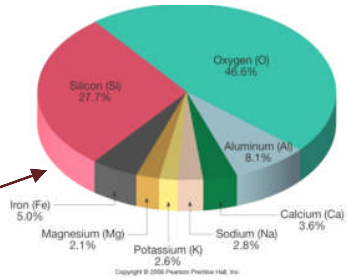
Chapter Outlines

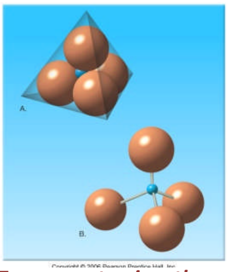
NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>



Breakdown of elements in Earth's crust

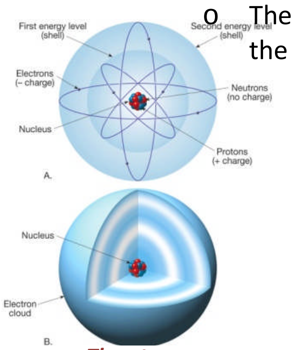
Minerals

- Minerals are the building blocks of Earth. A **mineral** is a combination of one or more elements that forms an **inorganic**, **naturally occurring crystalline solid** of a **definite chemical structure**. A **rock** is a solid material that is composed of various minerals *(with just a couple exceptions).*
  - There are over 4,000 identified minerals. Only 100 are common, 50 more are occasional, and the remainder are rare. AND, only ±20 minerals form the majority of all rocks *(the rock-forming minerals).*



Two ways to view the silicon-oxygen tetrahedron

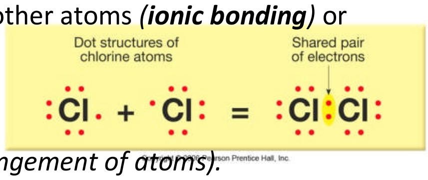
  - A mineral's chemistry and the architecture of its internal structure determine the physical properties used to distinguish it from other minerals.
  - Minerals are composed of one or more **elements**. Elements cannot be broken down by ordinary chemical methods, and are displayed in the periodic table. **Eight elements** compose 98% or Earth's crust: **O** (oxygen), **Si** (silicon), **Al** (aluminum), **Fe** (iron), **Ca** (calcium), **Na** (sodium), **K** (potassium), **Mg** (magnesium). At 46%, oxygen is the most abundant and an important part of most common minerals. The combination of oxygen and silicon *(the **silicon-oxygen tetrahedron**, SiO_4)* is the building block of the **silicates**, the largest mineral group.



The atom

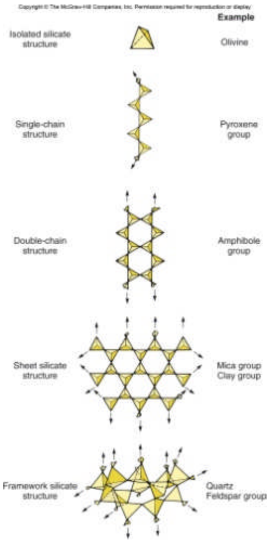
  - The basic building block of an element is the **atom**. An atom is the smallest particle that contains the identity of that element. Notes on atoms…
    - Each contains a **nucleus** *(extremely small compared to overall size of the atom)* made of protons *(+ charge)* and neutrons *(zero net charge).*
    - Each contains **electrons** *(- charge, and extremely small in mass)* existing in different energy levels ***(shells)*** around the nucleus. These are somewhat similar to orbits.
    - The number of protons determines the name of the atom *(element)* and is its '**atomic number'**. **Atomic mass** is the total number of protons and neutrons in an atom's nucleus.
    - An atom becomes an '**isotope'** of that element when neutrons are gained or lost and no longer equal the number of protons.
      - **Stable isotopes** retain their protons and neutrons through time.
      - **Unstable isotopes** spontaneously lose protons and/or neutrons over time.
    - An atom is naturally electrically neutral. If an atom *(or group of atoms)* takes on an electrical charge by losing or gaining electrons, it then becomes an **'ion'.**
    - Atoms bond to other atoms *(chemical reaction)* as a result of a partially filled outer shell ***(valance shell)***. A full valence shell is most stable. Atoms can obtain a full outer energy level *(valence shell)* by either exchanging electrons with other atoms ***(ionic bonding)*** or sharing electrons *(**covalent and metallic bonding**).*

Ionic bonding



Covalent bonding

  - Minerals can have a variety of crystalline shapes *(regular 3-D arrangement of atoms).* The shape of the crystal is dependent on the sizes of the atoms of the mineral, the chemical bonds that hold the atoms together, and the pressure and t° at which the mineral formed. Minerals form under a wide variety of condition from deep in Earth's interior, the ocean and ocean floor, and even at Earth's surface.
  - The two major mineral families are the **silicates** and **non-silicates**
    - Silicates are all built around the silicon-oxygen tetrahedron (SiO_4^{-4}). When alone, it is known as **silica** (SiO_2, or quartz). Joining of the tetrahedrons using various crystalline structures produces five major 'groups' of silicate minerals. And, substitution of atoms of various elements *(cations)* in the structure makes the various individual unique minerals within each group.



Silicate structures

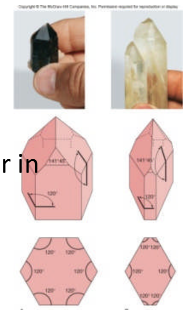
- Five main silicate mineral groups are:
  - **Olivine** group *(tetrahedrons are '**isolated**', no shared oxygens).*
  - **Pyroxene** group *(tetrahedrons are in '**chains**', each sharing one oxygen).*
  - **Amphibole** group *(tetrahedrons are in '**double chains'**, each sharing two oxygens).*
  - **Mica** group *(tetrahedrons are in '**sheets**', each sharing three oxygens).*
  - **Quartz** & **Feldspar** group *(tetrahedrons are in a '**framework**', each sharing four oxygens).*

Open pit copper mine in Utah

- Main non-silicate mineral groups are *(with an example of each):*
  - **Carbonate** group (calcite, $CaCO_3$)
  - **chloride** group (halite, NaCl)
  - **Sulfide** group (pyrite, FeS_2)
  - ***Sulfate*** *group (gypsum, $CaSO_4{\cdot}H_2O$)*
  - ***Oxide*** *group (hematite, Fe_2O_3)*
  - ***Native elements*** *(gold - Au, silver – Ag, diamond – C, etc.)*

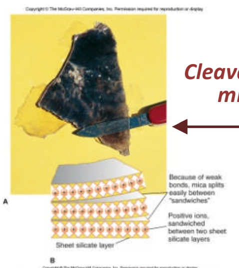
- Some minerals can show variations in their composition when atoms of similar size and charge substitute for each other in the formula *(in the crystalline structure).*

- Some minerals have exactly the same composition but different crystalline structure due to formation in differing environments. These are called **polymorphs**.



Crystal form of quartz

- The properties of a mineral can be used to identify a mineral. It is not always possible to identify a mineral without additional laboratory work.
  Mineral properties include:
  - **Color** – the visible hue of a mineral. Color can be misleading, but generally lighter in minerals with more silica and darker in minerals with more iron and magnesium.
  - **Streak** – color of the mineral in powder form left on a streak plate.
  - **Luster** – examples: glassy, vitreous, metallic, earthy.
  - **Hardness** – scratch resistance. Use Moh's hardness scale (talc = 1, diamond = 10).
  - **External Crystal form** – the result of its internal arrangement of atoms *(often not obvious).* This consists of a set of crystal faces *(external geometric form)* unique to a mineral.
  - **Cleavage –** tendency to break along preferred planar fractures *(this may be different from crystal form).* Cleavage planes are always parallel to a crystal face.
  - **Fracture** – breakage which is not controlled by cleavage. Examples are: conchoidal, irregular.
  - **Specific gravity *(density)*** – can be measured accurately, or estimated *(how heavy it feels).*
  - **Magnetism** – attracted to a magnet .
  - **Chemical reaction** –an example is the bubbling of weak hydrochloric acid indicating the presence of $CaCO_3$.
  - Many other **'special properties'** exist: smell, taste, double refraction, etc.



Cleavage of mica

Conchoidal fracture.

Glass has conchoidal fracture.

Cleavage of halite

- **Ore minerals** are those from which useful materials can be mined profitably. Most ore minerals are from the non-silicate group.

- Mineral formation can take place under many conditions:
  - During cooling of magma.
  - Precipitation from sea water resulting from evaporation of seas millions of years ago *(or in evaporating seas and gulfs today).*
  - Biological activity such as coral reefs.
  - Transformation of existing mineral resulting from weathering or increased heat & pressure.