

MINERALS

Mineral Definitions

- Naturally occurring
- Inorganic solid
- Unique set of physical properties
- Specific chemical composition
- Ordered crystalline structure

Elements

- Minerals are composed of **elements**
- An **element** is substance that cannot be broken down by ordinary physical or chemical means
 - Represented by the atom
- The basic atomic structure is the same for all atoms
 - Central nucleus containing one or more protons and neutrons
 - Electrons orbiting the nucleus

Atomic Structure

- Nucleus
 - Composed of protons and neutrons
 - Protons have a positive electrical charge and neutrons do not have any charge
- Electrons, which orbit the nucleus, have a negative electrical charge
 - Electrons orbit the nucleus at such high speeds, they are often visualized as a cloud that surrounds the nucleus

Atomic Structure

The diagram illustrates two models of atomic structure. Model A, the Bohr model, shows a central nucleus containing protons (red spheres with '+ charge') and neutrons (blue spheres with 'no charge'). Electrons (small blue spheres with '- charge') are shown orbiting the nucleus in two distinct energy levels, labeled 'First energy level (shell)' and 'Second energy level (shell)'. Model B, the electron cloud model, shows the same nucleus at the center, but the electrons are represented as a diffuse, blue, cloud-like region surrounding the nucleus. Labels include 'Nucleus', 'Electrons (- charge)', 'Neutrons (no charge)', 'Protons (+ charge)', 'First energy level (shell)', 'Second energy level (shell)', and 'Electron cloud'. A copyright notice at the bottom reads 'Copyright © 2006 Pearson Prentice Hall, Inc.'

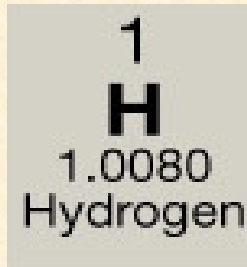
Periodic Table of the Elements

- All of the known elements are organized on a specialized chart known as the periodic table of the elements
- Everything we know to exist in nature is composed of the elements found on the periodic table

The Periodic Table of the Elements

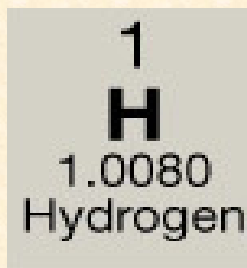
The Periodic Table of the Elements

- The single or double letter in each box (H, in this case) represents the chemical symbol
- The number above the symbol (1, in this case) is the atomic number
- The atomic weight is the number of protons in the nucleus of one atom



The Periodic Table of the Elements

- The number below the symbol (1.0080, in this case) is the atomic weight of the atom
- The name of the element is provided at the bottom of the box



Eight Dominant Elements

- Although many elements are found in various minerals around the world, eight elements make up the majority of all minerals (and thus, rocks) found within the earth
- The eight dominant elements include
 - Oxygen (O)
 - Silicon (Si)
 - Aluminum (Al)
 - Iron (Fe)
 - Magnesium (Mg)
 - Calcium (Ca)
 - Sodium (Na)
 - Potassium (K)

Electron Exchange

- Atoms commonly bond by one of four different methods
 - Ionic
 - Covalent
 - Metallic
 - Van der Waal

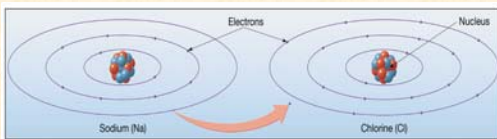
Atomic Bonding

- Atoms naturally bond together to form molecules
- Molecules bond together to form matter (including minerals)
- Atoms commonly bond by a number of different methods

Atomic Bonding

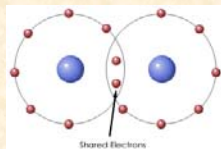
- Ionic
 - The simplest bond
 - The transfer of an electron from one atom to another
- Example: Sodium (Na) and Chlorine (Cl) bond to form NaCl
 - Na has a natural tendency to give an electron and Cl has a natural tendency to accept an electron
 - Once Na gives an electron, it then has one more proton than electron and therefore becomes an ion, specifically a **cation**
 - Once Cl accepts the electron, it becomes an **anion**
 - Since opposite charges attract, the Na bonds with the Cl

Atomic Bonding



Atomic Bonding

- Covalent
 - Two atoms share an electron
 - Can form very strong bonds
- Example: Diamond



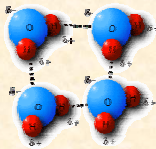
http://www.ider.herts.ac.uk/school/courseware/materials/images/covalent_bonding.gif

Atomic Bonding

- Metallic
 - Atoms that form metals will readily give up one electron and form a positive ion (cation)
 - As a result, a common cloud of shared electrons is formed
 - The shared electrons roam around the cations, holding them in place
 - Allow for properties commonly associated with metals: shiny appearance, conduct heat, conduct electricity, malleable
- Example: Lead, Iron, Gold, Copper

Atomic Bonding

- Van der Waal
 - Weak forces that are found between adjacent molecules, not adjacent atoms
 - **Weak bonds**
 - Forces of attraction that exist between the negatively charged electron cloud of one molecule and the positively charged nucleus of an adjacent molecule
 - Example: Water



Atomic Bonding

- *How atoms bond together to form molecules (and eventually minerals), is important because the way that the atoms bond together will determine the physical properties of the mineral*
- Example: Diamond versus Graphite
 - Both made of carbon (C)
 - Diamond is covalently bonded in all directions where graphite has layers of carbon covalently bonded but these layers are held together by Van der Waal bonds
 - Result: Graphite is much weaker than diamond



<http://www.gemexpert.com/images/400diamondberlitz.jpg>



<http://pydir.demon.co.uk/ja/minerals/pw/graphite1.jpg>

Mineral Properties

- Crystal Form
 - The geometric shape of the crystal
- Color
- Luster
 - How the mineral reflects light
 - Glassy, Dull, Metallic, etc.
- Streak
 - The color of the mineral in powdered form

Mineral Properties

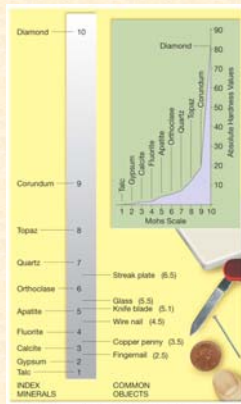
- Streak
 - The color of the mineral in powdered form



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Mineral Properties

- Hardness
 - The resistance of a mineral to scratching
 - NOT the resistance to breaking
 - Classified according to Moh's hardness scale
 - 1 = soft (Talc)
 - 10 = hard (Diamond)



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Mineral Properties

- Cleavage or Fracture
 - The tendency of a mineral to break along planes of weakness
 - Minerals that do not exhibit cleavage will fracture



Mineral Properties

- Specific Gravity
 - Refers to the density of the mineral

Other Mineral Properties

- Magnetism
 - Magnetite
- Smell
 - Sulfur
- Taste
 - Halite
- Effervescence
 - Calcite
- Fluorescence
 - Fluorite



<http://www.mcherry.edu/depts/EAS/courses/east70/minerals/images/Magnetite.jpg>



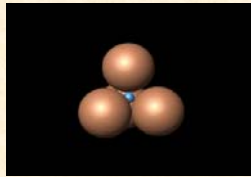
http://www.chemistry.msu.edu/Electromagnetism/fluorescence_rocks.jpg

Classes of Minerals

- **Silicates**
 - Minerals in which silicon and oxygen are chemically bonded to a variety of metallic cations including potassium, sodium, calcium, iron, aluminum, magnesium, and titanium.
- **Non-silicates**
 - Minerals formed without the bonds between silicon and oxygen

Structure of Silicate Minerals

- Every silicate mineral is based on the silicon-oxygen tetrahedron.
- The tetrahedron consists of a single small silicon cation surrounded by four large negatively charged oxygen anions.
- The tetrahedron may link together in a variety of ways to form certain structures.



Silicate Mineral Groups

- Quartz
- One of the most common silicate minerals
- Found in a variety of colors
- Composed chiefly of silicon and oxygen
 - Trace amounts of other elements (impurities) may occur giving quartz different colors



http://mineral.galleries.com/minerals/gemstone/rock_cry/roc-42.jpg

Silicate Mineral Groups

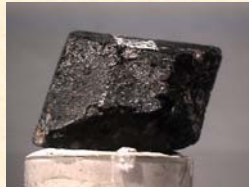
- Feldspars
 - Most common group of silicate minerals
 - Usually found in pink or white colors
 - Composed of Si and O but also relatively large amounts of Na, K, and Al
 - Examples
 - Orthoclase (pictured)
 - Plagioclase



<http://www.mindat.org/gallery.php?min=3026>

Silicate Mineral Groups

- Ferromagnesians
 - Contain lesser amounts of Si and O
 - Little to no Na, K, and Al
 - Abundant Fe and Mg
 - Dark color
 - Examples
 - Pyroxene
 - Amphibole



<http://galleries.com/minerals/silicate/augite/augite.jpg>

Non-silicate Mineral Groups

- Carbonates
 - Common metallic cations like calcium and magnesium are bonded to a combination of carbon and oxygen (I.e., CaCO_3).
 - Example: Calcite



<http://www.marmodelbotticino.it/img/calcite.jpg>

Non-silicate Mineral Groups

- Oxides
 - Metallic cations bonded with oxygen
 - Hematite (Fe_2O_3)
 - Magnetite (Fe_3O_4)
 - Corundum (Al_2O_3)
- Sulfides
 - Metallic cations bonded with Sulfur
 - Galena (PbS)
 - Pyrite (FeS_2)

Non-silicate Mineral Groups

- Sulfates
 - Metallic cations bonded with sulfate ion (SO_4^{2-})
 - Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
 - Anhydrite (CaSO_4)
- Native Elements
 - Gold
 - Silver
 - Copper
 - Sulfur

Importance of Minerals

- Many things that people interact with on a daily basis have their origin with minerals and other resources from the Earth
- Roads, buildings, wires, automobile parts, computers, and jewelry are just a few of the many things which utilize minerals

Importance of Minerals

TABLE 2.1 Common Nonsilicate Mineral Groups

Mineral Groups (by ions) or element(s)	Mineral Name	Chemical Formula	Economic Use
Carbonates (CO_3^{2-})	Calcite	CaCO_3	Portland cement, lime
	Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Portland cement, lime
Halides (Cl^- , F^- , Br^-)	Halite	NaCl	Common salt
	Fluorite (Fluorspar)	CaF_2	Hydrofluoric acid production, steelmaking
	Sylvite	KCl	Fertilizer
Oxides (O^{2-})	Hematite	Fe_2O_3	Ore of iron, pigment
	Magnetite	Fe_3O_4	Ore of iron
	Corundum	Al_2O_3	Gemstone, abrasive
	Ice	H_2O	Solid form of water
Sulfides (S^{2-})	Galena	PbS	Ore of lead
	Sphalerite	ZnS	Ore of zinc
	Pyrite	FeS_2	Sulfuric acid production
	Chalcopyrite	CuFeS_2	Ore of copper
	Cinnabar	HgS	Ore of mercury
Sulfates (SO_4^{2-})	Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	Plaster
	Anhydrite	CaSO_4	Plaster
	Baryte	BaSO_4	Drilling mud
Native elements (single elements)	Gold	Au	Trade, jewelry
	Copper	Cu	Electrical conductor
	Diamond	C	Gemstone, abrasive
	Sulfur	S	Sulfur drugs, chemicals
	Graphite	C	Pencil lead, dry lubricant
	Silver	Ag	Jewelry, photography
Platinum	Pt	Catalyst	

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