Latent Heat Captured on Video!

For Earth Science-related videos, go to www.teachertube.com , and type “Rod Benson” into the search window.

Introduction

Have you ever wondered what weather broadcasters mean when they say that a particular storm has lots of “energy," or that a hurricane is “fueled” by warm ocean water? Although these remarks may be confusing, recognizing the role that energy plays in various phase changes of water is actually an important key to understanding weather. The "energy" in a storm enters the air when water molecules absorb heat as they evaporate from the ocean. Water molecules need this heat to make the change from liquid to vapor. Storms that contain more vapor (humidity) really do have more “energy”. Eventually, as the vapor molecules condense or freeze to form clouds, this energy, called “latent heat,” is released into the surrounding air, often several days later and hundreds of miles from the nearest ocean.

One interesting weather phenomenon that involves latent heat is the "Chinook effect". When humid air forms clouds on the west slopes of the Rockies, latent heat is released into the air. Then as this air descends onto the east slope of the Rockies, this heat teams with compression to make the Chinook winds especially warm. The opposite effect happens with microbursts, where evaporation cools the surrounding air. To learn more about these phenomena, go to www.formontana.net/chinook and www.formontana.net/burst.

Latent heat also influences barometric pressure and wind speeds. For instance, within hurricanes, “energy” (latent heat) is released as vapor changes into cloud droplets, which eventually become raindrops. This heat helps air within the storm to rise even more, decreasing the pressure, and increasing the wind speed. As hurricanes move over land they quickly weaken because they are away from their source of “fuel”; the warm water that provides vapor (with latent heat; a.k.a. “energy”). Mid-latitude cyclones (low pressure systems) also intensify as humid air from the ocean blows toward their centers of low pressure.

Materials

400-500 ml plastic beaker or similar container, slush (snow, salt, water), small thermometer, Tic Tac container, distilled water, disposable plastic table knife

Procedures/Suggestions:

1. I would recommend this activity for students in grades 9-12. It is a good one to have on hand for that first big snowfall of the season. If you don't have snow you will have to substitute ice (smaller cubes work better).

2. Soak the Tic Tac containers in rubbing alcohol to remove the labels.

3. This can be done as a demonstration, or as a student-activity. A student handout is provided. I recommend that you (the teacher) go through the handout and figure out the answers to get a better feel for the activity. If you have any questions about what the correct answers are, refer to the answer key.

4. If the students perform the experiment, provide them with the handout. Do the "Pre-Lab questions" together. Explain to them how to do the experiment. Write reminders/instructions on the board as needed. When they are finished with the experiment, they can do the rest of the questions on the handout.

5. To make the slush, use snow, salt, and water. Use about 100-150 ml of salt per liter of slush. Try to make the slush about the same consistency of those that would be purchased to drink. I suggest that you (the teacher) make the slush in some sort of large container, and that you put it in their beakers as they bring them to you (especially if you teach grades 7-9).

6. Fill the Tic Tac containers about 2/3 full with distilled water. Insert the container into the slush as shown in the Teacher Tube video (called "Latent Heat Captured on Video"). Put a clean thermometer into the Tic Tac container.

7. DO NOT DISTURB! Leave the container and thermometer alone. Moving either may trigger the crystallization process (freezing). Let the temperature of the water drop to about – 4 C. If the water starts to freeze before it reaches - 4, empty the container, rinse it out, and start over.

8. To trigger the freezing, use the plastic knife to drop a few snowflakes into the Tic Tac container. I prefer to have the students call me over to their table when their water has reached – 4 C, and then I do this for them, or at least make sure that they are watching the water and the temperature as they do it. **This works best when new, clean snow is used.**

9. To see a related demonstration, go to www.formontana.net/energy.html

Latent Heat Experiment

name: _____

Pre-Lab Questions

1. What are clouds made of?

2. Which of the following molecules is moving "slowest", "medium", and "fastest".

_____ water vapor molecules
_____ frozen water molecules (ice)
_____ liquid water molecules

3. When sweat (mostly liquid water) evaporates from your skin, why does this help to cool your body?

4. Most of the water in the clouds over Montana came from the Pacific Ocean. What do water molecules absorb as they evaporate from the ocean?

5. What is "supercooled water"?

6. Complete the diagram shown below by putting arrows between all of the possible phase changes. Indicate whether water molecules absorb heat from their surroundings, or lose heat to their surroundings with each change.

WATER VAPOR

LIQUID WATER

FROZEN WATER
(ICE)

Perform the experiment, and then answer the following questions.

1. How cold did the water in the Tic Tac container get before it froze? _____ C

Did the water in the Tic Tac container become "supercooled" before it froze? _____

2. What happened to the temperature of the thermometer in the Tic Tac container as the water froze?

3. Why did this happen? Circle one.

a. Water molecules absorb heat from their surroundings as they changed from liquid to solid.

b. Water molecules release heat to their surroundings as they changed from liquid to solid.

4. As winds force very humid air up the western slopes of mountains in northwestern Montana, the air is cooled by expansion, causing clouds to form. As vapor changes to solid cloud crystals, the water molecules would . . . (circle one)

a. absorb heat from their surroundings, making the air colder

b. release heat to their surroundings, making the air warmer

This heat, called "latent heat," is what causes the Chinook Effect. If you want to learn more about Chinook winds, go to this web site: **www.formontana.net/chinook.html**

5. As rain falls through very dry air, much (or all) of the rain may evaporate. As this falling rain evaporates the water molecules . . . (circle one)

a. Water molecules absorb heat from their surroundings as liquid changes to vapor.

b. Water molecules release heat to their surroundings as liquid changes to vapor.

6. As the air described in question #5 gets colder than the surrounding air it becomes heavier than the surrounding air, causing it to accelerate toward the ground like a lead weight falling through water. As this rapidly falling air hits the ground surface winds can exceed 100 miles/hour. This is known as a "downburst". The most intense ones, which may last only 5 minutes and have wind speeds over 175 miles/hour, are called "microbursts". Scientists can tell whether an area has experienced a tornado, or a microburst by surveying the damage from an airplane.

How would the pattern of damage caused by a microburst differ from the pattern of damage caused by a tornado?

To learn more about microbursts, go to: **www.formontana.net/burst.html**

7. When a hard frost is expected, orange growers may spray their trees with water to keep the oranges from freezing. As the water on the oranges freezes, the ice provides insulation for the fruit within. Also, as the water freezes, this helps prevent the fruit from freezing because . . . (circle one)

a. Water molecules absorb heat as they change from liquid to ice.

b. Water molecules release heat as they change from liquid to ice.

8. A psychrometer, which is used to measure relative humidity, consists of a wet-bulb and a dry-bulb thermometer. Fill in the blanks in the following statement.

As water molecules evaporate from the wet bulb they_____ (absorb/release) heat, causing the wet bulb to become _____ (warmer/colder) than the dry bulb.

9. TV weather broadcasters occasionally say that a storm has "lots of energy," indicating that it has greater potential for precipitation (and wind). Why is it that storms with "lots of moisture" would also have "lots of energy"? Circle the correct answer.

a. The storm generates heat as a result of friction between water molecules and the ground.

b. The presence of water molecules in the air makes the air go faster.

c. The water molecules in the air absorbed heat in order to evaporate from the ocean.

10. Circle **all** of the phase changes listed below that would release heat into the air.

liquid water changes to vapor	ice changes to liquid
vapor changes to liquid	frost changes to vapor
liquid water changes to ice	vapor changes to frost

11. Consider the phase change listed in question #10 above. Complete the statement below by circling the correct choice.

The water molecules absorb heat if they change. . . (Circle one.)

a. from a phase where they are going slower to a phase where they are going faster

b. from a phase where they are going faster to a phase where they are going slower

12. Look at the diagram on the first page of this handout. Which phase change is responsible for releasing the heat that makes the Chinook winds warm?

13. Which phase change is the reason that downbursts (including microbursts) happen?

14. Which phase change is the reason a meteorologist might comment that a particular storm "has lots of energy"?

15. Which phase change is the reason for the temperature increase in your Tic Tac container at the end of your experiment?

Answer Key

Pre-Lab Questions: I like to make a transparency of the first page of the student handout and use it to go through the pre-lab questions with the students.

1. Clouds are made of tiny water droplets and/or ice crystals (not water vapor)
2. Slowest: frozen water molecules, medium: liquid, fastest: vapor
3. As liquid water (sweat) changes into vapor, the water molecules absorb heat from your skin, making you feel cooler.
4. They must absorb heat in order to evaporate (latent heat).
5. Super-cooled water is water that is liquid even though it is colder than 0 C.
6. Have the students draw arrows between the phases to indicate all the possible changes.

    a. As water vapor changes to ice (deposition) like when frost forms, the water molecules give off heat to their surroundings.
    b. As ice changes to liquid (melting), the water molecules absorb heat to make this change.
    c. As liquid water changes to vapor (evaporation), the molecules absorb heat.
    d. As vapor changes to liquid (condensation), the water molecules give off heat to their surroundings.
    e. As ice changes to vapor (sublimation) the water molecules absorb heat from their surroundings.
    f. As liquid changes to ice (freezing, crystallization), the water molecules give off heat.

Answers to follow-up questions:

1. Hopefully the water cooled to – 4 C, and "yes".
2. The temperature rose as the water froze.
3. "b"
4. "b"
5. "a"
6. Damage caused by a tornado would be more twisted because of the spiraling winds, whereas damage from a microburst indicates that the winds were "straight line".
7. "b"
8. absorb, colder
9. "c"
10. liquid water changes to vapor — ice changes to liquid
    vapor changes to liquid — frost changes to vapor
    liquid water changes to ice — vapor changes to frost
11. "a"
12. Deposition (vapor changing to cloud crystals)
13. Evaporation
14. Evaporation
15. Freezing

For more ideas, go to RODNEY'S HOMEPAGE for Earth Science Teachers at www.formontana.net/home.html