Reg. No. : | | | | | | | | | | | | |

Question Paper Code:R3902

B.E./B.Tech. DEGREE EXAMINATION, NOV 2024

Third Semester

Chemical Engineering

R21UCH302 – CHEMICAL PROCESS CALCULATIONS

(Regulations R2021)

Duration: Three hours | Maximum: 100 Marks

PART A - (10 x 2 = 20 Marks)

1.	How many kilograms of ethane are there in 210 kmol?	CO1 -U
2.	State Boyle's law and Charles's law	CO1 -U
3.	What is the significance of the McCabe-Thiele method in material balance calculations for distillation?	CO2 -U
4.	Sketch the block diagram for drying operation and write its material balance equation.	CO2 -U
5.	How does temperature affect relative humidity? Provide an example.	CO3 -U
6.	List difference between dry bulb temperature and wet bulb temperature.	CO3 -U
7.	Differentiate between sensible heat and latent heat. Provide an example of each.	CO4 -U
8.	Define heat capacity. How does it differ between solids, liquids, and gases?	CO4 -U
9.	How do temperature changes affect the heat of reaction?	CO5 -U
10.	What is the importance of calculating Gross Calorific value?	CO5 -U

PART – B (5 x 16= 80 Marks)

11.	(a)	A gaseous mixture has the following composition by volume: CH_4 = 1 % CO_2 = 8%, CO = 14, O_2 = 6%, H_2O = 1% N_2 = 66%. Calculate: (i) Average molecular weight of the gas mixture. (ii) Density of the gas mixture at 303 K (30°C) and 101.325 kPa.	CO1 -App	(16)
	(b)	By electrolyzing mixed brine, a gaseous mixture is obtained at the cathode having the following composition by weight. Cl_2 – 67%	CO1 -App	(16)

Br – 28%, and O_2 _ 5%.
Solve :
(a) Composition of gas by volume.
(b) Average molecular weight.
(c) density of Gas mixture at 298 K and 1atm.

12. (a) In manufacture of acetic acid by oxidation of acetaldehyde, 100 kmol of acetaldehyde is fed to a reactor per hour. The product leaving the reactor contains 14.81% acetaldehyde, 59.26% acetic acid, and rest oxygen (on mole basis). Find the percentage conversion of acetaldehyde. CO2 -App (16)

(b) A feed to a continuous fractioning column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of the distillate shows 60 weight % benzene and 7 weight % benzene was found in the bottom product.
(i) Calculate the amount of distillate and bottom product per 1000 kg of feed per hour.
(ii)Calculate the percent recovery of benzene. CO2 -App (16)

13. (a) A gas mixture containing benzene vapour is saturated at 101.325 KPa and 323 K. Calculate the absolute humidity if the other component of a mixture is (a) Nitrogen and (b) Carbon dioxide.

Data: Vapor pressure of the benzene at 323 K = 36.664 Kpa CO3 -App (16)

(b) An aqueous solution containing 58% $NaNO_3$ from an evaporator is fed to the crystallizer. The crystals obtained from crystallizer contain 4% water (crystals of $NaNO_3$ carry off 4% water). The mother liquor from the crystallizer is recycled to the evaporator with 1000 kg\h feed containing 20% $NaNO_3$. The mother liquor contains 0.5 kg $NaNO_3$ per kg water.
Calculate:
(i) The yield of crystals.
(ii) The mass flow rate of recycled mother liquor.
(iii) The composition of mixed feed entering the evaporator.
(iv) The total feed rate to the evaporator. (All percentages are by weight). CO3 -App (16)

14. (a) Methane is burned with air. Initially, both are at 298K. The flame temperature is 1598 K. The combustion reactions is CO4 -App (16)

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

The standard heat of reaction at 298 K is - 8.028 K.X10 J/mol methane burned. The mean heat capacities in J/ (mol K) are 51.66 for CO_2 40.45 for H_2O 34.01 for O_2 and 32.21 for N_2. Assuming complete combustion, determine the excess air used.

(b) In manufacture of chlorine, feed containing hydrochloric acid gas and air are fed to an oxidizer. The product gases leaving the oxidizer are found to contain 13.25 % HCL, 0.3% O_2 42.9 % N_2 30% Cl_2 and 7.6%H2O (by weight). CO4 -App (16)

Calculated:

(a) The percent excess air used.

(b) The composition by weight of gases entering the oxidizer.

(c) The degree of completion of oxidation.

15. (a) The producer gas made from the coke has the following composition by volume. CO5 -App (16)

CO- 28.0%, CO2-3.5%, O2-0.5% and N2-68.0%.The gas is burned with such a quantity of air that the oxygen from air is 20% in excess of the oxygen required for complete combustion. If the combustion is 98% complete. Calculate the weight of the gaseous product formed per 100kg of gas burned.

(b) The analysis of coal indicates 70% C, 20% H, 2% S and the balance non-combustible ash (by weight). The coal is burned at a rate of 5000kg/h and feed rate of air to furnace is 50 kmol/min. All of the ash and 60% of the carbon in the fuel leave the furnace as a molten slag: the remainder of the carbon leaves in the stack gas as CO and CO_2; the hydrogen in the coal is oxidized to water CO5 -App (16)