Register No : _____

THE KAVERY ENGINEERING COLLEGE

(An Autonomous Institution)

B.E/B.TECH DEGREE END SEMESTER THEORY EXAMINATIONS, NOV /DEC 2024

Third Semester

Chemical Engineering

CH3351 - Chemical Process Calculations

(Steam Tables may be permitted)

Regulations - 2021

Duration : 3 Hrs *Maximum : 100 Marks*

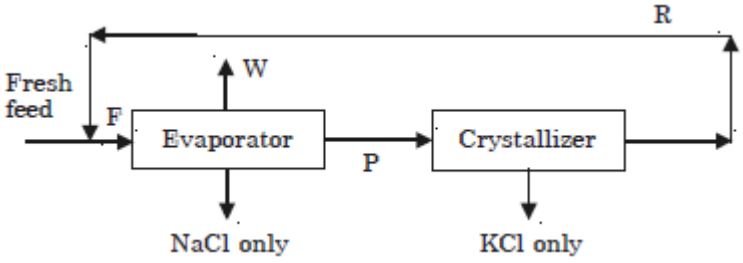
*PART – A (ANSWER ALL QUESTIONS) (Marks 10*2=20)*

Q. No	*Questions*	*BLT*	*CO*	*Marks*
1.	15 kg of CO_2 is compressed at a temperature of 303 K to a volume of 0.5 m^3. Calculate the pressure required for the given duty. Assume ideal gas law is applicable.	UN	1	2
2.	How many moles of K_2CO_3 will contain 117 kg of K?	RE	1	2
3.	Recall the material balance equations for distillation and evaporation.	RE	2	2
4.	What is limiting reactant and excess reactant?	RE	2	2
5.	Define relative humidity and saturation humidity.	RE	3	2
6.	Calculate the dew point when the mixture is at a temp of 30℃ and a pressure of 750mmHg.	UN	3	2
7.	How the heat capacity of solids is calculated using kopp's rule?	RE	4	2
8.	Define latent heat of vaporization and latent heat of condensation.	RE	4	2
9.	What are the things that would be found from proximate analysis of coal?	RE	5	2
10.	Define theoretical flame temperature and adiabatic flame temperature.	RE	5	2

*PART – B (ANSWER ALL QUESTIONS) (Marks 5*13 = 65)*

Q. No			*Questions*	*BLT*	*CO*	*Marks*
11.	a	i	By electrolyzing mixed brine a mixture of gases is obtained at the cathode having the following composition by weight: Cl_2 = 67%, Br_2 = 28%, O_2 = 5%. Using ideal gas law calculate (a) the composition by volume, (b) the density at 25℃ and 740 mm Hg, and (c) the specific gravity of the gas mixture.	AP	1	9
		ii	Calculate the average molecular weight of a gas having the following composition by volume. CO_2 = 13.1%, O_2 = 7.7% and N_2 =79.2%.	AP	1	4
			Or			
	b	i	Pure water and alcohol are mixed to get a 60% (weight) alcohol solution. The densities in kg/$m^3$of water, alcohol and the solution may be taken as 998, 798 and 895 respectively at 293 K. Calculate the following: (a) Volume percent of ethanol in the solution at 293K, (b) Molarity and Molality.	AP	1	9
		ii	A sample of limestone is reported to contain 54.5% CaO by weight. If this CaO is present as $CaCO_3$ in the limestone. Find the % content of $CaCO_3$ in limestone.	AP	1	4

12.	a	A waste acid from a nitrating process contains 23% HNO_3, 57% H_2SO_4 and 20% water by weight. This acid is to be concentrated to contain 27% HNO_3, 60% H_2SO_4 by the addition of concentrated H_2SO_4 containing 93% H_2SO_4 and concentrated HNO_3 containing 90% HNO_3. Calculate the amount of waste acids and concentrated acids that must be combined to obtain 1000 kg of desired mixture.	AP	2	13
		Or			
	b	A solution containing 10% NaCl, 3% KCl and water is fed to the process shown in Figure at the rate of 18,400 kg/h. The compositions of the streams are as follows: Evaporator product *P* - NaCl: 16.8%, KCl : 21.6% and water. Recycle product *R* - NaCl: 18.9% and water. Calculate the flow rates in kg/h and compute the composition of feed to the evaporator (*F*).	AP	2	13



13.	a	The dry bulb temperature and dew point of ambient air were found to be 302 K and 291 K respectively, Barometer reads 100 kPa. Calculate: (a) Absolute molal humidity, (b) Absolute humidity, (c) % Relative humidity, (d) % Saturation, (e) Humid heat and (f) Humid volume Data: Vapour pressure of water at 291 K = 2.0624 kPa Vapour pressure of water at 302 K = 4.004 kPa	AP	3	13
		Or			
	b	An air–water vapour mixture has relative humidity of 80% at 293 K temperature and 100 kPa pressure. Calculate: (a) molal humidity of air, (b) molal humidity of air if its temperature is reduced to 283 K and the pressure is increased to 174.65 Kpa condensing out some of the water, (c) the weight of water condensed from 500 kg of original wet air in the process of part (b), (d) the final volume of the wet air of the part (c). Data: Vapour pressure of water at 293 K = 2.40 kPa Vapour pressure of water at 283K = 1.266 kPa.	AP	3	13
14.	a	The gas having the following composition is at temperature of 775 K: SO_2 = 7.09%, O_2 = 10.55%, SO_3 = 0.45% and N_2 = 81.91%. Calculate the heat content of 1 kmol gas mixture over 298 K using the heat capacity date given below.	AP	4	13

$C^{o}_{P} = a + bT + cT^2 + dT^3$, kJ/(kmol. K)

Gas	a	b x 10^3	c x 10^6	d x 10^9
SO_2	24.7706	62.9481	- 44.2582	11.122
O_2	26.0257	11.7551	- 2.3426	- 0.5623
SO_3	22.0376	121.624	- 91.8673	24.3691
N_2	29.5909	- 5.141	13.1829	- 4.968

Or

	b	Calculate the enthalpy change between reactant and products if both are at 298.15 K if 60 mol CO_2 is produced according to the following reaction. $2\ C_4H_{10}\ (g) + 13\ O_2\ (g) \rightarrow 8\ CO_2\ (g) + 10\ H_2O\ (l)$ Component | ΔH^o_f, KJ/mol at 298.15 K C_4H_{10} (g) | - 125.79 CO_2 (g) | - 393.51 H_2O (l) | - 285.83	AP	4	7
	ii	Solve for the heat of formation of benzoic acid crystal ($C_7H_6O_2$) at 298.15 K using the following data. Standard heat of formation of CO_2 (g) = - 393.15 KJ/kmol. Standard heat of formation of H_2O (l) = - 285.83 KJ/kmol. Standard heat of combustion of benzoic acid crystal = - 3226.95 KJ/kmol.	AP	4	6
15.	a i	The flue gas from an industrial furnace has the following composition by volume. CO_2 = 11.73%, CO = 0.2%, H_2 = 0.09%, O_2 = 6.81% N_2 = 81.17%. Calculate the percentage excess air used, if the loss of carbon in the clinker and the ash is 1% of the fuel used.	AP	5	7
	ii	Determine the combustion gas analysis when a medium fuel oil with 84.9% carbon, 11.4% hydrogen, 3.2% sulphur, 0.4% oxygen and 0.1% ash by weight is burnt with 25% excess air. Assume complete combustion.	AP	5	6
		Or			
	b	A synthetic gas generated from coal has the following composition: CO_2 = 7.2%, CO = 24.3%, H_2 = 14.1%, CH_4 = 3.5% and N_2 = 50.9%. (a) Calculate the cubic metre of air necessary for complete combustion per cubic metre of synthetic gas at the same conditions. (b) If 38% excess air were used for combustion, what volume of flue gas at 400 °C and 738 mm Hg would be produced per cubic foot of synthetic gas at standard conditions? (c) Calculate the flue gas analysis for (a) and (b).	AP	5	13

*PART – C (Marks 1*15 = 15)*

Q. No		*Questions*	*BLT*	*CO*	*Marks*
16.	a	Hydrogen gas is burned in an adiabatic reactor with two times the theoretical quantity of air, both air and hydrogen being at 298 K initially. Calculate the temperature of the reaction products. The standard heat of formation of gaseous water is -241.826 KJ/mol. The heat capacities (KJ/Kmol K) of the gases are given below: Water vapour: $Cp = 30.475 + 9.652 \times 10^{-3} T + 1.189 \times 10^{-6} T^2$ Nitrogen: $Cp = 27.034 + 5.815 \times 10^{-3} T - 0.2889 \times 10^{-6} T^2$ Oxygen: $Cp = 25.611 + 13.260 \times 10^{-3} T - 4.2077 \times 10^{-6} T^2$	AP	4	15
		Or			
	b i	The purge gas obtained from ammonia synthesis loop has the following molar composition: H_2 = 69%; N_2 = 23%; Ar = 2.7% and CH_4 = 5.3%. It is burnt with 20% excess air. Calculate the theoretical air required and molar composition of the flue gas.	AP	5	8
	ii	100 kg coal containing 90% carbon and rest ash is burn with 20% excess air. 80% of coal burnt is converted to CO_2 and rest to CO. Calculate the flue gas composition.	AP	5	7