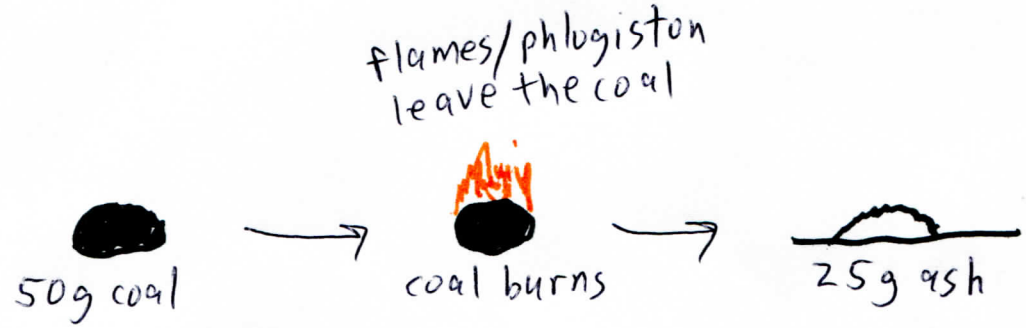
Chemistry Lecture #12: Law of Conservation of Mass

Why does a lump of coal burn? And why, after burning, are the ashes lighter than the original lump of coal?

Aristotle (384 BC - 322 BC) said that matter was made of earth, air, fire and water. Thus, a lump of coal is made of these four components. A lump of coal burns because it is releasing the fire that is inside of it.

Aristotle's ideas of matter lasted through the late 18th century. Georg Ernst Stahl (1659-1734) also believed that fire was a component of all matter that was combustible. He called this component *phlogiston*, from the Greek word for inflammable. (By the way, flammable and inflammable mean the same thing - capable of burning).

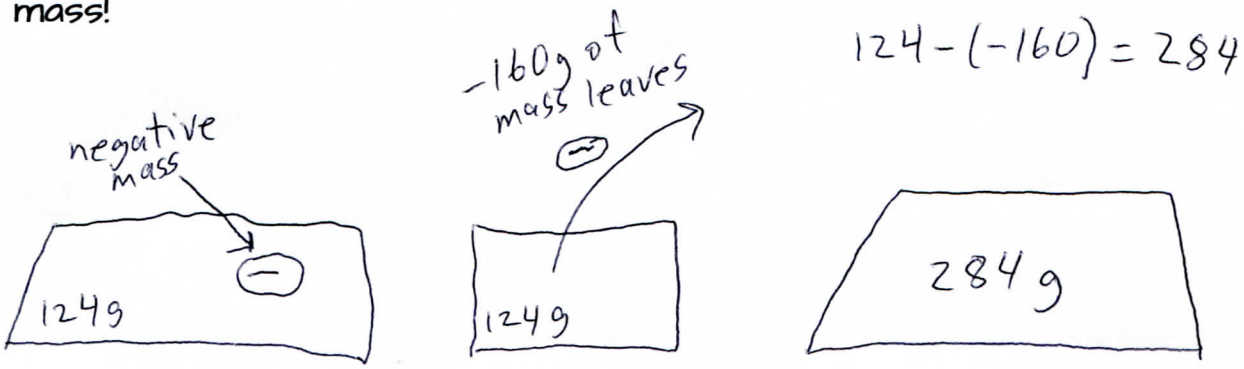
When a lump of coal burns, the phlogiston leaves the coal, and what is left is an ash that is lighter than the coal. When a material loses phlogiston, it loses mass. This is why the ash is lighter than the coal.



The phlogiston concept of matter explained why matter loses mass after burning. Unfortunately, it could not explain why some substances *gained* mass after burning.

For example, it was known that phosphorus gained mass after being burned.

Phlogistonists explained this anomaly by saying that phlogiston could have a negative weight. When you subtract a negative, you get a positive. So, if you remove a negative mass, you end up gaining mass!

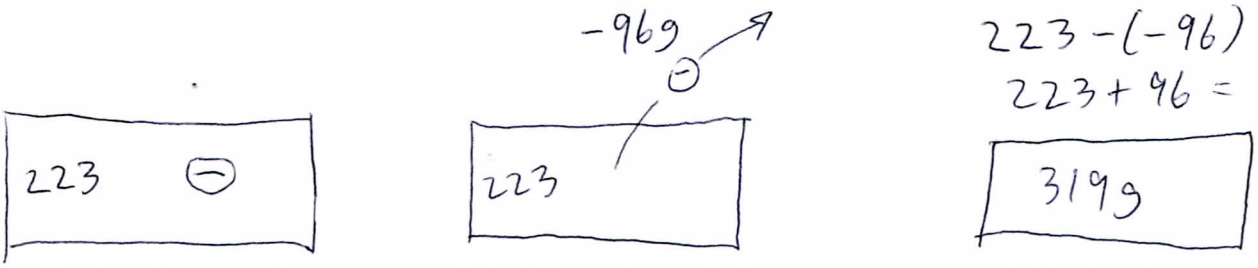


124 g Phosphorous

284 g burned phosphorus

This wasn't a very satisfying explanation. What the heck is negative mass? And how do you know when phlogiston will have a positive or negative mass? According to the phlogistonists, when you see flames coming out of burning coal, that's positive phlogiston. But when you see flames coming out of burning phosphorous, that's negative phlogiston.

Negative phlogiston was also used to explain why iron gains mass when it rusts. Phlogiston of negative mass was being freed by the iron, resulting in a substance, rust, which now had greater mass.



223 g Fe 223 - (-96) = 319 g Rust; heavier

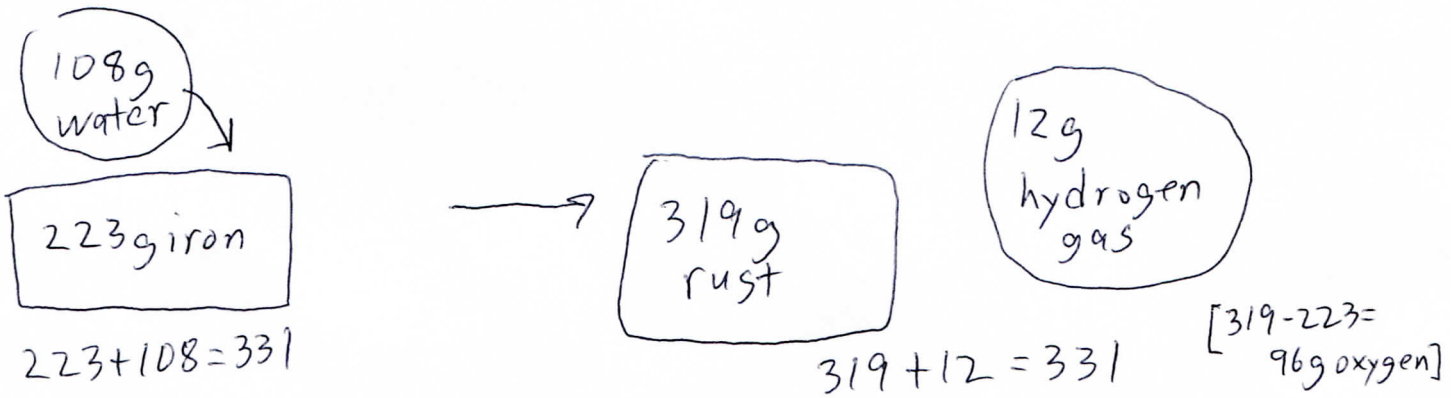
It was believed that phlogiston did not respond to gravity and therefore had no mass. Yet, phlogiston appeared to be a substance which, when it entered or left a material, could make mass appear or disappear. When negative phlogiston left an object, the object was heavier - mass has suddenly popped in from nowhere! Matter was created from nothing! Or if coal burned and became lighter, it was because phlogiston had left the coal; mass has suddenly disappeared or was destroyed.

If mass is being created from nothing and then disappearing (or being destroyed), then *mass is not being conserved in chemical reactions.*

It wasn't until Antoine-Laurent Lavoisier (1743-1794) began doing experiments that the idea of phlogiston was discredited. Lavoisier was able to show that when materials gained or lost mass, it was because the mass was transferred from one material to another.

In one experiment, Lavoisier heated a mixture of water and iron filings to a high temperature. The procedure caused the iron to rust, and a gas was also produced.. The mass of water and iron before the procedure matched the mass of the rust and gas produced after the procedure. This demonstrated that when new materials are made, matter is simply transferred from one material to another. Matter was not being created from nothing or being destroyed - it was conserved.

Simplified explanation & diagram of Lavoisier's experiment



Law of Conservation of Mass: In a chemical reaction, matter is neither created or destroyed. Matter is conserved.

Let's do one problem: 10.00 g of red mercury oxide powder is placed in an open flask and heated until it is converted to liquid mercury and oxygen gas. The liquid mercury has a mass of 9.26 g. What is the mass of oxygen formed in the reaction?

10.00 g mercury oxide ⟹ 9.26 g mercury + oxygen gas

10.00 = 9.26 + oxygen gas

oxygen gas = 0.74 g