Problem 2.32

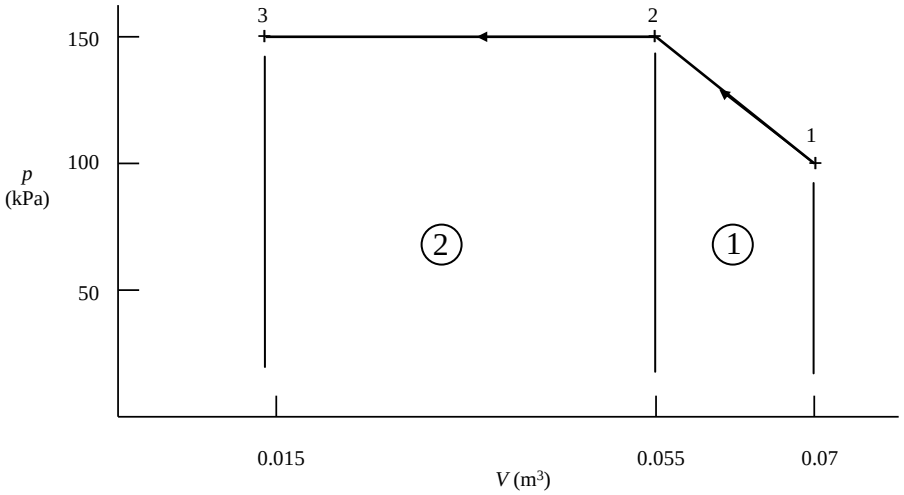
Air contained within a piston-cylinder assembly is slowly compressed. As shown in Fig P2.32, during this first process the pressure first varies linearly with volume and then remains constant. Determine the total work, in kJ.

KNOWN: Air within a piston-cylinder assembly undergoes two processes in series.

FIND: Determine the total work.

SCEMATIC AND GIVEN DATA:

ENGINEERING MODEL: (1) The air within the piston-cylinder assembly is the closed system. (2) The two-step *p*-*V* relation is specified graphically. (3) Volume change is the only work mode.



ANALYSIS: Since volume change is the work mode, Eq. 2.17 applies. Furthermore, the integral can be evaluated geometrically in terms of the total area under process lines:

$$W = \int_{V_1}^{V_2} p\,dV = \underset{①}{p_{\text{ave}}}(V_2 - V_1) + \underset{②}{p_2}(V_3 - V_2) = \left(\frac{p_1 + p_2}{2}\right)(V_2 - V_1) + p_2(V_3 - V_2)$$

$$= \left[\left(\frac{100+150}{2}\right)\text{kPa}(0.055 - 0.07)\text{m}^3 + (150)(0.015 - 0.055)\right]\left|\frac{10^3\text{N/m}^2}{1\text{ kPa}}\right|\left|\frac{1\text{ kJ}}{10^3\text{N·m}}\right|$$

= (-1.875 kJ) + (-6 kJ) = -7.875 kJ (in) ◄