Remember: \( Q = mc \Delta T \); \( P = \varepsilon A \sigma T^4 \); 273K=0°C
Useful constants: \( \sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K} \); For copper: \( c=390 \text{ Joules/kg°C} \);
For water: \( c\text{(water)}=c\text{(ice)}=4190 \text{ Joules/kg°C} \);
latent heat of fusion = \( 334 \times 10^3 \text{ J/kg} \); latent heat of vaporization = \( 2256 \times 10^3 \text{ J/kg} \)

Give answers with correct **units** and three significant figures

(a) A 0.5 kg block of copper is heated to 200°C. The block is then quickly placed in an insulated tub of 100g of ice at 0°C and sealed. How much heat is needed to melt the ice?

\[
\text{Heat needed to melt ice} = (\text{latent heat of fusion})(\text{mass})
= (334 \times 10^3 \text{ J/kg}) (0.1 \text{ kg}) = 334 \times 10^2 \text{ Joules}
\]

(b) Does the ice melt? \( \text{Yes.} \)

(c) What is the final temperature at equilibrium of the ice and block?

\[
Q = mc \Delta T = MBcB (T_f - Ti)
= -[ \text{heat used to melt ice} + MWcW (T_f - 0°) ]
\]

\[
MBcBT_f + MWcWT_f = -334 \times 10^2 \text{ J} + MBcBT_i
\]

\[
T_f = \frac{-334 \times 10^2 \text{ J} + (0.5 \text{ kg})(390 \text{ Joules/keG})(20°C)}{(0.5 \text{ kg})(390 \text{ J/keG} °C) + (0.1 \text{ kg})(4190 \text{ J/keG} °C)}
\]

\[
T_f = 9.12°C
\]

(over) \( T_f > 0°C \) = have enough heat to melt ice
There are 2 ways to work the problem. Both ways give correct answers.

Do not keep taking signs! heat from block = + heat from water/ice.

First solution solved for \( T_f \) taking into account how much heat to melt ice + how much heat to increase water to that water and block at same temperature.

Because specific heat of copper is small, it will lose a lot of heat.

Second method: calculate heat needed to melt ice to get water + calculate heat to get copper and water to same temperature.

Method 2:

\[
Q_{\text{from block to water}} = -Q_{\text{from ice to block}} \leq \\
MB (\Delta T) = -3.34 \times 10^2 \text{ Joules} \leq \\
\Delta T = T_f - 20^\circ C = -3.34 \times 10^2 \text{ Joules} \leq \\
\Delta T = -171.3^\circ C \Rightarrow T_f = 287^\circ C \leq \\
(\text{water has more energy heat than metal}) \leq \\
Q_{\text{from block to water}} = -Q_{\text{from water to block}} \leq \\
MB \cdot C_B (T_f - T_i) = -MW \cdot C_W (T_f - 0^\circ C) \leq \\
\]
\[ T_f = \frac{M_{BCB}}{M_{BCB} + M_{wC}} = T_1 M_{BCB} \]

\[ T_1 = T_f \left( \frac{M_{BCB}}{M_{BCB} + M_{wC}} \right) \]

\[ = (28.7^\circ C) \left( \frac{10.1 kg \times 391 \text{ Joules}}{kg \cdot ^\circ C} \right) \]

\[ = (0.5 kg) \left( 390 \frac{\text{ Joules}}{kg \cdot ^\circ C} \right) + (0.1 kg) \left( 480 \frac{\text{ Joules}}{kg \cdot ^\circ C} \right) \]

\[ T_f = 91.2^\circ C \]

**Notes:**
- Method #1: \( ^\circ C \) = \( \frac{\text{ Joules}}{\text{ Joules/}^\circ C + \text{ Joules/}^\circ C} \)

- Method #2: \( ^\circ C \) = \( \frac{\text{ Joules}}{\text{ Joules/}^\circ C} \)