

Ch 100: Fundamentals for Chemistry

Chapter 1: Introduction Lecture Notes

What is Chemistry?

- Chemistry is often described as the “central” science
- Chemistry is the study of matter
- Matter is the “stuff” that makes up the universe, i.e. anything that has mass and occupies space
- The fundamental questions of Chemistry are:
 1. How can matter be described?
 2. How does one type of matter interact with other types of matter?
 3. How does matter transform into other forms of matter?

Major Developments in Chemistry I

- ~400 BC: Democritus proposed the concept of the “atom”
- ~300 BC: Aristotle developed 1st comprehensive model of matter
- ~700 AD: Chinese alchemists invent gunpowder
- 1661: Robert Boyle proposed the concept of elements
- 1770-90: Lavoisier proposed the concept of compounds & the Law of Mass Conservation
- 1774: Priestly isolates oxygen
- 1797: Proust proposed the Law of Definite Proportions
- 1803: Dalton re-introduces the concept of the atom and establishes Dalton’s Laws
- 1869: Mendeleev creates the 1st Periodic Table
- 1910: Rutherford proposes the “nuclear” model of the atom
- 1915: Bohr proposes a “planetary” model of the hydrogen atom
- 1920: Schroedinger publishes his wave equation for hydrogen
- 1969: Murray Gell-Mann proposes the theory of QCD (proposing the existence of quarks)

Major Developments in Chemistry II

Discovery of subatomic particles:

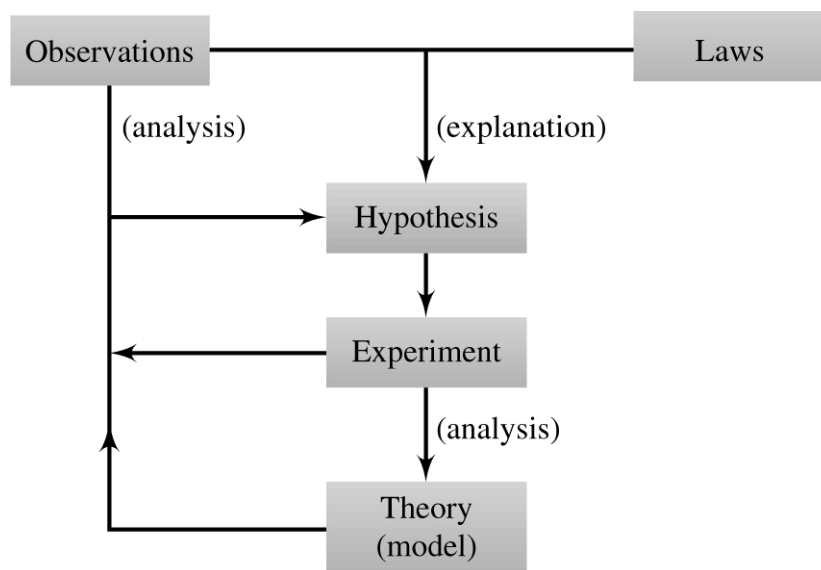
- 1886: Proton (first observed by Eugene Goldstein)
- 1897: Electron (JJ Thompson)
- 1920: Proton (named by Ernest Rutherford)
- 1932: Neutron (James Chadwick)

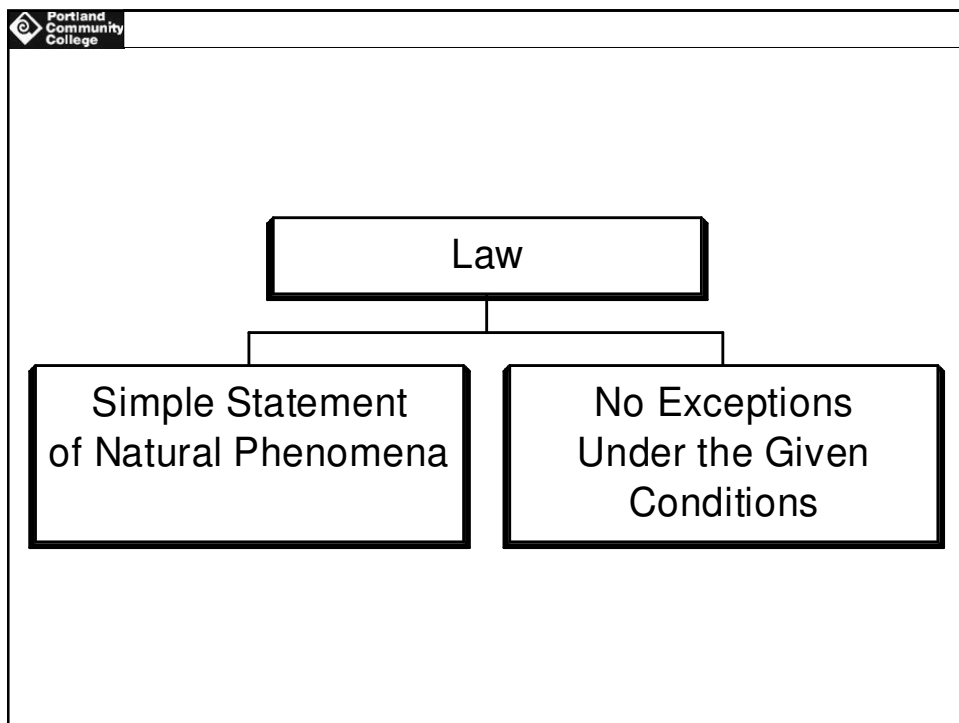
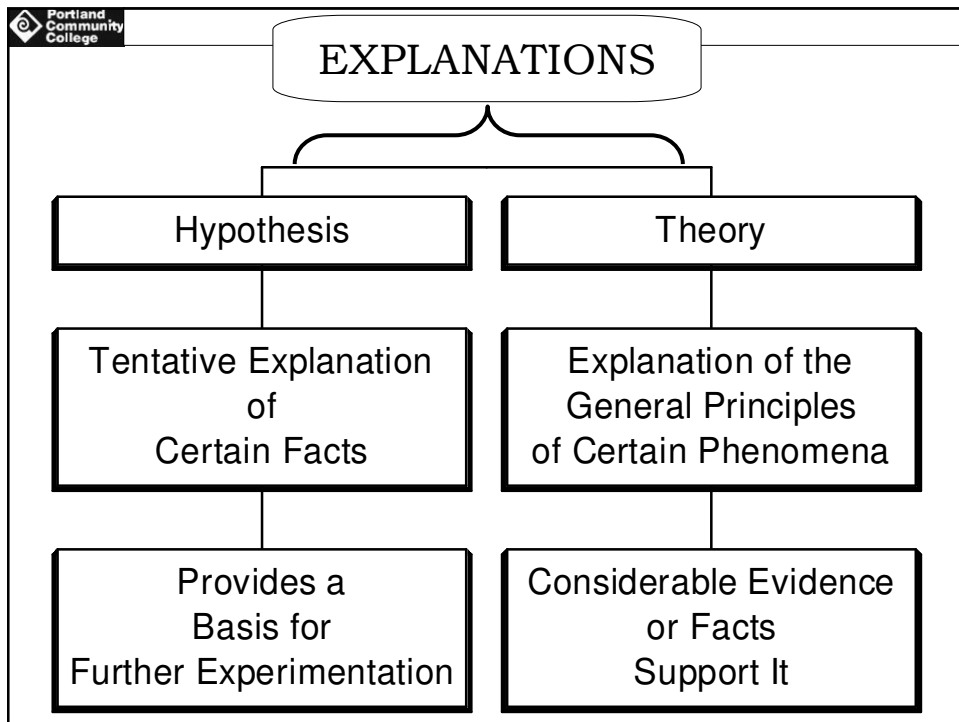
Other Important Discoveries:

- 1896: Antoine Henri Becquerel discovers radioactivity
- 1911: H. Kamerlingh Onnes discovers superconductivity in low temperature mercury
- 1947: William Shockley and colleagues invent the first transistor
- 1996: Cornell, Wieman, and Ketterle observe the 5th state of matter (the Bose-Einstein condensate) in the laboratory

Scientific Method

1. (OBSERVATION) Recognize a problem
 - Make observation
 - Formulate a question
2. (EXPLANATION) Make an educated guess - *a hypothesis*
 - Predict the consequences of the hypothesis
3. (VALIDATION) Perform experiments to test the predictions
 - Does experimental data support or dispute hypothesis?
4. Formulate the simplest rule that organizes the 3 main ingredients - develop a theory





Bottom Line: The Scientific Attitude

- All hypotheses must be testable (i.e. there must be a way to prove them wrong!!)
- Scientific: “Matter is made up of tiny particles called atoms”
- Non-Scientific: “There are tiny particles of matter in the universe that will never be detected”

The Particulate Nature of Matter

- Matter is the tangible substance of nature, *anything with mass that occupies space*
- At the most fundamental level, matter is discrete or particulate in nature
- The smallest, most basic units of matter are called atoms
- All matter is thus comprised of individual atoms, or specific combinations of atoms called molecules
- Molecules can be broken apart into their constituent atoms but atoms cannot be further broken apart and still retain the properties of matter
- Matter can exist in one or more physical states (or phases)

States of Matter

Solid $\xrightarrow{+Energy}$ Liquid $\xrightarrow{+Energy}$ Gas

State	Shape	Volume	Compress	Flow
Solid	Keeps Shape	Keeps Volume	No	No
Liquid	Takes Shape of Container	Keeps Volume	No	Yes
Gas	Takes Shape of Container	Takes Volume of Container	Yes	Yes

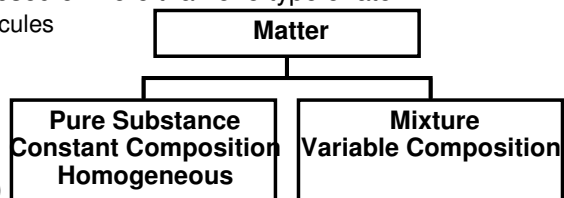
Solid $\xleftarrow{+Energy}$ Liquid $\xleftarrow{+Energy}$ Gas

Classification of Matter

Matter can be classified as either Pure or Impure:

– Pure

- **Element:** composed of only one type of atom
 - Composed of either individual atoms or molecules (e.g. O₂)
- **Compound:** composed of more than one type of atom
 - Consists of molecules



– Impure (or mixture)

- **Homogeneous:** uniform throughout, appears to be one thing
 - Pure substances
 - Solutions (single phase homogeneous mixtures)
 - Suspensions (multi-phase homogeneous mixtures)
- **Heterogeneous:** non-uniform, contains regions with different properties than other regions

Separation of Matter

- A pure substance cannot be broken down into its component substances by physical means only by a chemical process
 - The breakdown of a pure substance results in formation of new substances (i.e. chemical change)
 - For a pure substance there is nothing to separate (its only 1 substance to begin with)
- Mixtures can be separated by physical means (and also by chemical methods, as well)
- There are 2 general methods of separation
 1. Physical: separation based on physical properties
 1. Filtration
 2. Distillation
 3. Centrifugation
 2. Chemical: separation based on chemical properties