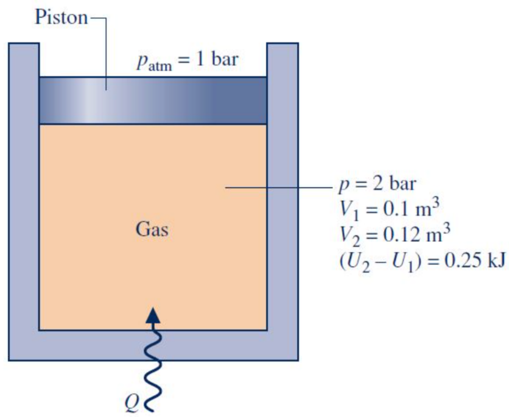
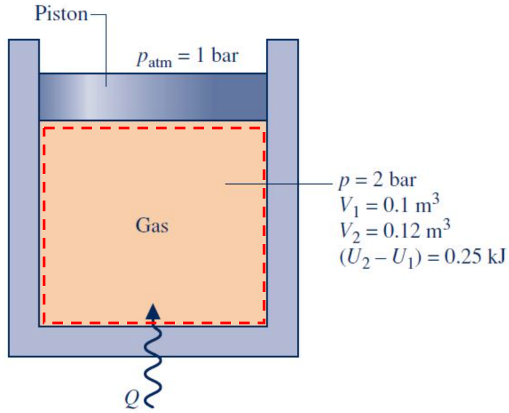
As shown in the figure, a gas contained within a piston-cylinder assembly, initially at a volume of 0.1 m^3, undergoes a constant-pressure expansion at 2 bar (abs) to a final volume of 0.12 m^3, while being slowly heated through the base. The change in internal energy of the gas is 0.25 kJ. The piston and cylinder walls are fabricated from heat-resistant material, and the piston moves smoothly in the cylinder. The local atmospheric pressure is 1 bar (abs). For the gas as the system, evaluate the work done by the gas and the heat transfer into the gas, each in kJ.



SOLUTION:



Let the system be the gas in the piston, as indicated by the red dashed line. Find the work done by the gas,

$$W_{by\ sys} = \int_{V_1}^{V_2} p dV = p \int_{V_1}^{V_2} dV = p(V_2 - V_1). \quad (1)$$

Note that the pressure remains constant during the process and, thus, can be moved outside the integral. Using the given data,

p = 2 bar (abs) = $2*10^5$ Pa (abs),

V_1 = 0.1 m^3,

V_2 = 0.12 m^3,

=> $\boxed{W_{by\ sys} = 4000 \text{ J} = 4.00 \text{ kJ}}$.

The heat transfer into the gas is found by applying the First Law to the control volume,

$$\Delta E_{sys} = Q_{into\ sys} - W_{by\ sys}, \quad (2)$$

where,

$$\Delta E_{sys} = \Delta U + \Delta KE + \Delta PE = \Delta U = U_2 - U_1 = 0.25 \text{ kJ}, \text{ (given; note that } \Delta KE = \Delta PE = 0), \quad (3)$$

$W_{by\ sys} = 4.00$ kJ (calculated previously),

=> $\boxed{Q_{into\ sys} = 4.25 \text{ kJ}}$.