Activity 3

1 Happy/Unhappy Spheres

Observe the effect of temperature on two similar, but not identical, spheres.

Safety: Be careful when handling the hot water. Ask an adult to help you do this part.

Materials

One pair of happy/unhappy spheres

Thermometer

Meter stick

Two bowls

Hot water

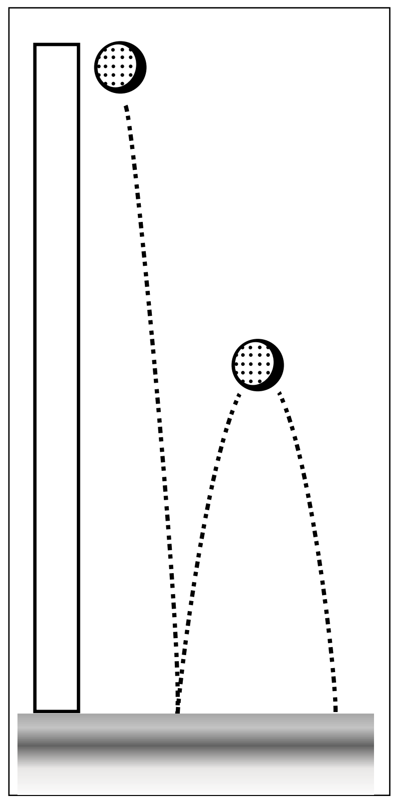
Ice cold water

Pencil

Paper

Instructions

1. Record the temperature of the room. The spheres should not be handled for a few minutes before the experiment so that they are at the same temperature as the room. Drop each of the spheres once to decide which spheres are happy and which ones are unhappy. (It is important that they do not get mixed up.)
2. Drop each sphere from a height of one meter onto a hard, smooth surface. Record the maximum height of first bounce of each sphere. Do this three times for each sphere.
3. Place the spheres in a bowl of near-freezing temperature water and wait about two minutes for the spheres cool to match the temperature of the water.
4. Record the temperature of the water.
5. Drop each sphere three times from one meter and record the bounce heights as in step 2.
6. Place the two spheres into the water again and add warm water or wait until the temperature of the water increases by about 5 degrees Celsius.
7. Repeat steps 4-6 until the water and spheres reach room temperature.
8. Place the spheres into the bowl of hot water. Water from the tap is fine, as long as it is considerably warmer than room temperature. Wait about two minutes for the spheres to warm to the temperature of the water and then record the water's temperature
9. Drop each sphere using the procedures from the above steps.
10. Place the spheres in the water again and wait for a decrease in temperature. Repeat the drops until the water and spheres reach room temperature.



Discussion Questions

What happened to way each sphere bounced when it was heated?

What happened to way each sphere bounced when it was cooled?

Make a graph of the height versus temperature for each sphere and compare the results.

Activity 3

1

FOR THE TEACHER

Happy/Unhappy Spheres

Discussion

The two black balls have the same shape and diameter, but there is a distinct characteristic that is not so noticeable at first. When the balls are dropped onto a flat, hard surface, they behave very differently. This is because the happy ball is made of neoprene, a common synthetic rubber used in wetsuits and laptop sleeves, and the unhappy ball is made of a polymer called Norbornene. This material, which is sometimes used in artificial leather, has a low restitution elasticity, which means that the ball absorbs much of its kinetic energy, or energy of motion, upon impact. When the unhappy ball hits the ground, its kinetic energy is converted into other forms of energy such as deformation of the ball, sound, and heat.

When testing the temperature dependence on the bounce of both balls, each ball should behave very differently. When the balls are warmed, the happy ball bounces higher and the unhappy ball remains the same: it hardly bounces at all. When the balls are placed in the near-freezing cold water, the happy ball bounces less high and the unhappy ball bounces much higher than before! We don't fully understand why this occurs; perhaps the next generation of scientists will investigate further and figure it out!

After the experiment is complete, the students should recognize that the way each ball bounces depends on the temperature. The happy ball behaves as many scientists would predict: it becomes more rigid as the temperature decreases and the height of its bounce decreases. The unhappy ball, however, behaves in exactly the opposite way, showing that predictions should be questioned and tested.

Materials

One pair of happy/unhappy spheres
Happy/Unhappy Spheres may be purchase at Educational Innovations: http://www.teachersource.com/catalog/index.html

Thermometer

Meter stick

Two bowls

Hot water

Ice cold water

Pencil

Paper

Suggested Resources

Happy/Unhappy Balls may be purchased at Educational Innovations:
http://www.teachersource.com/catalog/index.html

Elasticity:
http://www.physlink.com/Education/AskExperts/ae469.cfm

Bibliography

Sock User's Guide:
http://www.spsnational.org/programs/socks/2006sock_guide.pdf

Activity 3

2 Soda Bottle Collapse

Watch what happens as a soda bottle cools.

Safety: Be careful not to burn yourself with the hot water.

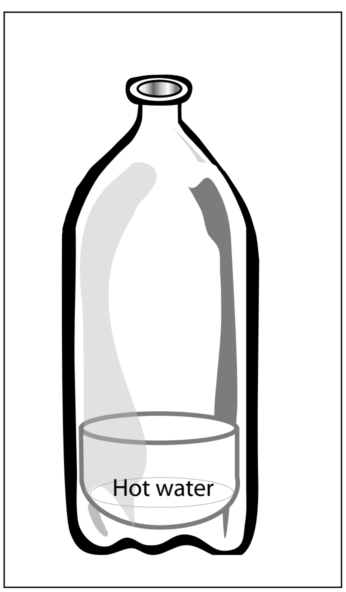
Materials

20oz plastic soda bottle (empty, label removed)

Hot water

Instructions

1. Fill the empty bottle one quarter of the way with very hot tap water.
2. Cap the bottle and swirl the water around for a few seconds to warm the whole bottle.
3. Undo the cap and pour the water into the sink. Quickly recap the bottle.
4. Observe what happens to the bottle.



Discussion Questions

What happened to the temperature of the air inside the bottle after it was recapped?

Would you have seen the same results if the cap was not on tight enough to seal the bottle?

If you assume the cap was tight enough that no air went in or out of the bottle, what made it collapse?

What happened to the pressure inside the bottle after pouring out the water and putting the cap back on?

Activity 3

2 FOR THE TEACHER Soda Bottle Collapse

Materials

20oz plastic soda bottle
(empty, label removed)

Hot water

Discussion

When the water is swirled around the inside of the bottle, the air inside and the bottle itself is heated. This hot air is trapped inside when the students pour out the water and recap the bottle. Left to sit on a desk or table, the bottle and the air inside it cool, eventually returning to room temperature. The collapse of the bottle is caused by the cooling of the air inside. As the air gets cooler, the molecules in it move more slowly. This makes them run into the side of the bottle less often and with less force than when the air was hot. We call this a change in pressure. Pressure is the amount of force per unit area, so the result of fewer collisions combined with less force on the wall from each collision is a decrease in pressure.

The results of the experiment can also be explained by the ideal gas law: $pV = nRT$. In this case the temperature is decreasing. The bottle collapses until the pressure is (almost) the same on both sides of the bottle. The result is a change in volume due to temperature change.

Students might benefit from the analogy of bouncing tennis balls off an unsupported wall from both sides: if one side throws the balls much faster, or throws more balls per minute, the wall will fall away from that side. This is like comparing the inside and outside of the bottle in the experiment. Before the bottle is capped the fast moving hot air molecules can leave the bottle quickly, just like the hot water dripping quickly out of the cup in the Hot Leaks activity in section 2. When the bottle is capped the fast moving (hot) air molecules are trapped inside. For some time the fact that they are moving faster makes up for there being less molecules inside, but as the molecules cool they get slower and no longer hit any faster than the room temperature molecules on the outside of the bottle. When this happens the pressure inside the bottle is lower than outside, and the bottle collapses.

Tips

Try this activity yourself before presenting it to your class to make sure the water in your classroom is sufficiently hot to show the desired results. If you want to convince your class that no air escaped after the bottle was capped run the collapsed bottle under hot water to bring it back to its normal size.

Put a balloon in the freezer to show another example of volume change with temperature. If the balloon is blown up with warm air and then cooled in the refrigerator or freezer it should shrink noticeably. To demonstrate that no air has escaped you can warm the balloon in your hands and let it expand back to its original size. Be sure not to leave the balloon in the freezer too long, or some air will have leaked out and the last part of the demonstration will be unconvincing.

Suggested Resources

Ideal Gas Law:
http://en.wikipedia.org/wiki/Ideal_gas_law

Kinetic Theory of Gases:
http://en.wikipedia.org/wiki/Kinetic_theory

Activity 3

3 Greenhouse Effect

Observe how the atmosphere keeps the Earth warm using household materials.

Safety: Never look directly into the sun.

Materials

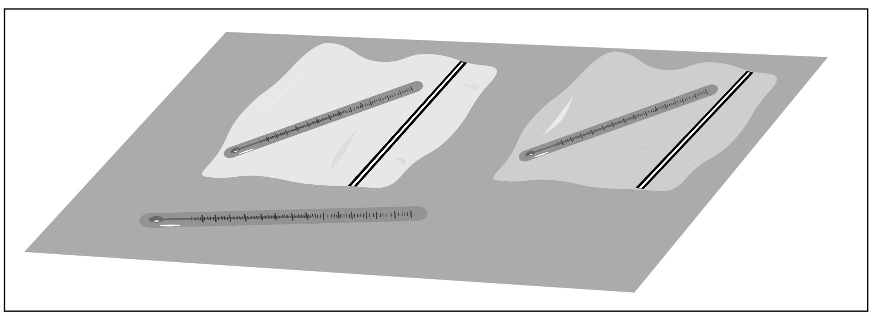
3 Thermometers
(any type that can show differences of 2°F or more, such as those included in PhysicsQuest kit)

2 Clear plastic bags
(sealable top type bag such as Ziploc® quart bags)

Grey cellophane

Instructions

1. Check that both thermometers read the same temperature before beginning the experiment.
2. Place one thermometer in a clear plastic bag. Seal it most of the way and then blow into it to trap more air and seal it completely.
3. Do the same with the second bag, but once it is blown up, cover it with the grey cellophane.
4. Wait a few minutes until the thermometers read the same temperature again.
5. Place the bags with thermometers and the free thermometer in the sun.



6. Wait about 10 minutes and then record the temperature on all three thermometers.

Discussion Questions

How did the final temperatures of the three thermometers compare?

Can you explain why the end temperatures were different? Think about heat entering and leaving the bag.

How did the cellophane wrapped bag compare to the clear bag? What practical uses can you think of for this result?

How is the experiment you preformed related to the effect that the atmosphere has on the climate of the Earth?

Why do you think this experiment is titled "Greenhouse Effect"?

Activity 3

3 FOR THE TEACHER
Greenhouse Effect

Materials

20oz plastic soda bottle
(empty, label removed)

Hot water

Discussion

In this activity students are observing the effect that the atmosphere surrounding the Earth has on the temperature of the Earth on a very small scale. The light from the sun easily penetrate the clear plastic bag, so that both thermometers receive about the same amount of light. When the light hits the thermometer, some of this energy is converted to heat energy. This heat energy cannot penetrate the bag as easily and is trapped inside. The heated air surrounding the thermometer that is not in a bag, however, moves away from the thermometer through conductive currents in the air as well as radiation. Think back to the extension activities in section 1. This is why the temperature inside the bag increases more than the temperature outside of the bag. In the cellophane wrapped bag not as much sunlight is getting through so the air remains a bit cooler.

We see the greenhouse effect in many everyday experiences. In the summer, cars get hot when parked with their windows up because of this very phenomenon. The sun's light can enter easily through the glass windows, but is then trapped inside the car causing the temperature to increase to as hot as 49°C (120°F). People can lessen this effect by tinting their windows, which is represented in this activity by the cellophane covered bag. Enclosed porches also warm up because of the greenhouse effect, just as the greenhouses the phenomenon is named for trap heat to help plants grow.

Students may have heard of greenhouse gasses in the negative context of human caused climate change. This may be a valuable topic to explore with your students. However, many will carry with them the misconception that the greenhouse effect is always a bad thing. This activity can help them realize that the greenhouse effect helps regulate Earth's climate and that without it the Earth would be much colder. However the greenhouse effect could also make the Earth too hot which is why it is currently seen as negative.

Suggested Resources

The Greenhouse Effect:
http://en.wikipedia.org/wiki/Greenhouse_effect

Greenhouse Effect Background Material:
http://www.ucar.edu/learn/1_3_1.htm