Quiz 10
Chemical Engineering Thermodynamics
March 28, 2019

Determine the fugacity (MPa) for n-pentane at (a) 350 K and 0.1 MPa and (b) 350 K and 0.8 MPa using the virial equation and the shortcut vapor pressure. (c) *First use PREOS.xls to calculate the saturated vapor pressure, and the fugacity's for "a" and "b".* **Put your answers in the chart on page 2 below. (Show your work, i.e. write the equations with values, units and answers.)**

T_c = 470 K, P_c = 3.37 MPa , V_c = 356 cm^3/mole, ω = 0.249, R = 8.31 J/(mole K) = 8.31 cm^3MPa/(mole K)

Determine if the short cut method is appropriate.
Calculate the vapor pressure and determine the state for each condition.
Determine if the virial equation is appropriate.
Calculate the fugacity (using different methods for the different states).

$$\log_{10} P_r^{sat} = \frac{7}{3}(1+\omega)\left(1-\frac{1}{T_r}\right) \qquad 9.11$$

Shortcut vapor pressure equation. Use care with the shortcut equation below T_r = 0.5.

$$\ln \varphi = \frac{BP}{RT} \qquad 9.31$$

$$Z = 1 + (B^0 + \omega B^1)P_r/T_r \quad \text{or} \quad Z = 1 + BP/RT \qquad 7.6$$

$$\text{where } B(T) = (B^0 + \omega B^1)RT_c/P_c \qquad 7.7$$

$$B^0 = 0.083 - 0.422/T_r^{1.6} \qquad 7.8$$

$$B^1 = 0.139 - 0.172/T_r^{4.2} \qquad 7.9$$

$$\text{Subject to } T_r > 0.686 + 0.439P_r \text{ or } V_r > 2.0 \qquad 7.10$$

Poynting Correction

$$f = f^{sat} \exp\left(\frac{V^L\left(P - P^{sat}\right)}{RT}\right)$$

$$V^{satL} = V_C Z_C^{(1-T_r)^{0.2857}}$$

$$Z_c = P_c V_c/(RT_c)$$

T	350K	350K	350K	350K
P	---	---	0.1 MPa	0.8 MPa
T_r, K	---	---		
P_r, MPa	---	---		
	P^{sat}, MPa	f^{sat}, MPa	f part a, MPa	f part b, MPa
PREOS.xls				
State				
Virial Eqn./ Shortcut M.				

T	350K	350K	350K	350K
P	---	---	0.1 MPa	0.8 MPa
T_r, K	---	---	*0.745*	*0.745*
P_r, MPa	---	---	*0.0297*	*0.237*
	P^{sat}, MPa	f^{sat}, MPa	f part a, MPa	f part b, MPa
PREOS.xls	*0.340*	*0.309*	*0.0974*	*0.316*
State	*L/V*	*L/V*	*V*	*L*
Virial Eqn./ Shortcut M.	*0.339*	*0.308*	*0.0972*	*0.316*

a)
Does SCM work? $T_r = 0.745 > 0.5$ **Yes**

$P^{sat} = P_c$ 10^(7/3 (1 + ω)(1 – 1/T_r)) = 3.37 MPa 10^(7/3 (1 + 0.249)(1 – 1/0.745)) = 0.106 MPa

Does Virial Eqn. Work?
$T_r = 0.745 > 0.686 + 0.439P_r$ = 0.686 + (0.439) 0.0297 MPa = 0.699 **Yes**

$B_0 = 0.083 – 0.422/T_r^{1.6} = -0.593$
$B_1 = 0.139 – 0.172/T_r^{4.2} = -0.453$
$B = (B_0 + \omega B_1)RT_c/P_c$ = -818cm^3/mole
$f = P$ exp(-818cm^3/mole 0.1MPa/(8.31 cm^{3}MPa/(Kmole) 350K)) = **0.0972 MPa**

b) Get $f^{sat} = P^{sat}$ exp($BP^{sat}/(RT^{sat})$) if
$T_r = 0.745 > 0.686 + 0.439P_r^{sat}$ = 0.686 + (0.439) 0.101 MPa = 0.730 **Yes**
f^{sat} = 0.339 MPa exp(-818cm^3/mole 0.339 MPa/(8.31 MPa cm^3/(mole K) 350K)) = 0.308 MPa

$V^L = V_c$ Z_c^(1-T_r)^(0.2857) = 356 cm^3/mole 0.307^(1-0.745)^0.2857 = 160 cm^3/mole
$Z_c = P_c$ $V_c/(RT_c)$ = 3.37 MPa 356 cm^3/mole/(8.31 MPa cm^3/(mole K) 470K) = 0.307

$f = f^{sat}$ exp(160 cm^3/mole (0.8 MPa – 0.339 MPa)/(8.31 MPa cm^3/(mole K) 350K)) =