

PHASE CHANGES

INTRODUCTION

Materials are found in nature as solids, liquids, or gases. The difference between these phases is the amount of energy contained in the individual molecules or atoms that make up the bulk substance.

OBJECTIVE

Students will visualize phase changes of condensation, freezing, melting, evaporation, and sublimation using Styrofoam balls as a model for the molecules or atoms of a material. The model will be reflected in phase changes of water.

MATERIALS, per group of about 4 students

- Balls and Pan
 - Styrofoam
 - Styrofoam balls, 2.5", 14 per group
 - Square aluminum cake pan, 8"
 - Other possibilities
 - If needed, use 14 other inexpensive balls, such as practice golf balls
 - Use appropriately sized flat boxes to hold the balls so 9 balls cover the bottom of the box. For example, 9 practice golf balls require a box 5 inches on a side. A "Rubbermade" plastic sandwich box fits for the practice golf balls.
- A bag or box to store the balls between model formations.
- Materials for accompanying demonstration by instructor
 - Hot plate
 - Glass pot to heat ice
 - Several cubes of ice

PROCEDURE

- 1) List examples of gases, liquids, and solids.
 - a) List properties of each of the materials
- 2) Model condensation and freezing using the Styrofoam balls and the aluminum cake pan
 - a) Shake the empty cake pan and add one Styrofoam ball. Continue shaking and notice how the ball moves around in the pan. What phase of matter might this single ball in the pan represent? Describe the movement of the ball in the pan. Relatively, does the ball have a lot of energy, or little energy?
 - b) Continue shaking the cake pan gently and add another Styrofoam ball. Notice again how the balls move around in the pan.

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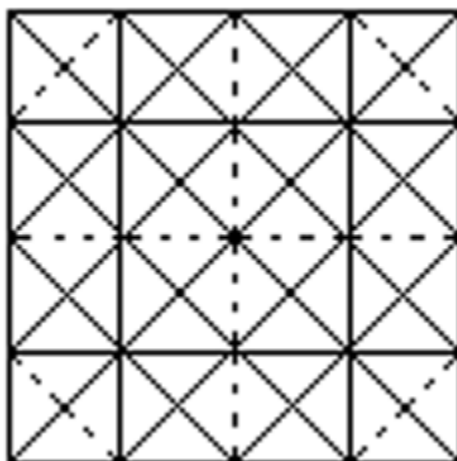
- i) Describe that movement of the balls in the pan. How are the movements like the situation with one ball alone? How are the movements different? Again, consider how much energy the balls have. What phase might be represented with two balls?
 - c) Continue shaking the cake pan gently and add two more Styrofoam balls. Notice again how the balls move around in the pan.
 - i) Describe the motion of the balls in the pan. Do the balls strike the sides of the pan more than striking each other? Consider how much energy the balls have, relatively. What phase might be represented by the 6 balls?
 - d) Continue shaking the cake pan gently and add 3 more Styrofoam balls. Describe the motion of the balls now.
 - i) How much energy do the balls have, relatively?
 - ii) What phase is represented by these 9 balls?
 - e) Shake the pan less vigorously and add another 4 balls, then a final ball.
 - i) Describe the model. What phase is represented? What are the properties of this phase?
 - f) The preceding models represented condensation from a gas to a liquid, then freezing to a solid. Now, the process can be reversed, adding the melting of ice cubes at the demonstration table.
 - g) Melt ice cubes at the demonstration table
 - i) Place several ice cubes into the Pyrex pan
 - ii) Place the Pyrex pan on the hot plate and turn the heat to high.
 - iii) At appropriate moments, the instructor should point out the properties of the melting ice and relate the process to the Styrofoam ball model.
- 3) Melting the model
- a) Add heat to the crystal model by shaking the pan a little more vigorously, but not too fast.
 - b) Watch which Styrofoam balls fall off first.
 - c) Relate the melting to the actual melting of an ice cube—the edges melt first.
 - i) Pause to pick up Styrofoam balls.
 - d) Shake the pan still more vigorously, adding in more heat
 - i) Describe the movement of the balls in (and out of) the pan.
 - ii) What phase is represented?
 - iii) Relate to the melting ice.
 - iv) Pause to pick up the balls
 - e) Add still more heat by shaking the pan more vigorously until only one ball is left in the pan.
 - i) What phase is represented?
 - ii) Relate to the melting ice and boiling water.
 - iii) How much energy is contained in the balls in the pan and outside it?

EVALUATION

- 1) Describe the phases in terms of the movement of the balls
- 2) Describe the phases in terms of the energy of the balls
- 3) How can heat be defined?

TEACHER NOTES

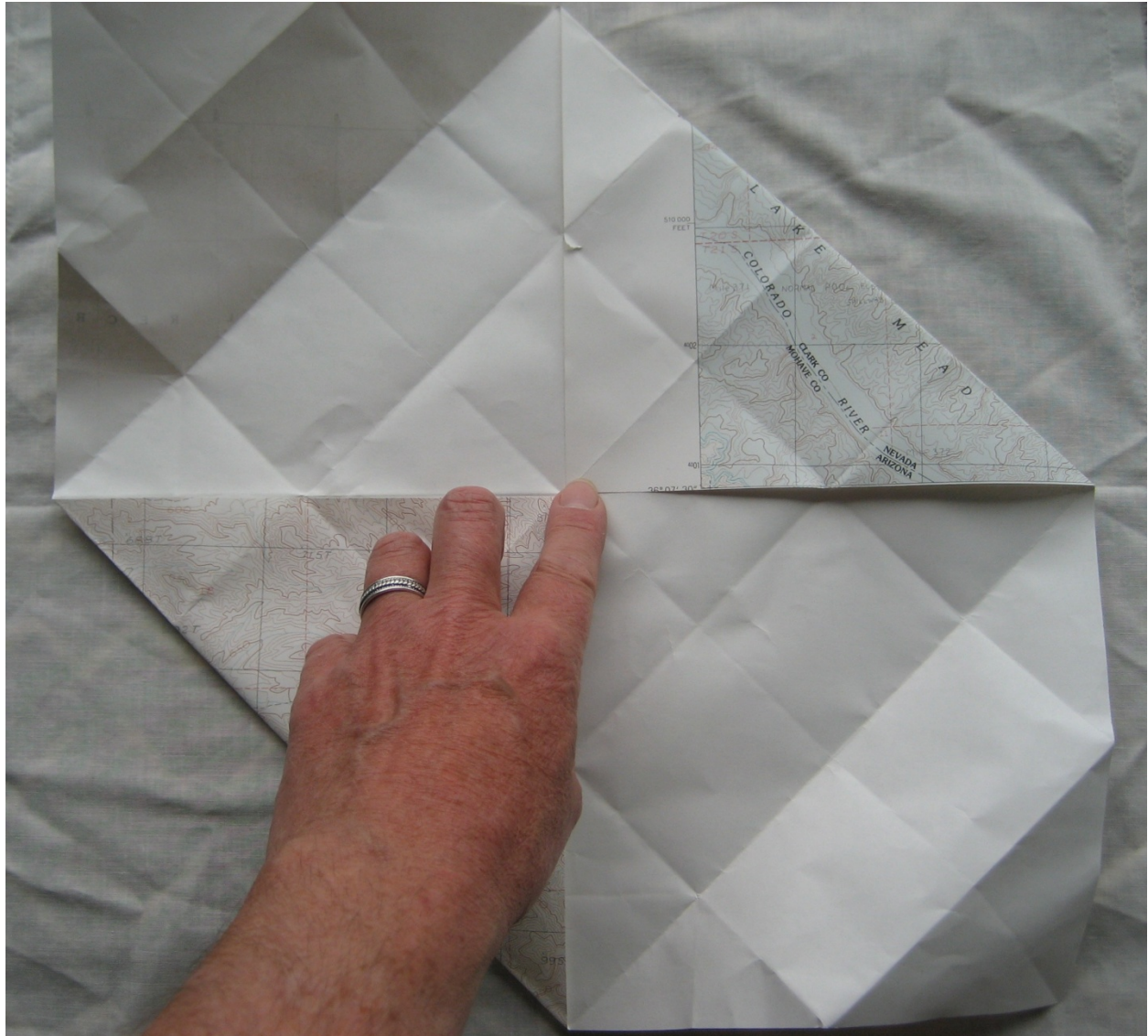
- 1) If a 2.5" Styrofoam ball represents an atom, the atom would have been magnified about a billion times. If a piece of solid material 0.5 cm X 0.5 cm were magnified a billion times, the piece of material would be about the size of the United States. Even then, the atoms would be only the size of a Styrofoam ball.
- 2) Heat is a measure of the energy contained in the molecules or atoms of a material. So, a gas has more heat contained in it than a liquid, at the same temperature and pressure.
- 3) The solid formed is a crystalline solid. The atoms (or molecules) can still move a little, but they stay in the same place with respect to each other. The atoms are in specific places in the pan. Everybody's pan looks alike. The observation that all crystals of the same material have the same structure and look alike at the atomic level is modeled in this step.
- 4) Make a box the size needed using origami methods.
 - a) Measure an array of 9 balls to determine the length of the side of a square box. If such a box is not available, calculate the size of a box and the respective needed for origami.
 - i) An array of 5 inches results from practice golf balls: This measurement is $\frac{1}{4}$ of the length of a diagonal of the required paper, so for this example, the diagonal needs to be 20 inches. Using the Pythagorean Theorem for an isosceles triangle, which means the side is about 14 inches. ($2s^2 = c^2$ where s is a side and c is the hypotenuse of the isosceles right triangle that is formed by the two sides of a square and the diagonal.)
 - b) Fold a 14 inch square of paper according to the following diagram where a solid line is a valley fold and a dashed line is a mountain fold.





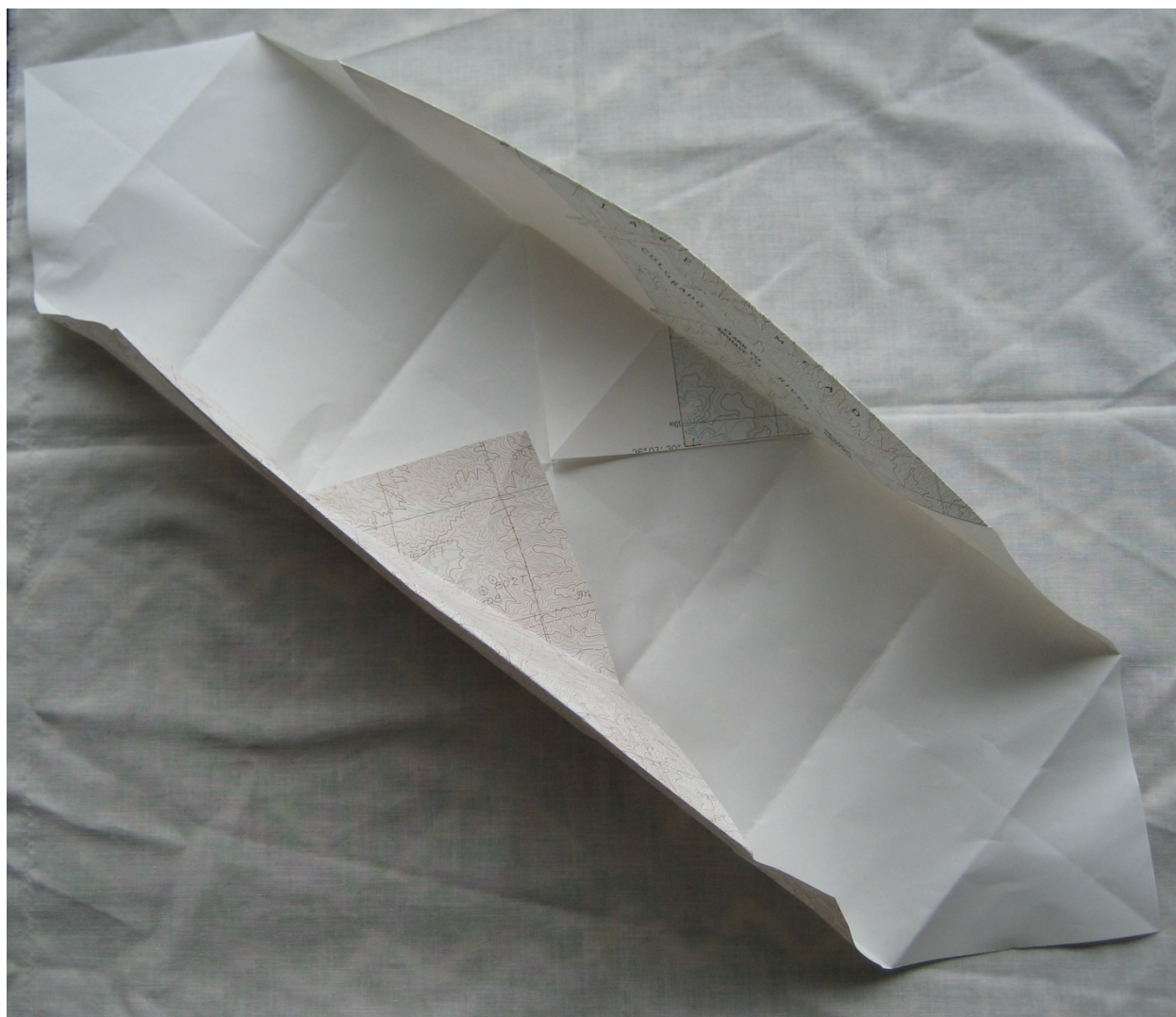
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c) Fold opposite corners to center.



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d) Fold up one unit on the side of those folded corners.



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- e) Fold up the opposite corners, tucking in the triangles that are already appropriately folded so the edges of the box are held in place and the corner reaches the center of the box.







5) For a different size box, calculate the edge and fold as above.