Name_____________________________________ Period_________ Date_________

CONCEPTUAL PHYSICS | **Experiment**

23.5 Change of Phase: Freezing

WARMING BY FREEZING

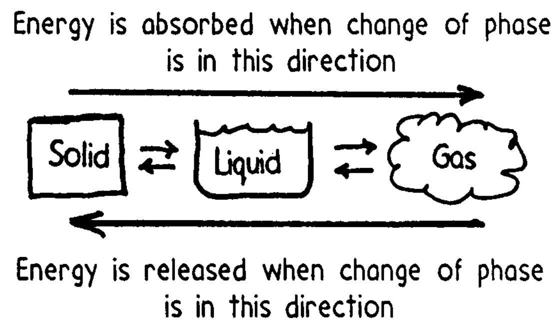
Purpose

In this activity, you will demonstrate that heat is released when freezing occurs.

Required Equipment and Supplies

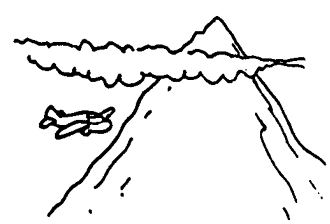
heat-generating pouch (RE-HEATER® or equivalent supersaturated sodium acetate pack)
hot plate
large pan or pot of boiling water

Discussion



We know that it is necessary to add heat to liquefy a solid or vaporize a liquid. In the reverse process, heat is released when a gas condenses or a liquid freezes. Thermal energy that accompanies these changes of state is called *latent heat of vaporization* (going from gas to liquid or liquid to gas), and *latent heat of fusion* (going from liquid to solid or solid to liquid).

Water, which normally freezes at 0°C (32°F), can be found under certain conditions in a liquid state as low as –40°C (–40°F) or more. This *supercooled* water (liquid water below 0°C) often exists as tiny cloud droplets, common in clouds where snow or ice particles form. Freezing in clouds depends on the presence of *ice-forming nuclei*, most of which are active in the –10°C to –20°C range. Ice-forming nuclei may be many different substances such as dust, bacteria, other ice particles, or silver iodide used to "seed" clouds during droughts. Silver iodide is active at temperatures as high as –4°C.



Cold clouds containing large amounts of supercooled water and relatively small amounts of ice particles can be dangerous to aircraft. The skin of the aircraft, well below freezing, provides an excellent surface on which supercooled water suddenly freezes. This is called aircraft icing, which can be quite severe under certain conditions.

The heat pack provides a dramatic example of a supercooled liquid. What you observe in the heat pack is actually the release of the latent heat of crystallization, which is analogous to the release of latent heat of vaporization or the latent heat of fusion. The freezing temperature of the sodium acetate solution inside the heat pack is about 55°C (130°F), yet it exists at room temperature. The heat pack can be cooled down to as low as –10°C before it finally freezes.

It only takes a quick click to activate the heat pouch. You will notice that the internal trigger button has two distinct sides. If you use your thumb and forefinger and squeeze quickly, you will not need to worry about which side is up.

After observing the crystallization of the sodium acetate and the heat released, you might want to try it again and measure the heat of crystallization. The package has a mass of about 146 grams. The packaging and the trigger mechanism have a mass of about 26 grams. Thus, the sodium acetate solution inside the package has a mass of about 120 grams.

Procedure

Place the heat pack in an insulated container (such as a larger Styrofoam cup) with 400 g of room-temperature water. Allow the water and heat pack to reach equilibrium. Measure and record its initial temperature. Activate the heat pack button. After 10 or 15 seconds, maximum temperature will be obtained. Return the heat pack to the container and measure the temperature of the water at regular intervals. How much heat is gained by the water?

Q = ________________________________

Summing Up

1. How does the crystallization inside the heat pack relate to heating and air conditioning in a building? *Hints:* Think about how steam heat and radiators operate or how the refrigerants in an air conditioner operate.

2. Speculate about how these processes relate to airplane safety?

3. Think of and list some practical applications of the heat pouch.