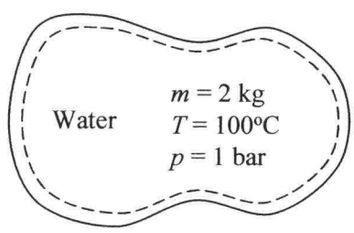
PROBLEM 7.11

7.11 A system consists of 2 kg of water at 100°C and 1 bar. Determine the exergy, in kJ, if the system is at rest and zero elevation relative to an exergy reference environment for which T_0 = 20°C, p_0 = 1 bar.

KNOWN: System of water at specified temperature and pressure exists in a reference environment with specified temperature and pressure.

FIND: Exergy of the system.

SCHEMATIC AND GIVEN DATA:



T_0 = 20°C
p_0 = 1 bar

ENGINEERING MODEL:
1. The water is a closed system defined by the dashed line on the accompanying diagram.
2. The effects of motion and gravity can be ignored.
3. T_0 = 20°C = 293 K and p_0 = 1 bar.

ANALYSIS:
The exergy of the system can be determined from Eq. 7.1

$$E = (U - U_0) + p_0(V - V_0) - T_0(S - S_0) + KE + PE$$

Ignoring motion and gravity effects and rewriting extensive properties in terms of mass times specific properties gives

$$E = m[(u - u_0) + p_0(v - v_0) - T_0(s - s_0)]$$

The water in the system is superheated vapor. From Table A-4, u = 2506.7 kJ/kg, v = 1.696 m^3/kg, s = 7.3614 kJ/(kg·K).

Water at the reference state is compressed liquid. From Table A-2 at T_0 = 20°C, $u_0 \approx u_{f0}$ = 83.95 kJ/kg, $v_0 \approx v_{f0}$ = 0.0010018 m^3/kg, $s_0 \approx s_{f0}$ = 0.2966 kJ/(kg·K). Substituting values and applying appropriate conversion factors give

$$E = (2\,\text{kg})\left[(2506.7 - 83.95)\frac{\text{kJ}}{\text{kg}} + (1\,\text{bar})(1.696 - 0.0010018)\frac{\text{m}^3}{\text{kg}}\left|\frac{10^5\ \frac{\text{N}}{\text{m}^2}}{\text{bar}}\right|\left|\frac{\text{kJ}}{10^3\,\text{N}\cdot\text{m}}\right| - (293\,\text{K})(7.3614 - 0.2966)\frac{\text{kJ}}{\text{kg}\cdot\text{K}}\right]$$

$$E = \underline{\mathbf{1044.5\ kJ}}$$