

Gas absorption

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What is gas absorption?

- Gas absorption also known as scrubbing is an operation in which a gas mixture is contacted with a liquid for the purpose of preferentially dissolving one or more components of the gas and to provide a solution of them in the liquid.
- Molecular diffusion requires the mass transfer of the gas components from the gas phase to the liquid phase.

Types of gas absorption

- Chemical gas absorption reaction between the absorbent and solute. Examples include using NaOH as an absorbent to dissolve acid gas, dissolving CO₂ and H₂S in aqueous solution of MEA.
- Physical gas absorption No significant chemical reactions between the absorbent and solute. Examples include almost all gas absorptions that use water or hydrocarbon oils as absorbent.

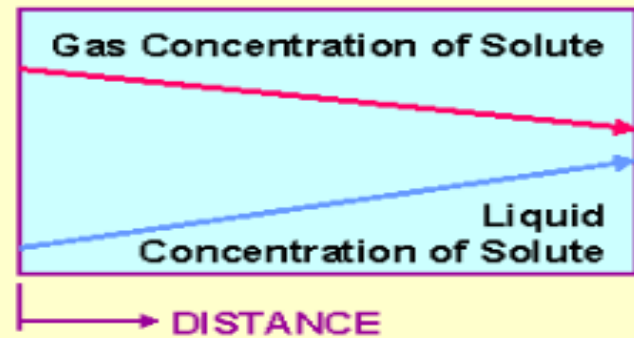
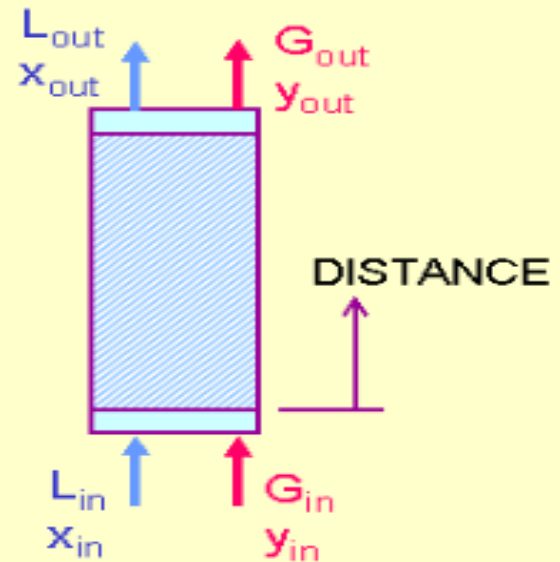
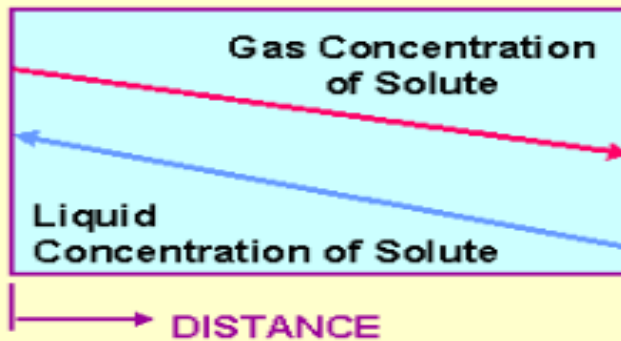
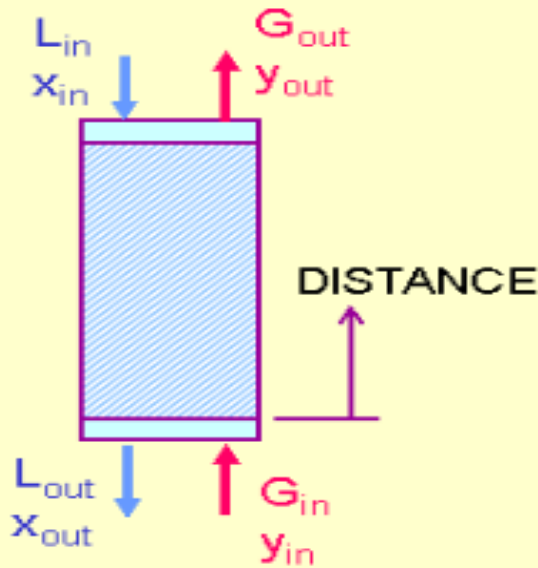
Choice of solvents for gas absorption

- Gas solubility- should be high in order to increase rate of absorption and decrease amount of solvent needed.
- Volatility-solvent should have low vapor pressure to reduce loss of solvent in the gas leaving the absorption column
- The materials of construction for the equipment should not be too expensive
- Low viscosity is preferred for high absorption rate, low pressure drop, and good heat transfer.
- The solvent should be inexpensive & readily available
- Solvent should be non-toxic, non-flammable and chemically stable

Factors considered in designing gas absorption column

- Minimum liquid flow rate
- Gas flow rate
- Loading point
- Flooding point
- Pressure drop along transfer units in the column
- Optimum operating condition for the packed column is located between the loading point & the flooding point
- Diameter and height of column (Number of transfer units, Height of transfer units)

Counter and co current gas absorption



Counter-current gas absorption

- The gas is introduced from the bottom while the liquid is introduced from the top.
- As we gradually move up the column, the gas component (A) is continuously transferred from the gas phase to the liquid phase.
- Moving up the column, there's a decrease in total gas flow rate and a decrease in concentration of A in the gas phase.
- Moving down the column, there's an increase in total liquid flowrate and an increase in concentration of A in the liquid phase

Co-current gas absorption

- The gas and liquid are both introduced from the same side of the column
- The operating line has a negative slope
- It is rarely used in industries as it is less efficient than counter-current.
- It requires an infinitely tall column to produce liquid and gas streams at equilibrium

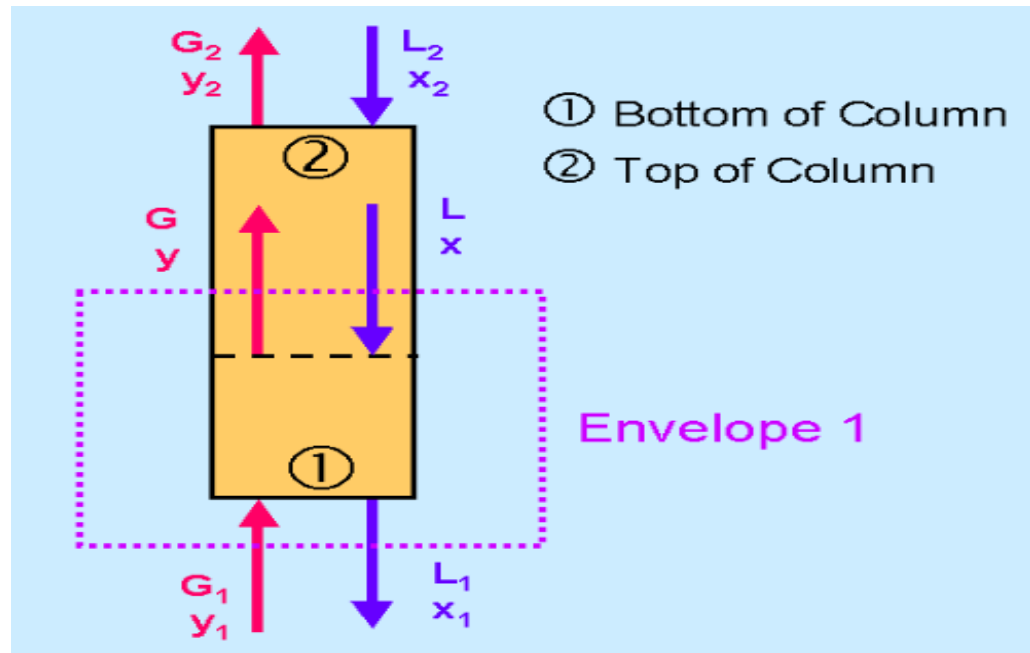
Mass balance of counter current gas absorption

Assuming steady state; mass in = mass out

$$\text{Thus, } G \cdot y + L_1 \cdot x_1 = L \cdot x + G_1 \cdot y_1$$

For dilute systems, the solute content is relatively small compared to the absorbent and non-soluble inert, so constant flowrate is assumed.

$$\begin{aligned} G_1 &= G = G_2 \\ L_1 &= L = L_2 \end{aligned}$$



Mass balance of counter current gas absorption

The equation becomes:

$$Gy = Lx + Gy_1 - Lx_1$$

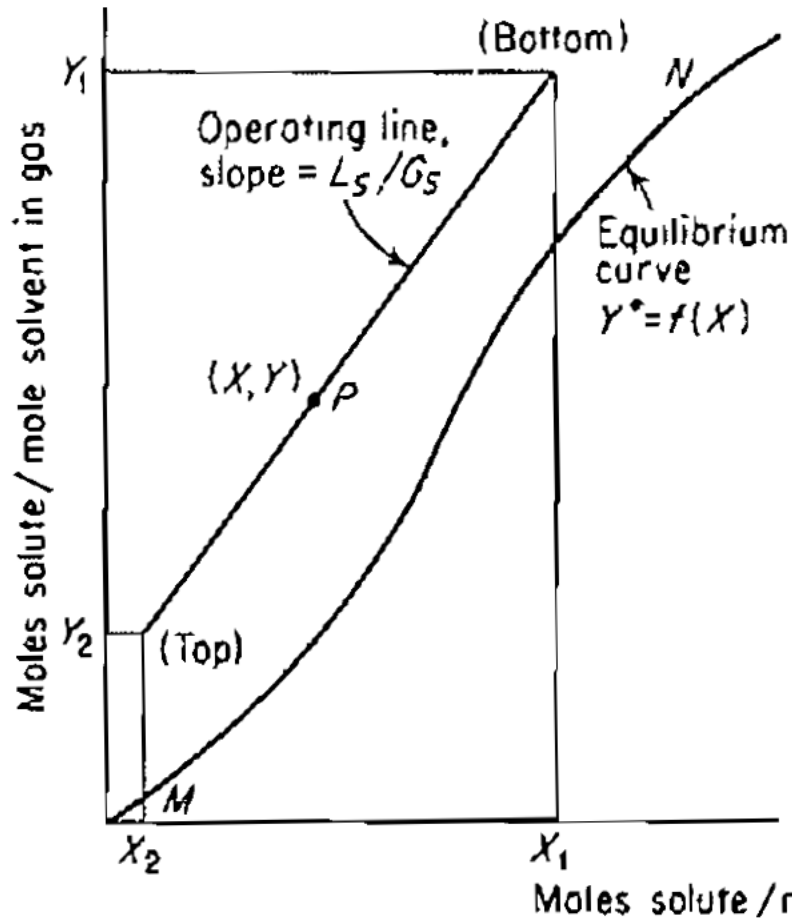
Rearranging, we get

$$y = \left(\frac{L}{G} \right) x + \left(\frac{Gy_1 - Lx_1}{G} \right)$$

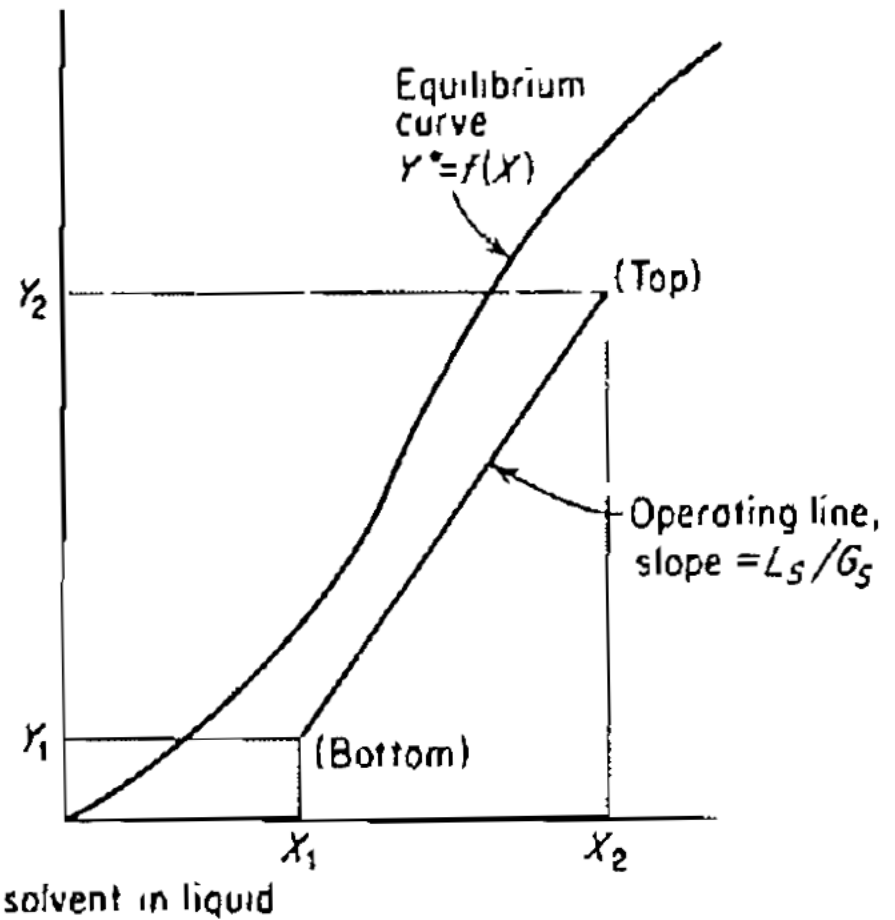
This is the equation of the operating line with gradient (L/G), the liquid to gas ratio.

$$\left(\frac{L_{\min}}{G} \right) = \left(\frac{y_1 - y_2}{x_{1(\max)} - x_2} \right)$$

Operating line for absorber and stripper

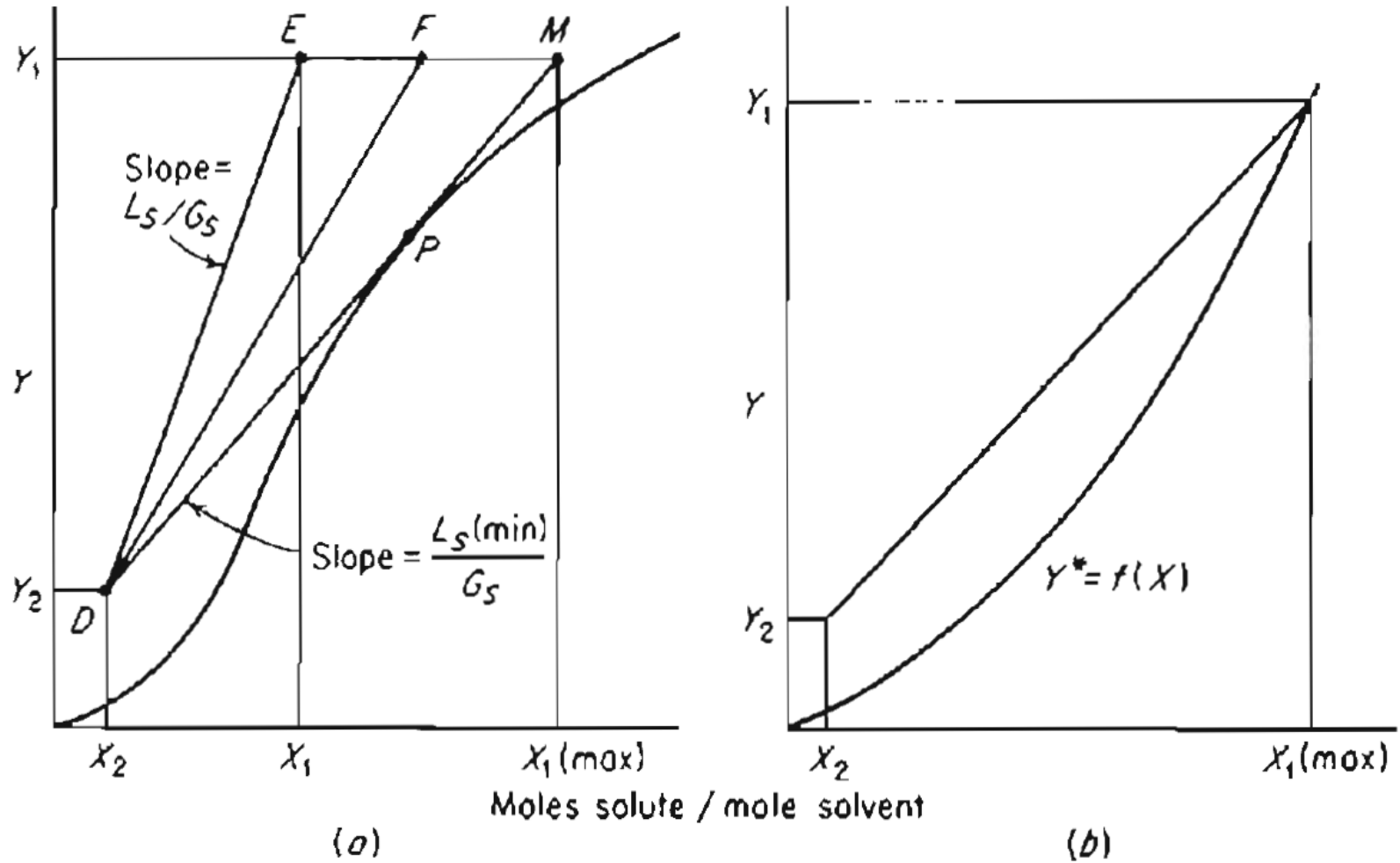


(a) Absorber



(b) Stripper

Minimum liquid gas ratio, absorption



Properties of ideal solution

- The intermolecular forces of attraction and repulsion in the solution are unchanged on mixing the constituents.
- The volume of solution varies linearly with composition.
- There is neither absorption nor evolution of heat in mixing the constituents.
- For gases, the total vapor pressure of solution varies linearly with composition. Expresses as mole fractions.

Benzene in toluene, ethyl & propyl alcohols; paraffin hydrocarbon gases in paraffin oils (nearly ideal).

Difference between gas absorption and distillation

Gas absorption	Distillation
Used to separate components present in a gas mixture	Used to separate components present in a liquid mixture
Liquid is used for separation of mixtures	Thermal heat is used for separation
Degree of separation depends on the selection of solvent and solubility of gas	Separation depends on volatilities of the components present in the liquid mixture

Industrial application of gas absorption?

- Refineries to separate gas components
 - CO₂ capture
 - Removing pollutants from gases
 - Recover valuable gases
- For scrubbing in chemical industries

Control of emissions of pollutants to the atmosphere, retaining polluting substances such as sulfur, chlorinated and fluorinated compounds; said control is based on the elimination of sulfur dioxide from combustion gases with aqueous solutions of sodium hydroxyl and the elimination of nitrogenous oxide with solutions of oxidizing agents.
- Recovery of gaseous stream products for production purposes

Limitations of gas absorption

- Gas solubility
- Temperature of both the gas and the solvent
- Flooding of the column
- Corrosiveness of the solvent to be used