Time: 2 Hours **Total Marks: 60**

N.B.: 1) Question No.1 is compulsory.
2) Answer any three questions from remaining questions.
3) Assume data if necessary and specify assumptions clearly.

Q.1 **Answer any THREE.** **[15]**

a) Write the following definitions:
1. Conversion 2. Selectivity 3. Purge ratio 4. Bypass 5. Latent heat

b) Draw the block diagram of Evaporation and Distillation operation and write the overall and component material balance.

c) Explain Hess's Law.

d) What do you mean by Recyle, Bapass and Purge operations, explain in detail.

Q.2 a) A feed to a continuous fractionating column analyses 28 % Benzene and 72 % toluene by weight. The analysis of the distillate shows that 52 weight % Benzene and 5 weight % Benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour. Also Calculate the % recovery of benzene. **[08]**

b) The gross heating value of gaseous propane at 298 K is 2219.71 kJ/mol. Compute its net heating value. **[07]**

Q.3 a) A vapor at 411 K and Standard atmospheric pressure, containing 0.72 mole fractions Benzene and 0.28 mole fractions Toluene serve as a feed to a fractionating column in which it is separated in to a distillate containing 0.995 mole fraction Benzene and bottoms with 0.97 mole fraction Toluene. The reflux ratio is desired to be 1.95 kmol/kmol of distillate product. For a feed of 100 kmol, compute the overall material and energy balances. Assume that there is no heat loss to the surrounding and the heat of solution is negligible. **[08]**
Enthalpy of Vapors(overhead)=42170 kJ/kmol mixture
Enthalpy of liquid(overhead)=11370 kJ/kmol mixture
Specific enthalpy of bottom product= 18780 kJ/kmol mixture
Enthalpy of feed = 44500 kJ/kmol

b) Oxidation of ethylene to produce ethylene oxide is given by reaction: **[07]**

$$C_2H_4 + \frac{1}{2}O_2 \longrightarrow C_2H_4O$$

If air is used 20 % in excess of that theoretically required, calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.

Q.4 a) Formaldehyde is Produced by dehydrogenation of methanol. **[10]**

$$CH_3OH \longrightarrow HCHO + H_2$$

The per pass conversion is 67%. The product leaving the reactor is fed to a separation unit battery where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to the reactor. If the production rate of formaldehyde is 1000 kg/h. Calculate

1. the combined feed ratio
2. The flow rate of methanol required to the process as fresh feed.

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b) A producer gas contains 28% CO, 3.5% CO_2, 0.5% O_2 and 68% N_2. 100 kg of this gas is burned with 20% excess air. If the combustion is only 90% complete, determine the composition of the flue gas. **[05]**

Q.5 a) A drier is fed with wet solids to reduce the moisture content from 80% to 15%. The product leaving the drier is admitted into an oven which further brings down the moisture to 2%. If the drier can handle 1000 kg of wet solids per day. Calculate **[08]**

1. The weight of product leaving the drier and oven per day.
2. The percentage of the original water that is removed in the drier and oven.

b) Temperature of oxygen is raised from 850 K to 1500 K. calculate the amount of heat that must be supplied for raising the temperature of 1 kmol oxygen using C_P^0 data given below. **[07]**

C_P^0 (Oxygen)=26.0257–11.7551×10 $^{-3}$ T-2.3426×10^{-6} T^2–0.5623×10^{-9} T^3.

Q.6 a) Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the reaction: **[08]**

$$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$$

Data: ΔH^0_R= -46.222 kJ

C_P^0 = a+bT+cT^2 , kJ/(mol.K)

Component	a	b×10^3	c×10^6
NH_3	25.48	36.89	-6.305
N_2	27.31	5.2335	-4.1868
H_2	29.09	-8.374	2.0139

b) Calculate the standard heat of formation of liquid methanol. **[07]**

Data:

Std. Heat of combustion of methanol= -726.55 kJ/kmol

Std. Heat of formation of gaseous CO_2 = -393.51 kJ/kmol

Std. Heat of formation of liquid H_2O = -285.84 kJ/kmol

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