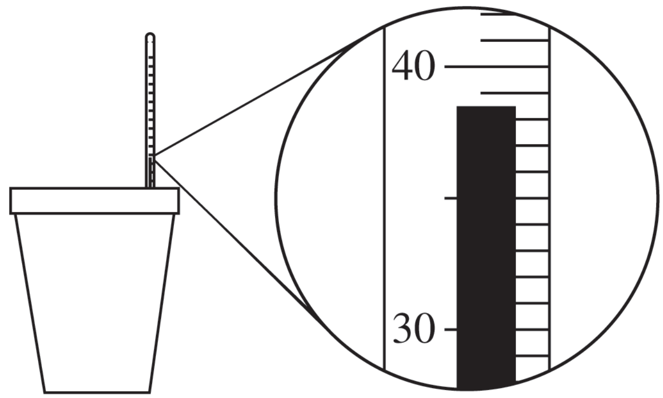
Begin your response to **QUESTION 4** on this page.

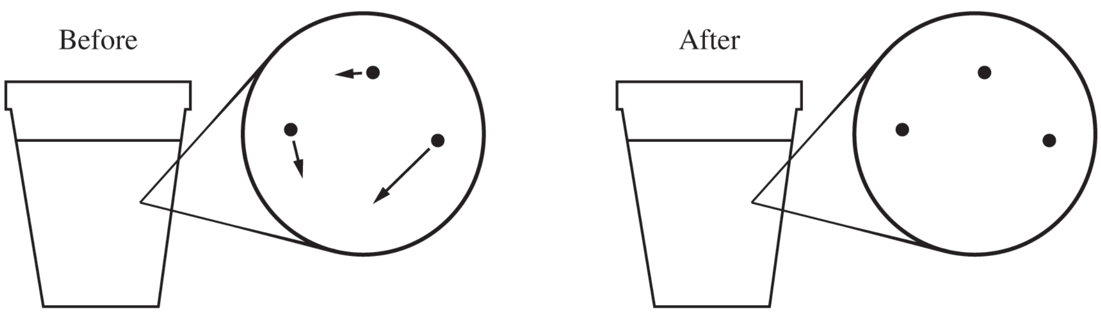
4. A student performs an experiment to determine the specific heat capacity of a metal. The student places a cube of the metal in boiling water so its temperature will be 100.0°C. The student then places the metal cube into a calorimeter that contains water and records the highest temperature of the water. A data table and a diagram of the thermometer at the highest temperature are shown.

Mass of metal cube	98.1 g
Mass of water	52.0 g
Initial temperature of metal cube	100.0°C
Initial temperature of water	25.0°C
Highest temperature of water	?



(a) What should the student report as the highest temperature of the water? ______________

(b) A particle-level representation of water molecules in the calorimeter before and after the metal cube was added is shown. The length of the arrows in the Before diagram represents the speed of the water molecules in the system. In the After diagram, draw an arrow for each molecule to indicate how the speed of each of the molecules changes after the metal cube is added.



GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 4** on this page.

(c) Assuming the metal transfers 2940 J of thermal energy to the water, calculate the specific heat of the metal in J/(g·°C).

(d) In a second experiment, 2940 J of thermal energy is transferred from 98.1 g of aluminum, which has a specific heat capacity of 0.897 J / (g·° C). Explain how the magnitude of the temperature change of the aluminum, ΔT_{Al}, compares with the magnitude of the temperature change of the metal in the original experiment.

GO ON TO THE NEXT PAGE.

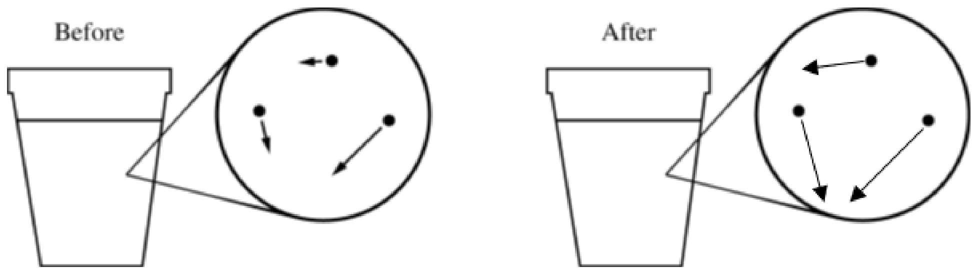
Question 4: Short Answer — 4 points

(a) For the correct answer, reported to the correct decimal place: **1 point**

38.5°C

(b) For a correct drawing: **1 point**

The "After" drawing should contain arrows that are longer, on average.



(c) For the correct calculated value, consistent with part (a): **1 point**

$q = mc\Delta T$

$$c_{metal} = \frac{q_{metal}}{m_{metal}\Delta T_{metal}} = \frac{-2940\text{ J}}{(98.1\text{ g})(38.5^\circ\text{C} - 100.0^\circ\text{C})} = 0.487\,\frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}}$$

(d) For a valid explanation, consistent with part (c): **1 point**

Accept one of the following:

- *The value of* ΔT_{Al} *will be smaller because Al has a greater specific heat capacity than the metal in the original experiment. Therefore, the same thermal energy transfer applied to the same mass will result in a smaller change in temperature, according to the equation* $q = mc\Delta T$.
- $q = mc\Delta T$

  $$|\Delta T_{\text{Al}}| = \left|\frac{q_{\text{Al}}}{m_{\text{Al}}c_{\text{Al}}}\right| = \left|\frac{-2940\text{ J}}{(98.1\text{ g})(0.897\,\frac{\text{J}}{\text{g}\cdot{}^\circ\text{C}})}\right| = 33.4^\circ\text{C}$$

  $|\Delta T_{metal}| = |38.5^\circ\text{C} - 100.0^\circ\text{C}| = 61.5^\circ\text{C}$

  Thus, $\Delta T_{\text{Al}} < \Delta T_{metal}$

Total for question 4 — 4 points