

TEACHER BACKGROUND INFORMATION

(Changes of Matter)

Matter can undergo physical or chemical change. In general, many physical changes can be reversed. For example, folding a sheet of paper changes the physical appearance of the paper but not its composition (it is still paper). The paper can also be returned to its original size and shape. On the other hand, most chemical changes cannot easily be undone. For example, burning a sheet of paper changes the chemical composition of the paper and it cannot be “unburned”. It is important to note that most chemical changes will be accompanied by a change in state (e.g. solid to liquid or gas).

A. PHYSICAL CHANGES OF MATTER:

The states of matter (solid, liquid, gas) are sometimes referred to as phases of matter. Matter can change phases and not change composition; this is known as a **physical change**. The key word is *physical*, because things only move from one phase to another by physical means.

If energy is added (like increasing the temperature or increasing pressure) or if energy is taken away (like decreasing the temperature or decreasing pressure) substances can be made to physically change into the different phases of matter. The easiest way to do this is to heat or cool a substance. This allows heat to flow into or out of a substance.

• MELTING (Phase Change Solid to Liquid)

What happens when you leave an ice cube out in the sun? It begins to melt. **Melting** is the change from a solid phase to a liquid phase (See Fig. 1).

The range of temperatures at which a solid becomes a liquid is called the **melting point**. When heat is applied to a solid, the molecules begin to vibrate more rapidly causing them to spread out. The molecules inside the solid begin to flow past each other, turning the solid into a liquid.

Note:

Molecules in matter are constantly moving, and this motion results in energy (heat) being transferred between molecules. The molecules in a solid are strongly attracted to each other. They vibrate in place, but the vibrations are not strong enough to break the attraction between molecules. If energy is added to a solid (e.g. it is heated), the molecules will vibrate faster and move apart from each other by a small amount. This will cause the solid to expand, but the mass remains unchanged.

• **FREEZING (Phase Change from Liquid to Solid)**

Freezing is the change from the liquid to the solid phase (See Fig. 1). The range of temperatures at which a substance changes from a liquid to a solid is the **freezing point**.

If energy is taken away from a liquid through cooling, the vibration of the molecules will slow down until the molecules can get closer and cannot overcome the attraction between them. This causes the object's size to decrease, but the mass remains unchanged.

• **SUBLIMATION (Phase Change from Solid to Gas)**

Some solids are able to go straight to the gas phase without becoming a liquid (think of the smoke coming off dry ice). This process is called **sublimation** (See Fig.1).

• **VAPORIZATION (Phase Change from Liquid to Gas)**

Vaporization and **evaporation** generally refer to the change of liquid into a gas (See Fig.1). The range of temperatures at which a substance changes from a liquid to a gas is the **boiling point**.

Vaporization and evaporation are the same change of state. The difference between them is where phase change takes place in the liquid and how fast this change occurs. For a particle to escape from a liquid, it must have enough energy to overcome the force of attraction between the molecules. For example, when boiling a liquid the energy comes from a heat source. Once the liquid is heated to the boiling point, molecules anywhere in the liquid can gain enough energy to break away from the other particles and form a gas. This means that the liquid is changing to a vapor throughout the entire liquid. The particles that escape from the middle and bottom of the liquid form the bubbles that we see when boiling occurs.

On the other hand, a liquid can be sitting there with no obvious heat source (e.g. drop of water on counter) and yet it will change into the gas phase. How can that happen when the temperature is low? The molecules evaporate only at the surface of the liquid by drawing energy from the surroundings (**Evaporation**). Not all of the molecules in a liquid actually have the same energy. The energy you can measure is really an average of all the molecules. There are always a few molecules with a lot of energy and some with barely any energy at all. Molecules with a lot of energy build up enough power to become a gas and leave the liquid. When a liquid takes in heat, the surface it is taking the heat from becomes cooler. Think about coming out of a swimming pool, the droplets of water on your skin remove heat from your body and evaporate, thereby making you feel cold.

Note: A **gas** is a substance that remains in the gas phase at 25°C (77°F) and a **vapor** is a substance that would be in the liquid phase at 25°C (77°F).

• **CONDENSATION (Phase Change from Gas to Liquid)**

Condensation is the change of a substance from the gaseous phase to the liquid phase (See Fig. 1). The range of temperatures at which a gas becomes a liquid is known as the **condensation point**. We have all observed that a cold soda gets wet on the outside when it is taken out of the refrigerator. We have also observed that in the morning, when you leave for school, most of the cars look wet. What happens to the cold can of soda out of the refrigerator? The air around the can starts to cool and energy is sucked out of the excited gas molecules in the air. This loss of energy, caused by the lowering of the surrounding temperature, makes the water molecules in the air (water vapor) slow down and become a liquid.

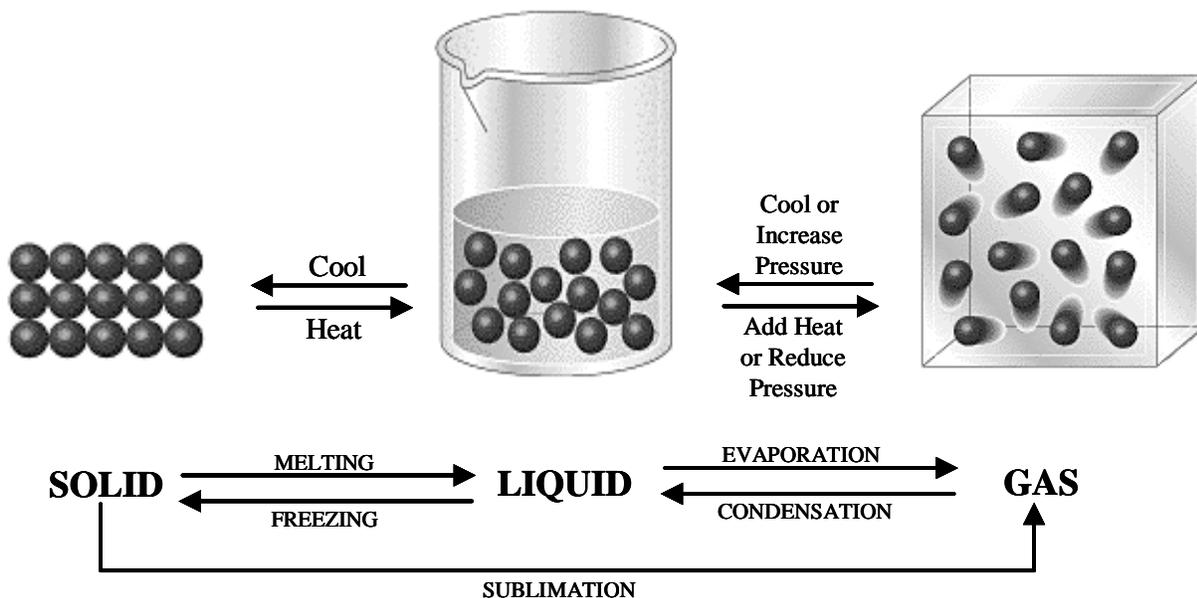


Figure 1- Changes of states of matter

B. CHEMICAL CHANGES IN MATTER

We just discussed that matter can change physically, but we also know that it can change chemically. In **chemical changes** (also called chemical reactions) a substance is transformed into a chemically different substance. Physical changes involve mostly a change in the spacing and order of particles (change of state), whereas chemical changes involve a rearrangement of particles into new combinations. The newly rearranged substances generally cannot be changed back to their original constituents. The new substances are called compounds or molecules and are represented by chemical formulas, for example the compound sodium chloride (table salt) is represented as the molecule NaCl.

To distinguish between physical and chemical changes, ask yourself if the change altered the identity of the substance. Generally the characteristics and properties (both physical and chemical) of the substance will have changed. For example, rust is visibly different from iron because it is red and powdery instead of shiny and hard. Furthermore iron conducts electricity, rust does not (change in chemical property). Common clues that can help identify if a chemical reaction has taken place include:

- Change in color* (e.g. paper turns black when burned)
- Production of light and heat (e.g. candle burning)
- Production of gas** (e.g. baking soda bubbles when mixed with vinegar)

*Color is not always a good indicator of a chemical change. For example a color change takes place when pale pink Gatorade powder (a solid) is added to water and dissolves to a red liquid (physical change).

** Sometimes it may seem like a gas is being produced when it's not. For example, when opening a can of soda, gas is released. This is not a chemical reaction, the carbon dioxide simply came out of the solution.