Understanding Matter

Ancient Ideas
Ancient Greece

- What is the nature of matter?
  - Continuous and infinitely divisible?
  - Discrete definite particles?

- Ancient Greek philosophers debated and speculated, but did not experiment or test their ideas.
Aristotle
Aristotle

- 4 types of matter
  - Earth, air, fire and water
Democritus

- Argued that matter consists of small particles
- Called the particles “atoms”
  - Greek for indivisible
Alchemy

- Developed a lot of practical knowledge, but few advances in theory.
Robert Boyle

- Published “The Skeptical Chymist” in 1661
Robert Boyle

- Published “The Skeptical Chymist” in 1661
- Insisted on publishing experimental detail
- Emphasized chemical analysis
Antoine Lavoisier (1743-1793)

- French Chemist
- "Father of Modern Chemistry"
- Executed during Reign of Terror in French Revolution
Antoine Lavoisier (1743-1793)
Conservation of mass

$S + Fe \rightarrow FeS$

$32g + 56g$ reactants $\rightarrow 88g$ products
La vo isier’s experiment

• Studied decomposition of mercury(II) oxide
La vo isier’s experiment

• Studied decomposition of mercury (II) oxide

- Found that mass before the reaction equaled the mass after the reaction
Lavoisier vs phlogiston

Phlogiston theory:

Metal $\rightarrow$ Calx + Phlogiston

Lavoisier theory:

Metal + Oxygen $\rightarrow$ Calx

A calx is what we call the metal oxide today.
Debunking phlogiston

Today is a good day I think to talk about phlogiston!

That's right! Phlogiston!

Phlogiston was proposed as a scientific explanation for combustion! It was clear that some things burned (like wood), while other things would not burn (like ash). Phlogiston was a colourless, odourless and weightless substance that was contained in things that could burn. When they burned, the phlogiston was released into the air!

That's a pretty crazy theory! Yeah, but it totally worked for a while!

It explained why if you burned things in a jar, they would go out: the air can only hold so much phlogiston! But it started to fall apart when people discovered that some things, like magnesium, actually gained mass when burned.

So phlogiston would have to have a negative mass!

Yeah! That seemed a little too krazy. But it's actually pretty close to what we now believe, only backwards!

Yes! We believe the materials are deoxygenated and become oxygenated when burning!

Man! I know it!!

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Joseph Proust

- Law of Definite Composition
Joseph Proust

- Law of Definite Composition
- Compound contains same ratio of elements, regardless of source or size of sample
Definite Composition

- Water
  - Always 11% hydrogen, 89% oxygen
Definite Composition

- Water
  - Always 11% hydrogen, 89% oxygen

- Table salt
  - Always 45% sodium, 55% chlorine
John Dalton (1766-1844)

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- Many research interests
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- English scientist and teacher
- Many research interests
- In 1808 Dalton published *A New System of Chemical Philosophy*
Dalton’s Atomic Theory

- All matter is made of indivisible particles called atoms.
- All atoms of an element are completely identical in properties and mass.
- Atoms of each element are different from atoms of other elements.
Definite Proportions

- Atoms of different elements combine in small whole number ratios to form compounds.
  - Water $\text{H}_2\text{O}$
  - Table salt (aka sodium chloride) NaCl
Multiple Proportions

- Atoms of different elements can combine in different whole number ratios to form different compounds.

  Water  \( \text{H}_2\text{O} \)
  \( 2:1 \) ratio

  Hydrogen peroxide  \( \text{H}_2\text{O}_2 \)
  \( 2:2 \) ratio