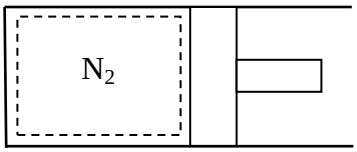
Problem 2.29

Nitrogen (N_2) gas within a piston-cylinder assembly undergoes a process from p_1 = 20 bar, V_1 = 0.5 m^3 to a state where V_2 = 2.75 m^3. The relationship between pressure and volume during the process is $pV^{1.35}$ = *constant*. For the N_2, determine (a) the pressure at state 2, in bar, and (b) the work, in kJ.

KNOWN: N_2 gas within a piston-cylinder assembly undergoes a process where the *p*-*V* relation is $pV^{1.35}$ = *constant*. Data are given at the initial and final states.

FIND: Determine the pressure at the final state and the work.

SCHEMATIC AND GIVEN DATA:



$pV^{1.35}$ = *constant*
p_1 = 20 bar, V_1 = 0.5 m^3
V_2 = 2.75 m^3

ENGINEERING MODEL: (1) The N_2 is the closed system. (2) The *p*-*v* relation is specified for the process. (3) Volume change is the only work mode.

ANALYSIS: (a) $p_1V_1^n = p_2V_2^n \quad \rightarrow \quad p_2 = p_1\left(\frac{V_1}{V_2}\right)^n$; n = 1.35. Thus

$$p_2 = (20\text{ bar})\left(\frac{0.5\text{ m}^3}{2.75\text{ m}^3}\right)^{1.35} = 2\text{ bar}$$ ←

(b) Since volume change is the only work mode, Eq. 2.17 applies. Following the procedure of part (a) of Example 2.1, we have

$$W = \frac{p_2V_2 - p_1V_1}{1-n} = \frac{(2\text{ bar})(2.75\text{ m}^3) - (20)(0.5)}{1-1.35}\left|\frac{10^5\text{N/m}^2}{1\text{ bar}}\right|\left|\frac{1\text{ kJ}}{10^3\text{N·m}}\right|$$

$$= 1285.7\text{ kJ}$$ ←