

2.4: Chemical and Physical Properties and Changes

A lump of gold can be hammered into a very thin sheet of gold foil (it is the most *malleable* of all of the elements). Nonetheless, the gold in the foil sheet is still just elemental gold; nothing has changed except the physical appearance of the sample. The same is true if you take any solid pure substance and melt it, or convert it to a gas. The atomic or molecular structure of the substance has not changed, it simply has a different physical appearance. Changes in outward appearances that do not alter the chemical nature of the substance and make no new substance are called **physical changes**. Pure carbon, in the form of a briquette, can be smashed to a fine powder without changing the fact that it is still just elemental carbon (thus, this is a physical change), but if pure carbon is heated in the presence of oxygen, something else happens. The carbon slowly disappears (often in flames) and the carbon atoms now appear as a compound with oxygen with the formula CO_2 . Carbon dioxide is a totally different substance than either the carbon or the oxygen that we started with. For example, carbon is a black solid and carbon dioxide is a colorless gas. You know that a **chemical change** has occurred when the chemical composition of the material changes and a new substance is produced.

Just like we defined a set of physical properties for substances, we can also define a set of **chemical properties**. Chemical properties are simply the set of chemical changes that are possible for that substance. For the element magnesium (Mg), we could say that chemical properties include:

- the reaction with oxygen to form MgO
- the reaction with hydrochloric acid to form MgCl_2 and hydrogen gas (H_2)
- the reaction with solid carbon dioxide (dry ice) to form MgO and carbon

Chemical changes can almost always be detected with one of our physical senses. Thus, when magnesium reacts with oxygen (burns in air) a bright white flame is produced, heat is evolved and the shiny metallic magnesium is converted to a crumbly white powder MgO . In the reaction with hydrochloric acid (the molecule HCl dissolved in water), the solid metallic magnesium disappears, bubbles of hydrogen gas (H_2) are evolved, heat is produced, and a clear solution containing MgCl_2 is formed. In the reaction with solid carbon dioxide (dry ice), a bright white flame is produced, heat is evolved and the shiny metallic magnesium is converted to a crumbly white powder and solid carbon. In general, when you are trying to identify a chemical change, look for evidence of heat or light, the evolution of a gas, a change in color or the formation of new solid products from otherwise clear solutions.

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