(P7.2) $P_r = 30, T_r = 15$

(a) Use virial equation of state.

$Z = 1 + (B^0 + \omega B^1)P_r / T_r$ ……………………………………………..Eqn. 7.6

Where, $B^0 = 0.083 - \dfrac{0.422}{T_r^{1.6}}$, $B^1 = 0.139 - \dfrac{0.172}{T_r^{4.2}}$ ………………………………. Eqns. 7.8 & 7.9

$\Rightarrow B^0 = 0.077459277$

$\& B^1 = 0.138998$

$\& \omega = -0.041(book)$

$$\Rightarrow Z = 1 + (0.077459277 - 0.041 * 0.138998) * \frac{30}{15} = 1.14$$

(b) $\rho = ??$

$T = T_r * T_C = 15 * 44.4 = 666K$

$P = P_r * P_C = 2.653 * 30 = 79.59MPa$

$$Z = \frac{PV}{RT}, \Rightarrow V = \frac{Z * R * T}{P * MW} = \frac{1.14 * 8.314 * 666}{79.59 * 20.179} = 3.93cm^3 / g$$

$$\Rightarrow \rho = \frac{1}{V} = \frac{1}{3.93} = 0.254 g / cm^3$$

(P7.4)

$T_1 = 111K$

$P_1 = 1atm \approx 0.1MPa$

$T_2 = 77^O F = 25^O C = 298.15K$

Use PREOS.XLS,

$\Rightarrow$

Current State		Roots		Stable Root has a lower fugacity
T (K)	111	Z	V	fugacity
P (MPa)	0.1		cm^3/gmol	MPa
answers for three		0.9670679	8924.6249	0.096803
root region		0.0263855	243.49944	
		0.0036451	**33.639114**	**0.093707**

Use Solver, and set target cell on the volume and make it equal to 33.639114*2 = 67.278228,
Then by changing the cell of pressure, making sure that T_2 = 298.15K

Current State		Roots	
T (K)	298.15	Z	V
P (MPa)	**33.839895**		cm^3/gmol

answers for three root region	#NUM!	#NUM!
	#NUM!	#NUM!
	#NUM!	#NUM!
& for 1 root region	0.9184568	**67.278228**

$\Rightarrow P_2 = 33.84MPa$

(P7.5) if the pressure change, implies the volume will change, but we have to keep in mind that the number of moles stay the same.
So, by using PREOS.XLS for $20^O C$ & $1bar \Rightarrow V = 24302.829cm^3 / gmol$

Current State		Roots	
T (K)	293.15	Z	V
P (MPa)	0.1		**cm³/gmol**
answers for three root region		#NUM!	#NUM!
		#NUM!	#NUM!
		#NUM!	#NUM!
& for 1 root region		0.9976523	**24302.829**

$\Rightarrow V = 0.0243m^3 / 1mole$

$\therefore \underline{V} = 4m^3 \Rightarrow n = \dfrac{4m^3}{0.0243m^3 / mole} = 164.61moles$

For T = 293.15 K and P = 200 bars $\Rightarrow V = 9.68E-5m^3 / mole$

Current State		Roots	
T (K)	293.15	Z	V
P (MPa)	20		**cm³/gmol**
answers for three root region		#NUM!	#NUM!
		#NUM!	#NUM!
		#NUM!	#NUM!
& for 1 root region		0.7948306	**96.860006**

$\Rightarrow \underline{V} = n * V = 164.61moles * 9.68E-5m^3 / mole = 0.01593m^3$

$\Rightarrow \underline{V} = 15.93L$

(P7.6)

Current State		Roots		
T (K)	311.15	Z	V	fugacity
P (MPa)	10		cm³/gmol	MPa
answers for three		#NUM!	#NUM!	#NUM!

root region	#NUM! #NUM!	#NUM! #NUM!	#NUM!
& for 1 root region	0.282507981	73.08617	5.546459

$$V = 73.1E-6m^3/mole$$

$$\Rightarrow n = \frac{0.15m^3}{73.1E-6m^3/mole} = 2051.98 moles$$

The molar volume will stay constant as the gas is cooled. Some checking shows that at 273.15 the saturated liquid volume is 48.2 cm3/mol, thus the system is 2 phase. The shortcut equation can be used to estimate the vapor pressure, but the EOS needs to be used to calculate the molar volumes. Using goal seek…

Current State		Roots	
T (K)	273.15	Z	V
P (MPa)	3.465769		cm^3/gmol
answers for three root region		0.69011426	452.2278
		0.195655461	128.2119
		0.073553994	48.1995

The container must be filled with compressed liquid at this temperature to reach 10 MPa.

Current State		Roots	
T (K)	273.15	Z	V
P (MPa)	10		cm^3/gmol
& for 1 root region		0.196286053	44.57849

Now, the molar volume stays constant when the vessel is heated. Use solver to find the pressure that gives the same molar volume.

Current State		Roots		
T (K)	311.15	Z	V	fugacity
P (MPa)	34.02393		cm^3/gmol	MPa
& for 1 root region		0.599451881	45.58	9.053131