Problem SP17. Carbon monoxide (CO) gas is stored at a pressure of 70 bars and a temperature of -110ºC in a tank with a volume of 10 m³. Calculate the mass of CO in the tank using
(a) the ideal gas equation of state
(b) the generalized compressibility chart
(c) the Van der Waals equation of state (iteration required, use ideal gas EOS solution for first guess)
(d) EES

Problem SP18. (a) One (1.0) kg of ammonia (NH₃) is contained in a piston cylinder device. The ammonia is present initially as a saturated liquid at a pressure of 2.0 bars and a temperature of -18.86 ºC. Heat is added to the piston cylinder device and the ammonia undergoes a phase change from a saturated liquid to a saturated vapor. The specific volume of the saturated liquid is \(331.507 \frac{m³}{kg}\). Assume that the saturated vapor is an ideal gas. The temperature dependence of the ammonia saturation pressure is given by
\[
p_{\text{sat}} = \alpha + \beta T_{\text{sat}} + \gamma T_{\text{sat}}^2\]
where \(\alpha = 7.6427 \times 10^3 \text{ kPa}\), \(\beta = -67.745 \frac{\text{kPa}}{\text{K}}\), \(\gamma = 0.1502 \frac{\text{kPa}}{\text{K}^2}\).
Using the Clausius-Clapeyron relation, calculate the enthalpy change \(h_2 - h_1\) of the ammonia for this constant pressure, constant temperature vaporization process. Compare your answer with the enthalpy of vaporization listed in the ammonia saturation table.

(b) Check to make sure that ammonia tables at \(p = 8.0\) bar, \(T = 60ºC\) are consistent with Eq. 11.35 from the textbook.

Problem SP19. One hundred (100) kg of high pressure butane (C₄H₁₀, \(M = 58.12 \text{ kg/kmol}\)) is compressed isothermally in a piston-cylinder container. The temperature in the cylinder is 500K throughout the process. The initial volume of the container is 1.5 m³, and the final volume is 0.65 m³. Use the van der Waals equation of state to analyze the isothermal compression process.
\[
p = \frac{\bar{R}T}{\bar{V}} - \frac{a}{\bar{V}^2}
\text{for butane: } a = 13.86 \frac{\text{bar} \cdot m^6}{\text{kmol}^2}, \ b = 0.1162 \frac{m^3}{\text{kmol}} \quad (\text{Table A-24})
\]
(a) Find the pressures in the tank at the initial and final conditions.
(b) Find the change in internal energy for the butane as a result of the isothermal compression.
(c) Find the change in enthalpy for the butane.
(d) Find the change in entropy for the butane.