Worksheet - Introduction to Specific Heat Capacities

Heating substances in the sun: The following table shows the temperature after 10.0 g of 4 different substances have been in direct sunlight for up to 60 minutes.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Air (°C)</th>
<th>Water (°C)</th>
<th>Sand (°C)</th>
<th>Metal (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (initial)</td>
<td>25°C</td>
<td>25°C</td>
<td>25°C</td>
<td>25°C</td>
</tr>
<tr>
<td>15.0 min</td>
<td>28.9°C</td>
<td>26.2°C</td>
<td>30°C</td>
<td>35°C</td>
</tr>
<tr>
<td>30.0 min</td>
<td>32.5°C</td>
<td>27.5°C</td>
<td>35°C</td>
<td>45°C</td>
</tr>
<tr>
<td>45.0 min</td>
<td>36.2°C</td>
<td>28.8°C</td>
<td>40°C</td>
<td>55°C</td>
</tr>
<tr>
<td>60.0 min</td>
<td>40°C</td>
<td>30°C</td>
<td>45°C</td>
<td>65°C</td>
</tr>
</tbody>
</table>

Step 1: Create a line graph for each substance on graph below. Label the substances.

Step 2: Answer questions
1. Order the substances based on the time required to heat them from: slowest
   - Water
   - air
   - sand
   - fastest
     - metal

2. Which do you think will cool the fastest? Explain
   - metal

3. When you boil water in a pot on the stove, which heats faster, the metal or the water? Explain.
   - metal. The metal's temperature increased more in the same amount of time.

4. Why do you think different substances heat up and cool down at different rates?
   - They have different heat capacities. (Different structures)

***Specific heat capacity = the amount of heat needed to raise the temperature of 1 g of a substance by 1 degree. ***

5. Based on the definition above, which of the 4 substances do you think has:
   a) the highest specific heat capacity?
   - Water
   b) the lowest heat capacity?
   - Metal

6. Here are the heat capacities of the four substances: 4.18 J/g °c, 1.00 J/g °c, 0.80 J/g °c, & 0.60 J/g °c. Match & then label each substance with its specific heat capacity on the graph.

7. If something has a high specific heat capacity will it take a lot of heat or a little heat to change its temperature? Explain. (careful! Use the definition, your graph, and the data from #6)
   - A lot! A high heat capacity means it requires more heat to increase the temp. 1°C

8. Assuming they both start at the same temperature, which will heat up faster, a swimming pool or a bath tub? Explain your thinking.
   - The Swimming pool has more mass.
Worksheet - Calculations involving Specific Heat

1. For \( q = m \cdot c \cdot \Delta T \): identify each variable by name & the units associated with it.

2. Heat is not the same as temperature, yet they are related. Explain how they differ from each other.

a. Perform calculations using: \( q = m \cdot c \cdot \Delta T \)
   
   1. Gold has a specific heat of 0.129 J/(g°C). How many joules of heat energy are required to raise the temperature of 15 grams of gold from 22°C to 85°C?

   \[
   Q = (0.129)(15)(63) \\
   = 121.9 \text{ J}
   \]

   **Endothermic or exothermic?** **Endothermic**

   3. If the temperature of 34.4 g of ethanol increases from 25°C to 78.8°C, how much heat has been absorbed by the ethanol? The specific heat of ethanol is 2.44 J/(g°C)

   \[
   Q = (2.44)(34.4)(53.8) \\
   = 4515.8 \text{ J}
   \]

   **Endothermic or exothermic?** **Endothermic**

   5. Copper has a specific heat of 0.385 J/(g°C). A piece of copper absorbs 5000 J of energy and undergoes a temperature change from 100°C to 200°C. What is the mass of the piece of copper?

   \[
   Q = (0.385)(m)(100) \\
   5000 = (0.385)(m)(100) \\
   5000 = 38.5m \\
   129.9 = m
   \]

   **Endothermic or exothermic?** **Endothermic**

   7. A 40 g sample of water absorbs 500 Joules of energy. How much did the water temperature change? The specific heat of water (liquid) is 4.18 J/(g°C).

b. Determine if it's endothermic or exothermic

2. An unknown substance with a mass of 100 grams absorbs 1000 J while undergoing a temperature increase of 15°C. What is the specific heat of the substance?

   \[
   1000 = C \cdot 100 \cdot 15 \\
   1000 = 1500C \\
   0.67 = C
   \]

   **Endothermic or exothermic?** **Endothermic**

4. Graphite has a specific heat of 0.709 J/(g°C). If a 25 gram piece of graphite is cooled from 35°C to 18°C, how much energy was lost by the graphite?

   \[
   Q = (0.709)(25)(17) \\
   = 301.3 \text{ J}
   \]

   **Endothermic or exothermic?** **Exothermic**

6. 45 grams of an unknown substance undergoes a temperature increase of 38°C after absorbing 4172.4 Joules. What is the specific heat of the substance? Look at the table on page 513 of your book, and identify the substance.

   **Endothermic or exothermic?**

8. If 335 g of water at 65.5°C loses 9750 J of heat, what is the final temperature of the water? Liquid water has a specific heat of 4.18 J/(g°C).

   **Endothermic or exothermic?**