Happy or Sad? It's All a State of Matter, not Mind!

Introduction:

This is a laboratory experience that uses two visually indistinguishable rubber balls to demonstrate how chemicals (polymers in this case) can have different properties at different temperatures. At room temperature, one ball bounces very well, while the other does not….nearly not at all. The "learning cycle" model of teaching science will be used for this laboratory module, and it can be suited for a variety of Wisconsin Science Standards for grades 5-12. One to three 50 minute class periods may be used for this activity. No prior knowledge is necessary for this lab module, but some knowledge may be required for more advanced application.

Potential Science Content Covered:

Grades 5-12 Appropriate:
Scientific Method: Asking a Question, Developing a hypothesis, deciding on Variables (Independent/ Dependent), Collecting data, Analyzing Data, Formulating a Conclusion, Asking Further Questions/ Implications of Findings.

Graphing: Collecting Data, Setting up a Line Graph (Spacing and Axis Placement: Dependent vs. Independent Variable), Graphical Analysis.

Grades 10-12 Appropriate:
Bonding: Covalent Bonding, Polymers, Intermolecular Forces, Physical Properties, States of Matter, Kinetic Theory.

Entropy Changes (Entropic Springs), *Glass Transition State, Coefficient of Restitution, Error Analysis, Precision, Significant Figures*

Potential Wisconsin State Science Standards Covered:

Grade 8: C.8.1, C.8.3, C.8.4, C.8.6, C.8.11, D.8.2, D.8.3, D.8.4

Grade 12: C.12.3, C.12.4, C.12.6, D.12.12, D.12.5, D.12.2, D.12.1, G.12.5, H.12.6

Lesson Plan:
(This Basic Plan is suited for any Science Wet Laboratory for grades 5-12)

Engaging Phase:

To grab the students' attention, there are a variety of demonstrations that can be done that any grade level would find stimulating:

A.) Use liquid nitrogen, if available, to super cool a racquetball, then drop the racquetball and watch it shatter
B.) Use liquid nitrogen to pound a piece of rubber tubing into a piece of balsa wood using a banana.
C.) Use slight-of-hand to successively drop the "happy" and "sad" balls without the students seeing that you changed the balls.

Exploration Phase:

Students will now perform the laboratory exercise. This lab will subject the "happy" and "sad" balls to changes in temperature.

Supplies list:
10-15 pairs of "happy" and "sad" balls
10 thermometers
8 1-2 Liter beakers
10 tongs
10 meter sticks
NaCl (for ice bath)
A couple pounds of ice
A couple pounds of dry ice
A cooler or other appropriate vessel for the dry ice

Experimental Procedure:
1. Students should work in pairs or threesomes for this lab.
2. Give each group a pair of "happy" and "sad" balls. Have students note qualitative and quantitative observations. (Raw data collected can be in the form of data written on a pre-set data table or left up to the students to arrange themselves)
3. One person in each group will drop each ball separately from a height of 100 cm. The other person will need to watch closely and determine the maximum height that the ball bounces after being dropped. (This will be the height of the first bounce). Record each of these bounces and determine an exact procedure for dropping the ball that is reproducible. Do this several times until you are sure that you have an accurate number (your measurements should be consistent to 2 cm). The temperature of the room will serve as the temperature reading for this data collection.
5. Make a prediction about what will happen to the bounce height for each ball as the temperature is changed.
6. Follow the same procedure at each of the following 5 stations:
Ice water
Dry ice (Temp about -78 Celsius)
Warm water
Salt and ice solution
Boiling water
Your balls will need 5 minutes in each bath to reach to the new temperature. If you remove them earlier, you will not get good results. For the dry ice, you will need to wait 10 minutes. Be sure to bounce your balls AS SOON as they are removed from each bath so that the temperature doesn't change!
7. Make a graph of the heights to which the balls bounced (after a drop from 100 cm) versus the temperature. How do the shapes of the graphs for each ball compare? (The students should see the same shape develop for both the "happy" and "sad" balls with the low points, or the glass transition phase, slightly offset along the x-axis.)

Concept Development (Explain Phase):

After the students have finished the experiment, begin to ask the students what they believe has happened. List, Group, Label might be a valuable exercise here, or a KWL chart can be used for more advanced classrooms. Once students have developed a series of hypotheses, begin to lead the students towards a discussion of Temperature and what affect temperature might have had on the "happy" and "sad" balls. The discussion can be led in many different directions here, depending on the grade level and what is the specific aim of this laboratory experience. For younger students, formulating a hypothesis, collecting data, and analyzing data (in the form of the graph) may be the objectives of the lab, and no further concept development is needed. For more advanced students a discussion of how the atoms of the polymers are arranged at different temperatures can lead down many paths…..from distance between atoms in the polymer to "entropic springs".

Notes/ Observations:

Questions?
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