Lecture 2: Mass Transfer & its applications

Previous lecture

1) Mass transfer
2) Chemical Engg. Unit operations

A + B

Difference in property: Solubility, boiling point

Adsorption, Absorption, Liquid-liquid extraction, distillation.

Q1: Which separation process / unit operation one should use?

Ex: $N_2 + CO_2$ ← Separate them using ChE UOP

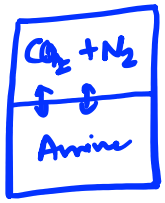
1) Absorption: $(N_2 + CO_2)$ + Amine → Achieve separation
2) Distillation
3) Adsorption: CaO solid adsorbents
4) Membrane separation

Which one is appropriate: Economics, Scalable, Safety, products of desired quality, etc

2) How much separation can be achieved? ← Extent of separation
   1) Extent of separation ← Thermodynamics
   2) Rate of separation ← Mass transfer

$(CO_2 + N_2)$ + Amine

Feed + Absorbent

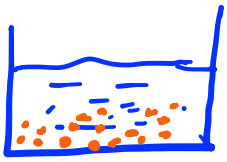


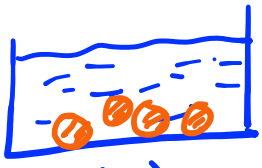
Equilibrium

Chemical potential of CO_2 is same in gas & liquid phases

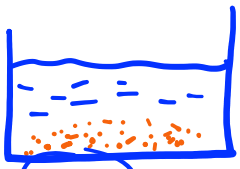
3) Rate of separation? ← Governed by mass transfer

Ex: Making Coffee:





(a)

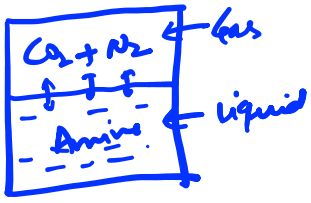


(b)

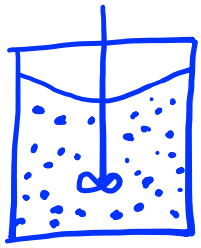
1) High interfacial surface area of case (b), faster mass transfer results in this case.

Q: In which case do you expect faster mass transfer?

Ex: (feed $CO_2 + N_2$) + Amine



(a)



(b)

In which case is the rate of mass transfer higher?

Factors:

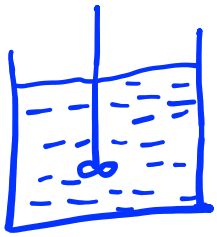
(i) Interfacial area

(ii) Flow (Laminar vs Turbulent)

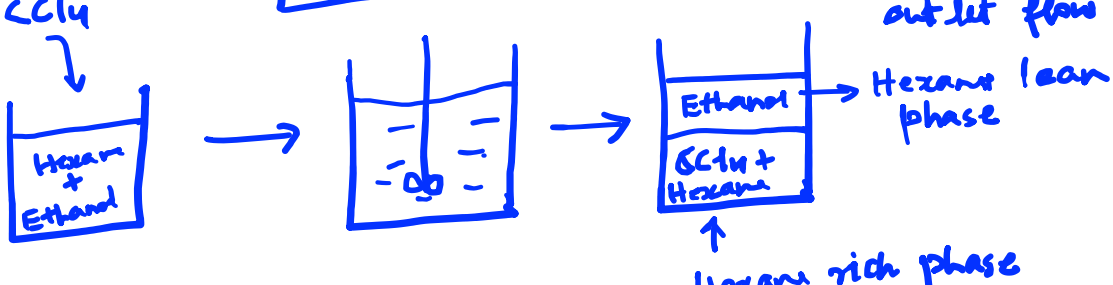
Methods of conducting mass transfer operations

Separate $\underbrace{(CO_2 + N_2)}_{\text{Gas}}$ using $\underbrace{\text{amine}}_{\text{Liquid}}$:

1) Batch operation



Separate Hexane & Ethanol using CCl_4



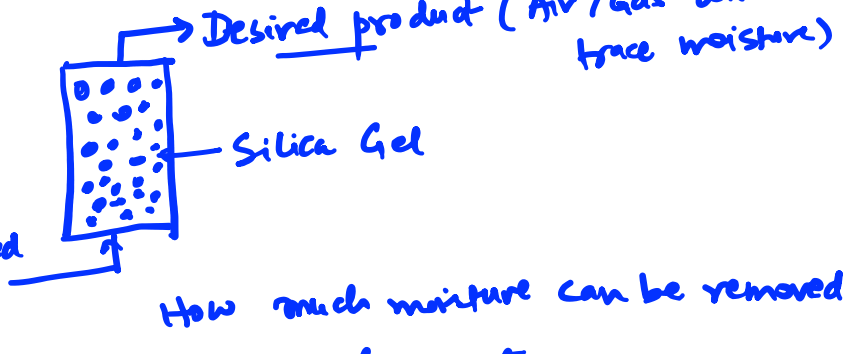
1) No inlet or outlet flow

Hexane lean phase

Hexane rich phase

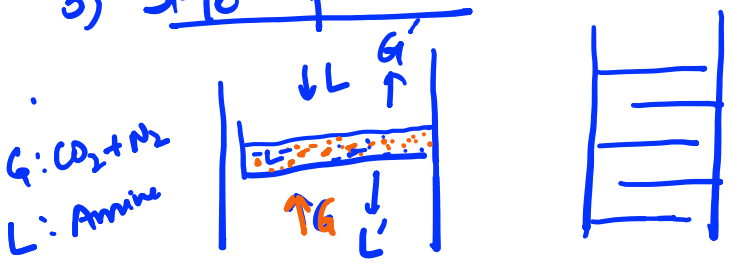
2) Semi batch operation: One phase is fixed

Example:
1) Water filtration
2) Dehumidification of air

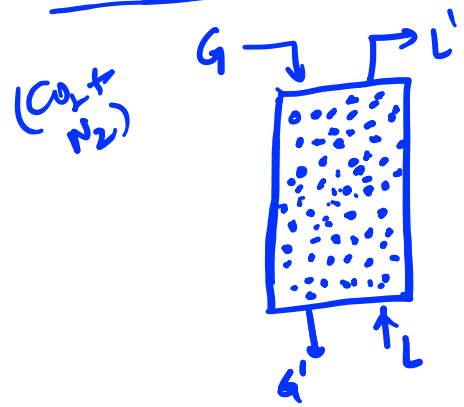


How much moisture can be removed?
1) Inlet flow rate
2) Inlet air/gas moisture content
3) Condition of the column
4) Temp, etc

3) Stage Operations:



4) Continuous Contact:

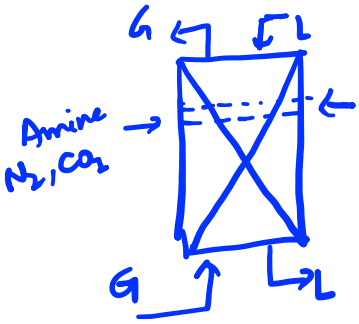


Gas & liquid are in contact throughout the column.

Some questions that chemical Engineers need to answer:
1) Height of the column / Number of stages
2) Permissible flow rate
3) Energy requirements

Steady state & unsteady state operations

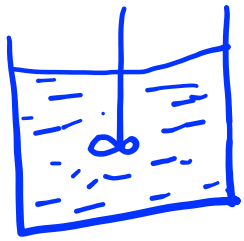
1) Steady state: Conc. at any position in the apparatus does not change with time



To achieve SS: Process parameters should not change.
Ex: Inlet flow rates, feed quality, T, P, etc

2) Unsteady state: Conc. inside the apparatus change with time.

Ex: Batch process



L_1: Hexane + Ethanol
L_2: CCl_4