

Heat vs. temperature student sheet

Objectives:

- The student will distinguish between temperature and heat
- The student will compare the temperature changes and heat absorbed by three different solids
- The student will understand and predict how temperature will change in a substance as heat is added to the substance based on the specific heat of the substance.
- The student will explain specific heat and describe how it differs from substance to substance.

Background:

In the late 1700s Lavoisier and Laplace conducted experiments that measured the amount of heat produced in a combustion reaction. However, it was not until the mid 1800s during the Industrial Revolution that scientists actually tried to explain the nature of heat and how it could be measured. During this time scientists realized that heat could be used to do work – a lot of work. Lavoisier had already proposed the idea that heat was a substance, which he called *caloric*, that flowed from hot to cold. While we still understand heat to move from hot to cold we now accept that it is a form of energy that is capable of doing tremendous work. When heat is released in a chemical reaction we often notice an increase in temperature, and yet temperature and heat are not the same thing. They are certainly related, but how? In order to answer that question we need to define temperature and heat.

Sources:

1. Cobb, Cathy and Harold Goldwhite, *Creations of Fire: Chemistry's Lively History from Alchemy to the Atomic Age*, 1995.

Thermochemistry is the study of heat changes in chemical reactions. In order to understand these changes, we need to understand what heat is and how we can measure heat. This lesson will allow you to discover these things.

Activities:

1. Upon arrival to class, you found cubes of wood, plastic, and metal on your desk. Arrange them in order from coolest to hottest. List the order here.
2. Have the teacher check your order.
3. Obtain a thermometer from your teacher and record the temperature of each block and the room temperature in Table 1 below.

Table 1: Temperature of solid samples

Room temperature (°C)	Temperature of wood (°C)	Temperature of plastic(°C)	Temperature of metal(°C)

4. What did you notice about the temperature of the samples in Table 1?
5. What do you think might happen to the temperature of these samples if they were placed in a boiling water bath for 2 minutes? Predict the temperature of each after 2 minutes. Have this step initialed by your teacher before moving to step 6.

6. Go to the lab and follow the directions on the “Heat vs. Temperature Calorimetry Activity.” Record all data in Table 2 below.

Table 2: Changes in Temperature of Solid Samples after 2 Minutes in Boiling Water

	Wood	Plastic	Metal
Mass of sample (g)			
Mass of tap water in calorimeter (g)			
Temperature of sample in boiling water (°C) (T _i for sample)			
Temperature of tap water in calorimeter (°C) (T _i for water)			
Final temperature of sample and water in calorimeter (°C) (T _f for sample and water)			
ΔT for the solid samples (°C)			
ΔT for the calorimeter water (°C)			
Highest(1) to Lowest(3) Specific heat			

7. Was the temperature change of the sample in the calorimeter the same for all three samples? How do you know?
8. Was the temperature change in the calorimeter water the same for all three samples?
9. Was the temperature change of the calorimeter water the same as the temperature change of the sample?

Read the definitions for heat and temperature below.

Temperature is a property directly proportional to the kinetic energy of a substance. Temperature is measured using a thermometer and has units of K, °C or °F. Temperature is represented by the symbol ΔT or T. ΔT is calculated as $T_{\text{final}} - T_{\text{initial}}$.

Heat is a transfer of energy between two objects due to a difference in temperature. Heat always moves from hot to cold. It has units of Joules, calories or Calories (kcal). The symbols used for heat are ΔH or q. Heat is not directly measurable. It must be calculated using the following formula $q = m\Delta T$.

10. Are heat and temperature the same?
11. What is the relationship between heat and temperature?
12. Do your answers to questions 7 – 11 support the definitions for heat and temperature? Explain.

Specific Heat (C) is the amount of heat it takes to raise the temperature of 1 g of a substance 1°C. The symbol for specific heat is C. It has units of joules / g °C or calories / g °C. Every substance has its own unique specific heat that can be found in reference books. The formula used to determine the specific heat of an unknown is $C = q / m\Delta T$.

13. Read the definition of specific heat given above. We can assume that the heat (q) applied to the three samples when they were in the boiling water was the same. Use this idea and the data in Table 2 to arrange the samples from lowest specific heat to the largest specific heat. **Hint:** If heat is constant, what is the relationship between specific heat (C) and $m\Delta T$? Write that order here and have it checked by your teacher.

Specific Heat of Water:

Specific Heat of most metals:

14. Would you expect a substance with a high specific heat (like water) to show a rapid change in temperature of a slow change in temperature compared to a substance with a low specific heat when exposed to the same amount of heat?
15. Would you expect a substance with a high specific heat to lose heat slowly or quickly compared to a substance with a low specific heat? What would you notice in the temperature change of these 2 substances?

Practice Problems

- How much energy is required to heat 120.0 g of water from 2.0 °C to 24.0°C?
- How much heat (in kJ) is given off when 85.0 g of lead cools from 200.0°C to 10.0 °C? (Specific heat of lead = 0.129 J/g °C)

Specific heat is useful because it is based on a 1-gram sample so you can compare one substance to another. Sometimes we want to know how much total heat a sample can hold and the sample may not have a mass of 1 g. Then we care about the **heat capacity**. The amount of heat necessary to increase the temperature of an object exactly 1°C.

16. How does heat capacity differ from specific heat?

Post-activity questions: Answer and turn in prior to leaving class or at the start of class tomorrow.

1. Is heat the same as temperature? Explain your answer.
2. You leave your sunscreen on your towel in the sun at the pool. Explain what happens to the sunscreen in terms of heat and temperature. Draw a diagram to help show how heat is transferred in this situation.
3. Energy that flows from a warm object to a cool object is called _____.
4. Which is a form of energy, heat or temperature?

Which would have more heat?

5. The Atlantic Ocean or a mug of hot coffee. Explain your answer.
6. A 5 g piece of aluminum or a 5 g piece of iron. Explain your answer.
7. A 100 ml beaker of sand or a 100 ml beaker of water. Explain your answer.
8. The sand on the beach in July or the sand on the same beach in January. Explain your answer.

Measuring energy changes

9. How much heat is released when 432 g of water cools from 71.0°C to 18.0°C?
10. In order to make 4 cups of tea, 1.00 kg of water is heated from 22.0°C to 99.0°C. How much energy is required?
11. When 15.0 g of steam drops in temperature from 275.0 °C to 250.0 °C, how much energy is released? (Look up the specific heat of steam in your textbook.)
12. If it takes 41.72 joules to heat a piece of gold weighing 18.69 g from 10.0°C to 27.0°C, what is the specific heat of gold?