SECTION 1: PHYSICAL & CHEMICAL PROPERTIES

What Are Physical Properties?

What differences between snow and sand can you detect with your senses? Snow and sand often have different colors. You can also feel that snow is softer than sand. Both color and hardness are physical properties of matter. **Physical properties** of matter are properties that can be measured or observed without matter changing to an entirely different substance.

Physical properties are typically things you can detect with your senses, such as an object's size, shape, or state (liquid, solid, or gas). They may also be things that you use to describe matter without changing the substance chemically. A substance's state of matter is an extrinsic property, meaning it can be changed by physical conditions in its environment, such as temperature and pressure. Several examples of physical properties are listed below:

- *Have you ever noticed the strong **odor** of chlorine in swimming pool water? Chlorine is added to the water to kill germs and algae. In contrast, bottled spring water, which contains no chlorine, does not have an odor.*
- *Antifreeze (or coolant) is added to the water in a car radiator to keep the water from boiling and evaporating. Coolant has a higher boiling point than water and adding it to the water increases the boiling point of the solution. A substance's **melting** and **boiling points** are considered physical properties.*
- *A teakettle is made of aluminum except for its handle, which is made of plastic. Aluminum is a **good conductor of heat**. It conducts heat from the flames on the range to the water inside the kettle, so the water heats quickly. Plastic is not a good conductor of heat. It stays cool enough to touch even when the rest of the teakettle becomes very hot.*
- *Copper is a **good conductor of electricity**. That's why electric wires are often made of copper. They are covered with a protective coating of plastic, which act as **insulators** does not conduct electricity.*
- ***Solubility** is a physical property. Sugar and salt are both compounds that can dissolve in water, while sand does not dissolve in water.*

What Are Chemical Properties?

Chemical properties are properties that can be measured or observed only when matter undergoes a change to become an entirely different kind of matter. These types of properties describe how a substance might be changed during a reaction or those substances that are likely to react.

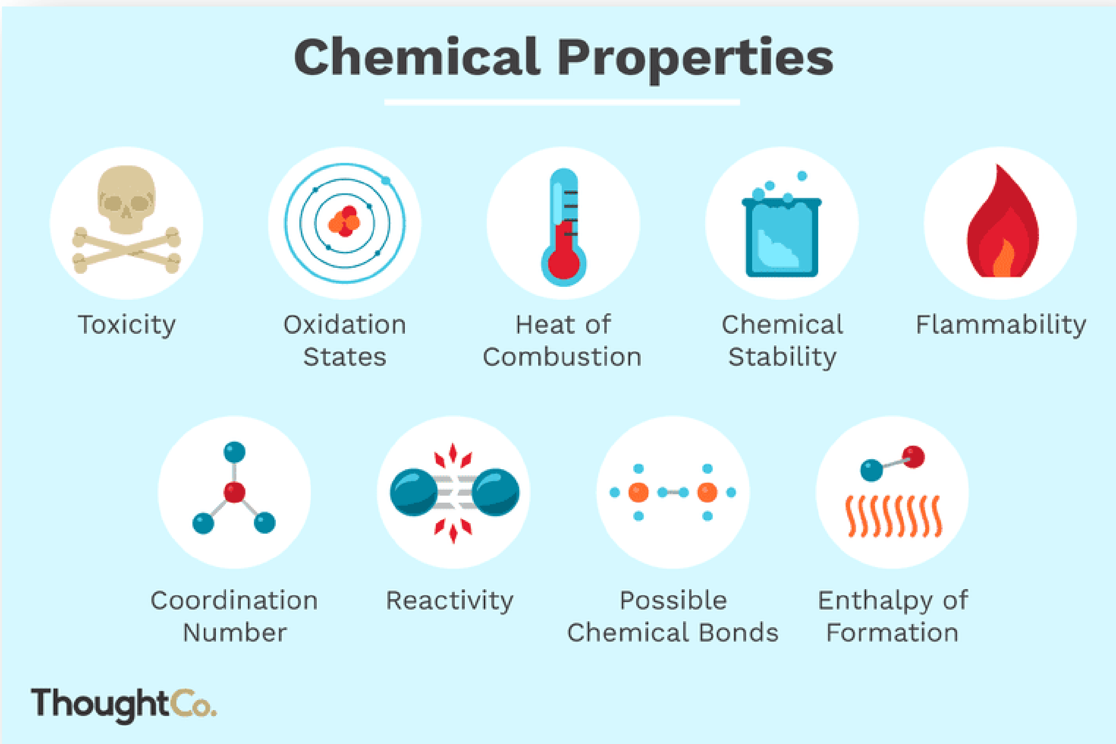
For example, the **ability to rust** is a chemical property for some metals, but it can only be observed when a metal actually rusts. When iron reacts with oxygen it becomes a different substance called iron oxide. Iron is very hard and silver in color, whereas iron oxide is flakey and reddish brown.

Aluminum is also a metal, but it doesn't rust like iron or steel. Instead, **corrosion** (also called **oxidation**) occurs when this metal is exposed to weathering and atmospheric oxygen. The resulting compound, called aluminum oxide, is a thin, hard layer that actually protects the metal from further corrosion.

Flammability is the ability of matter to burn. When matter burns, it combines with oxygen and changes to different substances. Wood is an example of flammable matter. Substances called **fuels** also have the property of flammability. They include fossil fuels (coal, natural gas, and petroleum) as well as fuels made from petroleum (gasoline and kerosene) or wood products (paper or cardboard.)

Reactivity is the ability of matter to combine chemically with other substances. Some kinds of matter are extremely reactive, while others are extremely unreactive. For example, potassium is very reactive, even with water. When a pea-sized piece of potassium is added to a small amount of water, it reacts explosively. In contrast, noble gases such as helium are inert, which means they almost never react with any other substances.

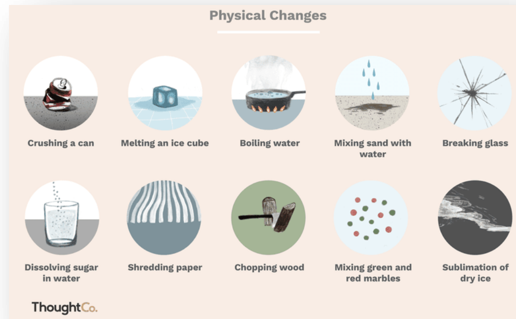
These two chemical properties and others are shown in the image below.



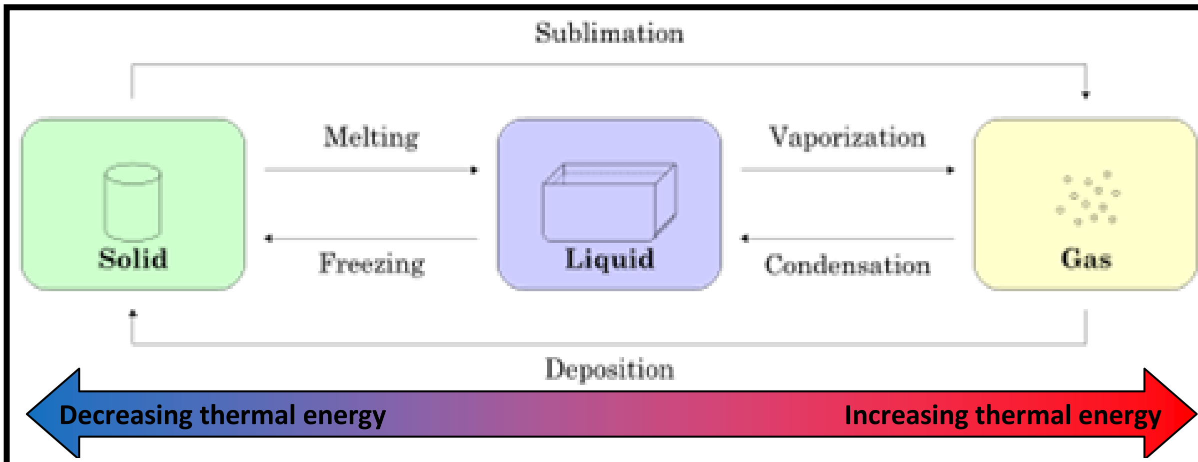
SECTION 2: PHYSICAL & CHEMICAL CHANGES

What is a physical change?

A **physical change** is a change in one or more physical properties of matter without any change in chemical properties. Examples of physical change include changes in the **size** or **shape** of matter, such as cutting, folding, bending, and dissolving.



Changes of **state** (solid, liquid, or gas) are also physical changes. Matter can change state when its temperature changes, such as freezing, boiling, and melting. The image below shows common changes in states based on changes in temperature.



When thermal energy is added to a substance, its temperature increases, which can change its state from solid to liquid (melting), liquid to gas (vaporization), or solid to gas (sublimation). When energy is removed, the opposite happens, decreasing the substance's temperature and turning it from liquid to solid (freezing), gas to solid (deposition), or from gas to liquid (condensation).

https://commons.wikimedia.org/wiki/File:Physics_matter_state_transition_1_en.svg

How does pressure affect the state of matter?

Changes in **pressure** can cause matter to change shape. When the pressure exerted on a substance increases, it can cause the substance to condense, such as changing a gas to a liquid. Decreasing pressure can cause it to vaporize. For some types of rock, decreasing pressure can also cause them to melt.

Can physical changes be reversed?

Physical changes are often easy to reverse. When matter undergoes physical change, it doesn't become a different substance. For example, when liquid water freezes to form ice, it can be changed back to liquid water by heating and melting the ice. Another example of a physical change is salt dissolving in water. This process could be reversed by boiling the solution until the water evaporates leaving behind the salt. Water vapor would condense and change back to liquid water.

Chemistry Unit 3 - Properties & Reactions

What is a chemical change?

A **chemical change** (also called a **chemical reaction**) occurs whenever matter changes into an entirely different substance with different chemical properties.

An example of a simple chemical change is the burning of methane. Methane is the main component of natural gas, which is burned in many home furnaces. During burning, methane combines with oxygen in the air to produce entirely different chemical substances, including the gases carbon dioxide and water vapor.

Communities often use fireworks to celebrate important occasions. Fireworks certainly create awesome sights and sounds, which are created through chemical changes. Most chemical changes are not as dramatic as exploding fireworks. What are some signs a chemical change has occurred? A chemical change has probably occurred if **bubbles are released**, there is a **change of color**, or an **odor is produced**. Other clues include the **release of heat, light, or loud sounds**. Examples of chemical changes that produce these clues are shown in the image.

Did you know? Chemical reactions take place inside our bodies every second. Do some research to find examples of chemical changes in your body.

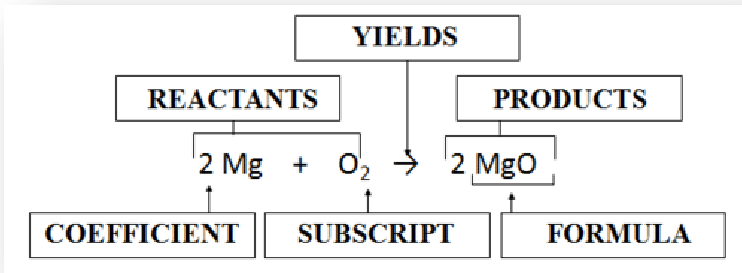
SECTION 3: LAW OF CONSERVATION OF MASS

If you remember from the previous section, a **chemical reaction** is a process in which some substances change into different substances. Substances that start (or enter into) a chemical reaction are called **reactants**. Substances that are produced in the reaction are called **products**. Reactants and products can be **atoms** or **compounds**.

Chemical reactions are represented by **chemical equations**, like the one shown below in the diagram. The reactants (on the left) are connected by an arrow to products (on the right). The arrows means "**yields**" in a chemical reaction.

The numbers in front of a chemical formula are called **coefficient** and represent the number of molecules for that substance.

The smaller numbers behind an element's symbol are called **subscripts**, which represent the number of atoms of the element in the compound.

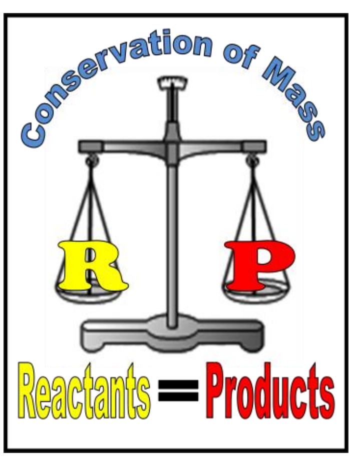


The **reactants** and **products** in a chemical reaction contain the same atoms, but they are **rearranged** during the reaction. As a result, the atoms are in different combinations in the products than they were in the reactants. This happens because chemical bonds break in the reactants and new chemical bonds form in the products.

Consider a simple chemical reaction, the burning of methane. In this reaction, methane (CH_4) combines with oxygen (O_2) in the air and produces carbon dioxide (CO_2) and water vapor (H_2O). The reaction is represented by the following chemical equation:

$$CH_4 + \mathbf{2}O_2 \rightarrow CO_2 + \mathbf{2}H_2O$$

This equation shows that one molecule of methane combines with two molecules of oxygen to produce one molecule of carbon dioxide and two molecules of water vapor.



The **law of conservation of mass** states that matter cannot be created or destroyed in chemical reactions, which is why all chemical equations must be **balanced**. This means that the same number of each type of atom must appear on both sides of the arrow. In other words, the **reactants must equal the products** as shown in the diagram.

A balanced chemical equation shows that mass is conserved during chemical reactions. To balance a chemical equation, you will need to add **coefficients** in front of the reactants and products to make them equal.

SECTION 4: ENERGY & CHEMICAL REACTIONS

Energy In and Energy Out

All chemical reactions involve **energy**. Energy is used to break bonds in reactants, and energy is released when new bonds form in products. In terms of energy, there are two types of chemical reactions: endothermic and exothermic.

In **exothermic** reactions, more energy is released when bonds form in products than is used to break bonds in reactants. These reactions release energy to the environment, often in the form of heat or light. Wood burning or rusting iron would be exothermic reactions. We can also refer to exothermic processes for physical changes, such as water giving off heat as it freezes into ice.

In **endothermic** reactions, more energy is used to break bonds in reactants than is released when bonds form in products. These reactions absorb energy from the environment. Baking bread, cooking an egg, or heating up sugar until it caramelizes would be endothermic reactions. We can also refer to endothermic processes for physical changes, such as water molecules in ice cubes absorbing energy into order to melt into water.

Types of Chemical Reactions

The chemical reaction in which water forms from hydrogen and oxygen is an example of a synthesis reaction. In this type of reaction, two or more reactants combine to synthesize a single product.

There are several other types of chemical reactions, including decomposition, replacement, and combustion reactions. The table below compares these five types of chemical reactions.

Type of Reaction	Description	General Equation
Synthesis	Two or more substances combine to make a more complex substance	$A+B \rightarrow C$ $2Na + Cl_2 \rightarrow 2NaCl$
Decomposition	Compounds break down into simpler substances	$AB \rightarrow A + B$ $2H_2O \rightarrow 2H_2 + O_2$
Single Replacement	Occurs when one element replaces another one in a compound	$A+BC \rightarrow B+ AC$ $2K + 2H_2O \rightarrow 2KOH + H_2$
Double Replacement	Occurs when different atoms in two different compounds trade places	$AB+ CD \rightarrow AD + CB$ $NaCl+ AgF \rightarrow NaF + AgCl$
Combustion	Occurs when a fuel reacts with oxygen to produce carbon dioxide and water	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

SECTION 5: REACTION RATES

Chemical reactions may occur quickly or slowly. How fast a chemical reaction occurs is called the **reaction rate**.

Sodium reacts quickly and violently with water. However, a reaction between iron and oxygen that causes a tool to rust occurs very slowly. Several factors affect the rate of a given chemical reaction, such as those listed below:

- **Temperature of Reactants**
  - When the temperature of reactants is higher, the rate of the reaction is faster. At higher temperatures, particles of reactants have more energy, so they move faster. As a result, they are more likely to bump into one another and to collide with greater force.
  - For example, food spoils because of chemical reactions, and these reactions occur faster at higher temperatures. This is why we store foods in the refrigerator or freezer. The lower temperature slows the rate of spoilage.
  - This also applies to physical changes. Sugar will dissolve faster in warm water than cold water.

- **Concentration of Reactants**
  - **Concentration** is the number of particles of a substance in a given volume. When the concentration of reactants is higher, the reaction rate is faster. At higher concentrations, particles of reactants are crowded closer together, so they are more likely to collide and react.
  - **Combustion**, or burning, is a chemical reaction in which oxygen is a reactant. A greater concentration of oxygen in the air makes combustion more rapid if a fire starts burning.

- **Surface Area of Reactants**
  - When a solid substance is involved in a chemical reaction, only the matter at the surface of the solid is exposed to other reactants. If a solid has more **surface area**, more of it is exposed and able to react. Therefore, increasing the surface area of solid reactants increases the reaction rate.
  - This also applies to physical changes, such as smashing a tablet into smaller pieces to help it dissolve faster in water.

- **Presence of a Catalyst**
  - Some reactions need extra help to occur or to occur more quickly. They need another substance called a **catalyst**, which is a substance that increases the rate of a chemical reaction.
  - A catalyst isn’t a reactant, so it isn’t changed or used up in the reaction. Therefore, it can catalyze many other reactions.