1) Given the following equation of state give expressions for the enthalpy and entropy departure functions.

\[
\frac{PV}{RT} = 1 + \frac{P}{RT} \left( b - \frac{a}{T} \right) \quad H - H^\text{ig} = -\int_T^P \left( \frac{\partial Z}{\partial T} \right)_P dP \quad S - S^\text{ig} = -\int_T^P \left[ (Z-1) + T \left( \frac{\partial Z}{\partial T} \right)_P \right] dP
\]

2) Ammonia is used in an industrial refrigeration cycle. Rather than a throttle, an expander is used to produce recoverable work in the gas expansion step. The gas vapor is initially at 230°C (503°K) and 8 MPa, the ammonia exits the expander at 1 MPa. If the expander has an efficiency of 85%,

- How much work is obtained per mole of ammonia? (List the PREOS.xls setup and solver steps)
- What is the final temperature of the ammonia? (List the solver steps)
- What is the temperature for a reversible expander?
- What is the temperature for a saturated vapor at 1 MPa? (List the solver steps)
- Show the four points, saturated vapor 1 MPa; reversible expander; 85% efficiency expander; and the initial condition on the following pressure-enthalpy chart for ammonia (Refrigerant 717).
Quiz 9
March 9, 2017

Answers

1) \[
\frac{H - H^{\alpha}}{RT} = - \int_0^p T \left( \frac{\partial^2}{\partial T^2} \right)_p \frac{dp}{p}
\]

\[ z = 1 + \frac{\rho}{\lambda T} (b - \frac{a}{T}) \]

\[ \left( \frac{\partial^2}{\partial T^2} \right)_p = \frac{p}{R} \left( - \frac{b}{T^2} + \frac{2a}{T^3} \right) \]

\[
\frac{H - H^{\alpha}}{RT} = \int_0^p \left( \frac{b}{RT} - \frac{2a}{RT^2} \right) dp
\]

\[
\frac{H - H^{\alpha}}{RT} = \frac{b\rho}{RT} + \frac{-2a\rho}{RT^2}
\]

\[ H - H^{\alpha} = b\rho - \frac{2a\rho}{T} \]

\[
\frac{S - S^{\alpha}}{R} = - \int_0^p \left[ (2-1) + T \left( \frac{\partial^2}{\partial T^2} \right)_p \right] \frac{dp}{p}
\]

\[ = \int_0^p \left[ \left( \frac{a}{RT^2} - \frac{b}{RT} \right) + \frac{1}{R} \left( \frac{b}{T} - \frac{2a}{T^2} \right) \right] dp \]

\[ = \frac{a\rho}{RT^2} - \frac{b\rho}{RT} + \frac{b\rho}{RT} - \frac{2a\rho}{RT^2} \]

\[ S - S^{\alpha} = \frac{p}{T} \left( \frac{a}{T} - \frac{2a}{T^2} \right) \]

\[ S - S^{\alpha} = \frac{-Pa}{T^2} \]
2)  
- Duplicate Props or Pys1(2)  
- Set Cell of Pys1 & cp values to ammonia  
  
- Pys set T to 503 K  
  
- Set Ref. Nat. P to 8 mHa  
  
- Pys1(2) set P to 1 mHa  
  
- Set cell \( S^\circ \)  
  \[ S^\circ = k^9 + L^4 - Pys1K_{12} \]  
  
- Add cell \( S^\circ \)  
  \[ S^\circ = I^9 + J^4 - Pys1I_{12} \]  
  (see vapor phase react for Pys1(2))  
  
- Solve cell \( S^\circ = 0 \)  
  by vary \( TK \)  
  
- \[ T_2 = 307 \text{ K} \]  
  \[ \Delta H = -6120 \text{ J/mole} \]  
  
- \[ \Delta H = W_j = \Delta H \cdot 0.81 = -5200 \text{ J/mole} \]  
  
- Solve cell \( \Delta H \) to reach \(-5200 \text{ J/mole}\)  
  by vary \( TK \)  
  
- \[ T_2 = 330 \text{ K} \]
- Find saturation temperature

Solve fusion, ratio $= 1$

Very TK

$t_2 = 299^\circ C$