ChemQuest 5

Specific Heat

Name: _____
Date: _____
Hour: _____

Information: Heat and Temperature

When a substance absorbs heat energy, the temperature of the substance increases. There are a number of factors (such as mass of the substance) that affect *how much* the temperature of a substance changes.

Critical Thinking Questions

1. Consider two pots of water. Each pot has the same diameter, but pot A is deeper than pot B and so there is more water in pot A. If both of the pots are exposed to exactly the same amount of heat for five minutes on a stove, which pot will contain the hottest water after heating?
   The water in Pot B will be hotter.

2. Propose an explanation for the fact that even though both pots were exposed to the same amount of heat, one got hotter.
   Since Pot A has more water in it, it will take more heat to increase the temperature.

3. Fill in the blank: *The greater the mass of a substance (like water in questions 1 and 2), the*

   _____lower_____ *the temperature change when heat is applied.*
   greater or lower

4. Consider the metal hood of a car on a warm sunny day. Next to the car is a large puddle of water. The puddle of water is so large that it has the same mass as the hood of the car. Assume that the hood of the car and the puddle are exposed to the same amount of sunlight. Which will be hotter after two hours—the hood of the car or the puddle?
   The hood of the car will be hotter.

5. Propose an explanation for the fact that even though both the hood and the puddle were exposed to the same amount of heat energy and their masses were the same, one still got much warmer than the other.
   The metal must heat up faster than water does. There must be something about metal that allows it to heat up faster than water.

6. In general is it harder to change the temperature of metal (like on a car hood) or of water? In other words, would it require more heat energy to change the temperature of metal or of water?
   It would require more heat energy to change the temperature of water.

7. In one of the following blanks you will need to write "400" and in the other blank you will need to write "200".
   If we wanted to change the temperature of water by 4 °C, then _400_ *Joules of heat energy are required, but to change the temperature of metal by 4°C, then* __200__ *Joules of heat energy are required.*

Information: Specific Heat

In questions 1 and 2 above you probably recognized that the temperature change of a substance depends on the mass of the substance. You also have probably experienced the fact that different substances heat at different rates as was discussed in questions 3 and 4 above. Each substance has its own specific heat capacity. The specific heat capacity is a measure of the amount of energy needed to change the temperature of the substance. The higher the specific heat, the more energy is required to change the temperature of the substance.

Critical Thinking Questions

8. Which substance has a higher specific heat—water or a metal like the aluminum in a car hood?
   Since it requires more heat energy change the temperature of water and since specific heat is a measure of how much energy is needed to change the temperature of a substance, water must have a higher specific heat.

9. Consider 200 Joules (J) of heat energy applied to several objects and fill in the blank: *The higher the specific heat of the object, the* __lower__ *the temperature change of the object.*
   lower or higher

10. Given the following symbols and your answers to the above questions, which of the following equations is correct. Make sure you have the correct answer before proceeding to the next questions!

    ΔT = temperature change of a substance
    C_p = specific heat capacity
    m = mass of the substance
    q = amount of heat energy applied to the substance

    A) $\Delta T = qmC_p$ B) $\Delta T = \frac{q}{(m)(C_p)}$ C) $\Delta T = \frac{(q)(m)}{C_p}$ D) $\Delta T = \frac{(C_p)(m)}{q}$

    HINT: equation D is not correct because according to that equation, a large mass (m) will lead to a large temperature change (ΔT), but this is not consistent with question 3.

11. If ΔT is measured in °C, m is measured in grams (g) and q is measured in Joules (J), what are the units for specific heat capacity?

$$\Delta T = \frac{q}{(m)(C_p)} \rightarrow C_p = \frac{q}{(m)(\Delta T)} \rightarrow \boxed{C_p = \frac{J}{(g)(^\circ C)}}$$

12. What is the temperature change of a 120 g piece of aluminum whose specific heat is 1.89 J/g°C after 1800 J of heat energy is applied?

$$\Delta T = \frac{q}{(m)(C_p)} \longrightarrow \Delta T = \frac{1800\,J}{(120\,g)(1.89\,\frac{J}{g\,^oC})} = 7.936508\,^oC = 7.9\,^oC$$

13. A beaker containing 250.0 g of water is heated with 1500.0 J of heat energy. If the temperature of the water changed from 22.0000°C to 23.4354°C, what is the specific heat of water?

$\Delta T = 23.4354\ ^oC - 22.0000\ ^oC = 1.4354\ ^oC$

$$\Delta T = \frac{q}{(m)(C_p)} \longrightarrow C_p = \frac{q}{(m)(\Delta T)} \longrightarrow C_p = \frac{1500\,J}{(250\,g)(1.4354^o\,C)} = 4.180\,\frac{J}{g\,^oC}$$

14. Heat energy equal to 25,000 J is applied to a 1200 g brick whose specific heat is 2.45 J/g°C.

a) What is the change in temperature of the brick?

$$\Delta T = \frac{q}{(m)(C_p)} = \frac{25{,}000}{(1200)(2.45)} = 8.503401 = 8.5\,^oC$$

b) If the brick was initially at a temperature of 25.0°C, what is the final temperature of the brick?

$25.0 + 8.5 = 33.5\ ^oC$