

Humidity Activity

Background

Water is the common name for a chemical that has two atoms of hydrogen (H) for each atom of oxygen (O). The chemical formula for water, then, is H₂O. Water has some special properties that are very important. For one, water molecules have a very strong attachment for each other. This is why water clumps into droplets, and insects like water striders can actually walk on top of the water. Another significant property is that many other chemicals mix easily with water, making water one of the most important solvents. Water occurs in three forms (phases): solid (ice), liquid, and gaseous (water vapor). Ice is less dense than liquid water, so it floats - which is very important for life on Earth, since bodies of water freeze from the top down rather than the bottom up. Water can change phases depending on whether it is cooled or heated. Liquid water can freeze to become ice, and ice can melt to become liquid water. If heated, liquid water will evaporate to become water vapor, and water vapor can be cooled to condense and form liquid water. Under certain conditions, water can go directly from the solid to the gaseous form or the other way in a process called sublimation.

The vast majority of the Earth's water (97.22%) is located in the oceans. Ocean water is salty, and cannot be used for drinking unless it is desalinated (a process by which the salt is removed). Of the fresh water, most (77.14%) is located in glaciers and ice sheets. 22.22% of the fresh water is underground, and only 0.3% in the atmosphere. The smallest portion (only 0.003% of the fresh water) is in rivers and streams.

Billions of years ago, the Earth was built up from the collision of very many smaller pieces (this process is called accretion). Some of these pieces were made of rock (called asteroids), and others were made mostly of frozen gases (comets). Over time, beginning when the Earth was so hot it was molten (liquid), the gases bubbled to the surface (called outgassing) and formed the early atmosphere. Some of the early atmosphere was made of water vapor, and when the Earth cooled down enough, the water vapor condensed and fell to the surface.

Today, there are two major sources of water. The first is that the Earth continues outgassing, mainly through volcanic eruptions. The second is that small comets continue to collide with the Earth every day. These comets heat up and melt high above the Earth and add their gases, including water vapor, to the atmosphere. The total amount of water added to the Earth through both of these processes is very small, though. The Earth does lose a small amount of water, but the total amount is also very small. One way water is lost is chemical - some of the water reacts with other chemicals in the atmosphere and at the surface in ways so that the water cannot be recovered. Another way is that high in the atmosphere, some water molecules break down into hydrogen and oxygen, and some of the hydrogen escapes from the atmosphere into space.

One of the most important facts about the Earth is that it is located at about the right distance from the sun for a temperature range that allows water to exist at the surface in all three phases. Water is constantly moving from place to place and changing form. Scientists call a process like this a system. Systems are sets of pathways, along which some entity (such as information, a material like water, or energy) moves and is transformed. You are already familiar with many systems. For example, your circulatory system moves blood throughout your body. Cars have cooling systems and electrical systems. Systems usually have inputs (called sources) where the entity enters the system and outputs (called sinks) where the entity leaves the system. Some systems, in which the sources and sinks are very small, are called closed systems or cycles. Other systems, that have important sources and sinks, are called open systems.

Since the sources and sinks of water on the Earth are very small, the Earth's water system is closed, and is called the hydrologic cycle. Since the amount of water on the Earth is essentially constant, we can study how it moves around and changes form. Studying the hydrologic cycle has enabled scientists to better understand weather, climate, floods, droughts, and how and where plants and animals live.

The best place to start studying the hydrologic cycle is where most of the water is - the oceans. At any particular time, a very large amount of water is evaporating from the surface of the oceans to become water vapor in the atmosphere. Most of this water vapor condenses and falls back into the oceans as precipitation (rain or snow). Some of the vapor, though, travels over the land and falls there. Every drop of water that falls onto the land can travel in one of three directions. First, the water can evaporate and go back into the atmosphere. Plants play a role in moving water back into the atmosphere, because they take water from the soil and release it in a process called transpiration. The combination of the two is called evapotranspiration. Second, the water can go into the soil (called infiltration), and perhaps into storage into an underground layer of rock with empty spaces which can hold the water. These layers are called aquifers and are important water resources for human activity. Third, the water can run off over the surface back to the ocean. All of our rivers and streams, down to the tiniest creek, are part of the runoff process.

Water vapor mixes with the other gases in the atmosphere in the same way that you can mix many liquids together. The amount of water vapor in the air is called the specific humidity, and is usually expressed as the number of grams of water vapor per kilogram of air (written as g/kg). Just like there is only so much salt that can be put into a glass of water, the air can only hold a certain amount of water vapor. This amount, called the maximum specific humidity or water vapor capacity, changes with temperature. Warm air can hold more water vapor than cold air. When the air holds as much water as it can (when the specific humidity equals the water vapor capacity), we call the air saturated. Meteorologists have developed a measure, called the relative humidity that indicates how close the air

is to being saturated. The relative humidity is the humidity number that is most often used in weather reports. The formula for calculating the relative humidity is:

$$\text{Relative humidity} = 100\% \times \frac{\text{Specific humidity}}{\text{Water vapor capacity}}$$

As you can see, if the specific humidity is equal to the water vapor capacity, the relative humidity is 100%. Usually, when the relative humidity is 100%, the water vapor will condense to form clouds, fog, and eventually precipitation.

Humidity Activity Should be Done Here

Some chemicals absorb water and release it later. At any time, the amount of water that is chemically absorbed is small compared to the other processes in the hydrologic cycle. However, over very long time periods, the chemical absorption and release of water plays a very important role in climate.

Part II of Humidity Activity Should be Done Here (will not be done in the summer)

INVESTIGATION

Question: How does the relative humidity change with air temperature?

NOTE: Prepare a presentation on this investigation using the Gowin Vee format.

Materials:

Gladware[®] Container with Lid (“Deep Dish” works well)

Two No. 3 Stoppers with holes

TI-83 Plus Calculator and link cable

Relative Humidity Probe

Temperature Probe

Tape

Ice in container that will allow the Gladware container to be placed

Heat lamp or high intensity desk lamp

Scissors

Knife

Preparation

1. Use the small end of the stopper to trace a circle at each end of the lid. Use scissors or knife to cut out the circle.
2. Cut a slit in the stopper to the hole.
3. Feed the probe connector through the hole such that the probe is on the inside of the lid.
4. Arrange the probes inside the bottom of the container and then seal the container lid.
5. Slide the connecting wires for each probe into a stopper. Place the stopper in the openings on the lid and seal any gaps with duct tape.

Set-up for Data Collection

1. Plug each probe into a channel on the LabPro.
2. Connect your calculator to the LabPro and start the Datamate Application.
3. Go into setup and identify each probe with its channel.
4. You will be using the Time Graph mode. The data collection rate should be set such that you have 1 minute (60 seconds) between each point for a total of 25 points (25 minutes).
5. Return to the main menu.
6. A desk lamp should be placed next to the container, with the bulb towards the container, but not turned on. A tray or container of ice water should be placed a short distance away.

Data Collection

1. Start the data collection program.
2. During the first 5 minutes of the experiment let the LabPro collect information.
3. At the end of the first 5 minutes place the container in the ice tray for 10 minutes.
4. At the end of this time, remove the container from the ice tray and place it under the lamp. Turn on the lamp and let the LabPro collect data for the remaining time.

Part II.

Repeat the experiment using placing a packet of CaCl in the container.

Analysis

1. How did the relative humidity change as the temperature changed?
2. Explain your relative humidity vs. time graph as compared to graph of just air.
3. Use the maximum humidity chart and the relative humidity measurements to calculate the specific humidity at each measurement in time. Show your work on how to transform the relative humidity equation into one that can be used to calculate specific humidity in the space below:

$$\text{Relative Humidity} = 100 \times \frac{\text{SpecificHumidity}}{\text{WaterVaporCapacity}}$$

4. Use your derived equation to calculate the specific humidity at each temperature. What trend do you observe?
5. CaCl is hygroscopic (look this term up!) and will absorb water below 30°C and release it above 30°C. How does help account for your observation on the specific and relative humidity?