Homework Problems
(#5-#10)

5. Limiting cases:

a. ***(required)***

The residual volume of a gas is defined as:

$$\bar{V}_{res} = \lim_{P \to 0} \left(\bar{V} - \frac{RT}{P} \right)$$

If a gas has the equation of state

$$P\bar{V}(1 - \alpha P) = RT$$

what is $\bar{V}_{res}$?

★b. ***(optional)*** **Engel & Reid P1.37**

6. E&R P2.6
AND IN ADDITION
calculate q for each of the irreversible and reversible processes in parts a and b.
all answers should be in energy units of joules (J)

7. One mole of ideal gas is heated reversibly at a constant pressure of 1 atm from 273.15 K to 373.15 K

a. Compute the work involved in the process.

b. If the gas were expanded reversibly and isothermally at 273.15 K from an initial pressure of 1 atm, what would the final pressure need to be in order to equal the work calculated in part a?

★**8.** (optional) A gas has the equation of state $P\bar{V} = RT + \alpha(T)P$

a. Show that for a reversible expansion between T_1 and T_2 at constant pressure P, the work done is:
$w = nR(T_1 - T_2) + n(\alpha(T_1) - \alpha(T_2))P$

b. Show that for a reversible expansion between V_1 and V_2 at constant temperature T, the work done is:
$$w = nRT \ln \left[\frac{\bar{V}_1 - \alpha(T)}{\bar{V}_2 - \alpha(T)} \right]$$

9. One mole of ideal gas at 298 K is in a piston at a pressure of 100 atm.

a. What is the work done by the gas if it expands isothermally against a constant pressure of 10 atm?

b. What is the total work done by the gas if the piston expands against constant pressure in 3 stages, reaching equilibrium between each stage:
first against 50 atm, then against 20 atm, and finally against 10 atm.

c. What is the total work done by the gas if it expands reversibly and isothermally from its initial 100 atm to 10 atm?

d. How does the work done by the gas compare for a vs b vs c ?

e. Plot, on the same P vs V diagram, the expansion paths in a, b, and c. Do the areas under the curves reflect the conclusions in part d.

10. [from Raff #2.14] One mole of a monatomic ideal gas at a temperature of 500 K and a pressure of 6 atm is subjected to the following changes:

STEP 1: The gas is expanded isothermally and reversibly to a final pressure of 5atm.

STEP 2: After completion of STEP 1, the gas is expanded adiabatically and reversibly until the pressure reaches 4 atm.

STEP 3: After STEP 2 is completed, the gas is compressed isothermally and reversibly to a final pressure of 4.800 atm.

STEP 4: After STEP 3, the gas is compressed adiabatically and reversibly to a pressure of 6 atm, returning the gas to a temperature of 500 K .

a. Compute *w, q, and ΔU* for STEP 1.

b. At the completion of STEP 2, what are the temperature and volume of the gas? Compute the amount of work done in STEP 2.

c. Compute *w, q, and ΔU* for STEP 3.

d. Compute the amount of work done in STEP 4.

e. Compute *w, q, and ΔU for* the entire process.