

08 DEC 2025 SE CHEMICAL (SEM-III) (NEP-2020) PC QP CODE: 10098321

Time: 02 Hrs

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) Explain in detail Recycle ratio and Purge operations
 b) Explain Hess's Law with example
 c) Write an note on following
 a) Proximate analysis b) Ultimate analysis c) Wet bulb temperature d) dry bulb temperature e) Theoretical excess air
 d) Draw the material balance diagram for Crystallization and Extraction and write down their material balance
- 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) Oxidation of ethylene to produce ethylene oxide is given by reaction: [07]

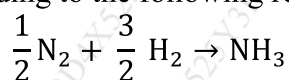
$$\text{C}_2\text{H}_4 + \frac{1}{2} \text{O}_2 \longrightarrow \text{C}_2\text{H}_4\text{O}$$
 If air is used 20 % in excess of that theoretically required, calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.
- Q.3 a) A producer gas contains 28% CO, 3.5% CO₂, 0.5% O₂ and 68% N₂. 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 [08]
 b) A weak acid containing 12.5% H₂SO₄ and the rest water is fortified by adding 500 kg of concentrated acid containing 80% H₂SO₄. Determine the amount of the solution obtained if it contains 18.5% H₂SO₄. [07]
- Q.4 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. [10]
 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) Using Hess's Law evaluate the heat of formation of CaCO_{3(s)} from following data: [05]

$$\text{Ca}_{(s)} + \frac{1}{2} \text{O}_{2(g)} \rightarrow \text{CaO}_{(s)} \quad \Delta H^0 = -635.8 \text{ kJ}$$

$$\text{C}_{(s)} + \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} \quad \Delta H^0 = -393.8 \text{ kJ}$$

$$\text{CaO}_{(s)} + \text{CO}_{2(g)} \rightarrow \text{CaCO}_{3(s)} \quad \Delta H^0 = -178.2 \text{ kJ}$$

Q.5 a) Ammonia is synthesized according to the following reaction: [08]



The specific heats of the components are represented by:

$$C_p = \alpha + \beta T + \gamma T^2$$

Where C_p is in $\text{J/mol} \cdot \text{K}$ and α, β, γ are constants

Component	α	β	γ
NH ₃	25.48	36.89×10^{-3}	-6.305×10^{-6}
N ₂	27.31	5.2335×10^{-3}	-4.1868×10^{-9}
H ₂	29.09	-8.374×10^{-3}	2.0139×10^{-6}

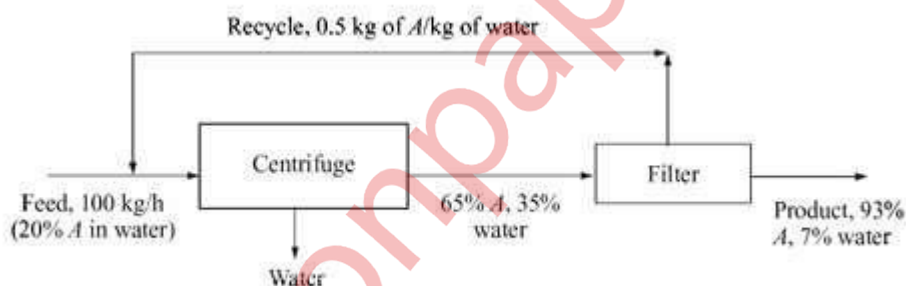
Determine the heat of reaction at 700 K.

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 CO₂ = -393.51 kJ/kmol, Std. Heat of formation of liquid H₂O = -285.84 kJ/kmol

Q.6 a) Final purification stage in the preparation of a pharmaceutical product A from natural sources requires centrifuging and continuous filtration as depicted in figure. Determine the flow rate of the recycle stream in kg/h. [08]



b) A stream of carbon dioxide is flowing at a rate of 100 kmol/h is heated from 298 K to 383 K. Calculate the heat that must be transferred: [07]

$$C_p^0 \text{ For CO}_2 \text{ (kJ/kmol.K)} = 21.3655 + 64.2841 \times 10^{-3} T - 41.0506 \times 10^{-6} T^2 - 9.7999 \times 10^{-9} T^3.$$
