19.69. The van der Waals equation of state, an approximate representation of the behavior of gases at high pressure, is given by Eq. (18.7):

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

where a and b are constants having different values for different gases. (In the special case of $a = b = 0$, this is the ideal-gas equation.) (a) Calculate the work done by a gas with this equation of state in an isothermal expansion from V_1 to V_2. Show that your answer agrees with the ideal-gas result found in Example 19.1 (Section 19.2) when you set $a = b = 0$. (b) For ethane gas (C_2H_6), $a = 0.554\ \text{J} \cdot \text{m}^3/\text{mol}^2$ and $b = 6.38 \times 10^{-5}\ \text{m}^3/\text{mol}$. Calculate the work W done by 1.80 mol of ethane when it expands from $2.00 \times 10^{-3}\ \text{m}^3$ to $4.00 \times 10^{-3}\ \text{m}^3$ at a constant temperature of 300 K. Do the calculation using (i) the van der Waals equation of state and (ii) the ideal-gas equation of state. (c) How large is the difference between the two results for W in part (b)? For which equation of state is W larger? Use the interpretation of the terms a and b given in Section 18.1 to explain why this should be so. Are the differences between the two equations of state important in this case?