Derivation of Energy Loss Due to Adiabatic Expansion

The internal energy of the ideal gas in a cell is given by

$$Q = \frac{3}{2} N\ k\ T$$

where N is the total number of particles in the cell. For adiabatic heating

$$PV^{\gamma} = C \rightarrow TV^{\gamma} = \text{C}$$

which in turn implies

$$dT/T = -(\gamma - 1)dV/V$$

so

$$dQ = \frac{3}{2} NkdT = -\frac{3}{2}\left(\frac{5}{3} - 1\right) NkT\frac{dV}{V} = NkT\frac{dV}{V}$$