

Alchemy

Skills to Develop

- Distinguish physical properties from chemical properties
- Understand the difference between homogeneous and heterogeneous mixtures

If everything is made of the same 4 elements in different ratios, perhaps you can adjust the ratios of elements through various processes and change one material into another. This was called **transmutation**. In particular, people wanted to change inexpensive metals into gold.

There were known examples of one material turning into another. For instance, there's a reddish mineral called cinnabar, and if you heat it, you get silvery liquid mercury. Oddly, if you heat it again, you get another red solid. We'll explain that in chemical terms soon (it's a chemical change!) but it looked like a proof of principle for transmutation, with one substance becoming another.

Also, some people claimed to be able to make gold. The problem here was that they weren't distinguishing between a **pure substance** and a **mixture**. A pure substance is composed of a single type of molecule. Gold (theoretically) is a pure substance: not just a pure substance, but a pure element. However, you can make compounds that look a little like gold, that are yellow and shiny, by mixing different metals, such as copper and tin. We call that a mixture (or more specifically an alloy, which is a mixture of metals).

A **compound** is a substance that contains multiple elements. Water is a compound of hydrogen and oxygen. However, water is a pure substance, because each molecule of water is the same. Air is a mixture, not a pure substance, because it contains different types of molecules, some of which are compounds, like carbon dioxide, which is a compound of carbon and oxygen. The difference between a compound and a mixture is that in a compound you always have the same ratio of the elements: in carbon dioxide, the ratio is there in the name: one carbon atom, two (di) oxygen atoms. Carbon dioxide is CO_2 . In a mixture, the ratio can vary. Air contains nitrogen (N_2) and oxygen (O_2) molecules and many other components, and a sample from a lecture hall and a sample from a forest would probably have slightly different ratios.



Alchemists did not always distinguish between mixtures and pure compounds or elements, for instance gold vs bronze (an alloy of copper and tin). We can distinguish different materials by using the **properties** of the materials. Properties are things like what temperature it melts at, whether it dissolves in acid, and so on. We can distinguish **physical properties** and **chemical properties**. Melting point is a physical property, and solubility in acid is a chemical property.

Alchemists developed many of the techniques of chemistry that we still use. For instance, a **heterogeneous** mixture of a solid and a liquid, such as sugar in oil, could be separated by filtration. If you have a solution, like sugar in water, that is **homogeneous**, because all the sugar has dissolved, you can't filter it. Instead, you could let the water evaporate slowly until big crystals grow. (We call that rock candy in English.) This process is called **recrystallization**, and is used to purify solids. To purify liquids, you can use **distillation**, which is based on different boiling points: heat at a temperature where one component boils and the other doesn't, and collect the vapor. **Sublimation** is similar: some solids will vaporize with heat, and can then be recollected from the vapor on a cold surface, where they solidify.

Overall, alchemists were sometimes excellent experimentalists, and they definitely spent time "in the lab." However, their explanations and reasons for beliefs may seem strange from a modern perspective. For instance, if a theory had parallels to Christian religious events, that might be considered evidence that it was correct. The other "unscientific" thing about their practice was that they often reported results in a way that was intended to confuse the reader, if they reported the results at all, and they often looked to ancient texts as an authority, even when there was no evidence that the authors had accomplished anything. Finally, the goals they chose were very ambitious, so instead of trying to look at the simplest questions first, to get clear answers, they used many complicated procedures and got results that are hard to explain even now.

Summary

Transmutation involves changing one material into another by adjusting the ratios of elements through various processes. A **pure substance** has a chemical composition of only one type of molecule. A **compound** is a substance that contains 2 or more types of atoms chemically bonded together. **Mixtures** have two or more substances physically combined, meaning that each component retains its chemical composition and properties. The components of a **heterogeneous** mixture are not uniformly combined while the components of a **homogeneous** mixture are. A substance's **physical properties** can be observed without changing its chemical composition (i.e. color, volume, melting point) while its **chemical properties** are observed through chemical changes (i.e. burning, rusting).

Outside Link

- [MissBettsChem: Homogeneous and Heterogeneous Mixtures](#) (8 min)

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