1. Obtain the expression for the total differential $dP$ for a van der Waals gas in terms of $dT$ and $dV_m$.

2. Determine the thermal expansion coefficient $\alpha$ for a gas that obeys the van der Waals equation of state. (hint: try using the cyclic rule for partial derivatives to express the thermal expansion coefficient in terms of more convenient quantities)

3. Calculate the molar volume of chlorine gas at 350 K and 2.30 atm using (a) the ideal gas law and (b) the van der Waals equation. For (b), you cannot solve the van der Waals equation explicitly for the molar volume. However, you can use the answer from (a) as a first approximation to the molar volume term on the right hand side and then use successive approximations to obtain a numerical answer for (b). Use
   \[ a = 6.26 \text{L}^2 \text{atm} \text{mol}^{-2} \]
   \[ b = 5.42 \times 10^{-2} \text{L} \text{mol}^{-1} \]

4. The compression factor for a gas, $Z$, is a measure of the deviation from ideal behavior. However, it can also be used to relate the properties of different gases. (a) Derive an expression for the compression factor for a van der Waals gas. (b) Express the result in (a) as a virial expansion in powers of $1/V_m$ and (c) obtain expressions for $B$ and $C$ in terms of the van der Waals parameters $a$ and $b$ and calculate their values. The expansion you will need is
   \[ \frac{1}{1-x} = 1 + x + x^2 + ... \]
   Measurements on argon at 273 K gave the following virial coefficients:
   \[ B = 21.7 \text{cm}^3 \text{mol}^{-1} \]
   \[ C = 1200 \text{cm}^6 \text{mol}^{-2} \]

5. Show that
   \[ \lim_{P \to 0} \left( \frac{\partial Z}{\partial P} \right)_P = \frac{1}{RT} \left( \frac{b}{a} - \frac{a}{RT} \right) \]
   for a van der Waals gas in the ideal gas limit. Remember that $1/V_m \to 0$ as $P \to 0$. (comment: Don't make this harder than it needs to be. Simply evaluate the derivative and take the necessary limit.)

6. Verify that the van der Waals, the virial, and the Redlich-Kwong equations all reduce to $PV = NRT$ in the limit of zero density. (hint: remember that the density goes to zero as $1/V_m \to 0$)