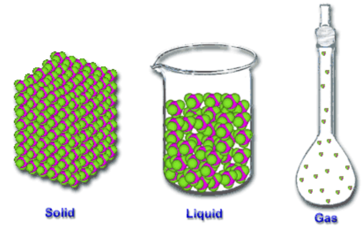


Chapter 2: Matter Diary

Chemistry is the study of matter. Chemists study what matter is made up of and how it reacts with other matter. Matter is the "stuff" that makes up the whole universe. Matter takes up space and has mass. Matter is measurable, and matter reacts in predictable ways.

The simplest forms of matter are the elements which are listed in the periodic table of elements. Elements are the unique types of matter that cannot be broken down into simpler substances by any chemical or physical process. Examples include mercury, iron, carbon, and uranium. The smallest bit of an element is called an atom.

Each element on the periodic table has unique properties that can be measured by scientists. Each element reacts in ways that are known, and which can be relied upon. Elements can chemically combine, or bond, with other atoms to form new substances called compounds. These new substances have their own measurable properties which are different from the properties of the atoms that make them up. Compounds can only be broken back down into elements by a chemical reaction, usually requiring energy as well.

Pure substances are types of matter made up of only one kind of matter. Examples include elements which are each made up of only one kind of atom as well as compounds. Compounds are made up of a specific ratio of at least two different kinds of atoms. Examples include water (H_2O), or table sugar also known as sucrose($C_{12}H_{22}O_{11}$).

Pure substances are always the same or consistent throughout. This is called homogeneous. The properties of the elements are always the same in every sample, and within any one sample. All samples of pure water have the same density (for example), and all of the properties water has are the same for all samples of pure water.

Physical vs. Chemical Properties

Some properties of matter can be measured. Density, boiling point, melting point, solubility, and particle size are all physical properties of matter. A physical property of matter is a quality that can be changed, or measured, without changing the chemical properties of the matter itself. A chemical property is a characteristic of matter that is observed when it undergoes a chemical change. Examples of chemical properties are heat of combustion, reactivity with water and pH.

Physical vs. Chemical Change

Physical changes are the result of a rearrangement of the atoms or molecules present, but not in the formation of new substances with new properties. They include changing shape, temperature, changing phase, dissolving into a solvent, etc. Chemical changes are the result of a rearrangement of atoms or molecules whereby new substances form, new properties form, and the original substances and their properties disappear. These are chemical reactions.

When methane gas reacts with oxygen, it releases much heat, carbon dioxide and water gas. The methane and oxygen are recombined into new compounds (molecules), the oxygen and methane "disappear" as substances, forming into the water and the carbon dioxide. There is no loss of mass, but big changes have happened. Some likely indicators that a chemical reaction has taken place (these are not always definite) are easily remembered with the acronym TOPIC-B.

T. Temperature changes. Often a chemical reaction will release energy or heat, or the opposite, will absorb energy, making the immediate environment cold. Heat release is an exothermic reaction, heat absorption is an endothermic reaction.

O. Odor release. New smells usually indicate something new has formed from the reactants at hand. Many kinds of matter have an odor, that's different from a new odor that was not present just previously.

P. Precipitates in solutions. Sometimes we mix solutions and form new compounds that cannot dissolve in the solvent. These compounds "fall out" of solutions as solids. Two clear solutions mix together, and a solid falls out is a good indicator that something chemical changed.

I. I stands for irreversibility. Just about every chemical reaction can be reversed, but to do so would require some chemistry knowledge and the input of energy. Once a reaction happens it will not spontaneously reverse itself. Chemical reactions tend to go one way and stay done. To reverse a chemical reaction is another chemical reaction.

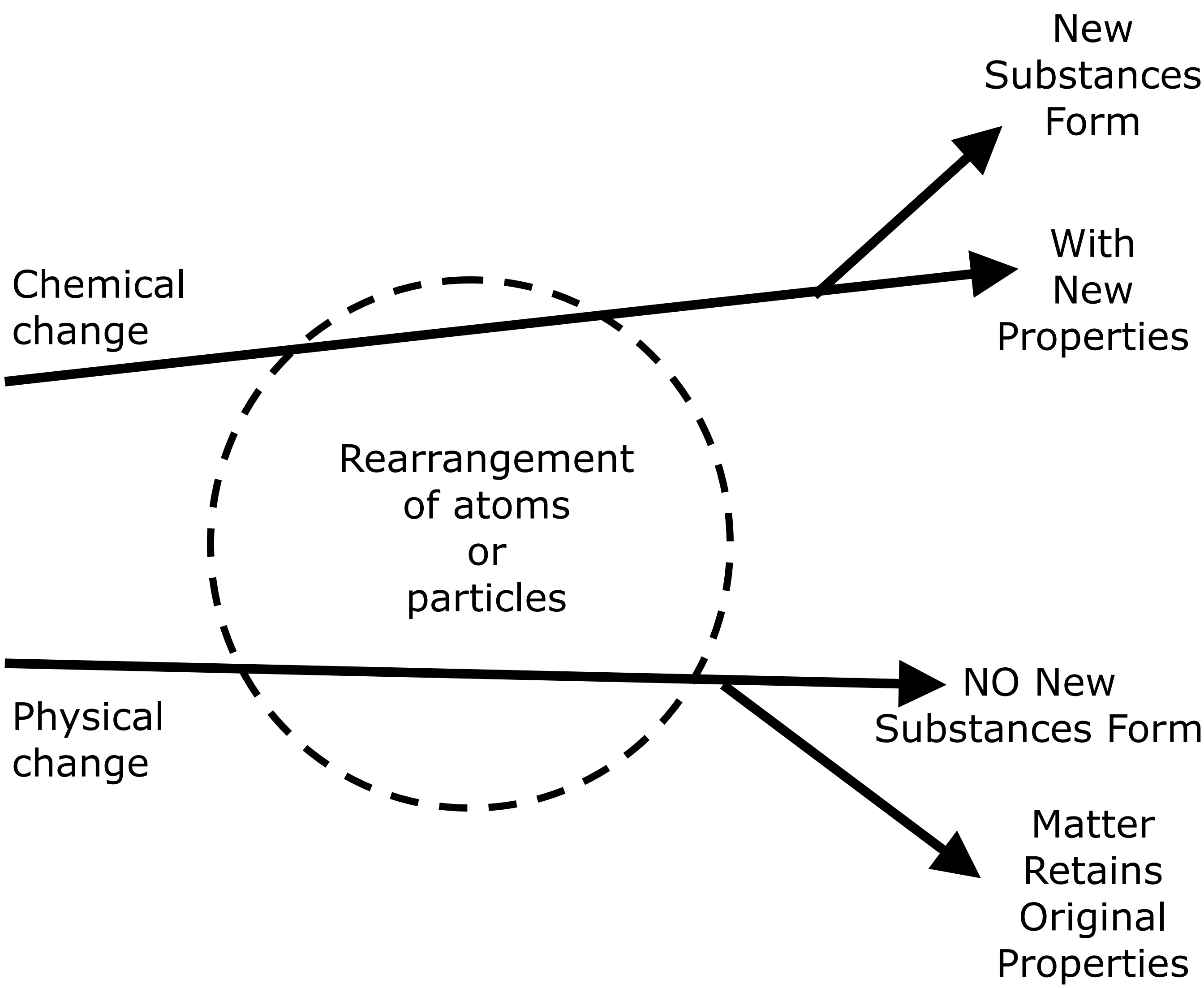
C. Is for color changes. Matter is fairly stable, color is directly connected to the atoms or molecules present. A change in color often indicates a change in the particles.

B. Bubbles that were not there before also indicates that something has chemically changed. Opening up a warm can of soda means someone gets sprayed. Funny, but not a chemical reaction. Those bubbles were already present. New bubbles, like new odors, are different.

<u>Physical vs. Chemical Changes</u>

In a chemical change, there is a rearrangement of atoms or particles in a substance. This rearrangement includes the formation of new substances with their own new properties. Examples include all chemical reactions.

Physical changes also have a rearrangement of atoms or particles, but no new substances form, so all the original properties remain. Examples include all phase changes, bending of metals, shattering of crystals, ripping of paper, or stirring paint colors together.



States of Matter

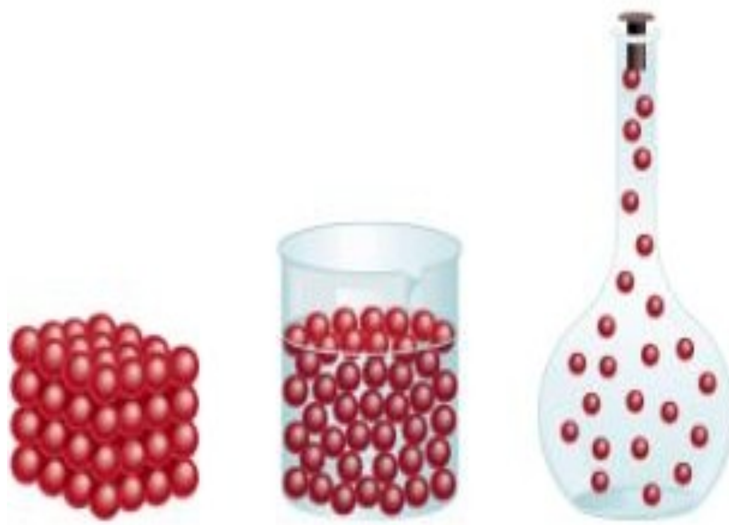
Matter comes in three states, or phases. They are solids, liquids and gases. Solid matter has it's atoms (or molecules) packed in very close together. These particles are in a rigid arrangement that does not change. Because of this the solids are hard, and hold their shape and volume. Solids cannot be compressed practically at all because of the closeness of the particles.

Liquids also have their atoms (or molecules) packed close together, but they are not locked in place, rather they constantly move, or flow over each other. The closeness of the particles means that liquids have a definite volume. Liquids do not hold their own shape, they take the shape of any container they are put into. Liquids cannot be compressed practically at all because of the closeness of the particles.

Gases are very different than either solids or liquids. Gas particles are very far apart from each other. They are always moving very rapidly, as they bounce around off of each other and the walls of any container that holds them. Gases have no definite shape and will expand to fill any size container they're put into. Gases have no definite volume either, therefore, they can be greatly compressed into small containers since there is plenty of room between the particles.

On the right is a diagram of a solid, liquid, and a gas. Each little red ball represents a particle (atom or molecule).

- *The atoms of a solid are very close together, and have a definite shape and volume.*
- *The liquid has closely packed particles moving around, but have the shape of the container they are in.*
- *The gas has a lot of space between the particles, and fills any shape or size container it 's put into.*



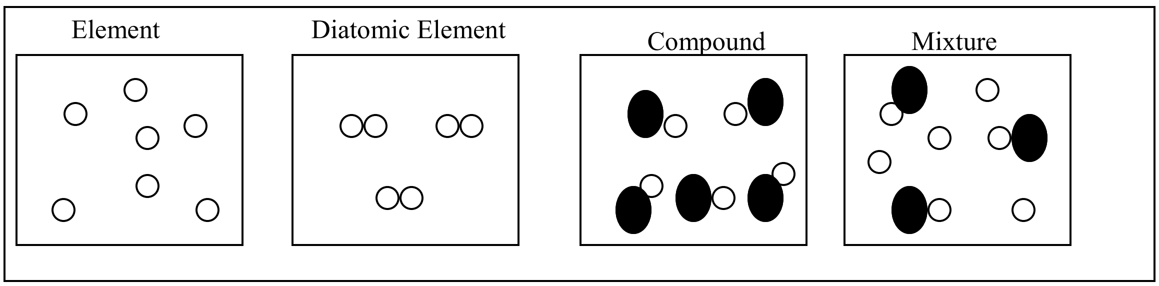
Elements, Compounds and Mixtures

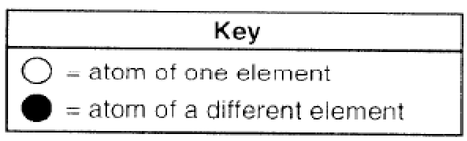
Matter can be chemically combined into compounds, or just mixed together, into mixtures. A mixture is a physical blend of pure substances. Two or more elements can be mixed, two or more compounds can be mixed, or elements and compounds together can be mixed. Mixtures have no definite ratio of the component parts like compounds have.   Because of this mixtures are not always homogeneous, they can also be heterogeneous, or different throughout.

Since mixtures are a physical combination, the pure substances that make them up keep their properties. No new substances are formed, rather there is just a rearrangement of the atoms or particles.

Particle diagrams

Because particles of matter ,atoms and molecules, are much too small to see, there is a technique called particle diagramming that allows us to create diagrams showing elements, compounds, and mixtures. Using different shapes, or colors, we'll use pictures to express the relationships between atoms and molecules. These diagrams can also show solid, liquid, and gas phases.





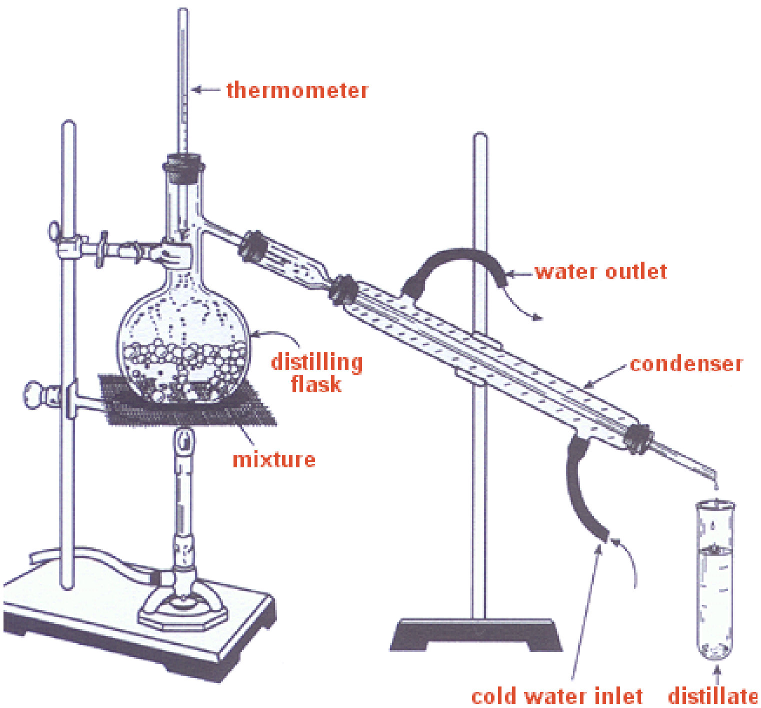
Any substance that contains only one kind of an atom is known as an element. Elements combine to form chemical compounds consisting of atoms of two or more different elements *bound together*. They can be broken down into a simpler type of matter (elements) by chemical means (but not by physical means), have properties that are different from its component elements, and always contain the same ratio of its component atoms. A molecule is the smallest particle that has any of the properties of a compound. It consists of two or more different elements and/or compounds physically intermingled and can be separated into its components by physical means. It often retains many of the properties of its components.

Separating Mixtures

Since mixtures are just physical blends, they can be separated easily by physical means (no chemical reactions required). The processes used to separate these mixtures work based on the differences in physical properties of the parts of the mixture. The next few sections review different techniques for separating mixtures.

Distillation

Distillation is used to separate a mixture called a solution. This is when a solute is dissolved into a solvent. If salt water is our solution, salt is the solute, water is the solvent. Salt (sodium chloride) and water each have a different boiling point(1465°C for the salt, just 100° C for the water).

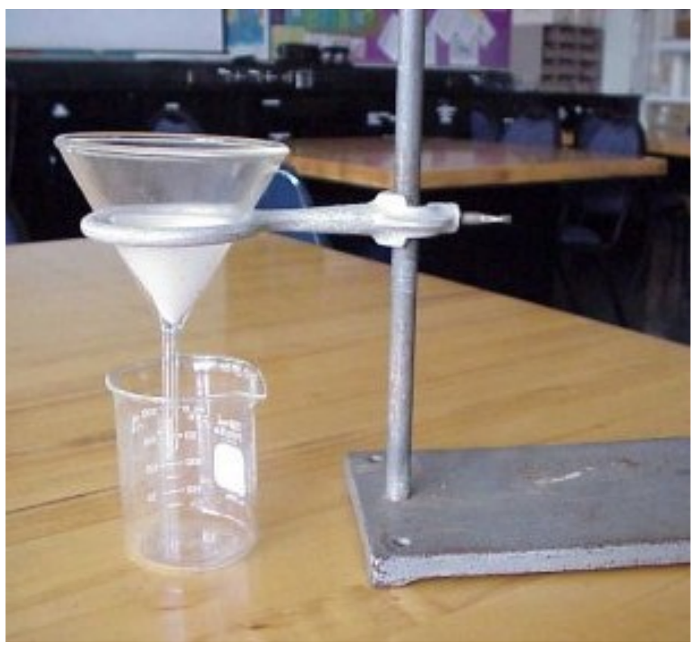


Therefore we can heat the mixture and separate it by using the differences in the boiling points of the parts of the mixture.

For example, boiling salt water will let the water change phase to a gas, rise up in the distilling flask, and be transported down the condenser tube where it cools and turns back to liquid water, to be collected at right. The salt, never reaching its own boiling point, just gets warm. The salt gets stuck in the distilling flask.

Filtration

Filtration separates mixtures by taking advantage of particle sizes. Salt water could not be separated this way since salt particles are much too small to be snagged in a filter. Any substance dissolved in the water would flow through as would the water. With sand or dirt, this is easy work.



For example, sand particles are relatively huge compared to the tiny size of the water molecules. Running your mixture through a filter (filter paper in a funnel) would catch the sand, allowing the water to easily run through and be caught in the beaker.

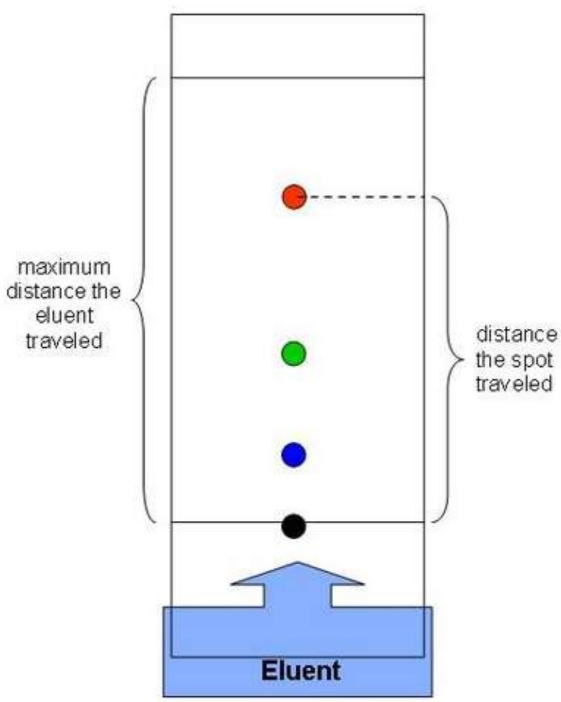
Magnetism

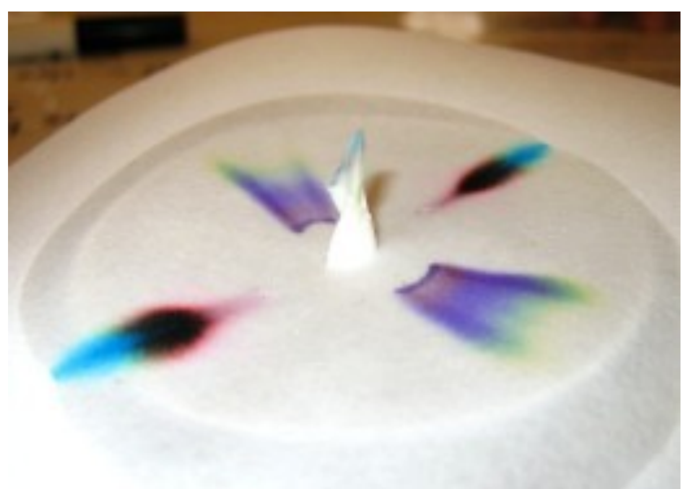
If your mixture is iron filings and dirt, you couldn't run it through a filter, both the iron and the dirt would be caught by on the filter. But you could use a magnet to pull out the iron.

Iron is attracted to magnets while the dirt is not. Isolating the parts of a mixture based upon charge is another way to separate your mixture. In this case, the fact that one part of your mixture is attracted to magnets and the other is not attracted allows for the parts to be separated.

Paper Chromatography

Chromatography uses differences in the density of the particles to separate a mixture. Most people "think" that magic markers are one color, but they're made up of many different colors of particles, so close together, that they appear as one color to our eyes. The water flowing through the filter paper transports the color particles and takes them on a short ride. The densest, or heaviest, drop out quickly, the lighter, or less dense travel further along on the paper. All of the parts of the mixture are separated. Taking advantage of the different densities of the color particles allows us to separate this kind of mixture.





More about mixtures

Solutions are mixtures where one part is dissolved into a liquid. The liquid part of this kind of mixture is called the solvent. The dissolved part is the solute. Water is a common solvent, although any liquid could be a solvent. Solutions (aqueous) are always homogeneous.

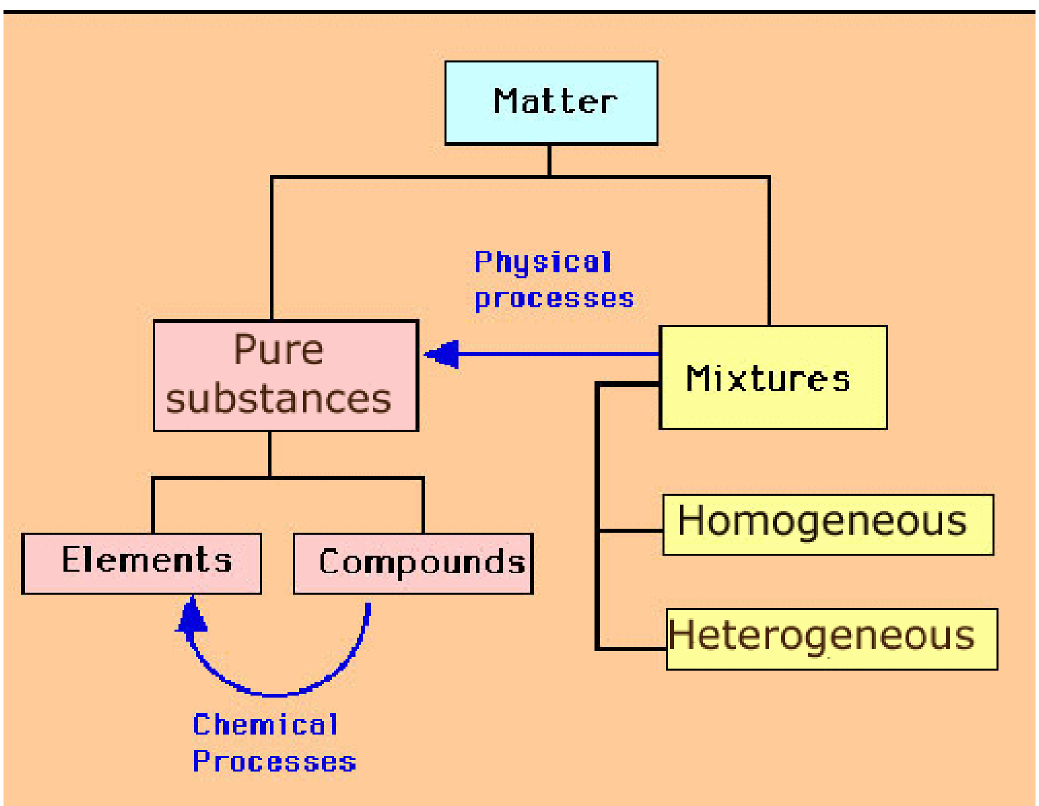
Not all solutes dissolve into all solvents. Solvents which do hold certain solutes have limits as well. You can only put a certain amount of sugar in a cup of coffee before it falls out to the bottom of the cup. Solvents can become maxed out, or saturated. Adding more solute after the solvent is full up just drops the excess solute to the bottom of the container.

Gases can mix as well, creating gaseous mixtures. Air is a mix of nitrogen, oxygen and other gases. You could mix helium and carbon dioxide gases—if you had them in one container.

Solids can also be mixed together, but this usually requires you melt them so they can actually mix. Mixtures, of metals melted together are called alloys. Silver with some copper mixed in is known as sterling silver. Copper mixed with tin makes bronze, while copper and zinc make brass. Carbon mixed with iron is steel.

A gas can be mixed into a liquid, for example, carbon dioxide in water (plus flavoring) is called soda.

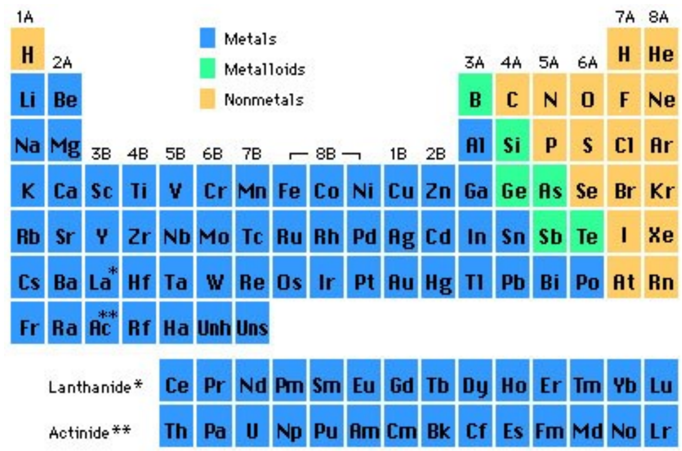
The chart below shows the relationship between all the different kinds of matter.



Chemical Symbols

The symbols of the atoms of the periodic table of elements come from a variety of languages, and therefore do not always seem to match the common names of the elements. Hydrogen is H, helium is He. These are simple enough. Then there are elements such as sodium (Na from the Latin term Natrium), and tin(Sn), or mercury(Hg). Don't try to memorize these, use table S whenever you have any concerns.

There are a few rules to naming elements. All element symbols are capitalized. If the symbol has more than one letter the second letter is never capitalized. When compounds form, only certain ratios of atoms to atoms are possible.



H_2O is water. It is a compound. The two indicates that there are two hydrogen atoms. The lack of a number next to the oxygen (O) means that only one atom of oxygen is present. So, H_2O has a total of three atoms. The two hydrogen are chemically bounded to the one oxygen and can not be separated by physical means.

NH_3 is ammonia. This means that one nitrogen is chemically bonded with three hydrogen atoms for a total of four atoms.

Methane gas is used for our Bunsen burners. It's symbol is CH_4, which is one carbon chemically bonded to four hydrogen atoms, for a total of five atoms.

$C_{12}H_{22}O_{11}$ is a much bigger molecule of sucrose (table sugar). The atoms making this compound are a dozen carbons, twenty-two hydrogen atoms & eleven oxygen atoms for a total of 45 atoms!

The Law of Conservation of Matter (or Mass)