By numerical substitution,

$$\Delta S = (0.38 \text{ kJ/kg K}) \ln \frac{(20+273.15)\text{ K}}{(120+273.15)\text{ K}} = -0.1115 \text{ kJ/kg K}.$$

Comments Temperature inside the logarithm must be in absolute units!

Example 4.3: Entropy of Compressed Liquid
Use the steam tables to estimate the entropy of water at 100 °C, 20 bar.

Solution Water at 100 °C, 20 bar is compressed liquid and its entropy is not listed in the steam tables that are provided in the appendix. It may be estimated, however, from the tabulated values at saturation. Since the entropy of liquids is largely independent of pressure and a function of temperature only, we may relate it to entropy on the saturation line in two different paths, one of constant temperature and one of constant pressure (see a very similar calculation of enthalpy in Example 3.13).

Constant-Pressure Path. Drawing a line of constant pressure from state $T_A = 100$ °C, $P_A =$ 20 bar to the saturated liquid at the same pressure ($P_C = 20$ bar, $T_C = T^{\text{sat}} = 212.38$ °C), we write the following relationship for the entropies at states A and C (see also Figure 3-9):

$$S_A = S_C + \overline{C}_{P\log} \ln \frac{T_C}{T_A}.$$

where $S_C = 2.4470$ kJ/kg K, obtained from the system tables. The heat capacity of water as a function of temperature is given by the equation,

$$C_P = 15.354 - 0.116117\,T + 0.000451\,T^2 - 7.842\times 10^{-7}\,T^3 + 5.206\times 10^{-10}\,T^4,$$

with T in kelvin and C_P in K/kg K. Using this equation, the log-T mean heat capacity between $T_A = 100$ °C $= 373.15$ K, and $T_C = 212.38$ °C $= 485.53$ K, is calculated to be

$$\overline{C}_{P\log} = 4.341 \text{ kJ/kg K}.$$

Using these results the entropy at A is

$$S_A = S_C + \overline{C}_{P\log} \ln \frac{T_{\cancel{C}\,A}}{T_{\cancel{A}\,C}} = 2.4470 \text{ kJ/kg K} + (4.341 \text{ kJ/kg K}) \ln \frac{373.15\text{ K}}{485.53\text{ K}} = 1.304 \text{ kJ/kg K}.$$

Constant-Temperature Path. Assuming entropy to be a function of temperature only, an isotherm is also a line of constant entropy. Therefore, the entropy at 100 °C, 20 bar may be taken to be approximately the same as the entropy of saturated liquid at 100 °C:

$$S_A \approx S_L(100\text{ °C}) = 1.307 \text{ kJ/kg K}.$$

This result agrees very well with the one obtained using the constant-pressure path.