

## Introduction

### Skills to Develop

- Understand some of the historically fundamental aspects of chemistry

**Chemistry** is different from physics. The chemical theories that we use to understand and predict aren't written in math. They also aren't based on anything we can see directly, like a ball falling. Instead, they are based in images, patterns, symmetry and imagination. How do we know what metaphors we can use to imagine, and predict accurately, things that we can't see? When you think about it, it's amazing how much chemists were able to figure out.

John Dalton proposed his **atomic theory** around 1805. He said:

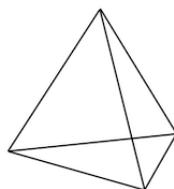
1. All **matter** is composed of **atoms**
2. Atoms come in different types, called **elements**
3. Atoms of each element have a distinct **mass**
4. Each atom of a given element is identical to every other atom of that element
5. Atoms are not created, destroyed or changed when chemical changes occur

Scientists scoffed, laughed at him, or at least remained skeptical, for at least 50 years after that, because how could he know? But he was almost completely right.

A little later, in 1830, Jons Jacob Berzelius proposed that even if you have the same **composition** (the same number of atoms of each element) you can have two different **molecules** (a combination of atoms), because the atoms are arranged differently. The first example discovered was silver fulminate ( $\text{AgCNO}$ , very explosive) and silver cyanate ( $\text{AgOCN}$ , a non-explosive grayish powder).

And then in 1874 Jacobus H. van't Hoff proposed that when carbon atoms form bonds to four other atoms, those other atoms around them have a particular arrangement called a **tetrahedron**. A critic said:

"A Dr. J. H. van't Hoff who is more suitable to mount Pegasus from the Veterinary School in Utrecht appears to find exact chemical research unsuited to his tastes. He finds it more suitable to mount Pegasus from the Veterinary School) and to proclaim ... how, during his flight to the top of the chemical Parnassus, the atoms appear in the universe." (In ancient Greek mythology, Pegasus is a horse with wings, and Parnassus is a mountain associated with art and knowledge because the Muses were said to live there.)



A tetrahedron.

You can tell from that how weird it seemed, at the time, to claim a particular spatial arrangement of tiny particles that nobody had ever seen. But van't Hoff, like Dalton and Berzelius, was right. How did they manage this? That will be one of the questions we answer in this class.

In fact, before the physicists had admitted that atoms exist, before they had been proven directly, chemists had already published many **chemical structures** showing how atoms were arranged in molecules.

### Summary

**Chemistry** is the study of the composition and structure of chemical substances and the changes that they undergo. An **element** is one type of atom. An **atom** is the smallest particle of an element that retains all of the element's properties. A **molecule** is a combination of atoms of the same element. A substance's chemical **composition** involves having a piece of the substance being made of the same number of atoms as well as the the same type(s) of atoms.

### Contributors and Attributions

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