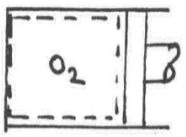
PROBLEM 2.30

KNOWN: O_2 gas within a piston-cylinder assembly undergoes an expansion where the p-V relation is $p = AV^{-1} + B$

FIND: Determine the initial and final pressures and the work.

SCHEMATIC & GIVEN DATA:



$p = AV^{-1} + B$
$A = 0.06\ \text{bar}\cdot\text{m}^3$
$B = 3.0\ \text{bar}$
$V_1 = 0.01\ \text{m}^3$, $V_2 = 0.03\ \text{m}^3$

ENGR. MODEL:

1. The O_2 is the closed system
2. The p-V relation during expansion is specified.
3. Volume change is the only work mode.

ANALYSIS:

(a) $P_1 = [(0.06\ \text{bar}\cdot\text{m}^3)/0.01\text{m}^3] + 3.0\ \text{bar}$

$\therefore P_1 = 9.0\ \text{bar}$

$P_2 = [(0.06\ \text{bar}\cdot\text{m}^3)/(0.03\ \text{m}^3)] + 3.0\ \text{bar}$

$\therefore P_2 = 5.0\ \text{bar}$ ←

(b) Since volume change is the work mode, Eq. 2.17 applies. That is,

$$W = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} \left[\frac{A}{V} + B\right] dV = A\ln\frac{V_2}{V_1} + B(V_2 - V_1)$$

$$= (0.06\ \text{bar}\cdot\text{m}^3)\ln\left(\frac{0.03\ \text{m}^3}{0.01\ \text{m}^3}\right) + (3.0\ \text{bar})[0.03 - 0.01]\ \text{m}^3$$

$$= [0.0659 + 0.06]\ \text{bar}\cdot\text{m}^3 \left|\frac{10^5\ \text{N/m}^2}{1\ \text{bar}}\right| \left|\frac{1\ \text{kJ}}{10^3\ \text{N}\cdot\text{m}}\right|$$

$$= 12.59\ \text{kJ}$$ ←