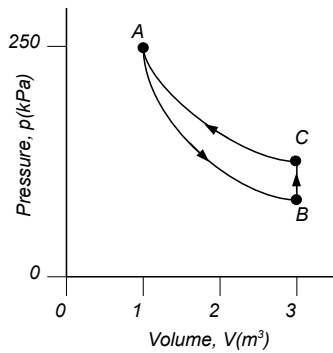


## Chapter 18 Problem 45 †



### Given

$$\gamma = 1.67$$

$$P_A = 250 \text{ kPa} = 2.5 \times 10^5 \text{ Pa}$$

$$V_A = 1.00 \text{ m}^3$$

$$V_B = 3.00 \text{ m}^3$$

### Solution

a) Find the pressure at  $B$ .

The process from  $A$  to  $B$  is adiabatic. The relationship between pressure and volume is then

$$PV^\gamma = \text{const.}$$

The pressure and volume at  $A$  and  $B$  are then related by

$$P_A V_A^\gamma = P_B V_B^\gamma$$

Solving for the pressure at  $B$  gives

$$P_B = \frac{P_A V_A^\gamma}{V_B^\gamma} = P_A \left( \frac{V_A}{V_B} \right)^\gamma$$

$$P_B = (2.5 \times 10^5 \text{ Pa}) \left( \frac{1.0 \text{ m}^3}{3.0 \text{ m}^3} \right)^{1.67} = 3.99 \times 10^4 \text{ Pa}$$

b) Find the pressure at  $C$ .

The process from  $C$  to  $A$  is isothermal. Their relationship between pressure and volume is then

$$PV = nRT = \text{const.}$$

The pressure and volume at  $C$  and  $A$  are then related by

$$P_C V_C = P_A V_A$$

Solving for the pressure at  $C$  gives

$$P_C = P_A \left( \frac{V_A}{V_C} \right) = (2.5 \times 10^5 \text{ Pa}) \left( \frac{1.0 \text{ m}^3}{3.0 \text{ m}^3} \right) = 8.33 \times 10^4 \text{ Pa}$$

†Problem from Essential University Physics, Wolfson

c) Find the net work done on the gas.

The work done during the adiabatic process is

$$W = \frac{P_A V_A - P_B V_B}{\gamma - 1}$$

$$W = -\frac{(2.5 \times 10^5 \text{ Pa})(1.0 \text{ m}^3) - (3.99 \times 10^4 \text{ Pa})(3.0 \text{ m}^3)}{1.67 - 1}$$

$$W = -1.94 \times 10^5 \text{ J}$$

The work done during the process  $B$  to  $C$  is  $0 \text{ J}$  since the volume does not change.

The work done during the isothermal process is

$$W = -nRT \ln \left( \frac{V_f}{V_i} \right)$$

Since  $nRT$  is constant, we can replace it with  $P_A V_A$ .

$$W = -P_A V_A \ln \left( \frac{V_A}{V_C} \right) = (2.5 \times 10^5 \text{ Pa})(1.0 \text{ m}^3) \ln \left( \frac{1.0 \text{ m}^3}{3.0 \text{ m}^3} \right)$$

$$W = 2.75 \times 10^5 \text{ J}$$

The total work is the sum of the work for all three processes.

$$W = -1.94 \times 10^5 \text{ J} + 0 \text{ J} + 2.75 \times 10^5 \text{ J}$$

$$W = 8.1 \times 10^4 \text{ J}$$