1. **Material Balances with Reaction**
   a. Species balances with generation/consumption
   b. Species balances with extent of reaction (\(\xi\))
   c. Elemental balances
   d. Definitions
      i. Limiting reactant
      ii. Yield
      iii. Single-Pass Conversion
      iv. Overall conversion
      v. Selectivity
   e. Combustion Reactions
      i. Should be able to write and balance these reactions for complete combustion, etc.
      ii. Theoretical and excess air
      iii. Dry basis for compositions

2. **Single-Phase Systems**
   a. Liquid densities of mixtures
   b. Ideal gas
      i. Most common equation of state
      ii. Range of applicability
      iii. Mixtures (partial pressure, volume fraction, mole fraction)
   c. Standard temperature and pressure
   d. Non-ideal equations of state
      i. Van der Waals
      ii. SRK
      iii. Corresponding States (\(P_r = P/P_c\), \(T_r = T/T_c\)) and compressibility factor (\(z\))
      iv. Kay’s rule for mixtures (\(P_i' = \sum y_i P_{c,i}, \ T_i' = \sum y_i T_{c,i}\))

3. **Multiphase Systems**
   a. Single-component phase behavior
   b. Tables for Saturated Steam (B.3, B.5, B.6)
   c. Vapor pressure estimation (\(P_i^*\)) – Antoine, DIPPR, Fig. 6.1-4
   d. Gibbs phase rule
   e. Gas-liquid systems with one condensable component
      i. Raoult’s Law (\(y_i P_{tot} = x_i P_i^*\), but \(x_i = 1\))
      ii. Humidity and drying (relative humidity, absolute humidity, degrees superheat)
   f. Multicomponent Systems
      i. Raoult’s Law (\(y_i P_{tot} = x_i P_i^*\))
         1. Assumptions
            a. Ideal systems
            b. Real systems where \(x_A\) is close to 1
         2. Dew point and bubble point
         3. 2 phase separation (Flash calculations)
         4. Non-condensable gas above liquid mixture
      ii. Henry’s Law (\(y_i P_{tot} = x_i H_i\), used for small \(x_i\)) (will not be on exam)
      iii. Diagrams
         1. Vapor-liquid diagrams (T-xy and P-xy)
         2. Solid-Liquid phase diagram
         3. Liquid-Liquid ternary diagram
         4. Tie lines and lever rule
      iv. Material balances using phase equilibrium data/calculations

Including DOF