12. (a) At point *a*, we know enough information to compute *n*:

$$n = \frac{pV}{RT} = \frac{(2500\,\text{Pa})(1.0\,\text{m}^3)}{(8.31\ \text{J/mol}\cdot\text{K})\,(200\,\text{K})} = 1.5\,\text{mol}.$$

(b) We can use the answer to part (a) with the new values of pressure and volume, and solve the ideal gas law for the new temperature, or we could set up the gas law as in Sample Problem 19-1 in terms of ratios (note: $n_a = n_b$ and cancels out):

$$\frac{p_b V_b}{p_a V_a} = \frac{T_b}{T_a} \Rightarrow T_b = (200\,\text{K})\left(\frac{7.5\,\text{kPa}}{2.5\,\text{kPa}}\right)\left(\frac{3.0\,\text{m}^3}{1.0\,\text{m}^3}\right)$$

which yields an absolute temperature at *b* of $T_b = 1.8\times10^3$ K.

(c) As in the previous part, we choose to approach this using the gas law in ratio form (see Sample Problem 19-1):

$$\frac{p_c V_c}{p_a V_a} = \frac{T_c}{T_a} \Rightarrow T_c = (200\,\text{K})\left(\frac{2.5\,\text{kPa}}{2.5\,\text{kPa}}\right)\left(\frac{3.0\,\text{m}^3}{1.0\,\text{m}^3}\right)$$

which yields an absolute temperature at *c* of $T_c = 6.0\times10^2$ K.

(d) The net energy added to the gas (as heat) is equal to the net work that is done as it progresses through the cycle (represented as a right triangle in the *pV* diagram shown in Fig. 19-19). This, in turn, is related to ± "area" inside that triangle (with area = $\frac{1}{2}$(base)(height)), where we choose the plus sign because the volume change at the largest pressure is an *increase*. Thus,

$$Q_{\text{net}} = W_{\text{net}} = \frac{1}{2}\,(2.0\,\text{m}^3)\,(5.0\times10^3\,\text{Pa}) = 5.0\times10^3\ \text{J}.$$