Latent Heat and the Atmosphere

Latent heat is the heat energy that is exchanged when a substance is changed from one state (vapor, liquid or solid) to another. At the Earth's surface, water can exist in all 3 phases and the transformation from one to another is an important mechanism for transferring energy in the environment. In the atmosphere, the processes include freezing, melting, vaporization and condensation. A process involving a change to a more disordered phase results in a cooling process; this includes melting and evaporation. A process that result in a change to a more ordered phase results in a heating process; this includes freezing and condensation. Vapor or gas is the most disordered type of phase because the gas molecules are bonded to one another. Solids generally have an orderly internal structure and are the most ordered phase compared to vapor and liquid. Liquids generally are intermediate in internal structure or order compared to gases and solids.

Humans transfer excess heat to the environment through evaporation. When it is hot, we perspire. The evaporation of perspiration causes cooling of the skin.

Evaporation of Hot Water. An easy way to demonstrate cooling due to evaporation is to fill a spray bottle (with a fine mist nozzle) with warm water. Let a student feel the warmth of the water in the bottle. Then spray the warm water on the student's bare arm and it should feel cold. Students may be surprised that the warm water feels cold when it is sprayed. The reason the water feels cold is that the fine mist results in the water droplets evaporating quickly. Since evaporation is a cooling process, the evaporating water droplets feel cold. This is a simple and good opening phenomenon to engage students.

Evaporation of Alcohol. Another demonstration or activity to illustrate cooling is the evaporation of rubbing alcohol. Starting with a sealed bottle of rubbing alcohol, remove the cap and quickly measure the temperature with an instant-read thermometer. Then pour some of the alcohol into a shallow dish. After a minute, take the temperature of the alcohol in the dish. The increased surface area causes the alcohol to evaporate more quickly resulting in a lower temperature.

Heat Packs. The two previous examples involve cooling processes during evaporation. Chemical heat pads or hand warmers demonstrate a heating process through the release of energy (heat) by crystallization. The hand warmer starts out as a supersaturated solution (liquid) of sodium acetate. Clicking the metal disk in the pad provides energy to the system causing it to crystallize. Students will observe that the fluid reacts to form a solid and heat is released. There are different types of hand warmers. This activity requires the type that contains a supersaturated solution that crystallizes. They are "rechargeable" by boiling them in water to dissolve the sodium acetate and can be reused. Air activated hand warmers produce heat by an oxidation reaction with oxygen in the atmosphere; this type of hand warmer uses a different type of chemical reaction and is not appropriate for this demonstration.