

S1: Humidity and Evaporation — Instructor Information

The water evaporates into the air. Air contains gas molecules (primarily oxygen and nitrogen and some other gases such as carbon dioxide) and water vapor. The amount of water in the air is called its humidity and is measured as the amount (mass) of water vapor in a given volume divided by the mass of air in that volume.

There is a maximum amount of water that the air can hold, depending on temperature, and once that maximum is reached water condenses out of the air. This is called the dew point. Sometimes in morning, or evening, outdoor surfaces will have water on them. The temperature of the surfaces were cold enough so the water in the air cooled off and condensed out on the surface, forming dew.

The greater the air's temperature, the more water it can hold. Relative humidity is the ratio of the air's actual humidity to the maximum amount it could hold at the same temperature—it is relative to the air's temperature. This ratio is expressed as a percent, hence when the relative is 60% it means that the air contains 60% of the maximum amount it could possibly hold. Thus, cold air with a 60% relative humidity contains less total water than hot air at 60% relative humidity. In the winter the outside air relative humidity may be 50%, but when that air goes into the house and is warmed up to room temperature, the relative humidity will drop to perhaps 10-20% relative humidity.

Think of a piece of cloth with water in it, as illustrated on the following page. The water molecules leave the fabric surface and evaporate into the air when the air does not contain the maximum amount of water. The further away from the maximum amount, the greater the rate of evaporation from the surface. Once the water evaporates from the surface, then water from the interior of the fabric moves by capillary action (a slow process) to the surface and evaporates. Only the water evaporates, dissolved material comes out of solution and stays behind. You have probably observed this. When water evaporates, imagine water droplets on a car, there is a circular shaped residue left behind—this is the matter that was dissolved in the water, but could not evaporate.

Water always exists in equilibrium with another phase—liquid-vapor, liquid-solid, and solid-vapor. The lower the temperature of the liquid, the less liquid molecules evaporate to create equilibrium, and hence cold air will contain less water molecules for equilibrium. From a microscopic point of view, the lower the temperature, the lower the water molecules' velocity and fewer escape from the surface into the air. From a macroscopic point of view, there is always a vapor pressure corresponding to the liquid's temperature for equilibrium to exist. If the vapor pressure is less than this, water will continue to evaporate to try and establish this pressure. Just as a temperature difference will cause heat to flow to try and to bring the temperatures to equilibrium, so will water evaporate to try and make the water vapor pressure the equilibrium value.

On a cold, cloudy day, the water evaporates most slowly. On a sunny, warm day it evaporates more quickly, and on a breezy, warm sunny day it evaporates most quickly. When the water evaporates from the fabric surface, the air next to the fabric receives the

water vapor and its humidity increases, slowing down the rate of transfer. If there is a breeze, the air does not remain near the surface and the rate remains constant.

Notice that a clothes drier models warm, sunny, windy conditions. The diagram below illustrates how wet fabric, such as a bathing suit, will dry.

