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Specific Heat Capacity Handout Answer Key

Objectives

- Calculate the specific heat capacity of a liquid.
- Determine the amount of energy required to heat a liquid to a particular temperature.

Data Collection Answers will vary, depending on collected data. Example answers in table below.

Mass of the iron:	**100 g**
Initial temperature of the iron (in boiling water):	**105 °C**
Final temperature of the iron:	**40 °C**
Mass of hot chocolate liquid:	**50 g**
Initial temperature of hot chocolate liquid:	**25 °C**
Final temperature of the hot chocolate liquid:	**40 °C**

Hot Chocolate Calculations Answers will vary, based on collected data. See example answers below.

1. Find the specific heat (SH) of the hot chocolate using the equation: $Q = mc\Delta T$.
   a. Find ΔT for the hot chocolate.

      Temperature change for hot chocolate = 40 °C – 25 °C = 15 °C

   b. Plug in known variables for the hot chocolate (HC).

      Q = (50 g)(specific heat of HC)(15 °C)

2. Since you have two unknowns, you cannot solve for the specific heat just yet. Put the known variables for iron into the equation: $Q = mc\Delta T$.
   a. First, find ΔT for the iron.

      Temperature change for iron = 105 °C – 40 °C = 65 °C

   b. Plug in known variables for the iron (SH iron = 0.45 J/g °C).

      Q = (100 g)(0.45 J/g °C)(65 °C)

3. We can assume that the heat lost by the iron equals the heat gained by the hot chocolate, so Q (heat energy) should be the same for the iron and the hot chocolate.
   a. Substitute Q for the iron into the Q for the hot chocolate equation.

      (100 g)(0.45 J/g °C)(65 °C) = (50 g)(specific heat of HC)(15 °C)

   b. Solve for the specific heat of hot chocolate.

      Specific heat of hot chocolate = 3.9 J/g °C

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4. To heat the hot chocolate to the optimal temperature of 57 °C, how much energy is needed?

   $Q = mc\Delta T$
   Q= (50 g)(3.9 J/g °C)(57 °C - 40 °C)
   Q= 3,315 J

Analysis Questions Answers will vary, depending on collected data.

1. Water has a specific heat of 4.18 J/g °C. How does this compare to the specific heat of the hot chocolate? If the two values are different, provide a possible explanation as to why.

   Example answer: The specific heat of the hot chocolate was 3.9 J/g °C, which is less than the specific heat of water. One possible reason for the difference is the specific heat of the hot chocolate powder that was mixed into the water. The powder might have lowered the specific heat. Another possible reason for the difference could be experimental error. Since the hot chocolate is mixed with water, I expected it to have the same SH as water. Errors might include measurement mistakes and external heat loss from the cup.

2. According to the *The American Association of Cereal Chemists* handbook, "Dairy-Based Ingredients" by Ramesh Chandan, skim milk has a specific heat of 3.97 J/g °C, whole milk has a specific heat of 3.89 J/g °C, and cream has a specific heat of 3.35 J/g °C.
   a. Why do you think that the specific heat for milk is different than cream?
      Possible answer: The specific heat of dairy products are different due to the amount of fat in the milk and cream; the more fat, the lower the SH of the liquid.

      Possible answer: Dairy products have different compositions that cause the liquids to have different specific heat.

   b. If you used whole milk instead of water to make the hot chocolate, how would that impact the cooling rate of the hot chocolate?
      Possible answer: Because whole milk has a lower SH than water, I think that the hot chocolate would cool faster if it was made with milk.

   c. If you wanted your hot chocolate to cool faster after it is made, which type of liquid would you use in the mixture? Explain your answer.
      Possible answer: I would use cream because it has the lowest specific heat —just 3.35 J/g °C. A lower specific heat causes the hot chocolate to be able to heat up and cool down faster. While the hot chocolate is cooling, it loses heat faster than if water was used. Hot chocolate made with cream loses heat faster than hot chocolate made with water.

3. Copper has a specific heat of 0.38 J/g °C. If you used the same mass of copper instead of iron in the experiment, how would this affect the hot chocolate?
   Possible answer: The specific heat of copper is less than iron so the copper gains and loses heat faster. If you used copper instead of iron, the heat lost from the copper would transfer to the hot chocolate faster, causing the hot chocolate to heat up faster. However, the specific heat of the hot chocolate would not change; it would just receive the energy needed to heat up faster due to the lower SH of the copper.