

Introduction to Chemistry

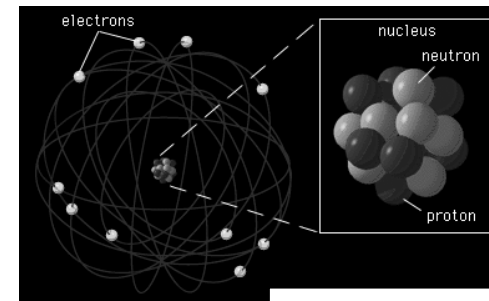
General Chemistry 1

Slide Set A

Slide A-1

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.

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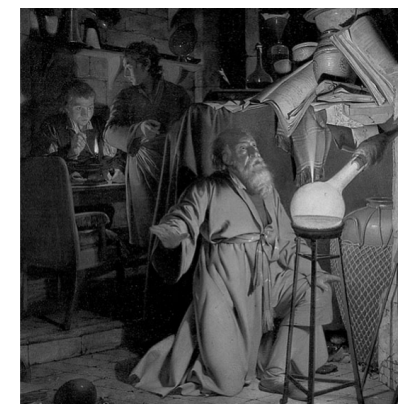
The Basics

- **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.

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Alchemy

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



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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.

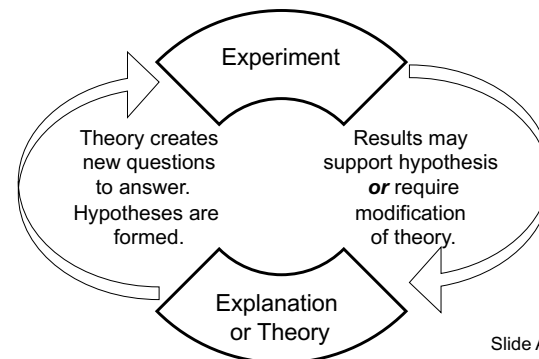


Slide A-5

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:



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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.

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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.

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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).

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ENERGY

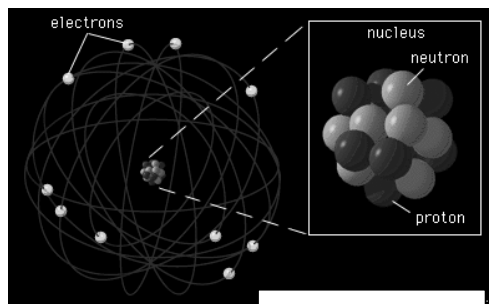
Energy is the capacity to move or change matter. It can have many different forms:

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

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The Modern Model of the Atom

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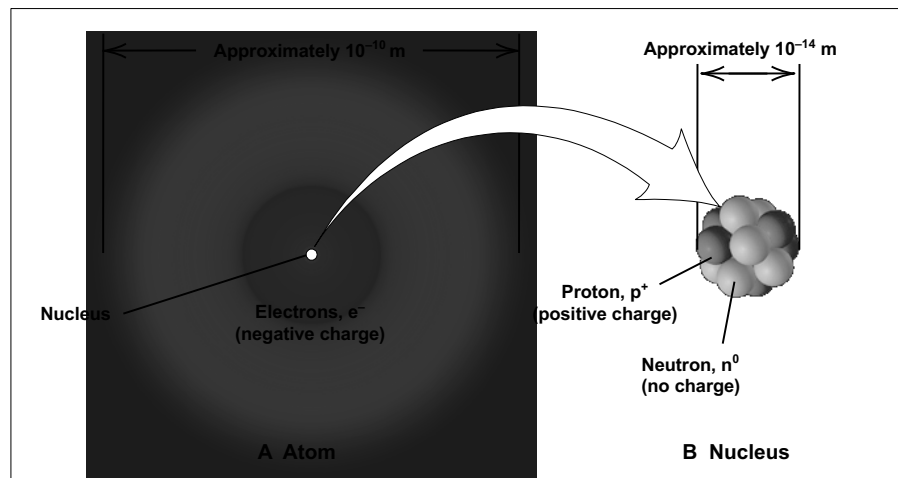


Atoms are made up of three subatomic particles:

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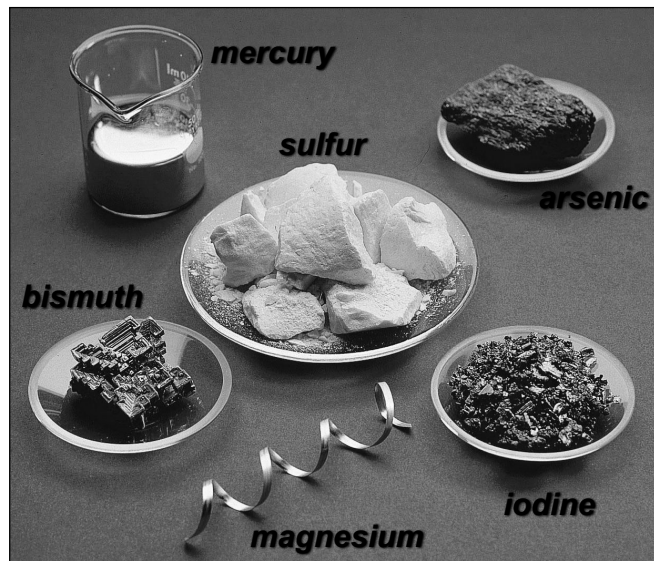
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The Modern Model of the Atom



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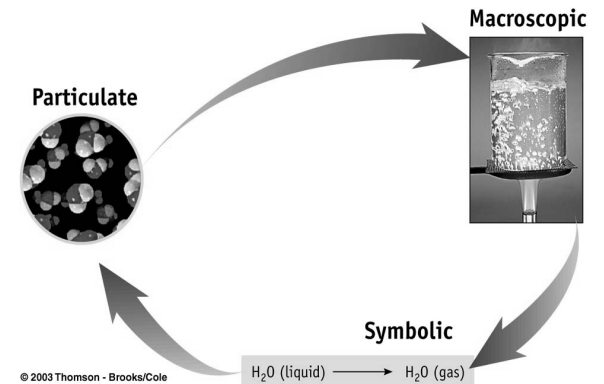
Elements



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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.



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Periodic Table of the Elements																																																					
1 1A H Hydrogen 1.008																	2 18 8A He Helium 4.003																																				
3 1A Li Lithium 6.941	4 2A Be Beryllium 9.012											5 13 3A B Boron 10.811	6 14 4A C Carbon 12.011	7 15 5A N Nitrogen 14.007	8 16 6A O Oxygen 15.999	9 17 7A F Fluorine 18.998	10 18 8A Ne Neon 20.180																																				
11 1A Na Sodium 22.990	12 2A Mg Magnesium 24.305	13 3B Al Aluminum 26.982	14 4B Si Silicon 28.086	15 5B P Phosphorus 30.974	16 6B S Sulfur 32.065	17 7B Cl Chlorine 35.453	18 8B Ar Argon 39.948											19 1A K Potassium 39.098	20 2A Ca Calcium 40.078	21 3B Sc Scandium 44.956	22 4B Ti Titanium 47.88	23 5B V Vanadium 50.942	24 6B Cr Chromium 51.996	25 7B Mn Manganese 54.938	26 8 Fe Iron 55.845	27 9 Co Cobalt 58.933	28 10 Ni Nickel 58.693	29 11 Cu Copper 63.546	30 12 Zn Zinc 65.39	31 13 Ga Gallium 69.723	32 14 Ge Germanium 72.61	33 15 As Arsenic 74.922	34 16 Se Selenium 78.96	35 17 Br Bromine 79.904	36 18 Kr Krypton 84.96																		
37 1A Rb Rubidium 84.468	38 2A Sr Strontium 87.62	39 3B Y Yttrium 88.906	40 4B Zr Zirconium 91.224	41 5B Nb Niobium 92.906	42 6B Mo Molybdenum 95.94	43 7B Tc Technetium 98.907	44 8 Ru Ruthenium 101.07	45 9 Rh Rhodium 102.906	46 10 Pd Palladium 106.42	47 11 Ag Silver 107.868	48 12 Cd Cadmium 112.411	49 13 In Indium 114.818	50 14 Sn Tin 118.71	51 15 Sb Antimony 121.760	52 16 Te Tellurium 127.6	53 17 I Iodine 126.904	54 18 Xe Xenon 131.29	55 1A Cs Cesium 132.905	56 2A Ba Barium 137.327	57-71 Lanthanide Series	72 3B Hf Hafnium 178.49	73 4B Ta Tantalum 180.948	74 5B W Tungsten 183.85	75 6B Re Rhenium 186.207	76 7B Os Osmium 190.23	77 8 Ir Iridium 192.22	78 9 Pt Platinum 195.08	79 10 Au Gold 196.967	80 11 Hg Mercury 200.59	81 12 Tl Thallium 204.383	82 13 Pb Lead 207.2	83 14 Bi Bismuth 208.980	84 15 Po Polonium [209]	85 16 At Astatine [209]	86 17 Rn Radon [222]	87 1A Fr Francium [223]	88 2A Ra Radium [226]	89-103 Actinide Series	104 3B Rf Rutherfordium [261]	105 4B Db Dubnium [262]	106 5B Sg Seaborgium [266]	107 6B Bh Bohrium [264]	108 7B Hs Hassium [265]	109 8 Mt Meitnerium [268]	110 9 Ds Darmstadtium [269]	111 10 Rg Roentgenium [272]	112 11 Cn Copernicium [285]	113 12 Nh Nihonium [284]	114 13 Fl Flerovium [289]	115 14 Uup Ununpentium [288]	116 15 Lv Livermorium [293]	117 16 Ts Tennessine [294]	118 17 Uuo Ununoctium [294]
<table border="1"> <tr> <td>All- Metal</td> <td>Alkali- Earth</td> <td>Transition Metal</td> <td>Semimetal</td> <td>Nonmetal</td> <td>Basic Metal</td> <td>Halogen</td> <td>Noble Gas</td> <td>Lanthanide</td> <td>Actinide</td> </tr> </table>																		All- Metal	Alkali- Earth	Transition Metal	Semimetal	Nonmetal	Basic Metal	Halogen	Noble Gas	Lanthanide	Actinide																										
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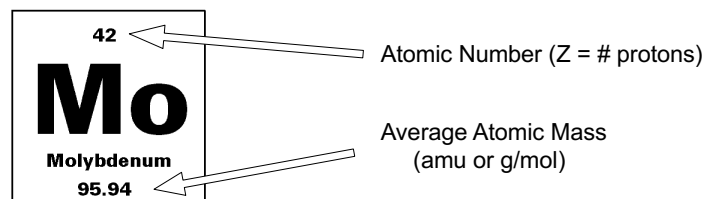
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Periodic Table

- 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.

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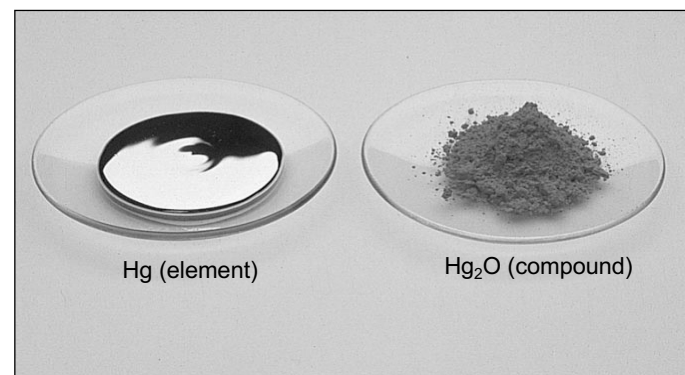
Interpreting an Element Box on the Periodic Table



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Compound formation

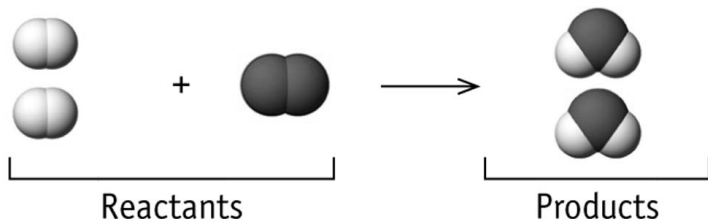
When elemental mercury is heated in air - where oxygen gas is present - Mercury (I) oxide is formed.



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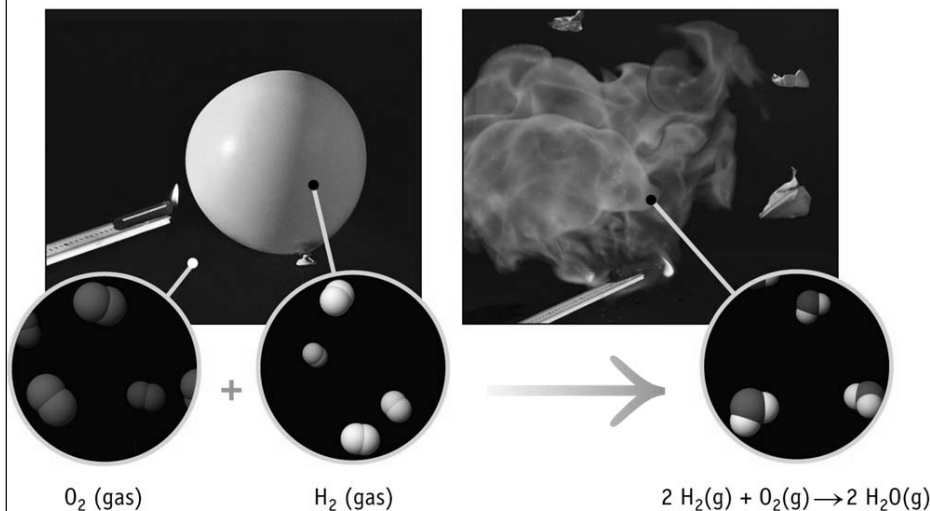
Chemical Reaction: Formation of Water

- 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.



Slide A-24

Chemical Reaction: Formation of Water



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Methane (CH₄) molecule



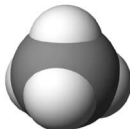
Simple perspective drawing



Plastic model

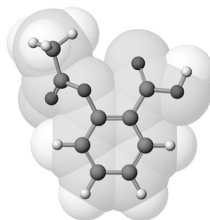


Ball-and-stick model

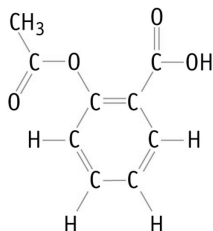


Space-filling model

Aspirin (C₉H₈O₄) molecule

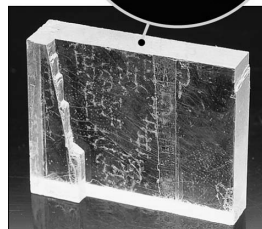
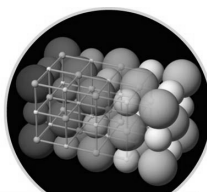


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NaCl crystal

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



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A The elements (lab view)

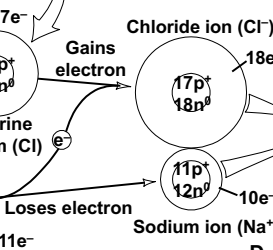
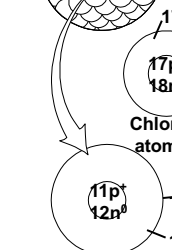
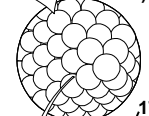


Sodium metal



Chlorine gas

B The elements (atomic view)

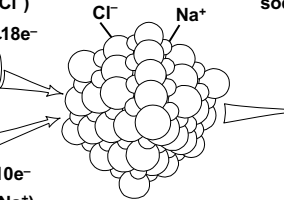
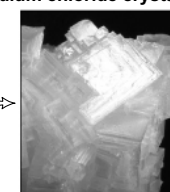


C Electron transfer

NaCl

Elements sodium and chlorine reacting to form an ionic compound

E The compound (lab view): sodium chloride crystal



D The compound (atomic view): Na⁺ and Cl⁻ in the crystal

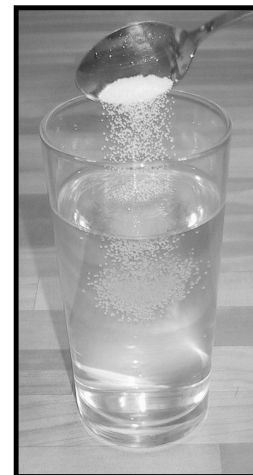
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Atoms, Ions, and Compounds

- **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**.

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Mixtures



Saltwater - homogeneous mixture, also called a solution.



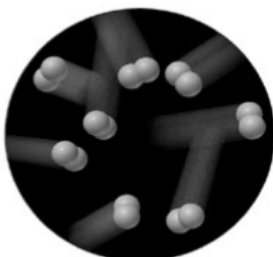
Jar of jelly beans - heterogeneous mixture

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Substances & Mixtures: a particle view



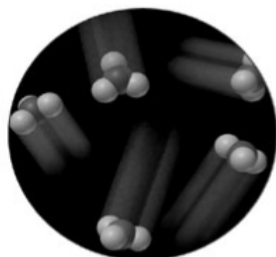
A Atoms of an element



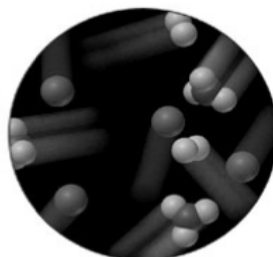
B Molecules of an element

Substances: A, B, C

Mixture: D



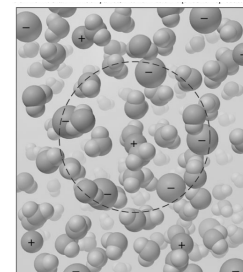
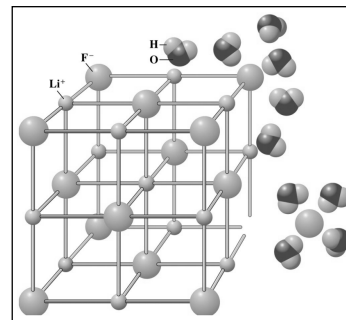
C Molecules of a compound



D Mixture of two elements and a compound

Dissolving Compounds

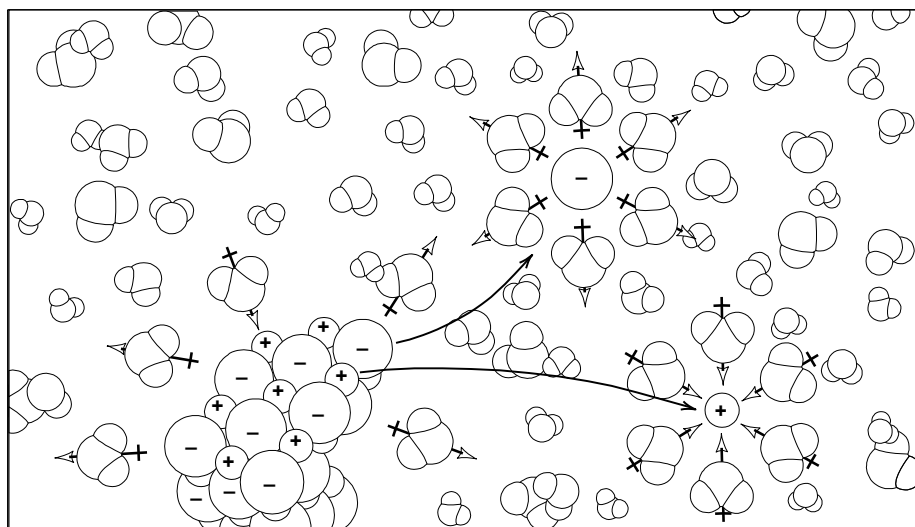
- When ionic compounds dissolve in water, they often dissociate into their individual ions.
- For example, when LiF dissolves in water, there are solvated Li^+ and F^- ions in solution.



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

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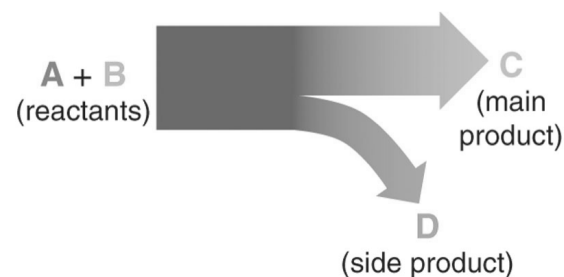
Dissolution of an ionic compound



Slide A-43

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.



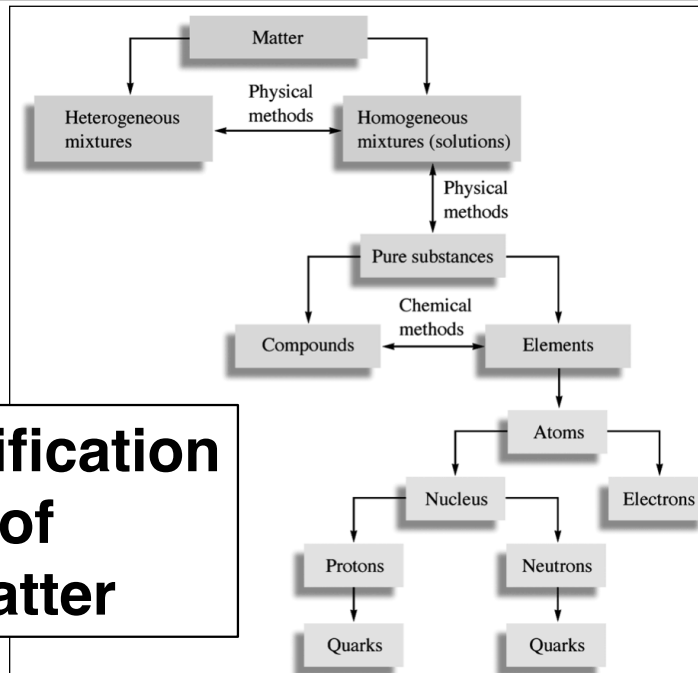
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Separation (& purification) of mixtures

- **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

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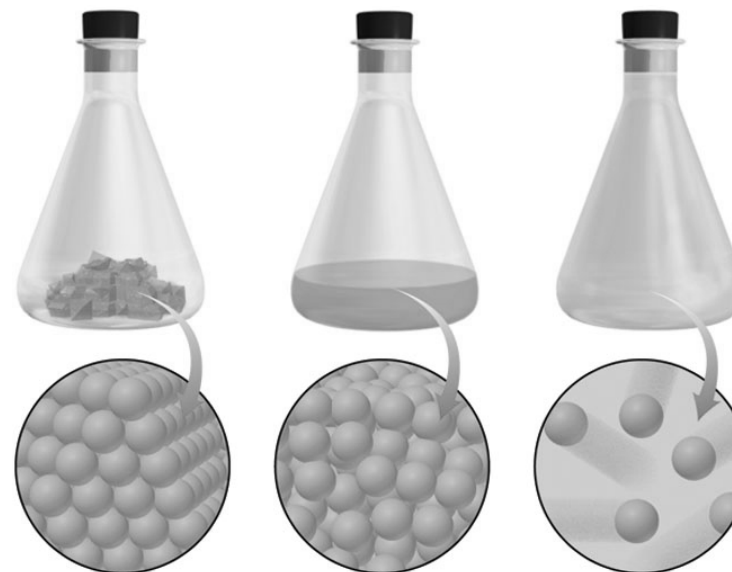
Classification of Matter



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.

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Solid
Particles close together and organized

Liquid
Particles close together but disorganized

Gas
Particles far apart and disorganized

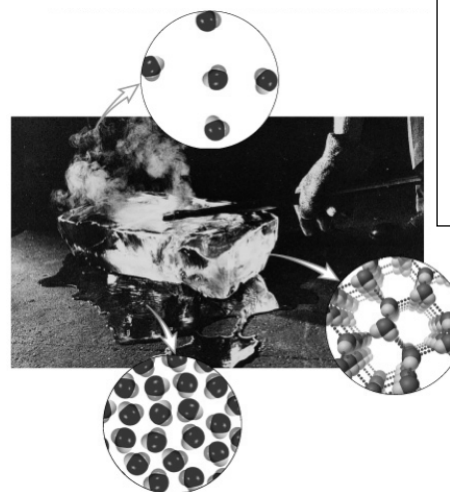
Slide A-48

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.*

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The three states of water.



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Slide A-50

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

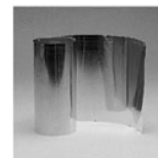
- A characteristic of matter that relates to the reactivity of a substance.
 - Flammability
 - Corrosiveness

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Table 1.1 Some Characteristic Properties of Copper

Physical Properties

Reddish brown, metallic luster



Easily shaped into sheets (malleable) and wires (ductile)

Good conductor of heat and electricity



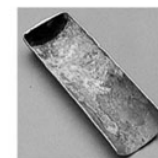
Can be melted and mixed with zinc to form brass

Density = 8.95 g/cm³

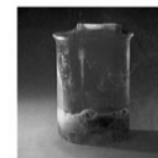
Melting point = 1083°C

Boiling point = 2570°C

Chemical Properties



Slowly forms a basic, blue-green sulfate in moist air



Reacts with nitric acid (photo) and sulfuric acid



Slowly forms a deep-blue solution in aqueous ammonia

Physical Changes

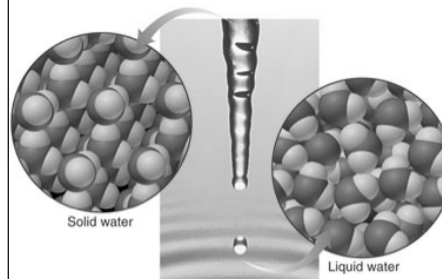
- A change in matter in which the chemical make-up of a substance is not changed.
 - Phase changes (freezing, boiling)
 - Breaking a glass
 - Dissolving a solid.

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.

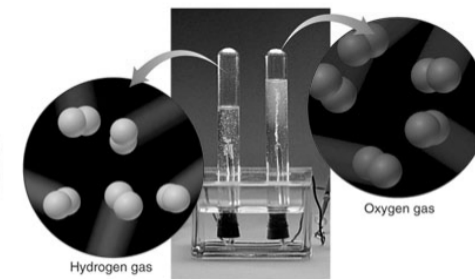
Slide A-53

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.

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