3	K4
d.	An aqueous solution of NaCl contains 20% NaCl. The 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 molarity, normality and molality of the resulting solution?	5	CO2	K3
3.a.	Write short note on Raoult's law.	5	CO1	K1
b.	The Antoine constants for n-heptane are A=13.8587, b=2911.32 and C= 56.56. P^s s in kPa and t is in K. Calculate (a) The vapour pressure of n-heptane at 325 K (b) The normal boiling point of n-heptane	5	CO2	K4
	(OR)			
c.	The vapour pressure of acetone at 273 K is 8.52 kPa and that at 353 K is 194.9 kPa. Dry air initially 101.3 kPa and 300K is allowed to get saturated with the vapours of acetone at constant temperature and volume. Determine (a) The final pressure of the mixture	5	CO3	K4

(b) The mole% of acetone in the final mixture

Assume the Clausius-Clapeyron equation is applicable to acetone

d.	Moist air contains 0.025 kg water vapour per cubic metre of mixture at 313K and 103.15 kPa. Calculate the following: (a) The relative saturation (b) The absolute humidity of the air (c) The percent saturation (d) 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 $lnP^S = 16.262 - \frac{3799.887}{T - 46.854}$	5	CO2	K3
4.a.	An single effect evaporator is fed with 10000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight (NaOH), calculate the (a) kg/h of water evaporated (b) kg/h thick liquor	5	CO2	K3
b.	The spent acid from a nitrating process contains 33% H_2SO_4, 36% HNO_3 and 31% water by weight. This acid is to be strengthened by the addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 78% HNO_3. The strengthened mixed acid is to contain 40% H_2SO_4 and 43% HNO_3. Calculate the quantities of spent and concentrated acids that should be mixed together to yield 1500 kg of the desired mixed acid.	5	CO3	K3
	(OR)			
c.	An aqueous solution of Na_2CO_3 contains 15% carbonate by weight. 80% of the carbonate is recovered as $Na_2CO_3.10H_2O$ by evaporation of water and subsequent cooling to 278 K. The solubility of Na_2CO_3 at 278 K is 9% (weight). On the basis of 100 kg of solution treated, determine the following: (a) the quantity of crystal formed (b) the amount of water evaporated	5	CO2	K4
d.	Soap as produced contains 50% moisture on a wet basis. Before it can be pressed into cake for sale, the moisture would be reduced to 20%. How many 100g cakes can be pressed from 1000 kg of wet soap?	5	CO2	K4
5.a.	Propane is burned with excess air to ensure complete combustion. If 55 kg of CO_2 and 15 kg of CO are obtained when propane is completely burned with 500 kg air. Determine: (a) The mass of propane burnt in kg (b) The percent excess air	5	CO3	K3
b.	Ethylene oxide is produced by oxidation of ethylene. 100 kmol of ethylene are fed to the reactor and the product is found to contain 80 kmol ethylene oxide and 10 kmol CO_2. Calculate (a) The percent conversion of ethylene (b) The percent yield of ethylene oxide	5	CO3	K5
	(OR)			
c.	The analysis of refinery gas by volume is	6	CO2	K3

H_2 = 74%, CH_4 = 13.5%, C_2H_6 = 7.4%, C_3H_8 =3.6%, n-C_4H_{10} =1.2%, n-C_5H_{12} = 0.3%

Component	-$\Delta H_c^0(gross), kJ/mol$	-$\Delta H_c^0(net), kJ/mol$
CH_4	890	802
C_2H_6	1560	1429
C_3H_8	2219	2043
n-C_4H_{10}	2877	2657
n-C_5H_{12}	3536	3272

Data

ΔH_f^0 of H2O(g) = -242 kJ/mol at 298 K

ΔH_f^0 of H2O(l) = -286 kJ/mol at 298 K

Specific volume at 298 at 298 K and 101.3 kPa = 24.4 m3/kmol

Calculate GCV, NCV of refinery gas in kJ/mol and kJ/m^3.

d. Calculate NCV at 298 K of a sample of fuel oil having C/H ration 9.33 (weight) and containing S as 1.3% by weight. 4 CO3 K3

GCV298K = 41785 kJ/kg, λ = 2442.5 kJ

6.a. The molal heat capacity of CO is given by 6 CO3 K3

C_p= 26.586 + 7.582 × 10^{-3} -1.12 × 10^{-6} T^2

Where C_p is in kJ/kmol.K and T in K

(a) Calculate the mean molal heat capacity in temperature range of 500-1000 K.

(b) CO enters a heat exchanger at a rate of 500 m^3 per hour at STP. Calculate the heat to be supplied to the gas to raise its temperature from 500 to 1000K

b. Calculate the std heat of formation of ethane gas at 25 ^{0}C using the following data. 4 CO2 K4

Heat of formation of CO_2(g)= -393.5 kJ/mol

Heat of formation of H_2O(l)= -285.8 kJ/mol

Heat of combustion of C_2H_6(g)= -1560.7 kJ/mol

(OR)

c. Obtain the empirical equation for calculating the heat of reaction at any temperature T (K) for the following reaction: 7 CO2 K4

$CH_4(g) + C_2H_6(g) \longrightarrow C_3H_8(g)$

Data: Standard heat of reaction at 298 k = -82.66 kJ/mol, C_p = a +bT+ cT^2, kJ/(mol.K)

Component	a	bx10^3	C x10^6
CH_4	19.2494	52.1135	11.973
C_2H_6	4.1261	155.0213	81.5455
C_3H_8	4.2227	306.264	158.6316

Using the same expression, calculate the heat of reaction at 600 ^{0}C.

d. Write short note on 'Heat of reaction'. 3 CO1 K2

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