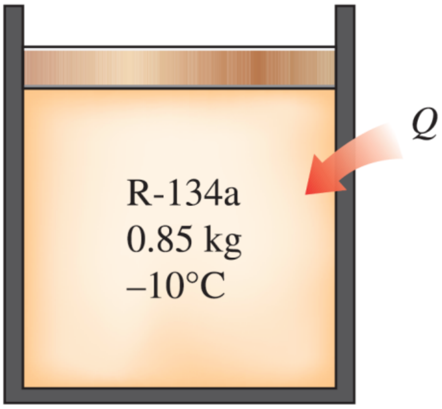
3–30 A piston–cylinder device contains 0.85 kg of refrigerant-134a at –10°C. The piston that is free to move has a mass of 60 kg and a diameter of 25 cm. The local atmospheric pressure is 88 kPa. Now, heat is transferred to refrigerant-134a until the temperature is 20 °C. Determine (*a*) the final pressure, (*b*) the change in the volume of the cylinder, and (*c*) the change in the enthalpy of the refrigerant-134a.



$A_{cir} = \pi r^2$

$= \frac{\pi}{4} D^2$

Part (a)

$P = \frac{mg}{A} + P_{atm}$ (see proof)

$= \frac{60 \times 9.81}{\frac{\pi}{4} \times 0.25^2 \times 1000} + 88 = 100 \text{ kPa}$

Part (b) & (c): First, we need to identify the phases:

For Phase of state ①: Go to Table A-12 and find T_{sat} at 100 kPa

$T_{sat} = -26.37^\circ C \rightarrow T_1 > T_{sat}$

$\rightarrow$ superheated vapor

For Phase of state (2): $T_2 > T_{sat}$

$\rightarrow$ superheated vapor

$\Delta V = V_2 - V_1 = m v_2 - m v_1 = m(v_2 - v_1)$

$\Delta H = H_2 - H_1 = m h_2 - m h_1 = m(h_2 - h_1)$

Go to Table A-13 and find v_1 & h_1

at $P_1 = 100$ kPa and $T_1 = -10^\circ C$

$v_1 = 0.20743 \ m^3/kg$

$h_1 = 247.51 \ kJ/kg$

Also from Table A-13, find v_2 & h_2

at $P_2 = 100$ kPa and $T_2 = 20^\circ C$

$v_2 = 0.23373 \ m^3/kg$

$h_2 = 272.17 \ kJ/kg$

$$\Delta V = m(v_2 - v_1)$$

$$= 0.85 \times (0.23373 - 0.20743)$$

$$= \square \ m^3$$

$$\Delta H = m(h_2 - h_1)$$

$$= 0.85 \times (272.17 - 247.51)$$

$$= \square \ kJ$$