c_{water} = 4200 \text{ J/kgK} \quad c_{ice} = 2100 \text{ J/kgK} \quad c_{copper} = 390 \text{ J/kgK}

L_{f, ice} = 3.34 \times 10^5 \text{ J/kg} \quad L_{v, water} = 22.5 \times 10^5 \text{ J/kg}

**Latent heat and Specific heat capacity questions.**

1. How much water at 50°C is needed to just melt 2.2 kg of ice at 0°C?

2. How much water at 32°C is needed to just melt 1.5 kg of ice at -10°C?

3. How much steam at 100°C is needed to just melt 5 kg of ice at -15°C?

4. A copper cup holds some cold water at 4°C. The copper cup weighs 140g while the water weighs 80g. If 100g of hot water, at 90°C is added, what will be the final temperature of the water?

5. a) Explain where the energy is going at each section of the curve from "a" to "e"

b) Using section "b", calculate the amount of ice used to produce the graph

c) Using section "c", calculate the amount of ice used to produce the graph
Solutions

1. How much water at 50°C is needed to just melt 2.2 kg of ice at 0°C?

Heat loss = heat gain
Heat loss of water = heat to melt ice
\[ m_{\text{water}} c_{\text{water}} \Delta T = m_{\text{ice}} c_{\text{ice}} \Delta T \]
\[ m_{\text{water}} \times 4200 \times (50 - 0) = 2.2 \times 3.34 \times 10^5 \]
\[ m_{\text{water}} = 3.50 \text{ kg} \]

2. How much water at 32°C is needed to just melt 1.5 kg of ice at -10°C?

Heat loss = heat gain
Heat loss of water = heat gain of ice + heat to melt ice
\[ m_{\text{water}} c_{\text{water}} \Delta T = m_{\text{ice}} c_{\text{ice}} \Delta T + m_{\text{ice}} L_f \]
\[ m_{\text{water}} \times 4200 \times (32 - 0) = 1.5 \times 2300 \times (0 - (-10)) + 1.5 \times 3.34 \times 10^5 \]
\[ m_{\text{water}} = 3.98 \text{ kg} \]

3. How much steam at 100°C is needed to just melt 5 kg of ice at -15°C?

Heat loss = heat gain
Heat to condense steam + Heat loss of water = heat gain of ice + heat to melt ice
\[ m_{\text{steam}} L_v + m_{\text{steam}} c_{\text{water}} \Delta T = m_{\text{ice}} c_{\text{ice}} \Delta T + m_{\text{ice}} L_f \]
\[ m_{\text{steam}} \times 22.5 \times 10^5 + m_{\text{steam}} \times 4200 \times (100 - 0) = 5 \times 2300 \times (0 - (-15)) + 5 \times 3.34 \times 10^5 \]
\[ 2.67 \times 10^6 \times m_{\text{steam}} = 1.84 \times 10^6 \]
\[ m_{\text{steam}} = 0.69 \text{ kg} \]

4. A copper cup holds some cold water at 4°C. The copper cup weighs 140g while the water weighs 80g. If 100g of hot water, at 90°C is added, what will be the final temperature of the water?

Heat loss = heat gain
heat gain of cup + heat gain of cold water = heat loss of hot water
\[ m_{\text{cup}} c_{\text{cup}} \Delta T + m_{\text{water}} c_{\text{water}} \Delta T = m_{\text{hot}} c_{\text{water}} \Delta T \]
\[ 0.14 \times 0.14 \times (T_f - 4) + 0.08 \times 4200 \times (T_f - 4) = 0.1 \times 4200 \times (90 - T_f) \]
\[ 390.6T_f - 1562.4 = 37800 - 420T_f \]
\[ 810.6T_f = 393624 \]
\[ T_f = 48.6°C \]

5. a) Explain what is occurring at each section of the curve from "a" to "e"

- a - ice particles are increasing in kinetic energy, raising temperature
- b - ice particles are breaking apart and increasing in potential energy as ice melts
- c - water particles are increasing in kinetic energy, raising temperature
- d - water particles are breaking apart and increasing in potential energy as water vaporises
- e - steam particles are increasing in kinetic energy, raising temperature
b) Using section "b", calculate the amount of ice used to produce the graph

\[ \Delta Q = mL_f \]
\[ 480 - 140 = m \times 3.34 \times 10^5 \]
\[ m = 0.001 \text{ kg} \text{ (approx 1 g, with error from reading graph)} \]

c) Using section "c", calculate the amount of ice used to produce the graph

\[ \Delta Q = mc\Delta T \]
\[ 920 - 480 = m \times 4200 \times (100 - 0) \]
\[ m = 0.001 \text{ kg} \text{ (approx 1 g, with error from reading graph)} \]