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Lab 5: Specific Heat of Land and Water

Purpose

To determine the differences between the specific heats of water and some of the elements that make up the land

Background

Jumping into a pool on a hot summer day is refreshing because the water is cooler than the air around you and the ground under your feet. You may wonder why the water is cooler since the water, air, and ground are being heated by the same source—the sun. One reason is that it takes more heat to raise the temperature of some substances than others. The amount of heat required to raise the temperature of 1 g of a substance by 1 degree Celsius is called the *specific heat capacity*, or *specific heat*, of that substance. Water, for instance, has a specific heat of 4.18 J/g°C. This value is high compared to the specific heats for other materials, such as concrete or metals. In this experiment, you will compare the specific heat of water and some of the elements in the surface of the earth using a simple calorimeter.

Skills Focus

Measuring, observing, drawing conclusions, applying concepts

Procedure

1. Start *Virtual Earth Science* and select *Specific Heat of Land and Water* from the list of assignments. The lab will open in the Calorimetry laboratory.
2. You will be measuring the specific heat capacity of Al and Ca, two common elements in the Earth's crust. Much of the Earth's crust is made of metal oxides, which have heat capacities similar to Al and Ca. Make sure to keep track of which sample you are testing by keeping accurate notes. Click on the *Lab Book* to open it. Record the mass of Al on the balance. If it is too small to read click on the *Balance* area to zoom in, record the mass of Al in the Data Table below, and return to the laboratory.
3. Pick up the Al sample from the balance pan and place the sample in the oven. Click the oven door to close. The oven is set to heat to 200°C.
4. The calorimeter has been filled with 100 mL of water. The density of water at 25°C is 0.998 g/mL. Use the density of the water to determine the mass from the volume and record the volume and mass in the Data Table.
Make certain the stirrer is *On*. (You should be able to see the shaft rotating.) Click the thermometer window to bring it to the front and click *Save* to begin recording data. Allow 20–30 seconds to obtain a baseline temperature of the water.

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Lab 13: Measuring the Orbital Speed of the Planets

Purpose

To determine how fast Earth and the other planets are moving

Background

When you are traveling fast in a car, objects along the roadside appear to move by quickly. But when you travel in an airplane, objects that you see below seem to move more slowly, even though the plane is moving faster than the car. Why is this? Every day Earth turns around or rotates once on its axis. This is what causes the sun to move across the sky. But besides rotating, Earth is also moving in its orbit around the sun. This motion takes a year, but you don't even notice it. In this assignment you will determine the speed of Earth in its orbit and come to appreciate how fast you are actually moving.

Skills Focus

Observing, predicting, calculating, drawing conclusions, relating cause and effect

Procedure

1. Start *Virtual Earth Science*. Select *Measuring the Orbital Speed of the Planets* from the list of assignments. The lab will open in the Mechanics laboratory.
2. The laboratory is set up in the *Solar System View* with the sun in the middle. You will see the inner planets (not to scale) in their orbits. Click on the *Start* button. The planets will begin to move in their orbits around the sun. Click *Pause* when you have finished observing. Each planet moves at a different speed in its orbit. You can calculate their speeds by using the formula:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Predicting Approximately how fast do you think Earth is traveling in its orbit?

3. You will first measure the distance from the sun to each planet in the solar system. A planet's distance from the sun is called the radius of orbit. Click on each planet and record, in the table below, the radial distance from the sun. This distance is displayed below the experiment window where it has a value for r . You will use the radius of orbit to estimate the circumference or length of each planet's orbit. The displayed radius is the radius at the given day, which could be larger or smaller than the average radius. The planets' orbits are ellipses rather than circles, but a good approximation can be made by considering them to be circles. Recall that the formula for the circumference of a circle is $C = 2\pi R$ where C is the circumference and R is the radius. Calculate the circumference of each planet's orbit and record it in the table.

Measuring the Orbital Speed of the Planets

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Object	Time Display at the End of One Orbit (year:day)	Period of One Orbit (in Earth years)
Mercury		
Venus		
Earth		
Mars		
Jupiter		
Saturn		
Uranus		
Neptune		
Pluto		
Comet		

4. **Observing** What general difference do you observe between the inner planets and the outer planets (those farther away from the sun than Mars)? What is different about the orbit of Pluto? What differences do you observe about the orbit of the comet?

5. **Predicting** From your view of the solar system, it looks as if the comet could collide with the other objects. Why do you think this doesn't happen very often?

6. **Drawing Conclusions** Change the view of the solar system by clicking on the *Parallel View* button. You can now view the motion of the objects from the side view or the plane of the orbits. Notice that most of the objects move in the same plane, but the orbits of Pluto and the comet are tilted at an angle from the plane of the planets. How does this support your answer in step 5?

7. **Observing** Change the view that you are looking at by clicking on the *Object View* button on the side. Click on each object to observe its moons. Only the major moons of each object are displayed. Which objects have the most moons? Are there any objects that do not have moons orbiting them?

8. Note one thing you have observed about the solar system that you did not know before.

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Lab 12: Making Observations of Our Solar System

Purpose

To investigate the motion of Earth and the other objects in the solar system

Background

It's hard to appreciate the magnitude or size of the solar system. The masses of the planets and other objects, the sizes of their orbits, and the speeds at which they travel are amazing. In order to gain some understanding, you can relate the motion of the objects to things you can understand, for example, the time it takes Earth to go around the sun (one Earth year). Then you can compare other objects to Earth. In this assignment, you will make qualitative observations about the solar system.

Skills Focus

Observing, predicting, drawing conclusions

Procedure

1. Start *Virtual Earth Science*. Select *Making Observations of Our Solar System* from the list of assignments. The lab will open in the Mechanics laboratory.
2. The laboratory is set up in the *Solar System View* with the sun in the middle. The inner planets (not to scale) are in their orbits. The outer planets, Pluto, and a comet are in the transfer table. You can click on the *Start* button to see the inner planets (Mercury, Venus, Earth and Mars) begin to orbit in their individual paths around the sun. Click *Pause* when you have finished observing. Click *Reset*.
3. **Observing** The planets move in their orbits at different speeds. The time it takes a planet to make one trip around the sun is called the period of its orbit. The Time display gives the current time for the solar system in year:day format. The experiment starts on the current day of the year, which is shown in the Time display. Choose a planet to watch first. Click the *Start* button and watch the planet. When the planet returns to the start of its orbit, click *Pause*. In the second column of the table on the next page, record the Time display at the end of one orbit. You can speed up or slow down the process using the *Time Acceleration* buttons.

To calculate the period of one orbit, first subtract the initial year at the beginning of the orbit, from the year after one orbit. Then divide the number of days by 365. This is a fraction of an Earth year. Add the whole number of years to the fraction to get the total period. Record this number in the last column of the table. Click *Reset* and repeat the procedure for each remaining object.

To find the periods of the outer planets, Pluto, and the comet, drag them from the transfer table to the work area.

Data Table 2

	100g H ₂ O	50g Au & 50g H ₂ O
initial temperature of water (°C)		
final temperature of water (°C) after heating		
final temperature of water (°C) 2 minutes after heating		

- Drag the Dewar over to the red waste basket to empty the water. Then fill a 50 mL graduated cylinder with water and add it to the Dewar. Drag the gold from the balance and drop it into the Dewar. Reset the timer, turn on the Thermometer again, and open the Graph window. Repeat the heating and recording steps as described in step 15.
- Drawing Conclusions** Explain what you observed about the differences in heating and cooling in the two experiments. Apply what you have observed to what you know about how land and water heat and cool at different rates.

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Analyze and Conclude**Specific Heat of Land and Water**

9. Determine the changes in temperature of the water (ΔT_{water}) for the Al experiment.
10. Calculate the heat (q) gained by the water using the following equation:

$$q_{water} = m_{water} \cdot \Delta T_{water} \cdot C_{water} = 4.184 \text{ J}/(\text{g}^\circ\text{C})$$
11. Determine the changes in temperature of the Al (ΔT_{Al}).
12. Remembering that the heat gained by the water is equal to the heat lost by the metal, calculate the specific heat of the metal. $q_{water} = q_{metal} = m_{Al} \cdot \Delta T_{Al} \cdot C_{Al}$ which when solved for the heat capacity is: $C_{Al} = \frac{q_{metal}}{(m_{metal})(\Delta T_{metal})}$. Record your result in the Table.
13. Repeat the calculation of specific heat capacity for Ca and record your result in the Data Table.

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14. You have just numerically found that the specific heat of metals is much lower than that of water, which means that when the same amount of heat hits land and water, the land heats up much faster and to higher temperatures. You will now observe the heat content differences in another way. Click the red disposal bucket to clear the lab. Click on the Stockroom to enter. On the Clipboard, select *Experiment #10: Heat Capacity of a Metal—Au*. This will preload a specific heat capacity setup with approximately 50 grams of Au. Gold has a low heat capacity which means that it heats up quickly with just a little bit of energy.

Predicting When heated the exact same amount, which will heat up to a higher temperature: 100 grams of water or 50 grams of water and 50 grams of gold together? Why?

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15. **Applying Concepts** Click *Return to Lab*. Click on the Timer in the bottom left hand side of the table to pull that up. On the heat controller by the dewar, pull the black slider so the current reads 150mA. The Dewar has 100 grams of water in it already. You will turn on the heater for approximately 30 seconds and observe how much the temperature of the water increases. Click Save on the Thermometer control. Click the green *On/Off* switch to turn on the Heater and after about 30 seconds turn off the heater. Restart the timer by clicking the arrow on the left hand side. After 2 minutes more click *Stop* on the Thermometer control, to save the data. Click on the data link and record in the table below the initial temperature, the highest temperature reached, and the temperature after cooling for 2 minutes.

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5. Click on the *Oven* to open it. Drag the hot aluminum sample from the oven until it snaps into place above the calorimeter and drop it in. Click the thermometer and graph windows to bring them to the front again and observe the change in temperature in the graph window until it reaches a constant value and then wait an additional 20-30 seconds. Click *Stop* in the thermometer window. (You can click on the clock on the wall labeled *Accelerate* to accelerate the time in the laboratory.) A blue data link will appear in the lab book. Click the blue data link and in the Data Table record the temperature before adding the Al and the *highest* temperature after adding the Al. Remember that the water will begin to cool down after reaching the equilibrium temperature.
6. Repeat the experiment with a Ca sample. Click the red disposal bucket to clear the lab. Click on the Stockroom to enter. Double-click the Dewar calorimeter to move it to the Stockroom counter. Click the metal sample cabinet. (The samples are arranged alphabetically.) Open the top drawer by clicking on it. Select the Ca by double-clicking and zoom out. Double-click on the Petri dish with the selected sample to move it to the Stockroom counter. Return to the laboratory.
7. Move the Petri dish with the sample to the spotlight next to the balance. Click on the *Balance* area to zoom and make sure the balance has been tared. Move the metal sample to the balance pan and record the mass in the Data Table. Return to the laboratory.
8. Double-click the calorimeter to move it into position in the laboratory. Click the oven to open the door. Move the metal sample from the balance pan to the oven and click to close the oven door. Click above the tens place several times on the front of the oven to change the temperature to 200°C. Fill the 100 mL graduated cylinder with water by holding it under the tap until it returns to the counter and then pour it into the calorimeter. Turn on the stirrer. Turn on the thermometer. Click on the *Graph* and *Save* buttons. Move your metal sample from the oven to the calorimeter. Follow the procedures used with Al to obtain the equilibrium temperature. Record all of your observations in Data Table 1.

Specific Heat of Land
and Water**Data Table 1**

	Al	Ca
mass of metal (g)		
volume of water (mL)		
mass of water (g)		
initial temperature of water (°C)		
initial temperature of metal (°C)		
max temp of water + metal (°C)		
Specific Heat (J/g°C)		