8. (a) It is possible to motivate, starting from Eq. 21-3, the notion that heat may be found from the integral (or "area under the curve") of a curve in a TS diagram, such as this one. Either from calculus, or from geometry (area of a trapezoid), it is straightforward to find the result for a "straight-line" path in the TS diagram:

$$Q_{\text{straight}} = \left(\frac{T_i + T_f}{2}\right) \Delta S$$

which could, in fact, be *directly* motivated from Eq. 21-3 (but it is important to bear in mind that this is rigorously true only for a process which forms a straight line in a graph that plots T versus S). This leads to $(300\,\text{K})(15\,\text{J/K}) = 4500$ J for the energy absorbed as heat by the gas.

(b) Using Table 20-3 and Eq. 20-45, we find

$$\Delta E_{\text{int}} = n\left(\frac{3}{2}R\right)\Delta T = (2.0\,\text{mol})\left(8.31\,\frac{\text{J}}{\text{mol}\cdot\text{K}}\right)(200\,\text{K} - 400\,\text{K}) = -5.0 \times 10^3\ \text{J}\ .$$

(c) By the first law of thermodynamics,

$$W = Q - \Delta E_{\text{int}} = 4.5\,\text{kJ} - (-5.0\,\text{kJ}) = 9.5\ \text{kJ}\ .$$