Name: _____

Skill Sheet 25-B Specific Heat

Many of our daily activities require the heating or cooling of matter to suit the needs of a specific situation. Cooking, heating or air conditioning a room, and freezing a popsicle all require some application or removal of heat energy from a system. It is easy to calculate the amount of energy that was added to or removed from a system. To do this, you use the heat equation, which relates heat energy to changes in temperature observed in bodies of matter.

1. Specific heat

Suppose you want to know how much energy is needed to see an increase in temperature in an object. You must first know the specific heat of the substance in question. Specific heat is defined as the amount of heat energy needed to raise 1 gram of a substance 1°C in temperature.

The higher the specific heat, the more energy is required to cause a change in temperature. Substances with higher specific heats require more loss of heat energy to experience a lowering of their temperature than do substances with a low specific heat. Some sample specific heat values are presented in the table below:

Substance	Specific Heat (calorie/g °C)
Aluminum	0.22
Copper	0.09
Glass	0.20
Iron	0.11
Fresh water	1.00
Gold	0.03
Carbon	0.17

Water has the highest specific heat of the listed types of matter. This means that water is slower to heat but is also slower to lose heat. This is why the temperature does not fluctuate to extremes in geographic areas where there is a body of water nearby. However, in areas that are far from large bodies of water, such as deserts, the air temperature goes from being very hot during the day to being very cold at night.

1. Which of the substances listed in the table above would heat up fastest if an equal amount of heat energy were applied to all of the substances at the same time? Explain your answer.

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2. Which of the substances listed in the table above would you choose as the best insulator (substance that requires a lot of heat energy to experience a change in temperature)? Explain your answer.

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2. Calculating changes in heat and temperature

With knowledge of the specific heat value for a substance, we can calculate how much heat energy is required to affect a needed change in temperature or how much change in temperature we would observe with the application of a specific amount of heat energy. To do this, we would use the heat equation:

$$Q = mc\Delta T$$

where Q is the heat energy (calories), m is the mass of the substance (grams), c is the specific heat of the substance (calories/g°C), and ΔT is the change in temperature (°C).

Example 1:

How much energy is required to heat 35 g of gold from 10°C to 50°C?

The mass of our substance is 35 g. We see from the table of specific heat values that the specific heat of gold is 0.03 calories/g°C. The change in temperature observed is 40°C (50°C – 10°C = 40°C). Inserting these values into the heat equation:

$$Q = mc\Delta T$$

$$Q = (35\ g)\left(0.030\frac{calories}{g \cdot °C}\right)(40°C)$$

$$Q = 42\ calories$$

To produce the necessary change in temperature, 42 calories of heat energy need to be put into this sample of gold.

Example 2

A 250 g sample of aluminum is provided with 1,200 calories of heat energy. What will be the change in temperature of this sample of aluminum?

The heat energy added to this system is 1,200 calories. The mass of the aluminum is 250 g. From our table, we find that the specific heat of aluminum is 0.22 calories/g°C. Inserting these values into the heat equation:

$$Q = mc\Delta T$$

$$1{,}200\ calories = (250\ g)\left(0.220\frac{calories}{g \cdot °C}\right)(\Delta T)$$

$$\Delta T = 21.8°C$$

3. Practice calculating changes in heat and temperature

Using the heat formula and the table of specific heat values, solve the following heat problems.

1. A 500 g piece of iron increases its temperature 7°C when heat energy is added. How much heat energy produced this change in temperature?

2. When 300 calories of energy are lost from a 125 g object, the temperature decreases from 45°C to 40°C. What is the specific heat of this object?

3. 1,200 calories of heat energy are added to a liquid with a specific heat of 0.57 calories/g°C. If the temperature increases from 20°C to 33°C, what is the mass of the liquid?

4. A scientist wants to raise the temperature of a 10 g sample of glass from –45°C to 15°C. How much heat energy is required to produce this change in temperature?

5. Sophie wishes to heat a pot of fresh water from 20°C to 100°C in order to boil water for pasta. She calculates that her pot holds 2,000 g of water and that she would need to apply 160,000 calories of heat energy to produce the desired temperature change. Is she correct in her calculations? Defend your answer and show your work.