Name______________________________ Date___________________________________

Modeling Thermal Convection

Directions: Use the materials listed and the procedures provided to model thermal convection in a fluid system.

Materials

- One rectangular, plastic bin (approximately 13" long x 8" wide and 5" deep, such as a dish-washing bin)
- Four 5" x 5" squares of thick cardboard (1/4" thick)
- Five 12-ounce polystyrene or plastic cups
- Hot water
- Ice cubes
- Melting chocolate or wax
- Paper towels for spills
- Red and blue liquid food coloring, each with dropper or Beral pipette
- Very cold water

Procedure

As you construct the model, take care to clean up any liquid spills or dropped objects so that they do not become a slip/fall hazard.

Part 1: Convection

1. Fill the bin with very cold water (a little ice is preferable), up to a depth of 4 inches.
2. On a flat table or desk, place four of the polystyrene (or plastic) cups upside down on top of the four squares of cardboard. These cups will support the bin of water so that a fifth cup of hot water can slide underneath. Place the bin on top of the four inverted cups so that the bin is steady.
3. Draw some of the red food coloring up into the pipette and then insert the pipette into the center of the cold-water bin to deposit the dye just above the bottom of the bin. Expel the food coloring slowly so that it stays (mostly) in a dense, circular area.
4. Using the blue food coloring, place two more circles of dye on either side of the red dye, about two inches to the left and to the right. Remember to expel the dye slowly so that it stays in dense circles near the bottom of the water bin.

5. Fill the last polystyrene cup with very hot tap water. Carefully slide it under the cold-water bin so that it is under the circle of red dye.
6. Observe how the dyes move within the bin as thermal energy travels through the system. It may take a few minutes to see the changes.

Part 2: Surface Forces

7. Empty the plastic bin and refill with fresh cold water to a depth of 4 inches.
8. Repeat steps 3 and 4 to add food coloring to the bin.
9. To model tectonic plates floating atop the asthenosphere, melt some chocolate or wax. Using a spoon, add the melted substance to the cold water in two or three locations. You may need to place an ice cube atop each floater to help it solidify, or to model a more massive plate.
10. Repeat steps 5 and 6, and record your observations. In which direction do the floating pieces move?
11. Repeat steps 7–10 two times to try new locations for the floating chocolate or wax, or to be certain that the behaviors you observe are consistent.

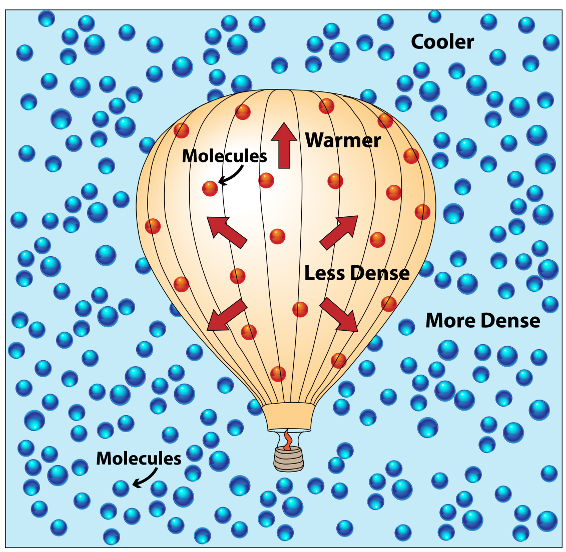
Analyze

1. Describe the motion of the red and blue dyes in the bin. Draw a simple, labeled diagram to show the movement of matter and energy. Use arrows to show how the dyes spread out, come together, or change direction. Then, provide a brief written explanation to supplement your drawing. **4 points**

Explanation:

2. What is the role of density changes in a convection cycle? **2 points**

3. Compare what happens with the red dye in the water bin with what happens to a hot air balloon surrounded by cool air. **2 points**



4. Recall that matter cannot move without energy. What is the energy source that moves the red dye? What is the energy source that moves the blue dye? **2 points**

5. Why is the motion of the water in the bin considered a cycle? What could stop the cycle? What could accelerate it? **3 points**

6. Describe the forces that moved the floating pieces of chocolate (or wax) during Part 2 of the activity. How did the forces relate to the direction of water flow in the bin? **2 points**

7. Water has a low viscosity (thickness). How might the movement of the dyes change if a fluid with a higher viscosity is used? **1 point**

8. Evaluate the food coloring and water bin model. What are its strengths and limitations in modeling thermal convection? **4 points**

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