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CTE Science Laboratory Investigation

THE SPECIFIC HEAT OF

SILLY PUTTY

**Introduction**

In class, we’ve discussed many concepts from physics that deal with motion. We know that work is a force applied over a distance, and that forces allow for movement if there is no other, opposing force. However, what is actually *doing* the work or providing the force? To explain that, we need to consider energy.

Energy is, in short, the ability to do work. So if an object has a bunch of energy in it, it can do work with that energy. For the purposes of this example, we are discussing only energy in relation to motion; there are, however, many different types of energy: electrical, magnetic, heat and so on. In terms of physics, we think of energy as the energy of movement, or kinetic energy. There is a very simple formula that can help you determine the amount of kinetic energy in an object:

Where KE is the kinetic energy, in joules; m is the mass of the moving object, in kilograms; and v is the velocity of the object, in meters per second. So if you are standing in the road and there is a truck coming at you at 55 miles per hour, given that the truck has a fairly large mass and it’s moving fairly quickly, it has the ability to do a tremendous amount of work. On your face.

Even things with a very small mass can have a lot of energy and can therefore do a lot of work. A bullet that is propelled out of a gun can do a tremendous amount of work, even though its mass is very small. This is because it is moving very quickly. Just throwing a bullet at a criminal is not likely to harm them; it just might make them angry.

But an object need not be in motion to have energy. An object can have the ability to do by virtue of its position or situation, such as a bucket of water perched above a door or a string drawn back on a bow. In both of these cases, there is energy stored in the system; it has the potential to be released, so we call it potential energy. There is a very simple formula for this concept, too:

Where PE is the potential energy, in joules; m is the mass of the object, in kilograms; g is the acceleration due to gravity in meters per second squared; and h is the height of the object above the ground, in meters. So if someone suspends an anvil on a rope above your head, the anvil, because it has a large mass and is high above the ground, has energy, and therefore the ability to do work. Cut the rope and the work will be done. Again, on your face.

These two examples are macroscopic, however. Small things like atoms and molecules can have energy, too. Indeed every atom around your right now has energy, and it is vibrating back and forth very quickly. It’s not moving very much, but it is moving. If we could find the mass of just one atom and figure out how fast it was moving, we could easily determine the amount of kinetic energy in it. That might be hard to do, however, so scientists use a much easier method of measuring the average kinetic energy of a compound. We call this measurement temperature. That’s right, kiddos, when you stick a thermometer in a beaker of warm water, the reason that the thermometer goes up is because the molecules of water are bouncing around and some of them bump into the thermometer. And when they hit the liquid in the thermometer, those molecules start moving too, the liquid becomes less dense, it expands and we see the liquid rise in the tube. The hotter the water is, the more motion it has, and the more energy it transfers to the thermometer. So temperature is indeed a measure of the average kinetic energy of a substance.

But not all substances are created equal. It takes much more energy to heat up 1 kg of water than 1 kg of sand. This is why at the beach, the sand is warmer than the water. By the same token, sand cools off much faster than water, so often at night, a swimming pool is a lot warmer than the air around it, because it takes longer to release the energy that it gained during the day. The measure of how much energy it takes to heat up a particular amount of a substance is called specific heat. There is, as you may have surmised, a formula for this:

Where Q is the total amount of energy needed, in joules; m is the mass of the substance being heated, in kg; c is the specific heat of the substance being heated, in joules per gram-degree Celsius; and T is the temperature, in degrees Celsius. So if you know the specific heat of water, and you know how much water you have, you could easily determine how much energy you need to put into that water to raise it a certain number of degrees.

Finally, keep in mind that the first law of thermodynamics states that energy can neither be created nor destroyed; it can only change forms. So you can convert potential energy into kinetic energy by dropping an anvil on someone, and that kinetic energy would then be converted into heat energy, slightly heating up the person whose skull was so recently decimated.

**Purpose**

The purpose of this lab is to give you practice with using the specific heat formula, as well as to experimentally determine the specific heat of silly putty by converting the potential energy in a suspended mass into kinetic energy by dropping it, then measuring the heat energy absorbed by the silly putty.

**Materials**

Silly Putty ® PENCIL

Meter stick Mass

Temperature probe Labpro/computer

**Procedure**

For this lab to work, we are going to assume that all the energy from one object (e.g. the mass that we will drop) is going to be transferred to another object (e.g. the silly putty), and that none is wasted. In reality, this is not the case. If you hear anything when you drop the mass, that means that some of the energy from the falling mass was used to vibrate air molecules, which you heard as noise. And some of the energy may go into the temperature probe or into the table. But for our calculations, we’ll assume that all the potential energy from the falling mass went into the silly putty.

1. Roll up your Silly Putty ® into a ball and stick it to your lab table, directly over one of the legs.
2. Stick a temperature probe into the putty, making sure the tip of the probe is in the middle of the ball.
3. Hold a 1 kg Mass a given distance above the silly putty and measure the distance from the top of the ball of putty to the bottom of the mass.
4. Start collecting temperature data, and drop the mass on the putty, and catch it on the return bounce. Hold it at the level that you caught it. Measure the new height.
5. Enter this data in your data table and determine the difference in potential energy of the mass using the formula given.
6. Determine the difference in temperature of the silly putty.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass of Mass (kg)** | **Drop height (m)** | **Bounce height (m)** | **Difference in height (m)** |
|  |  |  |  |

Table 1. Data for calculating potential energy difference of a falling mass.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass of Silly Putty ®** | **Initial Temperature (°C)** | **Final Temperature (°C)** | **Temperature difference (°C)** |
|  |  |  |  |

Table 2. Data for calculating specific heat of Silly Putty ®

Since we know that anything suspended above the ground has potential energy by virtue of its height above the ground, it stands to reason that if the mass bounces up off the Silly Putty ® and doesn’t go as high as it started, that some of the energy was lost of the silly putty. So we can say that:

QUESTION 1: Use the formula above to determine the difference in potential energy of the falling mass.

As previously discussed, we’re going to assume that all the energy lost by the falling mass (calculated in question 1) is gained by the silly putty. That is, we’ll assume that the result from question 1 will be the “Q” from the formula Q = mcΔT. We now know the mass of the putty, the energy input, and the temperature change, and we can solve for c, the specific heat.

QUESTION 2: Calculate the specific heat of silly putty using the specific heat formula. Remember to report your answer with the unit J/g·°C.

**Analysis**

QUESTION 3: Calculate your percent deviation based on the accepted value given to you by your kind caring teacher. Be sure to thank your teacher. Cupcakes are a good way to say thanks.

QUESTION 4: Would Silly Putty ® be a good insulator? That is, would you want to put it around your mug to keep your tea warm? Why or why not?

QUESTION 5: What are two things that you would change about this lab if you could?