44. We compute with Celsius temperature, which poses no difficulty for the J/kg·K values of specific heat capacity (see Table 19-3) since a change of Kelvin temperature is numerically equal to the corresponding change on the Celsius scale. If the equilibrium temperature is T_f then the energy absorbed as heat by the ice is $Q_I = L_F m_I + c_w m_I (T_f - 0°\text{C})$, while the energy transferred as heat from the water is $Q_w = c_w m_w (T_f - T_i)$. The system is insulated, so $Q_w + Q_I = 0$, and we solve for T_f:

$$T_f = \frac{c_w m_w T_i - L_F m_I}{(m_I + m_c)\, c_w} \; .$$

(a) Now $T_i = 90°\text{C}$ so

$$T_f = \frac{(4190\,\text{J/kg}\cdot\text{C}°)(0.500\,\text{kg})(90°\text{C}) - \left(333 \times 10^3\,\text{J/kg}\right)(0.500\,\text{kg})}{(0.500\,\text{kg} + 0.500\,\text{kg})(4190\,\text{J/kg}\cdot\text{C}°)} = 5.3°\text{C} \; .$$

(b) If we were to use the formula above with $T_i = 70°\text{C}$, we would get $T_f < 0$, which is impossible. In fact, not all the ice has melted in this case (and the equilibrium temperature is $0°\text{C}$) The amount of ice that melts is given by

$$m_I' = \frac{c_w m_w \,(T_i - 0°\text{C})}{L_F} = \frac{(4190\,\text{J/kg}\cdot\text{C}°)\,(0.500\,\text{kg})\,(70\,\text{C}°)}{333 \times 10^3\,\text{J/kg}} = 0.440\ \text{kg} \; .$$

Therefore, there amount of (solid) ice remaining is $\Delta m_I = m_I - m_I' = 500\,\text{g} - 440\,\text{g} = 60\,\text{g}$, and (as mentioned) we have $T_f = 0°\text{C}$ (because the system is an ice-water mixture in thermal equilibrium).