Lab 11 Radiation Energy Transfer

Name: _____ Lab Partner(s): _____

Driving Question

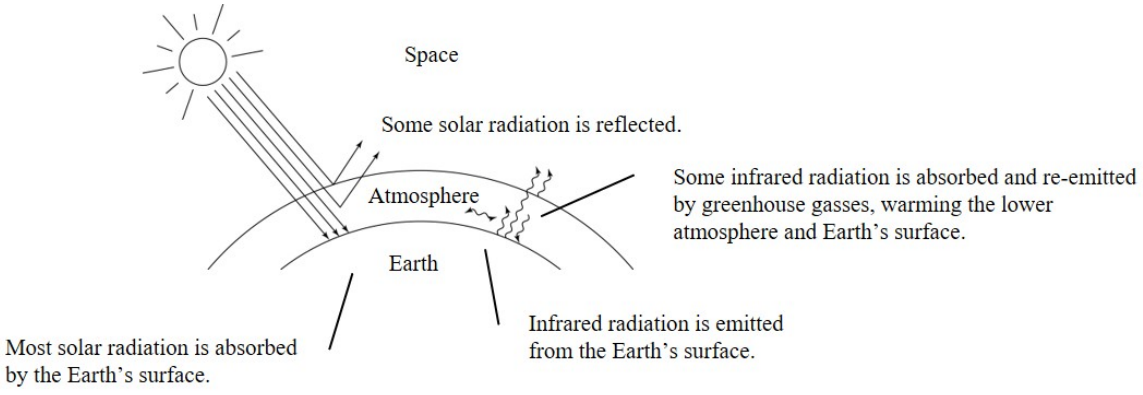
Determine the effect the color of a container has on the temperature of water in the container as it is heated using radiant energy.

- What is radiant energy?
- What is the relationship between an object's color and its ability to absorb energy?
- Does radiant energy heat all of Earth's surfaces equally?

Background

The Earth receives an enormous amount of radiant energy from the sun. Solar radiation is made up of the entire spectrum of electromagnetic waves. Visible light, the light that we can see, is only a tiny part of this spectrum. Other types of electromagnetic radiation produced by the sun include infrared radiation (thermal energy), microwaves, radio waves, ultraviolet light, X-rays, and gamma rays.

Incoming radiation is scattered, reflected or absorbed by the atmosphere or the Earth's surface. The atmosphere protects us from most X-rays, gamma rays and ultraviolet radiation by reflecting these wavelengths of light back into space. The light that travels through our atmosphere is either reflected or absorbed by Earth's surface. Different surfaces absorb and reflect differing amounts of solar radiation. The term albedo is used to compare the degree to which different surfaces reflect incoming solar radiation. Surfaces with high albedo reflect more radiation than surfaces with low albedo. Surfaces with low albedo absorb more radiant energy than they reflect.



When surfaces absorb radiant energy they become warmer. This in turn increases their thermal energy, or total internal energy. Likewise, cooling decreases thermal energy. The total amount of energy the Earth receives is in equilibrium with the total amount of energy the Earth loses and is called Earth's energy budget.

Materials and Equipment

- Temperature probe (2)
- Radiation can (2), 1 black, 1 silver
- Graduated cylinder, 100-mL
- Insulated pad (2)
- Heat lamp (or 150-W lamp)

- Ring stand
- Water, room temperature, 0.5 L

Procedure

1. Open *SPARKvue* and build a page with a graph display.
2. Connect the two temperature probes to your device.
3. Set the data collection system so that both temperature probes are collecting data once every five seconds.
4. Display a graph with both Temperature readings on the y-axis and Time on the x-axis.
5. Place each radiation can on an insulated pad. Keep the cans away from drafts.
6. Why are you asked to place each radiation can on an insulated pad and to keep the cans away from drafts?

7. Fill each can with 200 mL of room-temperature water (the cans should be the same size so that the water level in both is the same).
8. Put one temperature probe into the water in the black can and the other temperature probe into the water in the silver can.
9. Place the heat lamp so it is about 20 cm in front of the two cans. Make sure the lamp is the same distance from each radiation can to ensure even heating.
10. How do you think the change in water temperature in the black can will compare to that of the silver can? Explain your reasoning.

11. Turn on the lamp and start data recording.
12. Continue recording data for 20 minutes. Note: If necessary, adjust the scale of the graphs to show all data.

13. How will you know which can absorbed the most radiation?

14. What surfaces on Earth could the black can represent?

15. What surfaces on Earth could the silver can represent?

16. Stop data recording.

17. Save your experiment and clean up according to your teacher's instructions.

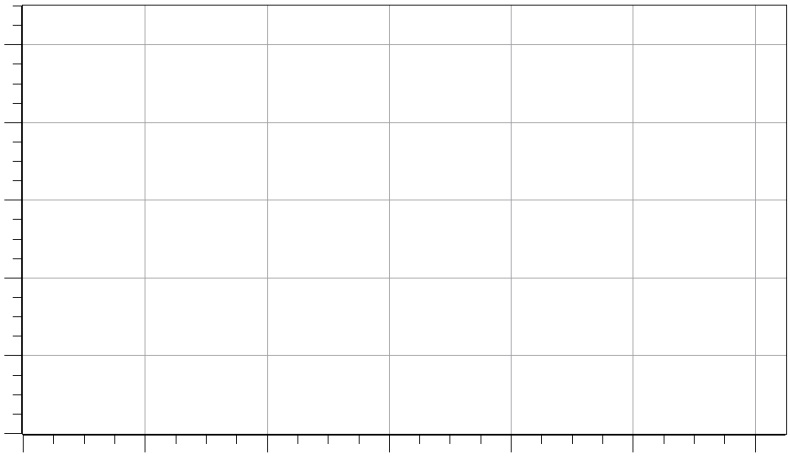
Data Analysis

1. Use the graph of Temperature versus Time to determine the initial temperature, final temperature, and change in temperature for each radiation can and record the answers in Table 1.

Table 1: Recorded and calculated temperatures

	Initial Temperature (°C)	Final Temperature (°C)	Change in Temperature (°C)
Silver can			
Black can			

2. Sketch or print a copy of the graph of Temperature versus Time. Include the data for both radiations on the same set of axes. Label each trial as well as the overall graph, the x-axis, and the y-axis, and include numbers on the axes.



Analysis Questions

1. Examine your Temperature versus Time graph and Table 1. Which can absorbed more radiant energy? Use your data to support your answer.

2. Compare the slope of data collected for the black can to the slope of the data collected for the silver can. What does this tell you about the efficiency of the black can's ability to absorb radiant energy?

3. What is the relationship between the color of an object and the object's ability to absorb heat?

4. Does radiant energy affect all Earth's surfaces equally? Use your data to support your answer.

Synthesis Questions

Use available resources to help you answer the following questions.

1. Suppose you had to choose a roof color for a new house and were given two choices: dark grey or light grey. Which would you choose to keep the house cooler in the summer? Why?

2. On a sunny summer day would you expect an asphalt street or a cement driveway to feel hotter? Explain.

3. Would you expect the albedo of a mountain range to change after the first snowfall? Explain.

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. What is the primary source of radiant energy for the Earth?

   A. Earth's moon
   B. The oceans
   C. The sun
   D. Electricity
   E. None of the above

2. Which of the following most accurately describes what happens to incoming solar radiation when it reaches Earth?

   A. It is reflected
   B. It is absorbed
   C. It is scattered
   D. It is reflected, absorbed, and scattered
   E. None of the above

3. Which of the following surfaces has the highest albedo?

   A. Dark colored rocks
   B. Grass
   C. Soil
   D. Snow
   E. Pavement

4. Which can do you expect will absorb more radiant energy under sunlight?

   A. A black can
   B. A white can
   C. A shiny metallic can
   D. A yellow can
   E. A green can

5. What process causes an object's temperature to increase the most?

   A. Scattering radiant energy
   B. Reflecting radiant energy
   C. Absorbing radiant energy
   D. Emitting radiant energy
   E. Transferring radiant energy