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

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\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}
$$

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\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) $\text{Ice}_{\text{temp}} = 0\,^{\circ}\text{C}$

   (d) $\text{Water}_{\text{temp}} = 50\,^{\circ}\text{C}$

   (e) $\text{c}_{\text{water}} = 4.186 \times 10^{3}\,\dfrac{\text{J}}{\text{kg}}{}^{\circ}\text{C}$

   (f) $\text{c}_{\text{ice}} = 2.090 \times 10^{3}\,\dfrac{\text{J}}{\text{kg}}{}^{\circ}\text{C}$

   (g) $\text{L}_{\text{ice}} = 3.33 \times 10^{5}\,\dfrac{\text{J}}{\text{kg}}$

   (h) $\text{Q}_{\text{water}} = -\text{Q}_{\text{ice}}$

   (i) $Q = mc\triangle T$

   (j) $Q = mL$

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\begin{aligned}
\text{Q}_{\text{water}} &= -\text{Q}_{\text{ice}} \\
\text{Water}_{\text{mass}} \times \text{c}_{\text{water}} \times (\text{Water}_{\text{temp}_1} - \text{Water}_{\text{temp}_0}) &= -((\text{L}_{\text{ice}} \times \text{Ice}_{\text{mass}}) + (\text{Ice}_{\text{mass}} \times \text{c}_{\text{Ice}} \times (\text{Ice}_{\text{temp}_1} - \text{Ice}_{\text{temp}_0}))) \\
2 \times 10^{-1} \times 4.186 \times 10^{3} \times (T_1 - 50) &= -(5 \times 10^{-1} \times 3.33 \times 10^{5}) - (5 \times 10^{-1} \times 2.090 \times 10^{3} \times (T_1 - 0)) \\
8.372 \times 10^{2} \times (T_1 - 50) &= -(16.5 \times 10^{4}) - (10.45 \times 10^{2} \times (T_1 - 0)) \\
8.372 \times (T_1 - 50) &= -(16.5 \times 10^{2}) - (10.45 \times (T_1 - 0)) \\
8.372T_1 - 418.6 &= -(16.5 \times 10^{2}) - 10.45T_1 \\
18.822T_1 - 418.6 &= -(16.5 \times 10^{2}) \\
18.882T_1 &= \frac{16.5 \times 10^{2}}{4.186 \times 10^{2}} \\
18.882T_1 &= 3.9417 \\
T_1 &= 0.2094\,^{\circ}\text{C}
\end{aligned}
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