General Physics Midterm Review

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1. A poorly designed electric device has two bolts attached to different parts of the device that almost touch each other in its interior, as shown. When they touch, a short circuit will develop and damage the device.If the initial gap between the ends of the bolts is 5.0 µm at 27 °C, at what temperature will the bolts touch?

   (a) $\text{Steel}_{\text{length}} = 0.01\,\text{m} = 1 \times 10^{-2}\text{m}$

   (b) $\text{Brass}_{\text{length}} = 0.03\,\text{m} = 3 \times 10^{-2}\text{m}$

   (c) $\text{Gap}_{\text{length}} = 0.05\,\mu\text{m} = 5 \times 10^{-6}\text{m}$

   (d) $\alpha_{\text{Steel}} = 11 \times 10^{-6}\,{}^{\circ}\text{C}^{-1}$

   (e) $\alpha_{\text{Brass}} = 19 \times 10^{-6}\,{}^{\circ}\text{C}^{-1}$

   (f) $\triangle L = \alpha L_0 \triangle T$

   (g) $\triangle L = \text{Gap}_{\text{length}} = 5 \times 10^{-6}\text{m}$

$$
\begin{aligned}
\triangle T &= \frac{\triangle L}{\alpha L_0} \\
&= \frac{\text{Gap}_{\text{length}}}{\alpha_{\text{Steel}}\text{Steel}_{\text{length}} + \alpha_{\text{Brass}}\text{Brass}_{\text{length}}}\,{}^{\circ}\text{C} \\
&= \frac{5 \times 10^{-6}}{(11 \times 10^{-6} \times 1 \times 10^{-2}) + (19 \times 10^{-6} \times 3 \times 10^{-2})}\,{}^{\circ}\text{C} \\
&= \frac{5 \times 10^{-6}}{(11 \times 10^{-8}) + (57 \times 10^{-8})}\,{}^{\circ}\text{C} \\
&= \frac{5 \times 10^{-6}\text{m}}{(68 \times 10^{-8})}\,{}^{\circ}\text{C} \\
&= \frac{5}{(68 \times 10^{-2})}\,{}^{\circ}\text{C} \\
&= \frac{5}{(68 \times 10^{-2})}\,{}^{\circ}\text{C} \\
&= 7.3529\,{}^{\circ}\text{C}
\end{aligned}
$$

$$
\begin{aligned}
T_1 &= T_0 + \triangle T\,{}^{\circ}\text{C} \\
&= 27 + 7.3529\,{}^{\circ}\text{C} \\
&= 34.3529\,{}^{\circ}\text{C}
\end{aligned}
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2. 500 g of ice is added to an insulated cup that contains 200 g of water at 50.0 °C. What is the final temperature.

   (a) $\text{Ice}_{\text{mass}} = 500\,\text{g} = 5 \times 10^{-1}\text{kg}$
   (b) $\text{Water}_{\text{mass}} = 200\,\text{g} = 2 \times 10^{-1}\text{kg}$
   (c) $\text{Ice}_{\text{temp}} = 0\,°\text{C}$
   (d) $\text{Water}_{\text{temp}} = 50\,°\text{C}$
   (e) $\text{c}_{\text{water}} = 4.186 \times 10^{3}\,\dfrac{\text{J}}{\text{kg}}°\text{C}$
   (f) $\text{L}_{\text{ice}} = 3.33 \times 10^{5}\,\dfrac{\text{J}}{\text{kg}}$
   (g) $\text{Q}_{\text{water}} = -\text{Q}_{\text{ice}}$
   (h) $Q = mc\triangle T$
   (i) $Q = mL$
   (j) **False Assumption:** All the ice is melted

How much Ice$_{\text{mass}}$ would it take for Water$_{\text{temp}}$ to bring to $0°\text{C}$ **?**

$$\begin{aligned}
\text{Q}_{\text{water}} &= -\text{Q}_{\text{ice}} \\
\text{Water}_{\text{mass}} \times \text{c}_{\text{water}} \times (0\,°\text{C} - \text{Water}_{\text{temp}_0}) &= -\text{L}_{\text{ice}} \times \text{Ice}_{\text{mass}} \\
2 \times 10^{-1} \times 4.186 \times 10^{3} \times (0 - 50) &= -3.33 \times 10^{5} \times \text{Ice}_{\text{mass}} \\
\frac{2 \times 10^{-1} \times 4.186 \times 10^{3} \times -50}{-3.33 \times 10^{5}} &= \text{Ice}_{\text{mass}} \\
\frac{2 \times 4.186 \times 5}{3.33 \times 10^{2}} &= \text{Ice}_{\text{mass}} \\
\frac{4.186}{3.33 \times 10^{1}} &= \text{Ice}_{\text{mass}} \\
1.257 \times 10^{-1} &= \text{Ice}_{\text{mass}} \\
125.7\,\text{g} &= \text{Ice}_{\text{mass}}
\end{aligned}$$

$\because$ It takes 125.7 g of Ice to bring Water$_{\text{temp}}$ to 0 °C

$\therefore$ The final temperature is 0°C with 325.7 g of Water and 374.3 g of Ice