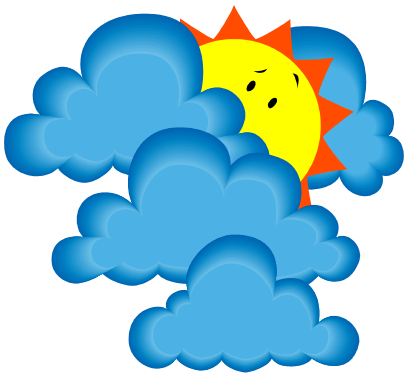
STATES OF MATTER



INTRODUCTION

In studying chemical reactions, we talk in terms of interactions between molecules, atoms, and electrons. However, in order to understand chemical changes, we must first have a grasp on physical changes. **Matter** is defined as anything that has mass and occupies space. Matter exists in three states: **solids, liquids, and gases**. In a chemical change, matter is being changed at the molecular and/or atomic level. For example, when two hydrogen atoms combine with one oxygen atom, the result is a new substance: water. When a physical change (often referred to as a "phase change") occurs, matter is generally being changed from one state to another. For instance, when water boils, it changes from a liquid to a vapor (gas).

Chemists use specific terms for certain changes in matter:

Physical Change	**Term**
Solid to Liquid	Melting
Liquid to Gas	Evaporation
Solid to Gas	Sublimation
Gas to Liquid	Condensation
Liquid to Solid	Freezing
Gas to Solid	Deposition

Our atmosphere is in a constant flux of matter phase changes. We have clouds, rain, and snow due to the phase changes of water. In the hydrologic cycle, water evaporates from water sources (oceans, lakes, and streams) and condenses in the atmosphere to form clouds. The water returns to the surface of the earth in the form of rain, snow, or some other form of precipitation. In today's experiment, we will take a look at some phase changes while examining four substances found naturally in our atmosphere: carbon dioxide (CO_2), nitrogen (N_2), water vapor (H_2O), and hydrogen (H_2).

TECHNIQUES

Using a Universal pH Indicator Chart

Compare the colored films on the chart to your solution. Find the color that best matches the color of your solution and write down the pH associated with that color as indicated by the chart.

SAFETY AND DISPOSAL

- The dry ice is **cold**! Use tongs to handle the dry ice.
- The liquid nitrogen can cause **frostbite** and should be handled only by the instructor.
- The solution remaining in the tube after Part III of the experiment should be discarded in the heavy metals waste container.
- Universal Indicator will stain skin and clothes! Handle with care.
- 6M HCl is corrosive and causes burns! Handle with care!

EXPERIMENTAL PROCEDURE

will appear to remind you of potential dangers and hazards.

NOTE: This lab is to be done in groups of four!

I. The Solid State

We will be using dry ice, the solid form of carbon dioxide (CO_2), to study the solid state of matter. In order to remain in the solid state, dry ice must be kept below room temperature (room temperature = 20 to 25°C). First, we'll take a look at what happens when dry ice is allowed to warm up to room temperature and then we'll examine the result of dissolving dry ice in water.

Handle the dry ice using tongs only! It can cause burns!

A. Phase Change: Sublimation

What usually happens when you take a substance that is a solid below room temperature and allow it to warm up? Depending on the amount you have, you either end up with a puddle or a big mess, right? Let's take a look at solid CO_2. Using tongs place a chunk of dry ice in a weigh boat and record your observations over a five minute period. Keep the dry ice for Part B.

B. Dissolution of Dry Ice in Water

1. Add approximately 50 mL of distilled water to a 250 mL beaker.
2. Add ten drops of Universal Indicator to the water in the beaker and stir the water with a stirring rod until a uniform color is obtained. Record the color of the solution.

Universal Indicator will stain skin and clothes! Handle with care!

3. Add 0.1M NaOH drop wise with stirring until solution turns a uniform purple color.
4. Using a Universal pH Indicator Chart (see "TECHNIQUES" section), record the pH of the water.
5. Using tongs, add a piece of dry ice to the beaker. Record your observations.
6. When the dissolution is complete, record the color and pH of the solution. The solution can be poured down the drain with plenty of running water.

II. The Liquid State

The liquid form of nitrogen (N_2) will be used for this portion of the experiment. Liquid N_2 is maintained at -196°C, well below room temperature. We'll see what happens when liquid nitrogen is exposed to room temperature conditions. Then, we will investigate what effect liquid N_2 has on solid materials.

Handle with care! Liquid nitrogen (N_2) can cause frostbite!

A. Phase Change: Evaporation

What do you think will happen when we take a substance that is a liquid at a temperature well below room temperature (over 200°C cooler!) and expose it to room temperature conditions? To find out, get a Styrofoam™ cup from the center bench and have your instructor put some liquid nitrogen in it. Observe the liquid N_2 in the Styrofoam™ cup and record your observations over a five minute period. Keep the liquid N_2 for Part B.

B. Effect of Liquid N_2 on Solid Materials

1. Plant Material
   a. Get a grape from the center bench. Record all pertinent physical information regarding the grape (for example, size, shape, texture, etc.).
   b. Using tongs, submerge the grape in the liquid N_2 for about two minutes.
   c. Remove the grape from the liquid N_2, hold it about 12" above the bench top, and release it. Record what happens as well

as all pertinent physical information regarding the grape now.

2. Latex
   a. Get a latex glove from the center bench. Record all pertinent physical information regarding the glove.
   b. Submerge the fingers of the glove in the liquid N_2 for about two minutes.
   c. Remove the glove from the liquid N_2 and rap the fingers lightly on the edge of the bench top. Record what happens as well as all pertinent physical information regarding the glove now. Keep the liquid N_2 for Part III A.

III. The Gas State

We will study two gases in this portion of the experiment: water vapor and hydrogen.

A. Phase Change: Condensation and Freezing

As you are aware, H_2O exists in the liquid state at room temperature. However, there is usually a small portion of H_2O in the air as a gas. What do you think will happen when a substance that exists as a gas above room temperature is allowed to cool to or below room temperature? Observe the outside of your Styrofoam™ cup and record what you see. When your observations are complete, you may **carefully** pour the remaining liquid N_2 out on the floor. **DO NOT THROW THE STYROFOAM™ CUP AWAY!**

B. Generation of a Gas via a Chemical Reaction

In this portion of the experiment, we will generate Hydrogen gas (H_2) in a test tube.

1. Attach a clamp about two-thirds of the way up on a ring stand.
2. Place 5 mL of 6M Hydrochloric Acid (HCl) in a test tube.

6M HCl is corrosive and causes burns! Handle with care!

3. Place the test tube securely in the clamp. Tilt the test tube to an approximate 30 - 45° angle.
4. Get a small piece of zinc (Zn) metal and a match book.
5. Drop the piece of Zn in the test tube with the HCl and record your observations.

6. Light a match and hold it near the opening of the test tube and record what happens.

BE PREPARED FOR A “POP” SOUND!

7. Once the reaction is completed, record your observations and discard the solution in the heavy metals waste container.