Chemical Engineering Thermodynamics
Quiz 8
March 2, 2017

1) To consider thermal expansion in an adiabatic turbine the adiabatic thermal expansion coefficient might be of use,

$\alpha_S = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_S$ **Adiabatic thermal expansion coefficient.**

Express the adiabatic thermal expansion coefficient in terms of T, V, P, $\alpha_P = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$,

$\kappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$, $C_V = T\left(\frac{\partial S}{\partial T}\right)_V = \left(\frac{\partial H}{\partial T}\right)_V$, and $C_P = T\left(\frac{\partial S}{\partial T}\right)_P = \left(\frac{\partial H}{\partial T}\right)_P$

Show how you use the "thermodynamic square" to obtain the necessary Maxwell relationships, use the triple product rule, and the definitions given above. Show your work.

2) Liquid isooctane is used as a model for gasoline. T_c = 544.0°K, P_c = 2.570 MPa, ω = 0.303, MW = 114 g/mole (*it is not listed in the critical parameters for PREOS.xls*).
   a) If a gas tank is filled at atmospheric pressure and 298°K, what is the specific volume (cm^3/mole) and density (g/cm^3)? (Use PREOS.xls to determine the lowest fugacity state).
   b) -Use PREOS.xls to determine the atmospheric boiling point for isooctane by finding the temperature where the fugacity ratio is 1 using Solver.
      -List the instructions you gave Solver.
      -Record the specific volume and density (g/cm^3) of the liquid and vapor states.
   c) What pressure would cause the isooctane to boil at 298°K? Use Solver and list your instructions to Solver.
   d) The engine compresses a spray of gasoline to 6 MPa at 973°K. What is the specific volume and density (g/cm^3) at this pressure and temperature? Use PREOS.xls.

ANSWERS:
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1) $\alpha_S = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_S$ $\quad \begin{array}{|ccc|} -S & U & V \\ H & & A \\ -P & G & T \end{array}$ No Maxwell for this

Triple Product

$$\left(\frac{\partial V}{\partial T}\right)_S \left(\frac{\partial T}{\partial S}\right)_V \left(\frac{\partial S}{\partial V}\right)_T = -1$$

$$\left(\frac{\partial V}{\partial T}\right)_S = \frac{-\left(\frac{\partial S}{\partial T}\right)_V}{\left(\frac{\partial S}{\partial V}\right)_T} = \frac{-\frac{C_V}{T}}{\left(\frac{\partial P}{\partial T}\right)_V}$$

$$\begin{array}{|ccc|} -S & U & V \\ H & & A \\ -P & G & T \end{array}$$

Triple Product

$$\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = -1$$

$$\left(\frac{\partial P}{\partial T}\right)_V = \frac{-\left(\frac{\partial V}{\partial T}\right)_P}{\left(\frac{\partial V}{\partial P}\right)_T} = \frac{+\alpha_P}{\kappa_T}$$

$$\boxed{\alpha_S = \frac{-C_V\,\kappa_T}{V\,T\,\alpha_P}}$$

2) a) 160 cm^3/mole 0.713 g/cm^3
b) Set Fugacity ratio equal to 1
Vary T
372 °K (99°C).
Liquid: 176 cm^3/mole 0.647 g/cm^3
Vapor: 29,500 cm^3/mole 0.00386 g/cm^3
c) 0.00671 MPa
Liquid: 161 cm^3/mole 0.708g/cm^3
Vapor: 367,000 cm^3/mole 0.0003.11 g/cm^3
d) 1300 cm^3/mole 0.077 g/cm^3