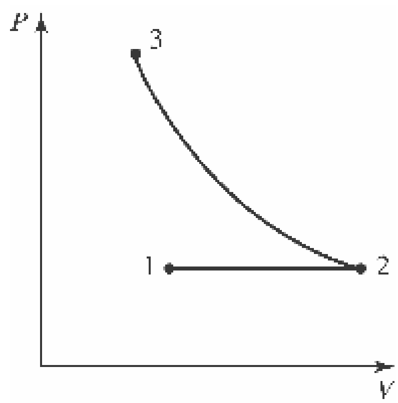
A cylinder with a frictionless movable piston contains a quantity of helium gas. Initially the gas is at a pressure of 1.00×10^5 Pa, has a temperature of 300 K, and occupies a volume of 1.50 L. The gas then undergoes two processes. In the first, the gas is heated and the piston is allowed to move to keep the temperature equal to 300 K. This continues until the pressure reaches 2.50×10^4 Pa. In the second process, the gas is compressed at constant pressure until it returns to its original volume of 1.50 L. Assume that the gas may be treated as ideal.

a) On a p V-diagram, show both processes.
b) Find the volume of the gas at the end of the first process, and find the pressure and temperature at the end of the second process.
c) Find the total work done by the gas during both processes.
d) What would you have to do to the gas to return it to its original pressure and temperature?

a)



b) At constant temperature,

$$V_2 = V_1 \frac{p_1}{p_2} = (1.5\,L)\left(\frac{1.00 \times 10^5\ Pa}{2.50 \times 10^4\ Pa}\right) = 6.00\ L$$

The final pressure is given as being the same as $p_3 = p_2 = 2.5 \times 10^4\ Pa.$ The final volume is the same as the initial volume, so

$$T_3 = T_1 (p_3 / p_1) = 75.0\,\text{K}.$$

c) Treating the gas as ideal, the work done in the first process is

$$= (1.00 \times 10^5\,Pa)(1.5 \times 10^{-3} m^3)\ ln\left(\frac{1.00 \times 10^5\,Pa}{2.50 \times 10^4\,Pa}\right) = 208\ \text{J},$$

For the second process, $p_2(V_3 - V_2) = P_2(V_1 - V_2) = p_2 V_1 (1 - (p_1/p_2)).$

The total work done is $208\ \text{J} - 113\ \text{J} = 95\ \text{J}.$

d) Heat at constant volume.