Problem 1
How much heat is required to change 1.0 kg of ice, originally at \(-20.0^\circ\text{C}\), into steam at \(110.0^\circ\text{C}\)? Assume 1.0 atm of pressure.

Useful constants:
- \(c_{\text{water}} = 4186 \text{ J/(kg C)}^\circ\)
- \(c_{\text{ice}} = 2.00 \times 10^3 \text{ J/(kg C)}^\circ\)
- \(c_{\text{steam}} = 2.00 \times 10^3 \text{ J/(kg C)}^\circ\)
- \(L_f = 33.5 \times 10^4 \text{ J/kg}\)
- \(L_v = 22.6 \times 10^5 \text{ J/kg}\)

\[Q = m c_{\text{ice}} \Delta T + m L_f + m c_{\text{water}} \Delta T + m L_v + m c_{\text{steam}} \Delta T\]

\[Q = (1.0 \text{ Kg}) \left[ (2.00 \times 10^3 \text{ J/Kg C}) (20.0^\circ\text{C}) + 33.5 \times 10^4 \text{ J/Kg} + (4186 \frac{\text{ J}}{\text{Kg C}}) (100.0^\circ\text{C}) + 22.6 \times 10^5 \text{ J/Kg} + (2.00 \times 10^3 \frac{\text{ J}}{\text{Kg C}}) (10.0^\circ\text{C}) \right]\]

\[Q = 3.1 \times 10^6 \text{ J}\]
Problem 2
What mass of water at 95.0 °C must be mixed with 150.0 g of ice at -5.00 °C, in a thermally insulated container, to produce liquid water at 50.0 °C?

Useful constants:

\[ c_{\text{water}} = 4186 \text{ J/(kg °C)} \]
\[ c_{\text{ice}} = 2.00 \times 10^3 \text{ J/(kg °C)} \]
\[ L_f = 33.5 \times 10^4 \text{ J/kg} \]
\[ L_v = 22.6 \times 10^5 \text{ J/kg} \]

\[ Q_{\text{lost by water}} = (\text{water mass}) \cdot c_{\text{water}} \cdot (\Delta T_{\text{water}}) = 45.0 \circ C \]

\[ Q_{\text{gained by ice}} = (\text{ice mass}) \cdot c_{\text{ice}} \cdot (\Delta T_{\text{ice}}) + (\text{ice mass}) \cdot L_f + (\text{ice mass}) \cdot c_{\text{water}} \cdot (\Delta T) \]

\[ \text{ice warming to -5.00 °C} \]
\[ \text{ice melting} \]
\[ \text{water warming to 50.0 °C} \]

\[ M_{\text{water}} \cdot c_{\text{water}} \cdot (\Delta T_{\text{water}}) = (\text{ice mass}) \cdot c_{\text{ice}} \cdot (\Delta T_{\text{ice}}) + (\text{ice mass}) \cdot L_f + (\text{ice mass}) \cdot c_{\text{water}} \cdot (\Delta T) \]

\[ M_{\text{water}} = \frac{(\text{ice mass}) \cdot (c_{\text{ice}} \cdot (\Delta T_{\text{ice}}) + L_f + c_{\text{water}} \cdot (\Delta T))}{c_{\text{water}} \cdot (\Delta T_{\text{water}})} \]

\[ M_{\text{water}} = \frac{(0.150 \text{ Kg}) \cdot [(2.00 \times 10^3 \text{ J/kg °C})(5.00 °C) + 33.5 \times 10^4 \text{ J/kg} + (4186 \text{ J/kg °C})(50.0 °C)]}{(4186 \text{ J/kg °C})(45.0 °C)} \]

\[ M_{\text{water}} = 0.441 \text{ Kg} = 441 \text{ g} \]

Note: when using \( Q_{\text{gained}} = Q_{\text{lost}} \) to solve calorimetry problems, \( Q \) is always \( > 0 \), so we must use \( \Delta T > 0 \), even if the temperature decreased.
Problem 3
One end of an iron poker is placed in a fire where the temperature is 502 °C, and the other end is kept at a temperature of 26 °C. The poker is 1.2 m long and has a radius of \(5.0 \times 10^{-3}\) m. Ignoring the heat lost along the length of the poker, find the amount of heat conducted from one end of the poker to the other in 5.0 s.

Note: the heat \(Q\) conducted during a time \(t\) through a
bar of length \(L\) and cross-sectional area \(A\) is given by:

\[
Q = \frac{(KA \Delta T)t}{L}
\]

where \(\Delta T\) is temperature difference between the ends of the bar and \(K\) is thermal conductivity of the material.

\[
\Delta T = 502\,^\circ C - 26\,^\circ C = 476\,^\circ C
\]

\(L = 1.2\,m\)

\(A = \pi r^2 = \pi (5.0 \times 10^{-3}\,m)^2 = 7.85 \times 10^{-5}\,m^2\)

\(t = 5.0\,s\)

\(K_{\text{iron}} = 79\,J/(s\cdot m\cdot ^\circ C)\)

\[
Q = \frac{(KA \Delta T)t}{L} = \frac{(79\,J/(s\cdot m\cdot ^\circ C))(7.85 \times 10^{-5}\,m^2)(476\,^\circ C)(5.0\,s)}{(1.2\,m)}
\]

\[
Q = 12.3\,J
\]