ACTIVITY | Clouds, Air Pressure and Temperature

After completing this investigation, you should be able to:

- Describe how air temperatures change as air pressure changes
- Make clouds appear and disappear
- Explain how most clouds form in the atmosphere

Materials

A clean, clear plastic 2-litre or larger beverage bottle with cap, thin liquid crystal temperature strip (available in aquarium supply stores), tape, paper strips.

Approach

Tape a paper strip to the ends of the temperature strip to bend it into an arc with the face of the thermometer on the convex side. Tape another short paper strip midway and extending sideways on the paper strip attached to the thermometer, to provide a crossed paper platform to hold the temperature strip in a viewing position and away from the sides of the bottle. Gently roll the side strip in under the temperature strip and slide the entire assembly end first into the clean, dry bottle. Screw on the cap tightly.

Method:

Examine the sealed bottle given to you. Lay it on its side on your desk so the temperature strip inside faces upward and is easy to read. Do not handle the bottle any more than necessary, so that its inside temperature will not be affected by the warmth of your hands.

Procedure and Questions

A. Air pressure and temperature relationships

Read and record the temperature of the air inside the bottle as indicated by the temperature strip. Place the bottle so about half of it extends beyond the edge of your desk or table. Standing with one hand on each end of the bottle, push down on both ends of the bottle so it bends in the middle and compresses the trapped air. Hold it this way to keep the air compressed while carefully watching the temperature strip. After a half-minute or so, release the pressure by letting up on the bottle. Continue to carefully observe the temperature for at least another minute.

1. What happened to the temperature as a result of the air in the bottle being compressed?
2. When you released the bottle so the air inside was no longer being squeezed, what happened to the air temperature in the bottle?
3. State, in your own words, the relationship between changes in air pressure and temperature.
4. Air pressure decreases with an increase in altitude. This happens because air pressure is determined by the weight of the overlying air. Consequently, air rising upward experiences lower pressure and expands. Based on your findings in (2) above, what must happen to the temperature of air rising through the atmosphere?

5. what happens to the temperature of air when it moves downward in the atmosphere? Explain your answer.

B. Making clouds appear and disappear

Open the bottle and pour a few drops of water in it. Twist and turn the bottle to wet the inner surface. Cap tightly and let stand for a couple of minutes so enough water evaporates to saturate the air.

Lay the bottle on its side, open the bottle and push down to flatten the bottle to about half its normal diameter. Have someone light a match, blow it out, and insert the smoking end into the bottle opening. Quickly release your pressure on the bottle so it returns to its rounded shape and the smoke from the extinguished match is drawn inside. Quickly cap the bottle tightly. The smoke was added to the air because atmospheric water vapour needs particles on which to condense.

Now apply and release pressure on the bottle as before, keeping track of temperature changes. Look very carefully in the bottle for any evidence of a cloud. It will be detected by a change in air visibility. If you cannot detect cloud, repeat the process of applying and releasing pressure until you do.

6. Did the cloud form when you applied pressure or when you released pressure? Did it form when the temperature rose or when it fell? Why?

7. Most clouds in the atmosphere form in the same basic way as the cloud in the bottle. In your own words, describe this process in the open atmosphere.

8. Once you have a cloud in the bottle, make the cloud disappear. What makes it disappear?

9. Most clouds in the atmosphere appear and disappear the way your bottle cloud did. State in your own words the temperature and pressure relationships that lead to cloud formation and, assuming no precipitation, cloud dissipation.

10. Based on this activity, what can you infer about vertical motions in the atmosphere where (a) it is cloudy and (b) it is clear?

11. Generally, High-Pressure areas in the atmosphere tend to be clear and Low-Pressure areas have clouds. What must the general vertical motions in these weather systems be?

12. Examine a weather satellite picture and point out broad areas where air is probably rising and those where air is likely to be sinking.

ACTIVITY Additional Activities

1. Keep a journal of cloud types and weather conditions over a period of a week. Make observations at least three separate times each day, such as morning, afternoon and evening. Can you relate the predominant cloud types seen to the weather conditions? Watch television weathercasts and note the position of any fronts present during this time. When were convective-type clouds present?

2. On a clear, sunny summer's day, watch the development of cumulus clouds as the day goes on. If possible, try to determine over what types of ground cover the clouds form. Additionally, one might try to videotape short segments at regular intervals to playback later as a time-lapse movie of the cloud formation and growth.

3. If you have episodes of fog, what were the conditions that preceded the fog? What changes occurred to cause the fog to dissipate? How do these conditions relate to cloud formation as described above?

4. Observe the turbulent motions that keep cloud droplets aloft by watching specks of dust moving in a beam of sunlight through a window. (The best views will be from the side, at right angles to the beam.)

5. Watch convection currents set up in a pan of water put on a stove and heated, The convection motions can be made more visible by adding pepper, crushed tea leaves or other non-soluble small particles to the pan.

6. Obtain a dry cleaning or other large, thin plastic bag. Tape any holes shut except the bottom opening with transparent tape. Tape a loop of thin wire around the opening inside the bag to keep the opening expanded. Use a hair dryer to fill the bag with hot air. How long does it take the bag to become buoyant? How high does the bag rise before failing again?

7. Make a Cartesian diver. A Cartesian diver moves vertically in water due to buoyancy forces just as atmospheric vertical motions do. Fill a 2-litre, clear plastic soda bottle with water to within about 10 cm of the top. Take a small cylinder open at one end (such as a ballpoint pen cap) and fill partially with water, allowing an air bubble to remain in the cylinder. This diver must be just slightly buoyant, that is, it must just barely float. When properly balanced the diver will float to the top of the water. Place the diver in the soda bottle and cap it securely. Now when the bottle is squeezed, the diver's air bubble will be compressed causing the diver to sink to the bottom of the bottle. Release the bottle and the decreased pressure within will again allow the bubble to expand and the diver to rise to the top.