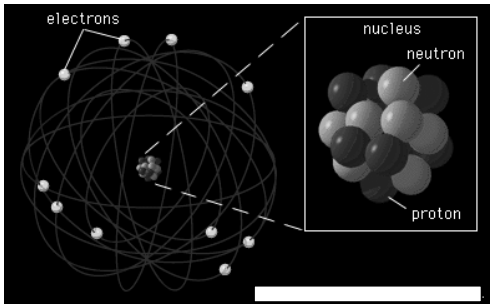
Introduction to Chemistry

General Chemistry 1

Slide Set A

The Modern Model of the Atom

Particle	Mass
Electron	9.11×10^{-31} kg
Proton	1.67×10^{-27} kg
Neutron	1.67×10^{-27} kg



Atoms are made up of three subatomic particles:

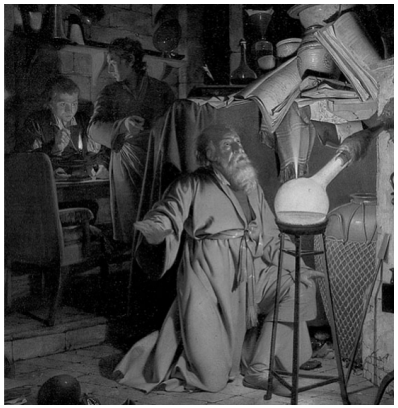
Proton (p^+):	Positively charged subatomic particle found in the nucleus of the atom.
Neutron (n^0):	Neutral subatomic particle found in the nucleus of the atom.
Electron (e^-):	Negatively charged subatomic particle found outside the nucleus.

The Basics

- **Chemistry** is the study of **matter**, its interactions and reactions, and the **energy** associated with those processes.
- **Matter** is substance that has mass and volume – all of the objects around us.
- **Energy** is the potential or capacity to move or change matter.

Alchemy

- Alchemy was the earliest attempts to practice chemistry as a “science”.
- Alchemists attempted to change cheap metals into gold, among other things.



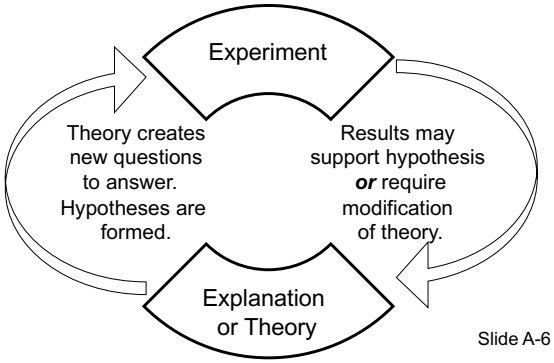
Modern Chemistry

- Modern Chemistry is often considered to have begun with the work of Antoine Lavoisier in the late 18th Century.
- Lavoisier was one of the first chemists to use **quantitative measurements** in chemistry.
- Lavoisier was an **experimentalist** – testing his theories in the physical world, rather than simply arguing them philosophically.

Scientific Method

- Lavoisier was one of the first chemists to apply a modern **Scientific Method** to his work.
- The scientific method is a cyclical process of **experimentation** - controlled observation and explanation to increase understanding about the universe:

Scientific Method:



Theory

- The scientific method, hypotheses, and experimentation are used to develop theories about the nature of matter.
- Theories are not absolute truths.
- Theories are the best explanation of observed phenomena.
- Theories are continually revised and updated.
- A good theory not only explains the observed data, but also accurately predicts what future observations should be.
- Many of the theories studied in this course are thought to be very close to the truth, because they have been tested numerous times.

Matter

- Matter is anything that has mass and volume.
- Matter is anything that we may think of as chemicals, physical objects, air, water, cars, people, etc. – All of this is composed of matter.

Matter

- In this course, we will study **chemical substances** (a material with distinct chemical properties that can be changed only by a chemical reaction) and **mixtures** of substances.
- **Elements** are substances composed only of atoms with the same atomic number. The atom cannot be subdivided by chemical means.
- Elements can combine to make a **chemical compound** (also a substance) in a chemical reaction. *Compounds have properties distinct from the elements that form them.*
- **Mixtures** are a physical combination of two or more substances that can be separated by physical means (without a chemical reaction).

ENERGY

Energy is the capacity to move or change matter. It can have many different forms:

- Kinetic Energy
- ***Heat Energy***
- Potential Energy
- ***Chemical Potential Energy***
- Electrical Energy

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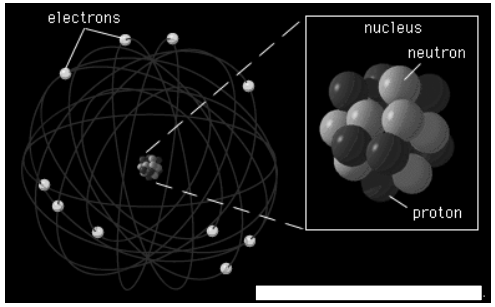

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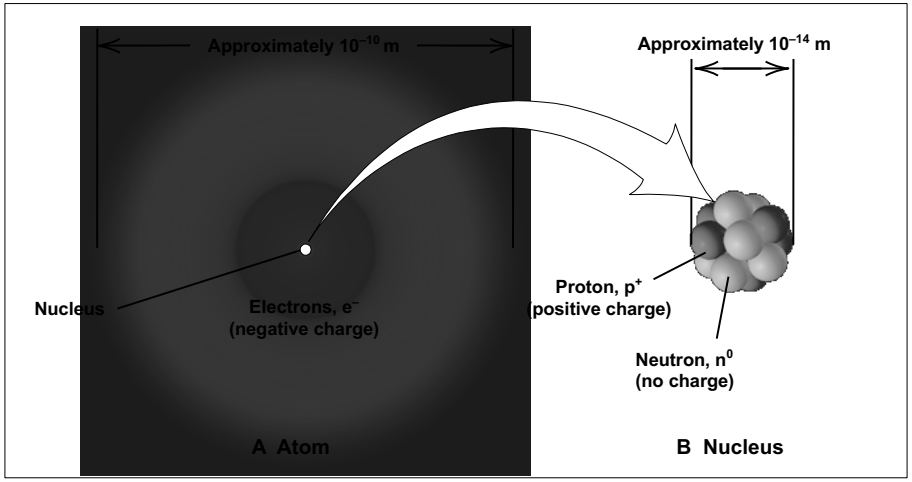
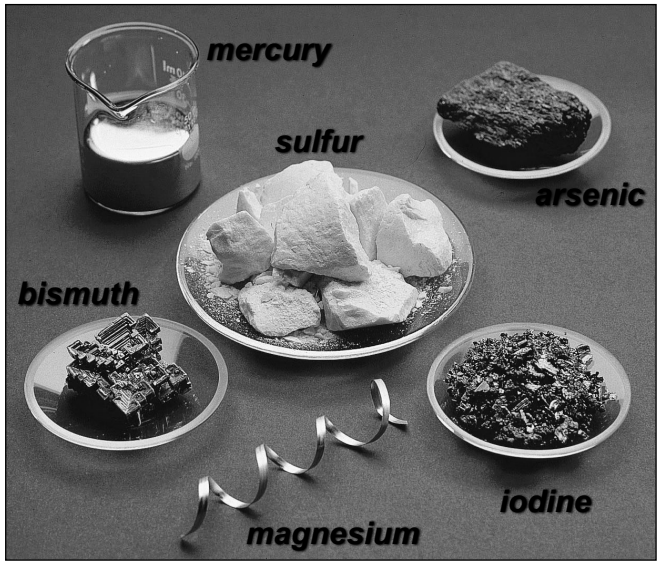
The Modern Model of the Atom

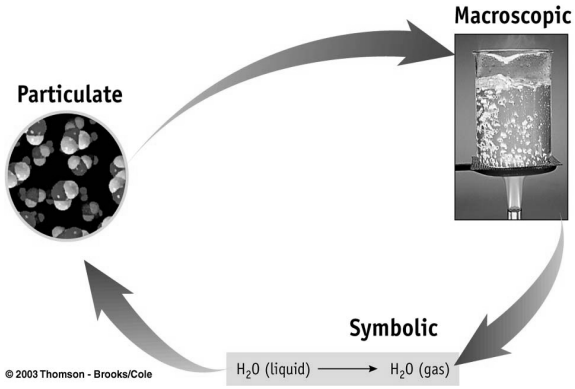


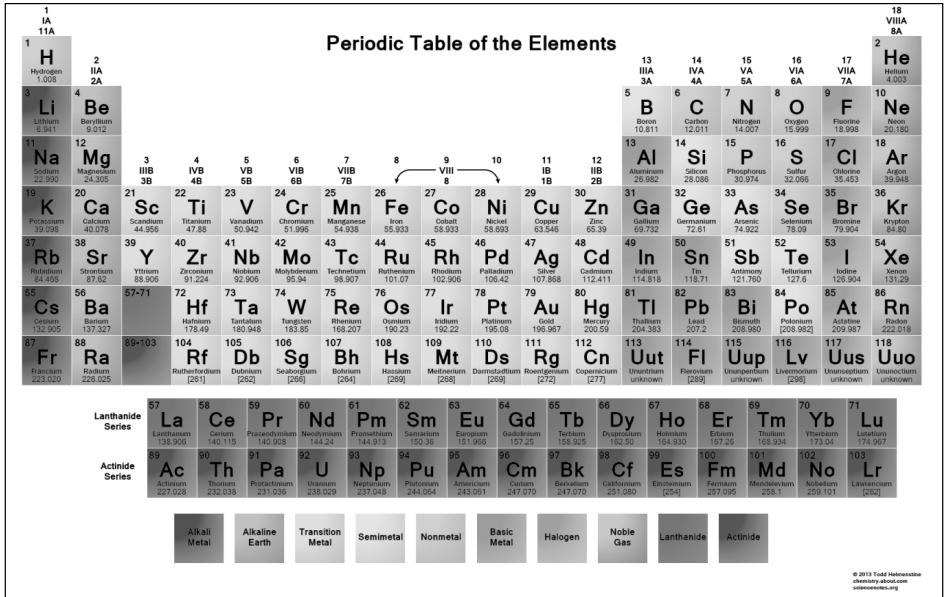
Elements



Macroscopic vs. Microscopic vs. Particulate

- ***Macroscopic:*** large scale, amounts generally seen with the naked eye. This is how we usually observe natural phenomena.
- ***Microscopic:*** small scale, amounts or sizes that cannot be seen without some sort of magnification aid.
- ***Particulate:*** Atoms, molecules, and ions. Cannot be visualized with a light microscope. Generally represented with models.

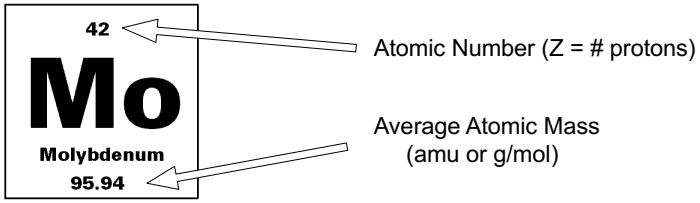




Periodic Table

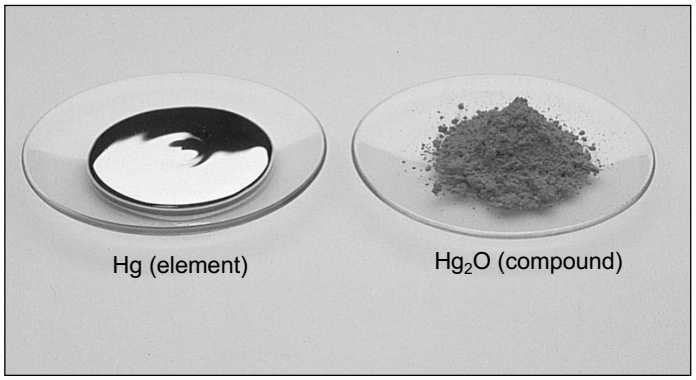
- The **periodic table** organizes the **elements**, by their atomic number (Z) and by repeating, or periodic, properties.
- Elements in the same family or group (column) share similar properties.
- Now, 118 elements are known, approximately 90 of which are naturally occurring. The rest have been prepared in a laboratory.

Interpreting an Element Box on the Periodic Table



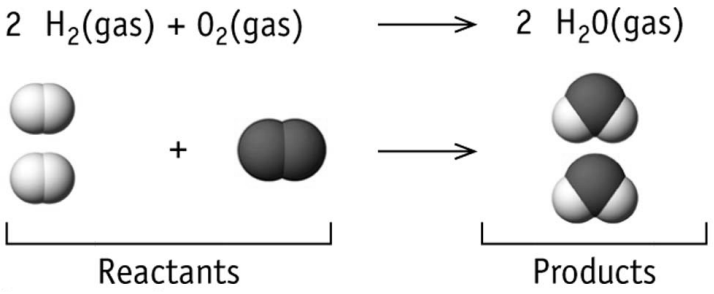
Compound formation

When elemental mercury is heated in air - where oxygen gas is present - Mercury (I) oxide is formed.

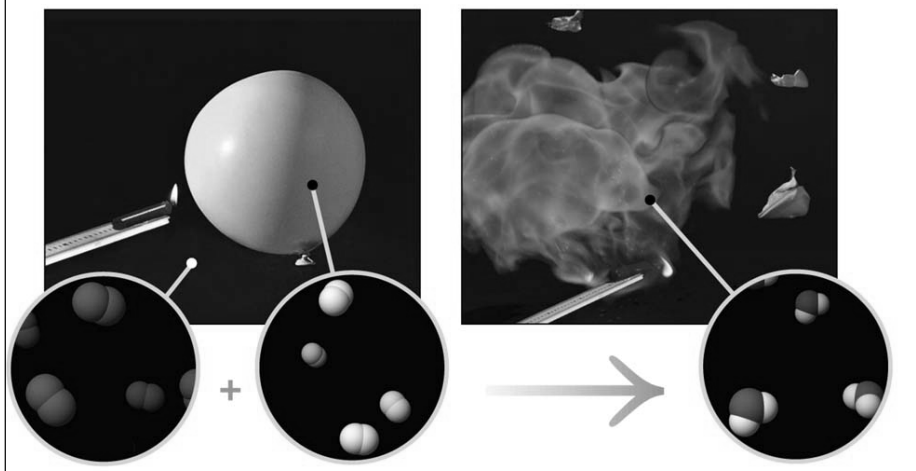


Chemical Reaction: Formation of Water

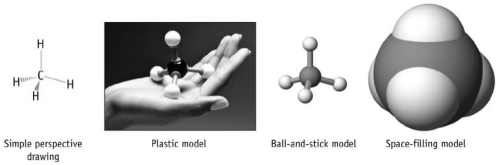
- Two hydrogen molecules and one oxygen molecule combine to make two water molecules.
- In their elemental diatomic forms, hydrogen is an explosive gas and oxygen supports combustion.
- However, as a compound, water is relatively non-reactive.



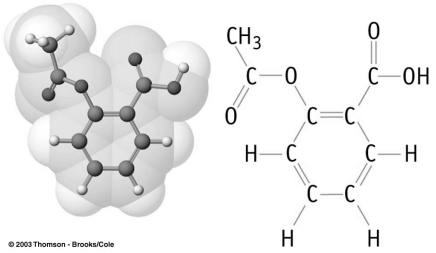
Chemical Reaction: Formation of Water



Methane (CH_4) molecule

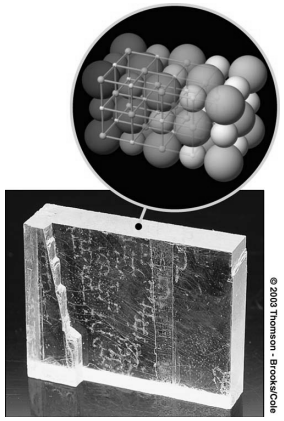


Aspirin ($C_9H_8O_4$) molecule

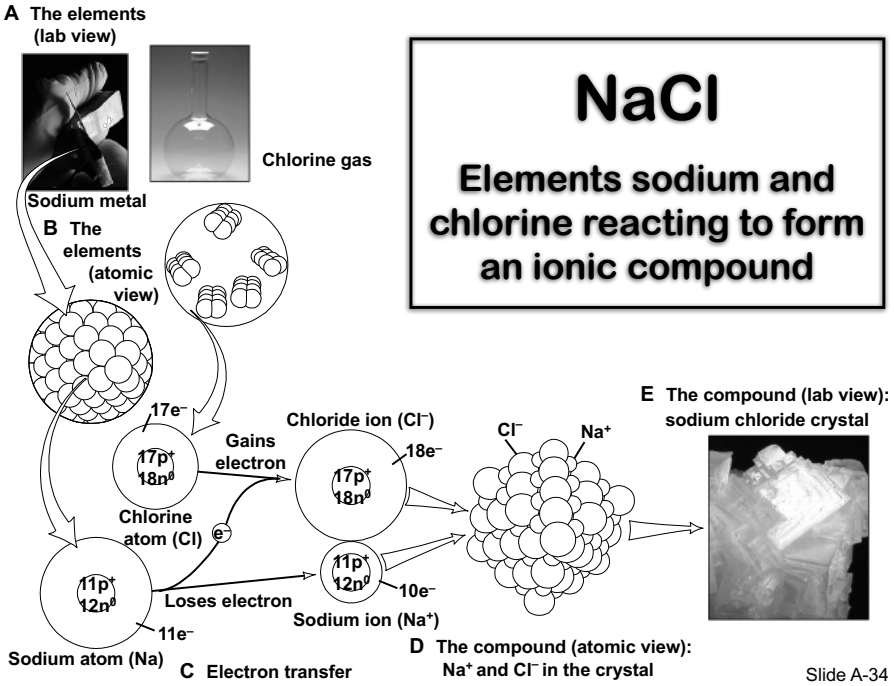


NaCl crystal

- There are no molecules of NaCl.
- The formula unit NaCl is the smallest ratio of Na^+ and Cl^- ions



Slide A-26



NaCl

Elements sodium and chlorine reacting to form an ionic compound

Slide A-34

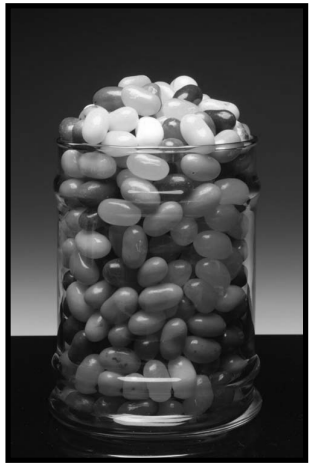
Atoms, Ions, and Compounds

- **Atoms** are the smallest unit of an **element**.
- Atoms can share electrons to form **molecules**.
- Molecules are the smallest unit of a **covalent compound**.
- Atoms, usually metals, can lose electrons to form **cations** - positively charged ions.
- Atoms, usually nonmetals, can lose electrons to form **anions** - negatively charged ions.
- Cations and anions are attracted to one another and form **ionic bonds**.
- The **formula unit** is the smallest ratio of cations and anions in **ionic compounds**.

Slide A-35

Mixtures

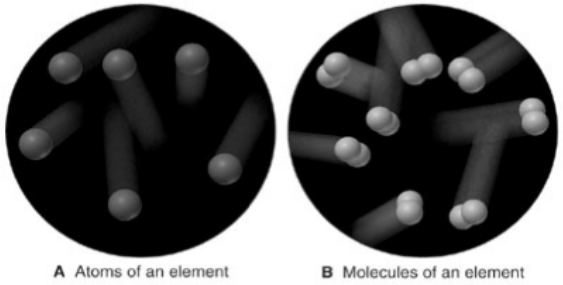
Saltwater - homogeneous mixture, also called a solution.



Jar of jelly beans - heterogeneous mixture

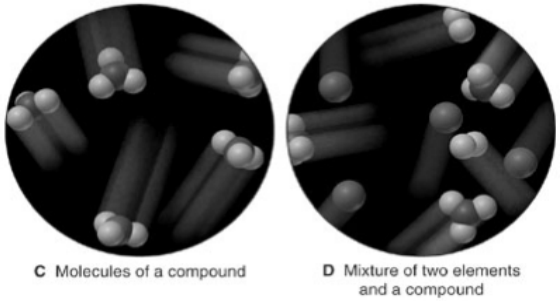
Slide A-36

Substances & Mixtures: a particle view



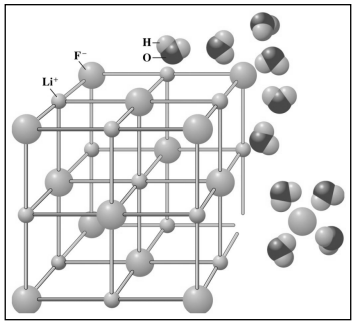
Substances: A, B, C

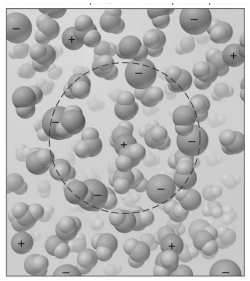
Mixture: D



Dissolving Compounds

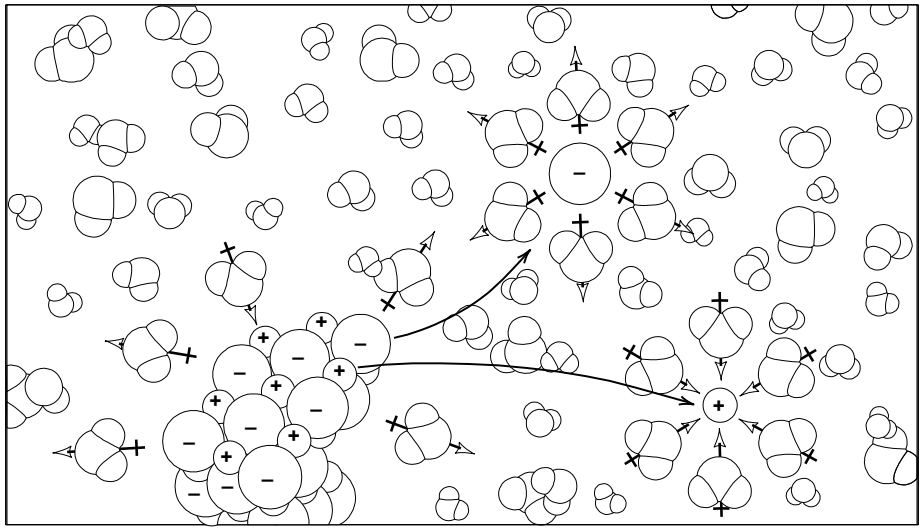
- When ionic compounds dissolve in water, they often dissociate into their individual ions.
- For example, when LiF dissolves in water, there are solvated Li^+ and F^- ions in solution.





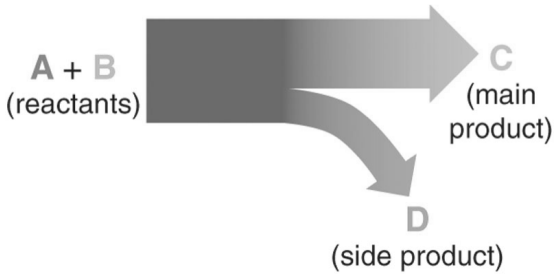
- **Molecular compounds do NOT dissociate when they dissolve in water.**

Dissolution of an ionic compound



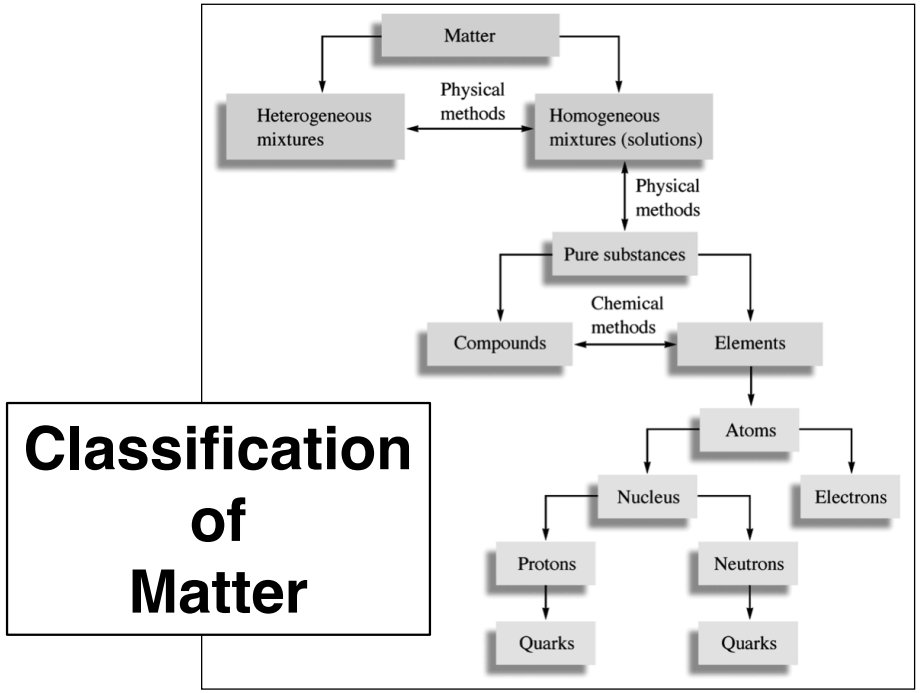
Separation of mixtures

- In nature, some materials are mixtures and we wish to extract only one part of the mixture.
- In the chemistry laboratory, some reactions create a mixture of products. You may be interested in isolating a single product from that mixture.



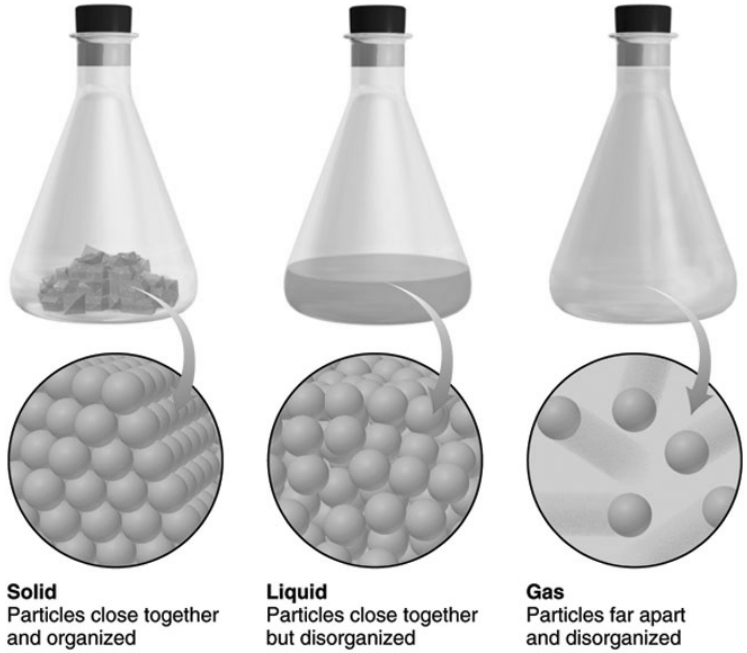
Separation (& purification) of mixtures

- ***Homogenous*** and ***heterogeneous*** mixtures are generally separated by different means. Some common means of separations in chemistry include:
  - Crystallization
  - Distillation
  - Chromatography
  - Extraction
  - Filtration
  - Exploiting other physical properties



Kinetic Molecular Theory

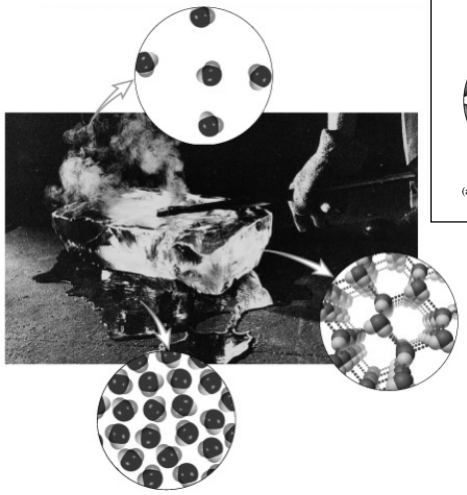
- Matter can exist in three primary states – solid, liquid, and gas.
- The ***Kinetic Molecular Theory*** explains how we may think of these three different phases at the particle level:
  1. Matter can be thought of as tiny particle spheres, called atoms or molecules.
  2. These particles are in constant motion.
  3. The kinetic energy of the molecules is directly proportional to the absolute (Kelvin) temperature.

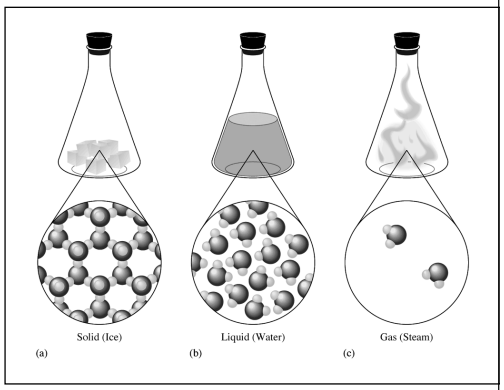


States (Phases) of Matter:

- ***Solid:*** State in which particles are generally tightly packed in to regular, repeating patterns, or crystals. *Solids have both a definite shape and volume.*
- ***Liquid:*** State in which particles are close to one another, but move freely past each other. *Liquids have a definite volume, but assume the shape of their container.*
- ***Gases:*** State in which particles are very distant from one another, and have little interaction. *Gases have no definite shape or volume.*

The three states of water.





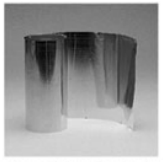
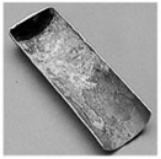
Physical properties

- A characteristic that can be observed without changing the chemical composition of the substance.
  - Density
  - Boiling Point
  - Melting Point
  - Specific Heat Capacity

Chemical properties

- A characteristic of matter that relates to the reactivity of a substance.
  - Flammability
  - Corrosiveness

Table 1.1 Some Characteristic Properties of Copper

Physical Properties	Chemical Properties
Reddish brown, metallic luster	
	
Easily shaped into sheets (malleable) and wires (ductile)	Slowly forms a basic, blue-green sulfate in moist air
Good conductor of heat and electricity	
	
Can be melted and mixed with zinc to form brass	Reacts with nitric acid (photo) and sulfuric acid
Density = 8.95 g/cm^3	
Melting point = 1083°C	Slowly forms a deep-blue solution in aqueous ammonia
Boiling point = 2570°C	

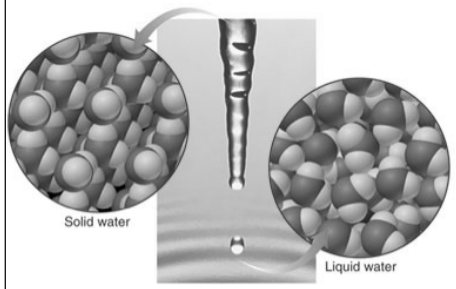
Physical Changes

- A change in matter in which the chemical make-up of a substance is not changed.
  - Phase changes (freezing, boiling)
  - Breaking a glass
  - Dissolving a solid.

Chemical Changes

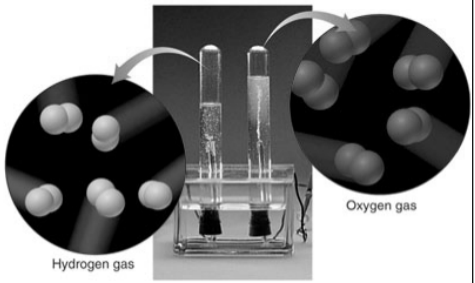
  - One or more substance is transformed into one or more different substances.
  - Iron reacting with oxygen to form rust.
  - Wood burning in oxygen to form carbon dioxide and water.
  - Water reacting with sulfur trioxide to form sulfuric acid.

Physical Change:



A Physical change:
Solid form of water becomes liquid form; composition does not change because particles are the same.

Chemical Change:



B Chemical change:
Electric current decomposes water into different substances (hydrogen and oxygen); composition does change because particles are different.