**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: **metal**, then **sand**, then **air**, then **water**

2. Which do you think will cool the fastest? Explain.
   - **metal**, since it heated up the fastest.

3. When you boil water in a pot on the stove, which heats faster, the metal or the water? Explain.
   - The metal (lower specific heat capacity)

4. Why do you think different substances heat up and cool down at different rates?
   - Due to the bonds between particles (how hard it is to make particles move/amount of kinetic energy increase).

**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, sand & 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 of heat, since you need a larger amount of energy to bring the temp. of 1g of a substance up by 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.
   - A bath tub, since there is less of water to heat up (smaller amount of mass).
Worksheet - Calculations involving Specific Heat

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

- \( q \): heat (J)
- \( c \): specific heat (J/(g \cdot ^\circ C))
- \( m \): mass (g)
- \( \Delta T \): change in temp \(^\circ C\)

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

Heat is the transfer of energy. Temperature is the average motion of particles in a substance.

a. Perform calculations using: \( q = m \cdot c \cdot \Delta T \)

1. Gold has a specific heat of 0.129 J/(g \cdot ^\circ C). How many joules of heat energy are required to raise the temperature of 15 grams of gold from 22 \(^\circ C\) to 85 \(^\circ C\)?

\[
q = \frac{(15g)(0.129)(85 - 22)}{121.9 J}
\]

- **Endothermic or exothermic?** endothermic

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

\[
1000 J = (100g) \cdot c (15)\]

\[
c = \frac{100 J}{9g \cdot ^\circ C}
\]

- **Endothermic or exothermic?** endothermic

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

\[
q = (34.4g)(2.44)(78.8 - 25)
\]

\[
q = 4516 J
\]

- **Endothermic or exothermic?** endothermic

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

\[
q = (25g)(0.709)(35 - 18)
\]

\[
q = -301 J
\]

- **Endothermic or exothermic?** exothermic

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

\[
5000 J = m (0.385)(200 - 100)
\]

\[
m = 129.879 g
\]

- **Endothermic or exothermic?** endothermic

6. 45 grams of an unknown substance undergoes a temperature increase of 38 \(^\circ C\) 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.

\[
4172.4 J = (45g) \cdot c (38)
\]

\[
c = \frac{2.44 J}{9g \cdot ^\circ C}
\]

- **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 \cdot ^\circ C).

\[
500 J = (40g)(4.18) \Delta T
\]

\[
\Delta T = 2.49 ^\circ C
\]

- **Endothermic or exothermic?** endothermic

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

\[
-9750 J = (335g)(4.18)(T_f - 65.5)
\]

\[
-9750 J = 1400.3T_f - 91719.65
\]

\[
81969.65 = 1400.3T_f
\]

\[
T_f = 58.5 ^\circ C
\]

- **Endothermic or exothermic?** exothermic