GATE PSUs
State Engg. Exams

MADE EASY Workbook 2024

Detailed Explanations of Try Yourself *Questions*

Chemical Engineering

Process Calculation

1 Basic Chemical Calculations

Detailed Explanation of Try Yourself Questions

T1 : Solution

[Ans : (i) 24.44, (ii) 2.95]

For ideal gas [Volume% = Mole%]

$$\text{Mole fraction of } CH_4 = \frac{66}{100} = 0.66$$

$$\text{Mole fraction of } CO_2 = \frac{30}{100} = 0.30$$

$$\text{Mole fraction of } NH_3 = \frac{4}{100} = 0.04$$

$$M_{avg.} = \text{Average molecular weight of gas}$$

$$= 16 \times 0.66 + 44 \times 0.30 + 0.04 \times 17 = 24.44$$

$$\rho = \text{Density of gas} = \frac{PM_{avg}}{RT}$$

$$P_{abs} = 202.65 + 101.325 = 303.975 \text{ kPa}$$

$$T = 303 \text{ K}, M_{avg} = 24.44$$

$$\rho = \frac{303.975 \times 24.44}{8.314 \times 303} = 2.95 \text{ kg/m}^3$$

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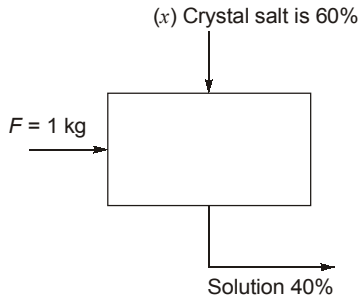
2 Material Balances with and Without Chemical Reactions

Detailed Explanation of Try Yourself Questions

T1 : Solution

[Ans : (1)]



$$\text{\% Salt in crystal} = \frac{135}{135+5\times18} = 0.6$$

$$1 \times 0.2 + k \times 0.60 = (1 + x) \times 0.40$$

$$x = 1 \text{ kg crystal}$$

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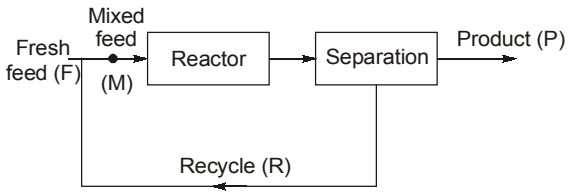
3 Recycle, Purge and Bypass Operation

Detailed Explanation of Try Yourself Questions

T1 : Solution

(Ans : 8.54, 195 kmol)

Assuming 100 kmol of C_3H_8 as fresh feed.



By propane balance:

$$(100 + R \times 0.9947) \times 0.9 = P \times 0.026 + R \times 0.9947 \quad \text{... (i)}$$

$$(100 + R \times 0.9947) \times 0.1 = P \times 0.487 \quad \text{... (ii)}$$

On solving equation (i) and (ii)

$$R = 853.84 \text{ kmol}$$

$$P = 195 \text{ kmol}$$

(a) Ratio of recycle to feed $= \dfrac{853.84}{100} = 8.54$

(b) Quantity of product stream in kmol per 100 kmol of fresh feed is 195 kmol.

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4 Energy Balance

Detailed Explanation of Try Yourself Questions

T1 : Solution

(Ans : 92600 kJ/hr)

Basis 100 mol of A as feed

Product contains: C = 200 mol, D = 300 mol, B = 50 mol

Heat of reaction at 300°C = Enthalpy of products – Enthalpy of reactants + Std. heat of reaction

$= (200 \times 12 + 300 \times 15 + 50 \times 10) - 0 - 100 \times 10^3$

$= -92600$ kJ/hr

Heat transferred from the reactor = 92600 kJ/hr.

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5 Combustion

Detailed Explanation of Try Yourself Questions

T1 : Solution

(i) 552.38 kg, (ii) 505.6 kg (N_2), (iii) 691.2 kg

$$\underset{\substack{32\\(2}}{CH_4} + \underset{\substack{64\\4}}{2O_2} \rightarrow \underset{\substack{32\\2}}{CO_2} + \underset{\substack{64\\4)}}{2H_2O}$$

(i) $\dfrac{4}{0.21} \times 29 = 552.38$ kg air

(ii) $\dfrac{4.8}{0.21} \times 0.79 \times 28 = 505.6$ kg (N_2)

(iii) $CH_4 + \dfrac{3}{2}O_2 \rightarrow CO + 2H_2O$

$$\underset{\substack{0.2\\1.8}}{CH_4} + \underset{\substack{0.3\\3.6}}{2O_2} \rightarrow \underset{\substack{0.2\\1.8}}{CO_2} + \underset{\substack{0.4\\3.6}}{2H_2O}$$

Now, effluent streams

$CO_2 \rightarrow 1.8$ kmol $\rightarrow 79.2$ kg

$CO \rightarrow 0.2$ kmol $\rightarrow 5.6$ kg

$H_2O \rightarrow 4$ kmol $\rightarrow 72$ kg

$O_2 \rightarrow 0.9$ kmol $\rightarrow 28.8$ kg

$N_2 \rightarrow 505.6$ kg

Total = 691.2 kg

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