20. (a) The final pressure is

$$p_f = (5.00\,\text{kPa})e^{(V_i - V_f)/a} = (5.00\,\text{kPa})e^{(1.00\,\text{m}^3 - 2.00\,\text{m}^3)/1.00\,\text{m}^3} = 1.84 \text{ kPa} .$$

(b) We use the ratio form of the gas law (see Sample Problem 20-1) to find the final temperature of the gas:

$$T_f = T_i\left(\frac{p_f V_f}{p_i V_i}\right) = (600\,\text{K})\frac{(1.84\,\text{kPa})(2.00\,\text{m}^3)}{(5.00\,\text{kPa})(1.00\,\text{m}^3)} = 441 \text{ K} .$$

For later purposes, we note that this result can be written "exactly" as $T_f = T_i\left(2e^{-1}\right)$. In our solution, we are avoiding using the "one mole" datum since it is not clear how precise it is.

(c) The work done by the gas is

$$\begin{aligned} W &= \int_i^f p\,dV = \int_{V_i}^{V_f} (5.00\,\text{kPa})e^{(V_i - V)/a}\,dV \\ &= (5.00\,\text{kPa})e^{V_i/a} \cdot \Big[-ae^{-V/a}\Big]_{V_i}^{V_f} \\ &= (5.00\,\text{kPa})e^{1.00}(1.00\,\text{m}^3)\left(e^{-1.00} - e^{-2.00}\right) \\ &= 3.16 \text{ kJ} . \end{aligned}$$

(d) Consideration of a two-stage process as suggested in the hint, brings us simply to Eq. 21-4. Consequently, with $C_V = \frac{3}{2}R$ (see Eq. 20-43), we find

$$\begin{aligned} \Delta S &= nR\ln\left(\frac{V_f}{V_i}\right) + n\left(\frac{3}{2}R\right)\ln\left(\frac{T_f}{T_i}\right) \\ &= nR\left(\ln 2 + \frac{3}{2}\ln\left(2e^{-1}\right)\right) \\ &= \frac{p_i V_i}{T_i}\left(\ln 2 + \frac{3}{2}\ln 2 + \frac{3}{2}\ln e^{-1}\right) \\ &= \frac{(5000\,\text{Pa})(1.00\,\text{m}^3)}{600\,\text{K}}\left(\frac{5}{2}\ln 2 - \frac{3}{2}\right) \\ &= 1.94 \text{ J/K} . \end{aligned}$$