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Process Chem and Pharmaceutical Engineering 1

Mass Balance and Mass Transfer Part 1

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Chapter Description

- **Aims**
  - Apply the knowledge of mass balance and mass transfer in separation process

- **Expected Outcomes**

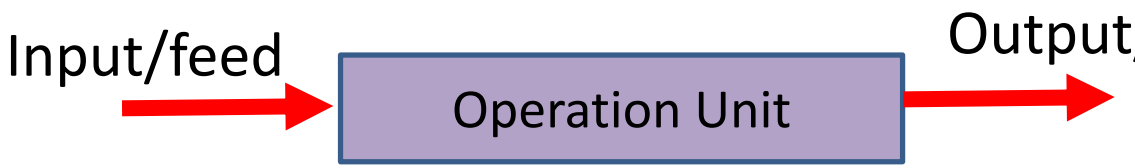
  - Explain the process variables

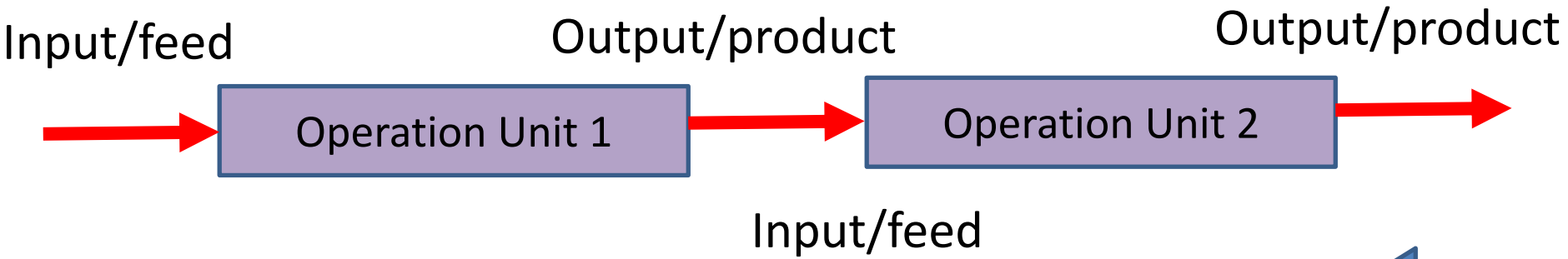
- **References**
  - Elementary Principles of Chemical Processes, Global Edition, Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard, Wiley, 4th Edition, 2017.
  - Unit Operations of Chemical Engineering, McCabe Smith Harriott, Mc Graw Hill, 7th Edition, 2005.

Introduction to Process & Process Variables

1. Process
2. Process variables – mass, volume, density, flow rate, concentration, pressure, temperature

What is process?





Mass, volume and Density

- ✓ Mass (m)

  - unit – g, kg, lb_m

- ✓ Volume (V)

  - unit m^3, cm^3, ft^3, L, mL

- ✓ Density (ρ)

  -unit kg/m^3, g/cm^3, lb_m/ft^3

Specific Gravity

- Specific gravity (SG):

  $SG = \rho/\rho_{ref}$

- The reference most commonly used for solids and liquids is water at 4 °C.

ρ_{ref} of water at 4°C = 1.000 g/cm^3

= 1000 kg/m^3

= 62.43 lbm/ ft^3

Flow Rate

- Flow rate:

  Rate at which a material is transported through a process line

- The flowrate of a process stream may be expressed as:

mass flow rate (mass/time)	volumetric flow rate (volume/time).

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Mass and Mole Fraction

- Mass fraction, $x_{species\ A} = \frac{mass\ of\ species\ A}{total\ mass}$
- Mole fraction, $y_{species\ A} = \frac{moles\ of\ species\ A}{total\ moles}$

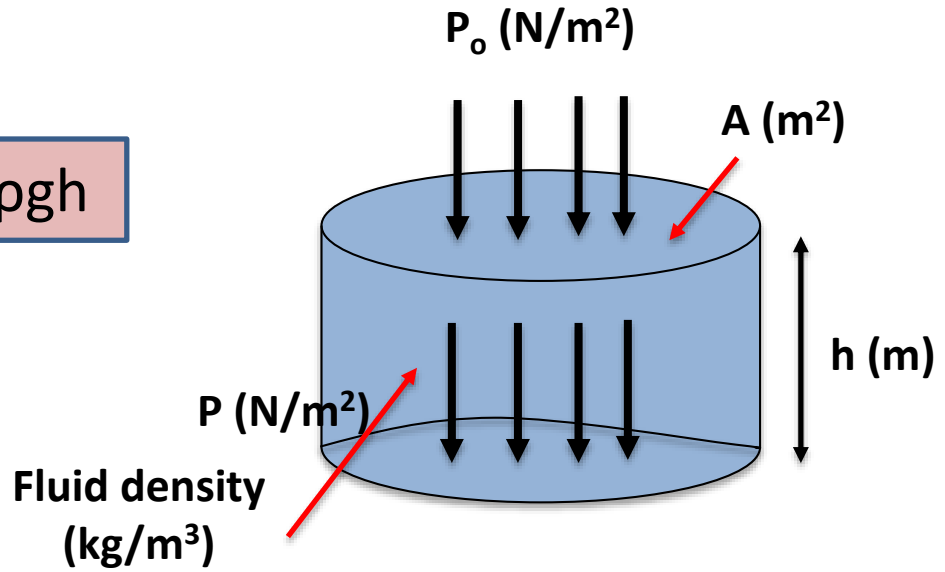
Concentration

- Mass concentration unit: g/cm^3, lbm/ft^3, kg/in^3
- Molar concentration unit: $kmol/m^3$, $lb\text{-}moles/ft^3$
- Molarity: mol/L (eg: 4 molar solution of A contains 4 mol A in a liter solution)

Pressure

- Pressure: ratio of **force** to the **area** on which the forces act
  : unit N/m^2, Pascal

Hydrostatic Pressure = $P_0 + \rho gh$



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Atmospheric Pressure, Absolute Pressure and Gauge Pressure

$$P_{absolute} = P_{gauge} + P_{atmospheric}$$

What is absolute pressure? Gauge pressure?

Temperature

Temperature conversion:

$$T(K) = T\,(°C) + 273.15$$

$$T\,(°R) = T(°F) + 459.67$$

$$T(°R) = 1.8\,(K)$$

$$T(°F) = 1.8T\,(°C) + 32$$

Conclusion of The Chapter

This chapter discussed about process variables, i.e mass, mole fraction, pressure, temperature, concentration, flow rate etc.

Elementary Principles of Chemical Processes, Global Edition, Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard, Wiley, 4th Edition, 2017.

Unit Operations of Chemical Engineering, McCabe Smith Harriott, Mc Graw Hill, 7th Edition, 2005.