Project 1: syn gas for ammonia production via steam reformation

Natural gas

1. Reforming
   (1) \( \text{CH}_4 + \text{H}_2\text{O} \leftrightarrow 3\text{H}_2 + \text{CO} \)
   (2) \( \text{CO} + \text{H}_2\text{O} \leftrightarrow \text{CO}_2 + \text{H}_2 \)

2. Steam

3. Oxidation reactor
   (3) \( \text{CH}_4 + 2\text{O}_2 \leftrightarrow \text{CO}_2 + 2\text{H}_2\text{O} \)
   (4) \( \text{CH}_4 + \text{H}_2\text{O} \leftrightarrow 3\text{H}_2 + \text{CO} \)

4. Steam
5. Air

6. Methanator
   (6) \( \text{CO} + 3\text{H}_2 \leftrightarrow \text{CH}_4 + \text{H}_2\text{O} \)

7. Low temperature water gas shift reactor
   (5) \( \text{CO} + \text{H}_2\text{O} \leftrightarrow \text{CO}_2 + \text{H}_2 \)

8. H₂O separator
9. Product
   H₂: N₂ 3:1 mole ratio

10. H₂O separator
11. CO₂ separator
12. Product

Prepared by Ehrman for ENCH446, Spring 2013
Think About:

• effect of influent T, P, feed composition (reactant ratio) on product
• heat integration, where to add/remove heat: pre-heat? at reactor?
• sensitivity of:
  – model parameters (reaction rate)
  – process specifications
  – CO removal, H2O removal
  – NH3 concentration
• process control
  – what are possible upsets?
  – meet specifications in face of model parameter drifts (catalyst poison, scale built up and erosion of heat transfer coefficient)
• built-in process safety (safety by design)