Where does the “sweat” on a glass come from?

Overview

Where does the “sweat” on a glass of cold water come from? This is a very intriguing question that your students will explore and discuss as they experiment and collect hard data. The results may be quite surprising!

Theory

To answer this introductory question, you and your students will consider how the molecules in the vapor (gas) phase and the liquid phase are behaving, and will tap into your experience doing the “Be the Molecule” kinesthetic activity.

First, though, we have to tackle a common misconception that students have about water vapor and liquid water. Water vapor is invisible — if you can see it, it’s a liquid. Fog and clouds are made of liquid water droplets. The air around a cloud contains some invisible water vapor, but the cloud itself is made of liquid water. Clouds form via condensation: water vapor in the air undergoes a phase change from gas to liquid. Condensation is the opposite of evaporation. During condensation, water molecules cool down, releasing energy. As the water molecules slow down (due to the release of energy) and start sticking to other water molecules, they change phase into a liquid. Where does the released energy go? It goes out into the environment: The air around the the molecules and the surfaces where condensation is occurring warm up!

Doing the activity

1. Turn on the digital scale and let it reset to zero.
2. Place the empty bottle with the lid attached on the scale and write down the weight.
3. Add crushed ice and cool water to the bottle and attach the lid.
4. Place on the scale and write down the weight of the bottle with the ice water.
5. Watch the scale and the bottle. It may be a few minutes before you see a change. Is water vapor starting to condense on the bottle? Is the weight of the bottle changing? (The weight of the bottle should be increasing; if you are using the original States of Matter kit supplies, you can expect to see a change on the order of a few hundredths of a gram.)
6. As you wait for the condensation to appear on the bottle, you may want to start discussing what is happening to the molecules and how they are behaving. (As water vapor molecules in the air around the bottle release energy to the ice and therefore cool down, they move more slowly and begin to bond together, transitioning to the liquid phase. The liquid phase is much more dense than the gas phase — liquids tend to pack a lot more molecules into a given area than gases do. Because a lot of “extra” liquid water molecules are now stuck to the outside of jar, the jar will weigh more. At the same time, solid water molecules in the ice are absorbing energy from the water vapor molecules in the air, so they are moving faster. Some of the molecules start losing tight bonds with their neighbors, and the ice beings to melt.)

Necessary materials:

- water
- crushed ice
- 1 small glass jar with lid*
- digital scale
- see “Troubleshooting” section (below) for additional materials you may need

*If you’re restocking or getting new items for this activity, check the maximum capacity of your digital scale when selecting jars. Our scale had a maximum capacity of 100 grams, so we needed a pretty small jar.
7. Let the experiment keep running for a while. The weight should stabilize, then start decreasing back to its original reading (from step 4). What's going on here? (Eventually, once all the ice is melted, the liquid water that condensed on the bottle's exterior will start absorbing energy from the warmer container and surrounding air. Once some molecules have enough energy to “escape” from the liquid, that water will start going through a second phase change: It will evaporate back into the air.)

**Troubleshooting:** In the winter, when it’s cold and dry indoors, there isn’t much water vapor in the air, so you won’t get much (if any) condensation on the bottle. If you encounter this problem, try running a hot pot or a small humidifier near the experiment to add moisture to the air. If there is enough moisture in the air, it will condense when it interacts with the cold bottle, and the weight reading on the scale should increase. If this doesn’t work, you will most likely need to wait until you have more humid, warmer weather.

If you are using the original supplies from the States of Matter kit, your scale will most likely automatically turn off during the experiment. When this happens, just remove the bottle, turn on the scale and let it reset to zero, and put the bottle back on.

When you first put the bottle on the scale, you may notice that the weight fluctuates a bit. This is normal, and the reading will settle at a stable value after a few moments.

**Summing up**

This experiment may surprise students, as water in the liquid form appears to weigh more than water vapor. This is much easier to understand if students think about what is happening to the molecules and how they are behaving as they change phase from one state to another. It also is a great experiment to discuss the properties of water vapor — if you see it, it’s a liquid, not a solid!

**For more information**

Little Shop of Physics: [https://www.lsop.colostate.edu](https://www.lsop.colostate.edu)

Colorado State University College of Natural Sciences: [https://www.natsci.colostate.edu](https://www.natsci.colostate.edu)