

Solve the following problems. Write the numerical answer on the blank space provided. Please show your work.

1. A reversible compression is carried out of a gas in an initial volume of 6 L and pressure of 4 atm at 500 K. The gas is compressed to a volume of 2 L. Calculate the work of compression.

- A. Determine the number of moles of gas (2 points).

Answer:

$$n = PV/RT = (4 \text{ atm})(6 \text{ L}) / (0.08206 \text{ L-atm/mol-K})(500 \text{ K}) = 0.584 \text{ moles}$$

Answer _____ 0.584 moles _____

- B. Calculate the reversible work of compression (2 points).

Answer:

$$w = -nRT \ln(V_2/V_1) = (0.584 \text{ mol})(8.31 \text{ J/mol-K})(500 \text{ K}) \ln(2/6) = +2665 \text{ J}$$

Note that the work of compression is positive. The natural logarithm is negative because the final volume is smaller than the initial volume. The minus sign cancels the initial minus sign to make the answer positive in agreement with the sign convention.

Answer _____ +2665 J _____

2. Compare the work of compression in question 1 with the work required in a single step irreversible compression.

- A. Determine the required external pressure to compress the gas from 6 L to 2 L (2 points).

Answer:

$$P_1 V_1 = P_2 V_2 \rightarrow P_2 = P_1 (V_1/V_2) = 4 \text{ atm}(6/2) = 12 \text{ atm}$$

Answer _____ 12 atm _____

- B. Calculate the work of compression. (2 points)

Answer: $w = -P_{\text{ext}}(V_2 - V_1) = -(12 \text{ atm})(2\text{L} - 6\text{L}) = + 48 \text{ L-atm}$

Note that L-atm is a unit of energy (a pressure times a volume). To convert to Joules you can use the definition of the gas constant in both units
 $R = 8.31 \text{ J/mol-K} = 0.08206 \text{ L-atm/mol-K} \rightarrow 101.3 \text{ J/L-atm}$ is the conversion factor.
 Therefore, $w = + 4860 \text{ J}$. Note that the irreversible work of compression is larger than the reversible work.

Answer _____ +4860 J _____

3. The molar heat capacity of a polyatomic ideal gas is $C_{V,m} = 3R$. What is the molar heat capacity at constant pressure (2 points)?

Answer: the general relationship is $C_{P,m} = C_{V,m} + R$

Therefore, $C_{P,m} = 4R$

Answer _____ 4R _____