Thermal Physics

Helium

Problem 1.- Helium expands adiabatically in a well-insulated container to four times its original volume. It started at room temperature (25 ºC) and at a pressure of one atmosphere.

a) What is the final pressure?

b) What is the final temperature?

Solution: Helium is mono-atomic and at the conditions of the problem, it behaves very much like an ideal gas.

a) To get the final pressure, we know that: $P_{initial} V_{initial}^{\gamma} = P_{final} V_{final}^{\gamma}$, where $\gamma = 5/3$, so:

$$P_{final} = \frac{P_{initial} V_{initial}^{\gamma}}{V_{final}^{\gamma}} = 1\text{atm}\left(\frac{1}{4}\right)^{5/3} = \mathbf{0.099\ atm}$$

b) To get the final temperature, recall that $T_{initial} V_{initial}^{\gamma-1} = T_{final} V_{final}^{\gamma-1}$, so:

$$T_{final} = \frac{T_{initial} V_{initial}^{\gamma-1}}{V_{final}^{\gamma-1}} = 298\text{K}\left(\frac{1}{4}\right)^{2/3} = \mathbf{118\ K}$$