SUSB-053 – Problem 3

1) A student performed part 1 of the procedure. After plotting data as described in the calculations section, the student found the temperature of cold water, hot water, and temperature at time of mixing to be 22.3 °C, 47.7 °C, and 34.6 °C respectively. Calculate the calorimeter constant, \( C_{\text{cal}} \) for the calorimeter. Use the density and heat capacity values as shown in the calculations section.

The problem tells us the temperatures of the hot water, cold water and the backward extrapolated temperature of the mixture at 3 minutes (the time of mixing) that have been deduced in accordance with a graph like the following one. (The graph is drawn with an unbroken Y axis. The Temperature axis should be broken into segments to provide maximum precision in the reading of the extrapolated values.)

![Graph showing Temperature vs Time](image)

The amount of hot and cold water used was 50.0 mL of each. The hot and cold water underwent temperature changes of:

\[
\Delta T_{\text{hot}} = 34.6 - 47.7 = -13.1 \, \text{C}^\circ \\
\Delta T_{\text{cold}} = 34.6 - 22.3 = +12.3 \, \text{C}^\circ
\]
Note that the decrease in the hot water is larger than the increase in the cold water!¹

The heat change of each is proportional to the weight and the temperature change.

The heat lost by the hot water was:

$$ q_{\text{hot}} = 50.0 \text{ mL} \times 1.00 \text{ g/mL} \times 4.18 \text{ J/g}^\circ \text{C} \times (-13.1 \text{ C}^\circ) = -2.73 \times 10^3 \text{ J} $$

The heat gained by the cold water was:

$$ q_{\text{hot}} = 50.0 \text{ mL} \times 1.00 \text{ g/mL} \times 4.18 \text{ J/g}^\circ \text{C} \times (+12.3 \text{ C}^\circ) = 2.57 \times 10^3 \text{ J} $$

The difference in the magnitude of heat lost and gained is heat that warmed the calorimeter (by the same 12.3 C^° as the cold water which it contained).

That amount of heat was:

$$ q_{\text{cal}} = +2.57 \times 10^3 - (-2.73 \times 10^3) = 1.6 \times 10^2 \text{ J} $$

That amount of heat warmed the calorimeter by 12.3 C^°. So, the effective heat capacity of the calorimeter (the calorimeter constant) is

$$ C_{\text{cal}} = 1.6 \times 10^2 / 12.3 = 13 \text{ J/C}^\circ $$

¹ If the weight of hot and cold water are equal, the final temperature of mixing them will always be lower than the average of the hot and cold water temperatures. This permits easy checking of the calibration data without much calculation.