Name: _____ Date: _____ Period: _____

States of Matter READING Resource Page

Focus Question: How do particles in the three states of matter behave differently?

What's the Matter?

Think about the different states you have observed water in: the solid ice you place in a drink on a hot day, the water vapor that you breathe out onto a window on a cold day, and the liquid that living things need to survive. All three of these examples, though different in appearance, are actually made of the same exact tiny particles that make up water. All organisms and nonliving substances, like water, on Earth are are also made up of similar particles called atoms that when arranged in different combinations make up all matter in the universe. Thus, these microscopic atoms can be called the basic building blocks of all matter. Atoms can also bond with each other to create combinations, e.g. a carbon dioxide molecule is made up of 2 oxygen atoms . combined with one carbon atom (see Figure 1).

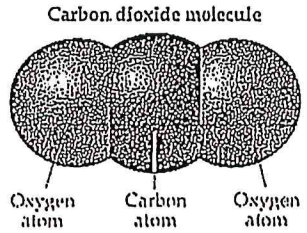

Figure 1. Atoms that make up a carbon dioxide (CO_2) molecule. (Taken from CUNY.edu)

Matter — Solid, Liquid, Gas

On Earth, matter is mostly found either as a solid, liquid, or gas, but all are made up of atoms. To the right are simplified models of these three different states of matter. One is a solid, another is a liquid and the other is a gas. In Figure 2, the little motion lines show that the particles (atoms or molecules) that make up the solid, liquid, and gas are moving. You will also notice that the three states are all made of the same particles. However, one main difference that defines each state is the speed of the particles' motion or movement. Thus, the larger the arrow connected to the atom, the FASTER the particle is moving.

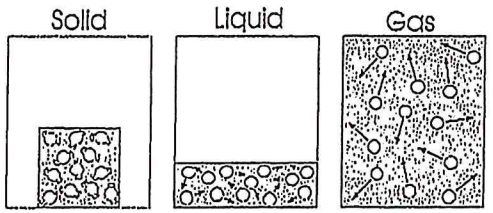

Figure 2. The states of matter defined by particle motion: (a) particles in a solid vibrate but stay in place, (b) liquid particles move more than a solid, (c) particles in a gas move the fastest.

Attraction Compared to Motion

Another big idea is that the atoms or molecules that make up a solid, liquid or gas are attracted to each other (much like a magnet is attracted to a nail). When studying different states of matter, the

atoms or molecules are competing between the attraction they have for each other as opposed to the motion of their molecules. The attraction tends to keep the atoms or molecules together, while the motion tends to make the atoms or molecules moving farther apart. When in motion, the particles are said to have more kinetic energy (the energy of motion) the faster they move. In Figure 3, notice the difference in spacing between the particles for a solid, liquid, and gas. What would happen if one could increase the overall kinetic energy (thermal energy) of the particles in one of the states?

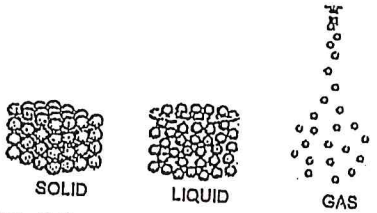

Figure 3. The spacing between the particles in the three states of matter.

In a solid, the atoms are very attracted to one another. Because of this strong attraction, the atoms are held tightly together. The attractions are strong enough that the atoms can only vibrate where they are. They cannot move past one another. This is why a solid keeps its shape, meaning solid has a definite shape and occupies a definite space (volume).

In a liquid, the molecules are also in motion. The attractions between the molecules in liquids are strong enough to keep the molecules close to each other, but they don't have to be in the same place and can move past one another. This is why a liquid can easily change its shape, meaning that liquid has undefined shape (copies the shape of its container) but occupies a definite space (volume).

In a gas, the molecules are also moving. The attractions between the molecules of a gas are too weak to bring the molecules together. This is why gas molecules barely interact with one another and are very far apart compared to the molecules of liquids and solids.

Heating and Cooling:

Heating and cooling a substance can affect how far apart or close together the molecules are. One example is the red alcohol inside the thin tube of a thermometer. When the thermometer is heated, the molecules of alcohol move faster. This faster motion competes with the attraction between the molecules which causes them to spread out a little. Thus, the molecules now have more kinetic energy and spread out more. They have nowhere else to go so they move up the tube.

When the thermometer is cooled, the molecules of alcohol slow down and the attractions bring the molecules closer together. As a result, the molecules have less kinetic energy and this attraction between the molecules brings the alcohol down in the tube. Another example is with water molecules as se Figure 4.

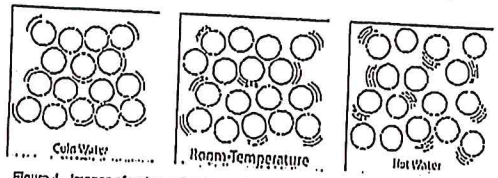

Figure 4. Images of water molecules and different temperature. Notice the difference in movement and spacing.

Kinetic Energy and Changing Phases:

Since molecules are always moving, any substance has a certain amount of kinetic energy. He an example of a cold spoon in hot liquid, the molecules of hot liquid are moving quickly so they a lot of kinetic energy. The fast-moving molecules from the hot liquid transfer some of their kine energy to the slower atoms of the cool spoon so that these slower atoms now have more kineti energy. This process of transferring energy by direct contact is called **conduction**. The opposit also true where a hot

metal spoon is put into cool air in a fridge. The atoms in the spoon transfer some of their energy the air molecules in the fridge, making the spoon cool down and lose energy.

This transfer of energy can also lead to a phase change, where enough kinetic energy has bee added to or removed from a substance so that the particles that make up that substance change they behave. For example in Figure 5, as energy is added to solid, the particles move more and spread out. However, as energy is removed, the gas particles slow down and move closer together. Yet, not all substances behave the same, e.g. water is the only substance whereas a liquid, the molecules are closer together than as a solid. Thus, solid water floats on top of liquid water.

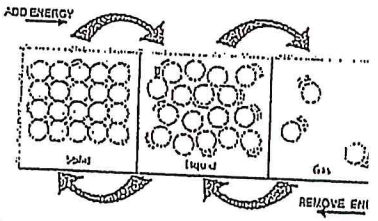

Figure 5. The phase changes caused by adding and removing ene

Adapted from "Chapter 1 and 2 - Middle School Chemistry Unit" American Chemical Society 2011