Introduction to Separation Processes
What is Separation and Separation Processes?

• Separate (definition from a dictionary)
  - to isolate from a mixture; [extract]
  - to divide into constituent parts

• Separation process
  - In chemistry and chemical engineering, a separation process is used to transform a mixture of substances into two or more distinct products.
  - The specific separation design may vary depending on what chemicals are being separated, but the basic design principles for a given separation method are always the same.
Separations

• Separations includes
  – Enrichment
  – Purification
  – Isolation
  – Concentration
  – Refining

• Separations are important to chemist & chemical engineers
  – Chemist: analytical separation methods,
    small-scale preparative separation techniques
  – Chemical engineers: economical, large scale separation methods
Why Separation Processes are Important?

- Almost every element or compound is found naturally in an impure state such as a mixture of two or more substances. Many times the need to separate it into its individual components arises.

- A typical chemical plant is a chemical reactor surrounded by separators.

- Chemical plants commonly have 50–90% of their capital invested in separation equipments.
Why Separation is Difficult to Occur?

- Second law of thermodynamics
  - Substances are tend to mix together naturally and spontaneously
  - All natural processes take place to increase the entropy, or randomness, of the universe
  - To separate a mixture of species into products of different composition, we must supply the equivalent of energy (heat or work)
How Separations are Achieved?

- Enhancing the mass transfer rate of certain species
- Rate of Separation: how fast?
  - Governed by mass transfer (Rate-controlled separation)
- Extent of Separation: how far?
  - Limited by thermodynamics (Equilibrium-staged separation)
- Properties of Importance

<table>
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<tr>
<th>Molecular Properties</th>
<th>Thermodynamic and Transport Properties</th>
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<tr>
<td>Molecular weight</td>
<td>Vapor pressure</td>
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<td>van der Waals volume</td>
<td>Solubility</td>
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<td>van der Waals area</td>
<td>Adsorptivity</td>
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<td>Molecular shape (Acentric factor)</td>
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<td>Dipole moment</td>
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<td>Polarizability</td>
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<td>Dielectric constant</td>
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<td>Electric charge</td>
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<td>Radius of gyration</td>
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Data sources: Handbooks, journals, electronic databases, commercial process simulators
General Separation Techniques

(a) By phase creation

(b) By phase addition

(c) By barrier

(d) By solid agent

(e) By force field or gradient
Which Separation Process Will You Choose?

- There are numerous approaches for separation.

1. Supply heat and boil water off, condensing the water at a lower temperature.
2. Supply refrigeration and freeze out pure ice, melting the ice at a higher temperature.
3. Pump the water to a higher pressure and force it through a thin solid membrane.

⇒ Consider product requirement, cost, environmental effects, etc.