



Chapter 12. How Clouds Form—Understanding the Basic Principles of Precipitation: A Structured-Inquiry Activity

Think About This!

Have you ever observed the fluffy cumulus clouds that are often seen in the sky on a partially clear summer day? Often they seem to change shape and some even disappear and others appear in their places. Have you ever wondered why this change of shape and why they seem to appear and disappear? Where do the clouds come from and where do they go? Have you ever observed the clouds in the sky as a storm approaches? What do they look like? What kinds of clouds are in the sky prior to extended precipitation? How are cloud formation and precipitation related to each other?



Probing Further

In previous activities, you learned about several properties of air. You learned that it has weight, that it moves in response to pressure differences, that it contains moisture, and that temperature affects the

amount of moisture that the air can contain. Normally, in the troposphere, as the altitude above the surface of the Earth increases, the temperature and atmospheric pressure decrease (see Figure 2-1 on page 5 and Table 2-2 on page 8). Might this change in temperature and pressure have anything to do with the formation and disappearance of clouds?

Purpose

The purpose of this investigation is to facilitate understanding of the basics of cloud formation and involving the changing of state of water. This activity should enhance the understanding of the change of state concept, which is important in the study of meteorology.

Objectives for Student (Essentials of Inquiry)

Conceptual Theme: To develop a basic understanding of the change that takes place when water condenses from a gas to a liquid and how a change in pressure affects this transformation.

Content: Developing basic information related to the condensation process and establishing a basic understanding of cloud formation. Further, providing the student additional and basic content.

Skills: The focus is on the design of steps in conducting an investigation using laboratory equipment, making careful observations, recording physical changes, drawing conclusions, and describing and communicating results.

Scientific Habits of Mind: The importance of careful observations, respect for data, and verifying results.

Materials

Large clear plastic soda bottle with screw-on cap (two-liter size is ideal)

Squeeze bottle with long plastic hose to add water to the bottle

Dark-colored construction paper or similar material

White paper

5 marking pens that range from very light to very dark in color

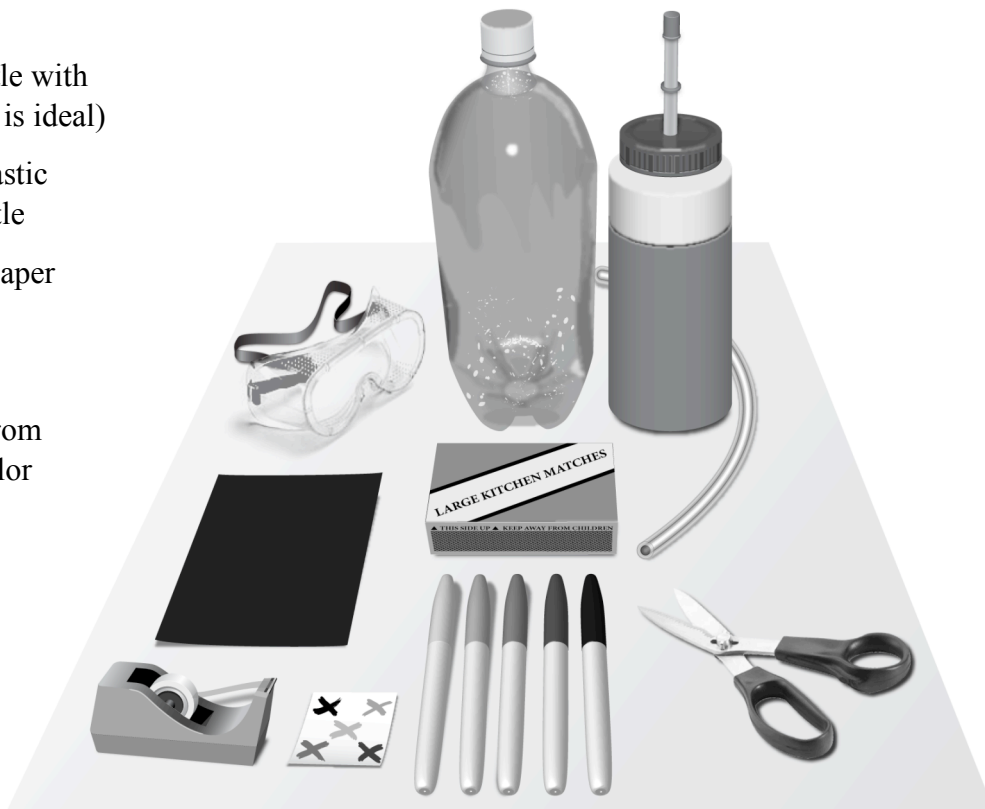
Scissors

Clear tape

Wooden matches (such as fireplace matches)

Tap water

Safety glasses



Procedure

Completely remove the label from the two-liter soda bottle to ensure that the view inside the bottle is unobstructed.

Cut an approximately 4 cm by 4 cm (1.5 in. by 1.5 in.) square from the sheet of white paper. Use the five marking pens to draw four Xs at each corner and one in the center of the white paper, each about 1.5 cm (.5 in.) high.

Using the clear tape, tape the strip with the five Xs onto the back of the two-liter bottle, approximately 10 cm (4 in.) below the top of the bottle, facing inward so that the Xs can be clearly viewed by looking through the bottle.

Next, cut a 10 cm by 15 cm (4 in. by 6 in.) strip of the dark-colored construction paper and tape it behind the white paper with the Xs, beginning near the neck of

the soda bottle. This arrangement will better enable the investigator to view and determine important changes inside the bottle.

There are three conditions to manipulate, investigate and note changes of inside the environment of the bottle. The three conditions are no liquid water, liquid water, and liquid water plus smoke. The two-liter soda bottle can be used to investigate all three different conditions. Each condition should be repeated four to five times and the results recorded. Changes can be manipulated for each of these conditions by pressing on and holding the bottom of the bottle. Squeeze the bottle and hold 5 to 10 seconds for each of the three conditions. Repeat four or five times. Carefully observe the results inside the bottle. Pay special attention to the upper portion of the bottle and note the clarity with which you can see the series of Xs. Make special note if certain colored Xs are more visible under the differing conditions varying from no water to water plus smoke.

Condition One (No Water): Make sure that the cap is screwed on tightly. As you look through the bottle at the series of five Xs on the opposite side, squeeze the bottle near the bottom and hold for 5 to 10 seconds and then release the squeeze. Repeat this procedure four to five times. During each trial observe the Xs to determine if they become less visible and also note any changes in the side of the bottle as well. Record your results.

Condition Two (Just Water): Remove the cap from the bottle and add fifty milliliters of water. You should be very careful not to get water on the sides of the bottle. A plastic or rubber hose attached to a squeeze bottle can prevent getting water on the bottle sides. Replace the cap and carefully swirl the bottle for about 10 to 15 seconds. Repeat the procedures and the observations described above. Record your results.

Condition Three (Water and Smoke): Remove the cap from the bottle after condition two. Wearing safety glasses, carefully light one of the wooden matches and place it into the neck of the bottle (do not drop the match into the bottle), squeeze the bottle to extinguish the match and then let go quickly to draw the smoke into the bottle. Remove the match and screw the cap on the bottle. Repeat the procedure as described above. Record your results.

Examining Results

The purpose of this activity is to facilitate learning to examine, in a concrete way, some factors involved in cloud formation and to understand how these factors interact to form a cloud. Learners should also understand that the basis of precipitation begins with cloud formation.

What change did you observe inside the bottle in condition one?

There was probably no detectable visible change inside the bottle, especially if the bottle was dry

inside. The relative humidity is probably very low. Although squeezing the bottle produced an increase in the pressure inside the bottle that probably resulted in a temperature increase, visible changes were likely not present. This bottle served as a type of control for the activity.

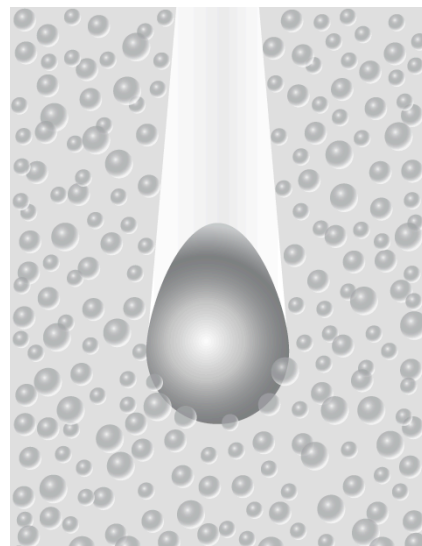
What change did you observe inside the bottle in condition two?

In condition two, there is no place inside the bottle for condensation to take place except on the sides of the bottle. Therefore, it is a possibility that droplets formed on the sides of the bottle and some droplets might have gotten smaller or disappeared when the bottle was squeezed.

What change did you observe inside the bottle in condition three?

The most dramatic results should occur in condition three. By introducing smoke into the bottle, there are now microscopic particles, called condensation nuclei, which provide a surface for small droplets of water to form. Thousands of these particles provide many surfaces for cloud formation. As the bottle is compressed, the temperature rises slightly and the droplets disappear. When the pressure is released (the squeeze relaxed), the temperature decreases slightly and the cloud reappears.

Within clouds, the water that is condensed around the condensation nuclei travels up and down in the cloud. Eventually, the water droplets forming around the nuclei get heavy enough and precipitate out of the cloud to the Earth's surface.



Conclusion

What major conclusion did you draw about conditions for cloud formation after conducting this activity?

The conclusions should be based upon the results. Very likely a cloud formed only in the bottle where the smoke was introduced (condensation nuclei). A logical conclusion would be that some particles are essential for water to condense and form a cloud.

Going Further

How could you better validate that “condensation nuclei” are an essential part cloud formation?

Repeat the procedure several times using fine dust as particles and repeat several times without using any particles. Chalk dust or fireplace ash is useful.

Challenge

What do you think happens inside a cloud to get precipitation (droplets) to fall to the Earth in the form of rain, snow or even hail? What do you think are the conditions that ultimately determine which form of precipitation finally reaches the surface of the Earth. You might want to discuss this with your teacher or to do some further research.

Have the learner select one or more of these questions to research and prepare a written report.

