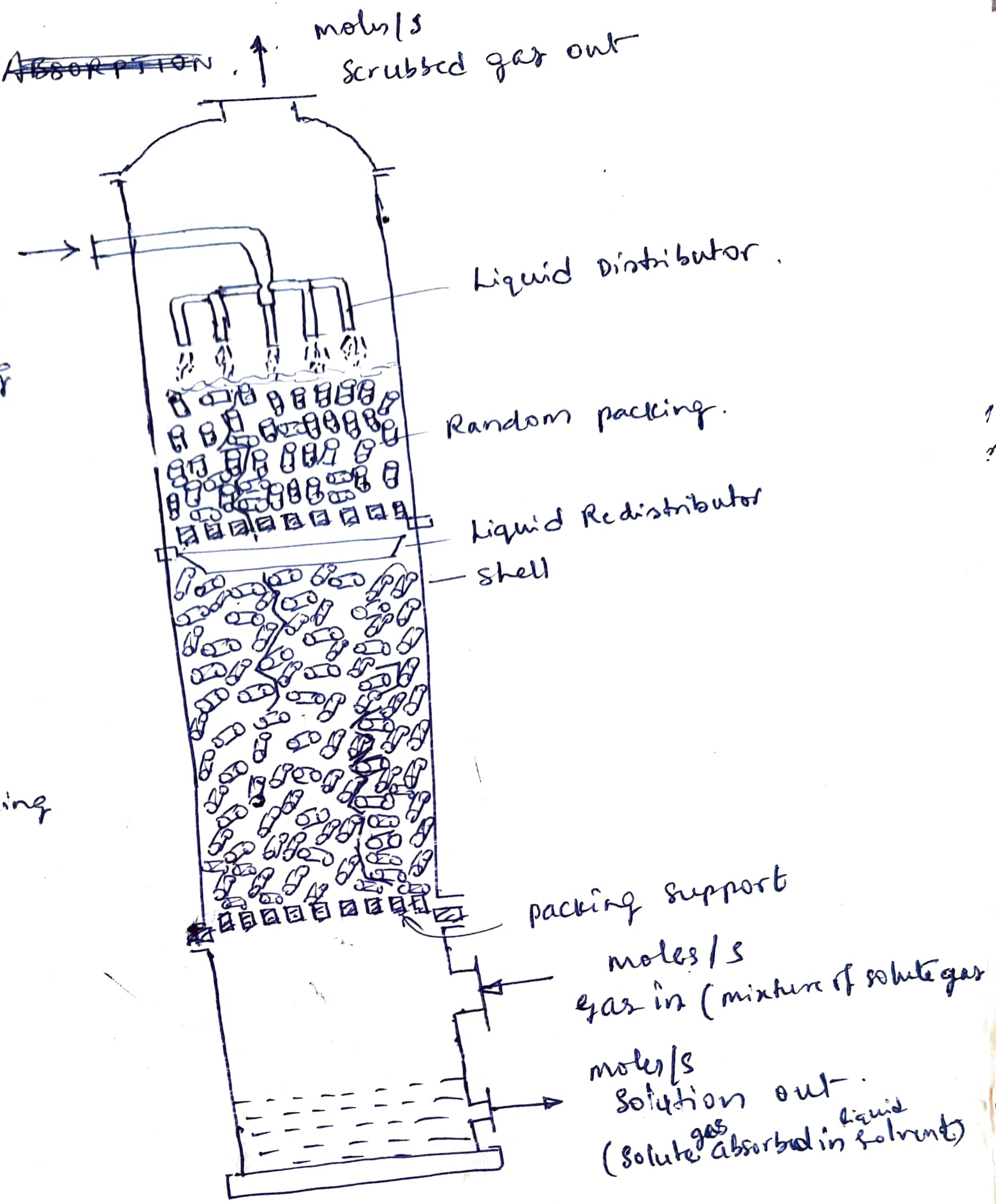
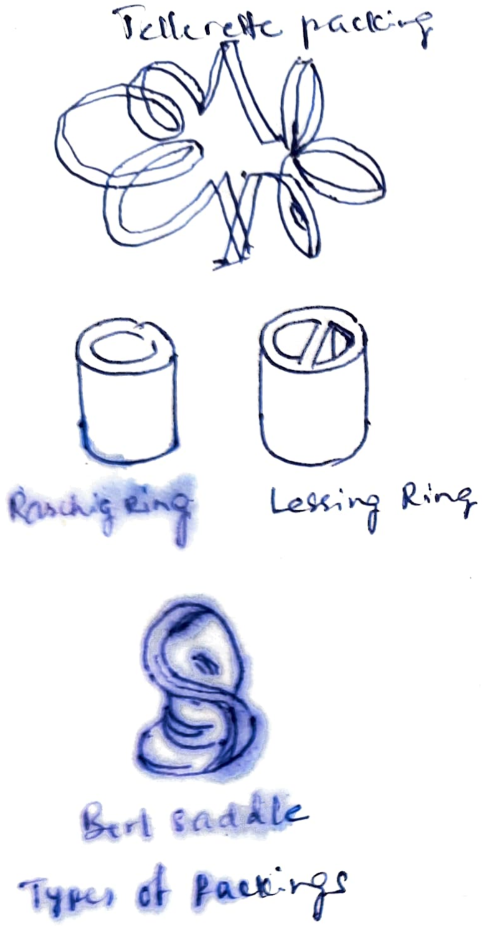
ABSORPTION OR SCRUBBING



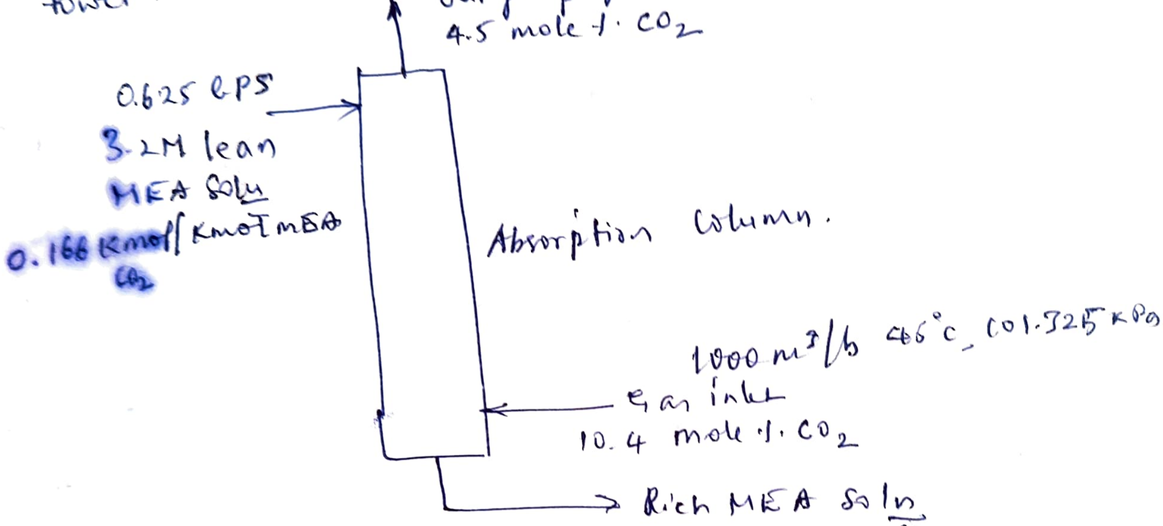


Gas absorption is an operation in which a gas mixture is contacted with the liquid for the purposes of dissolving one or more components of the gas and to provide a solution of them in the liquid. For, example, the gas from by product coke ovens is washed with water to remove ammonia.

Stripping:

Stripping or desorption is an operation in which a dissolved gas of a solution is stripped off from the liquid using a stripping medium (steam or air)

① An Absorption tower is packed with Tellerette Packing is used to absorb carbon dioxide in an aqueous monoethanolamine (MEA) solution. The volumetric flow rate of incoming dry gas mixture is 1000 m³/h at 45°C, 101.325 kPa, The CO_2 content of the gas is 10.4 mole %, while the outgoing gas mixture contains 4.5 mole % CO_2. A 3.2M MEA solution is introduced at the top of the tower at the rate of 0.625 lps. Dissolved CO_2 concentration of the entering solution is 0.166 kmol/kmol of MEA. Find the concentration of dissolved CO_2 in the solution leaving the tower.



Absorption of CO_2 in aqueous MEA soln

Basis: 0.625 lps MEA soln.

Concentration of MEA soln = 3.2 M
= 3.2 mole/lit.

Chemical formula of MEA = $HOCH_2CH_2NH_2$

Molecular weight of MEA = 61 kg/kmol or g/mole

Concentration of MEA in soln = $3.2 \frac{mole}{lit} \times 61 \frac{g}{mole}$

= 195.2 g/l solution

Total MEA entering the tower = $195.2 \times \frac{g}{l} \times 0.625 \frac{l}{s}$

= 122 g/s

= $\frac{122}{(1/3600)} \frac{g}{hr}$

= 439200 g/hr.

Moles of MEA entering the tower $= 3.2 \frac{\text{moles}}{\cancel{\ell}} \times 0.625 \frac{\cancel{\ell}}{s}$

$= 2 \text{ Moles}/s$

$= \frac{2}{1000} \text{ Kmoles}/s$

$= 0.002 \text{ Kmol}/s$

$= \frac{0.002 \times}{\left(\frac{1}{3600}\right)} \text{ Kmol}/\text{hr}$ $\qquad 1s = \frac{1}{3600} \text{ hr}$

$= 7.2 \text{ Kmol}/\text{hr},$

Dissolved CO_2 in the entering soln.

$= 0.166 \text{ Kmol}/\text{Kmol MEA}.$

1 Kmol MEA contains — 0.166 Kmol CO_2

7.2 Kmol/hr MEA contains — ? $\frac{7.2 \times 0.166 \text{ Kmol}}{1 \text{ Kmol}}$ $\frac{\text{Kmol MEA}}{\text{hr}}$

$= 1.1952 \frac{\text{Kmol } CO_2}{\cancel{\text{Kmol}}\ \text{hr}}$

$\frac{\text{Kmol } CO_2}{\cancel{\text{Kmol MEA}}} \times \frac{\cancel{\text{Kmol MEA}}}{\text{hr}}$

volumetric flow rate of dry gas mixture $= 1000 \text{ m}^3/\text{hr}.$

Specific volume of dry gas mixture at 45°C (318 K), 101.325 kPa.

1 - Conditions at STP
2. Existing gas conditions

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\frac{\cancel{101.325} \times 22.416 \frac{m^3}{\text{Kmol}}}{273} = \frac{\cancel{101.325} \times V_2}{318}$

$V_2 = 26.11 \text{ m}^3/\text{Kmol}.$

Molar flow rate of gas $= \frac{1000 \frac{m^3}{hr}}{26.11 \frac{m^3}{\text{Kmol}}}$

$= 38.299 \text{ Kmol}/\text{hr}.$

Moles of CO_2 in the inlet gas $= 38.299 \frac{\text{Kmol}}{\text{hr}} \times \left(\frac{10.4}{100}\right)$

$= 3.983 \text{ Kmol}/\text{hr}.$

dry gas % = 100 − 10.4 = 89.6%

dry ~~free~~ gas in the inlet gas mixture $= 38.299 \times (0.896)$
$= 34.315$ Kmol/hr.

Outgoing gas contains 4.5 mole% CO_2 and 95.5% dry gas

~~Molar flow rate of CO_2 in the outgoing gas mixture = 34.318 / 0.955~~ 0.045

Material balance of dry gas.

Dry gas in the outlet gas = dry gas in the inlet gas = ~~35.931 Kmol/hr~~

Molar flow rate of outgoing gas mixture (CO_2 + dry gas) × 0.955 = 34.315

~~CO_2 absorbed =~~

Molar flow rate of the outgoing gas mixture

$$= \frac{34.315}{0.955}$$

$= 35.931$ Kmol/hr.

mole of CO_2 in the outlet gas $= 35.931 \times 0.045$
$= 1.616$ Kmol/hr.

CO_2 absorbed = CO_2 in inlet gas − CO_2 in outlet gas

$= 3.983 - 1.616$
$= 2.366$ Kmol/hr.

CO_2 in rich MEA soln = CO_2 in lean MEA soln entering tower + CO_2 absorbed by lean MEA soln

= ~~7.2 kmol/hr~~ 1.1952 + 2.366 kmol/hr.

= 3.5612 kmol/hr

Concentration of CO_2 in rich MEA soln $= \frac{3.5612}{7.2}$
$= 0.4946$ kmol CO_2/kmol

$$\frac{\text{kmol } CO_2/\cancel{hr}}{\text{kmol MEA}/\cancel{hr}}$$