PROBLEM 3 (cont'd.)

(a) In words describe the distinct steps in the cooling of lead.

1. Lead is cooled from $T_p$ to its melting point (MP).
2. Lead freezes at its melting point.
3. The solid lead cools from its MP ($232 \, ^\circ \text{C}$) to the equilibrium temperature ($218 \, ^\circ \text{C}$).

(b) How many calories of heat are absorbed by the calorimeter and the water it contains to reach $21.8^\circ \text{C}$?

\[
Q_{\text{gain}} = M_w c_w (218^\circ \text{C} - 10^\circ \text{C}) + M_{\text{al}} c_{\text{al}} (232^\circ \text{C} - 218^\circ \text{C})
\]

\[
= (150 \text{g})(1.00 \text{cal/g}^\circ \text{C})(118^\circ \text{C}) + (150 \text{g})(0.50 \text{cal/g}^\circ \text{C})(114^\circ \text{C})
\]

\[
Q_{\text{gain}} = 3740 \text{ cal}
\]

(c) How many calories are lost by the lead in cooling from $T_p$ to the final equilibrium temperature of $21.8^\circ \text{C}$? Assume $Q_{\text{lost}} = 0$. $Q_{\text{L}} = 3740 \text{ cal NEEDED}$

\[
Q_{\text{lost}} = -3740 \text{ cal}
\]

(d) What was the original furnace temperature?

\[
Q_{\text{lost}} = -3740 \text{ cal} = -M_{\text{al}} c_{\text{al}} (322^\circ \text{C} - T_f) + M_{\text{al}} c_{\text{al}} (322^\circ \text{C} - 218^\circ \text{C})
\]

\[
= (150 \text{g})(0.50 \text{cal/g}^\circ \text{C})(322^\circ \text{C} - 10^\circ \text{C}) - (150 \text{g})(0.50 \text{cal/g}^\circ \text{C})(322^\circ \text{C} - 218^\circ \text{C})
\]

\[
= 997 \text{ cal} - 305 \text{ cal/}^\circ \text{C} 
= 692 \text{ cal} - 524 \text{ cal/}^\circ \text{C} 
\]

\[
T_f = \frac{2176 \text{ cal}}{305 \text{ cal/}^\circ \text{C}} = 713^\circ \text{ C}
\]

(e) If the same mass of aluminum ($c_{\text{al}} = 0.215 \text{ cal/g}^\circ \text{C}$ and $L_m = 21.5 \text{ cal/g}$) were used in the same furnace instead of lead, would the final equilibrium temperature be higher, less or the same as in the lead case? No calculation is need to answer this. Please explain. Since both $c_m > c_p$ and $L_m (al) > L_m (pb)$ an equal amount of Al can store more thermal energy than the same amount of Pb at the same T. Thus, the final temp of the system will be higher for the aluminum material than for the lead system.