CHAPTER 5 - ATOMS TO MINERALS

I. Matter

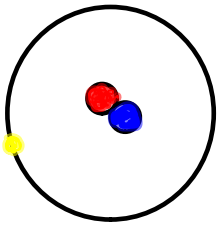
A. Matter is anything that has mass and occupies space. Periodic Table pg 698-699

B. All matter is made from elements.

1. There are 92 naturally occurring elements found as part of the earth.
2. There are over 100 elements known to man. 93 and above are man-made and also radioactive
3. The 92 naturally occurring elements can combine in thousands of ways.

C. The smallest unit of an element that still maintains all the characteristics of that element is an atom.

1. An English chemist, John Dalton, formulated the modern particle model - the concept that each element is made up of tiny particles, all alike, called atoms. The three most important parts of the atom are the proton, the neutron, and the electron.
2. The electrical properties of an atom determines how it behaves and reacts with other elements.

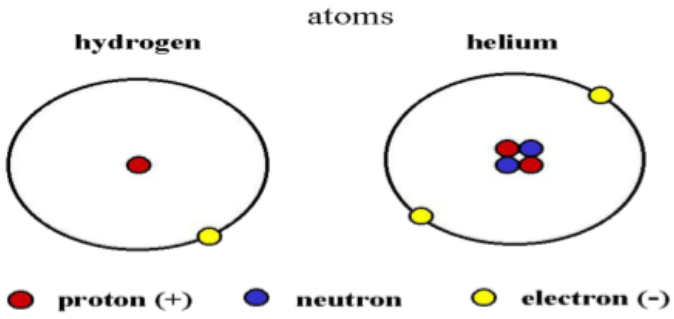


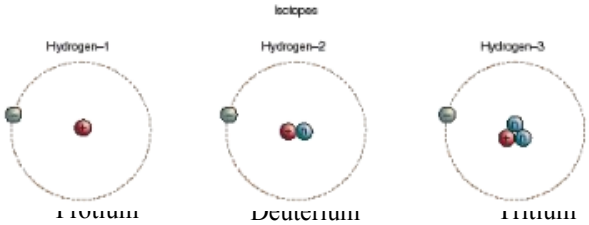
a. Protons have a positive electric charge.

b. Electrons have a negative electric charge.

c. Neutrons have no electric charge.

3. The modern theory or mental model of an atom states that protons and neutrons are grouped together in the nucleus or center of an atom. Electrons orbit around the nucleus at different distances from the core.
   a. The area where each electron is normally found is called an energy level.
   b. Together all the energy levels are called an electron cloud.
4. Each element is made of atoms having the same number of protons. The number of protons in the atoms of an element is unique to that element.
   a. The number of protons in an atom is referred to as the atomic number.





c. The mass of an atom can be calculated by adding the number of protons and neutrons together. The sum of protons and neutrons is called the mass number.

1. Protons have a mass of 1 AMU and neutrons have a mass of 1 AMU. AMU stands for Atomic Mass Unit.

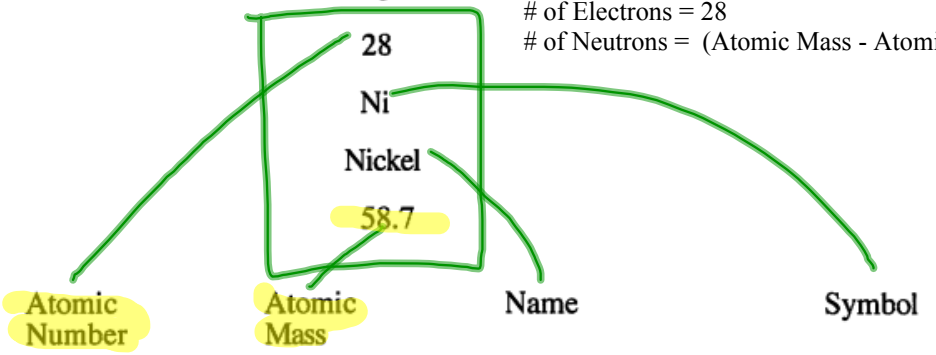
2. Electrons are so small that their mass is not counted when calculating mass.

D. The Periodic Law - When the blocks are arranged on a chart in order of increasing atomic number we find that as you move across the chart the average size of the atom and its isotopes increases and that atoms of similar properties fall together in groups. Information about the elements has been compiled on a table called the periodic chart.

1. Each block on the chart contains the information about one element.

2. The chart is read in the following manner.

# of Protons = 28
# of Electrons = 28
# of Neutrons = (Atomic Mass - Atomic Number) 31

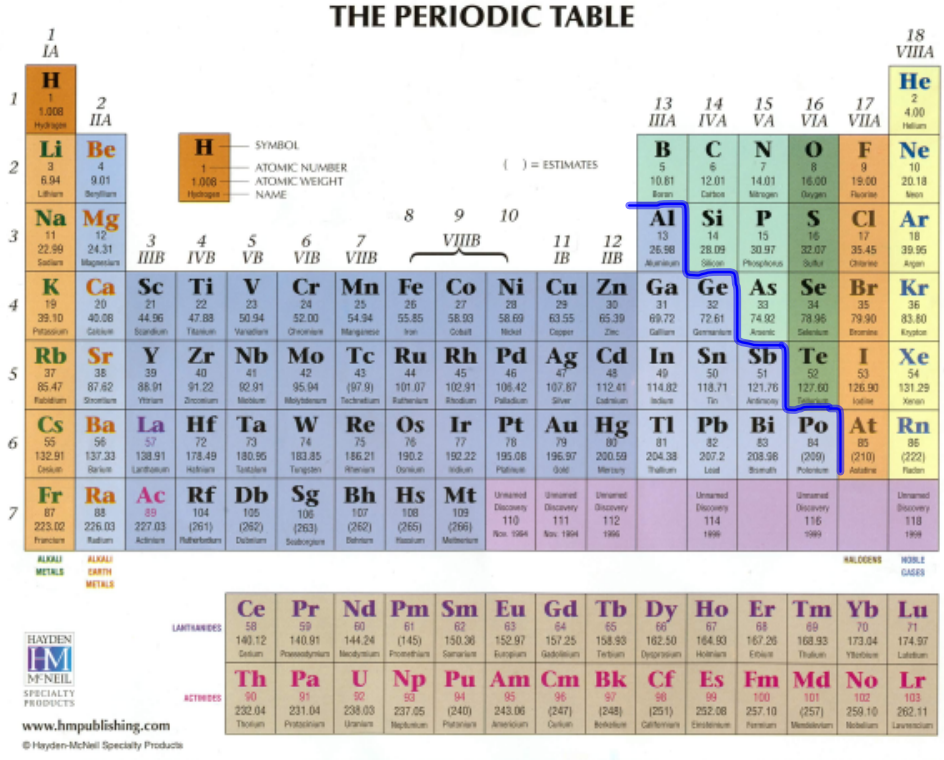


Atomic Number = # of protons

Atomic Mass = average mass of the element and all isotopes.

3. A horizontal row of blocks is called a period or series. The period number is also the same number of energy levels for an atom.

4. A vertical column is called a family.


THE PERIODIC TABLE
1 IA
18 VIIIA
2 IIA
13 IIIA
14 IVA
15 VA
16 VIA
17 VIIA
3 IIIB
4 IVB
5 VB
6 VIB
7 VIIB
8 9 10 VIIIB
11 IB
12 IIB
H
1
1.008
Hydrogen
SYMBOL
ATOMIC NUMBER
ATOMIC WEIGHT
NAME
( ) = ESTIMATES
ALKALI METALS
ALKALI EARTH METALS
HALOGENS
NOBLE GASES
LANTHANIDES
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E. Compounds, Mixtures and Solutions

1. Chemical Compounds - When atoms of different elements chemically combine and form a new type of matter it is a chemical compound. The new compound has properties different than those of the atoms that make it up.

   a. Molecule - The smallest unit of a chemical compound that maintains all the properties of that compound.

   b. Water is an example of a chemical compound. H_2O = 2 Hydrogen atoms and 1 oxygen

   c. When elements combine together chemically, they form bonds. If electrons are shared between two or more elements in a compound, a **covalent bond** is formed (Covalent compounds). If electrons are gained or lost between elements, an **ionic bond** is formed (Ionic compounds).

2. Mixtures are physical combinations of matter. In a physical combination of matter the individual substances mixed do not lose their individual properties.

   a. Unlike a compound, a mixture does not contain specific amounts of each element.

   b. Elements in a mixture can usually be separated without difficulty (Exception-solid mixtures). Concrete= gravel / cement

   c. Sand and salt mixed to be spread on a snow covered road do not lose their individual properties, the salt remains salt and the sand remains sand.

3. Solutions are a kind of mixture in which one substance is dissolved in another. The most common type of solution is a solid dissolved in a liquid.

   a. The dissolved substance is evenly distributed throughout the solution. EXAMPLE: Salt and water.

   b. Dissolved substances cannot easily be separated out in a solution.

F. Chemical and Physical Properties

1. Chemical Properties are those properties which determine how an atom or molecule behaves in the presence of other atoms or molecules.

   a. The arrangement of the electrons in an atom or molecule is the most important factor for determining how an atom or molecule will react in the presence of other atoms or molecules.

   b. An ion is an atom that has a different number of electrons than protons giving it a positive or negative electric charge. An atom with more protons than electrons has a positive charge. An atom with more electrons than protons has a negative charge.

   c. A metal is an element that loses electrons easily to form positive ions. A nonmetal is an element that gains electrons easily to form a negative ion.

NaCl = table salt

Salad

PiggyBank

Chocolate Chip Cookies

Quik Powder / Milk

Koolaid / Sugar / Water

Mineral Identification

2. Physical Properties - are properties which can be measured. Length, width, height, speed, color, luster, malleability, and conductivity, are all physical properties.

II. Minerals

A. Rocks of the Earth are made up of one or more minerals. There are some 3000 [redacted] different types of minerals.

1. Minerals can best be described by five key characteristics:

a. All minerals are solid.

b. All minerals are found naturally as part of the Earth. No man-made

c. The substances that make up minerals were never part of a living thing; they are inorganic substances.

d. Each kind of mineral has a definite chemical composition. Quartz is SiO_2, meaning it is composed of one atom of Silicon and 2 atoms of Oxygen. This does not vary where ever Quartz is found.

e. The atoms of minerals are connected to one another in an orderly, repetitive arrangement. This characteristic is known as crystal shape. Some elements or compounds have more than one arrangement of atoms. This can lead to the same element or compound appearing as a different mineral. For example, the mineral graphite is composed of pure carbon. A diamond is also made of pure carbon. These two minerals made up of the same element are very different because of their crystal shapes. Carbon atoms in graphite are arranged in thin sheets held by weak bonds. Carbon atoms in a diamond are arranged in 3-dimensional shapes with very strong bonds.

2. The Earth crust is composed of elements which in turn make up minerals. The eight most abundant Earth elements are listed in order from largest to smallest.

NAME	SYMBOL	% OF CRUST
		Silicates ~75 %
Oxygen	O	46.60%
Silicon	Si	27.72%
Aluminum	Al	8.13%
Iron	Fe	5.00%
Calcium	Ca	3.63%
Sodium	Na	2.82%
Potassium	K	2.59%
Magnesium	Mg	2.09%
		98.58%

All other elements make up less than 1.5% of the Earth crust

All the other 84 elements on the periodic table

Time / Space

Crystallization = mineral crystals grow

outside Earth

Lava vs. Magma

inside Earth

2. Minerals are thought to form by one of three different means.

   a. **The Magma Process:** Minerals form from molten rock, called **magma**, which if found beneath the Earth's surface. As the magma cools down, mineral crystals begin to grow. How fast magma cools will determine the size of the mineral crystals. The longer magma has to cool, the larger the crystals will grow. The shorter the time that magma has to cool, the smaller the crystals will grow.

   b. Minerals are also thought to form from a hot water (hydrothermal) solution. **Black Smokers** on the ocean floor pump hot mineral-rich water out of volcanic cracks into the sea and the black mineral "smoke" blankets the ocean floor around the vents. These layers of mineral build up and are compressed over time into some of the most precious of metals and minerals.

   c. **The Pressure Process:** Minerals can form when a rock is subjected to high temperature and pressure, The minerals can begin to break down chemically. The temperature and pressure becomes great enough to change the minerals iin a solid state, without melting them. The free atoms, ions, and molecules recombine in new ways, forming new minerals. More growth occurs in directions away from the pressure.

B. Of the more than 3000 minerals discovered thus far, only about 20 make 95% of the Earth crust. These minerals are known as the rock-forming minerals because almost all of the rocks of the crust contain at least on of the these 20 minerals.

II. Mineral Identification

A. The 8 most common properties used to identify minerals are:

1. **LUSTER:** Luster is the way a mineral reflects light. There are two different classifications of luster:

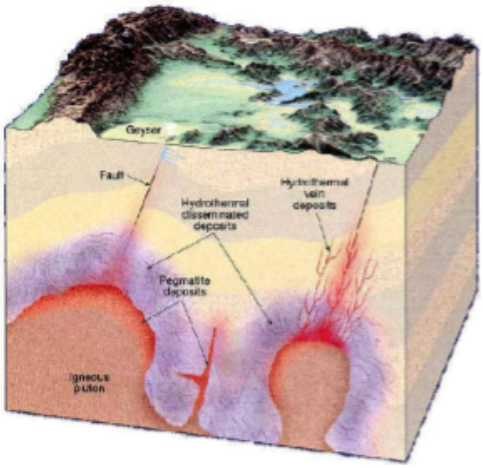
   1. **METALLIC-** reflects light like a metal. Brassy, gold or silver
   2. **NONMETALLIC-** does not reflect light like a metal.

2. **STREAK:** Streak is the color of the mineral's powder. Streak can be found for mineral's with the hardness of less than five by rubbing them on an unglazed porcelain tile.

3. **COLOR:** The color is simply the color of the mineral. It must be remembered that some minerals have the same color but minerals can occur in more than one color. Last resort - do not rely on

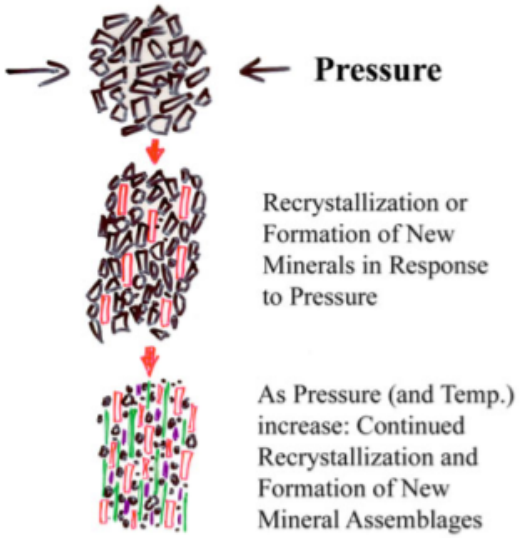
4. **HARDNESS:** Hardness is what a mineral will scratch or what will scratch a mineral. Hardness is reported by using the Moh's Hardness Scale. On this scale, ten reference minerals are arranged in order of their increasing hardness. Each mineral is given a number between one and ten. Each reference mineral will scratch any mineral with a lower number on the Moh's Hardness Scale. The hardness of the mineral is found by scratching its edge against a reference mineral. The reference minerals are:

Mineral formation from magma



Black Smokers

Mineral formation from pressure



Mineral Growth under Stress

Moh's Hardness Scale of Minerals

1.	**TALC** Softest	6.	**ORTHOCLASE**
2.	**GYPSUM**	7.	**QUARTZ**
3.	**CALCITE**	8.	**TOPAZ**
4.	**FLUORITE**	9.	**CORUNDUM**
5.	**APATITE**	10.	**DIAMOND** Hardest

If these minerals are not available, simple tests can be run on hardness by using common objects each having known hardness, such as:

1. SOFT, GREASY, FLAKES ON FINGER
2.5 FINGERNAIL
3.5 COPPER
4. NAIL
5.5. GLASS PLATE
6.5 STEEL FILE
8. SCRATCHES QUARTZ

NO APPROXIMATIONS ABOVE 8

5. **CRYSTAL SHAPE:** Crystal shape refers to the one of six basic shapes that crystals in a mineral can be. The six crystal shapes are : (Refer to Table 5-2)

1.	**CUBIC**	4.	**ORTHORHOMBIC**
2.	**TETRAGONAL**	5.	**MONOCLINIC**
3.	**HEXAGONAL**	6.	**TRICLINIC**

6. **CLEAVAGE OR FRACTURE:** Cleavage or fracture refers to the way a mineral breaks. Cleavage refers to a mineral breaking, with a regular, definite shape, usually along flat surfaces or angled sides. Fracture refers to breakage along an irregular surface. The surface may be rough, conchoidal (conic shaped patterns), or jagged edges.

7. **SPECIFIC GRAVITY:** Specific gravity is the comparison of the density of a mineral to the density of water. For example, silver is 10.5 times more dense than water. Water has a specific gravity of 1, therefore, silver has specific gravity of 10.5. 1 cubic centimeter of water = mass of 1 gram

8. **SPECIAL PROPERTIES:** Special properties are properties which are unique or out of the ordinary. For example, the fibrous cleavage of asbestos, the fact that calcite will fizz when it comes in contact with hydrochloric acid, sulfur has a distinct odor, and halite has a salty taste.

B. All minerals can be classified as being part of one of two main Mineral Groups. The minerals are further classified into families based upon the elements that they contain. The two main groups are **SILICATE & NONSILICATE** minerals.

1. **Silicates:** Minerals made up of oxygen (O), silicon (Si), and some other element of elements. Silicates are common because silicon and oxygen are the two most common elements. Examples: Quartz (SiO_2), Feldspars

   Silicates can be further classified based on element content:

Olivine: $Si(Fe, Mg)_2O_4$

   a. **Ferromagnesian Silicate-** Silicates that also contain Iron (Fe) and Magnesium (Mg) as well as silicon and oxygen Dark colored

Quartz: SiO_2

   b. **Nonferromagnesian Silicate** - Silicates that do not contain Iron and Magnesium as well as silicon and oxygen. Light Colored

2. In addition to the Silicate group of minerals, there is a second main group of minerals known as the **Nonsilicate** minerals. The nonsilicates can be divided into five families.

   a. **Oxides-** Minerals made up of Oxygen (O) and some other element or elements excluding Silicon (Si) and Carbon, Sulfur and any of the Halide elements (Chlorine (Cl), Fluorine (F), or Bromine (B)).
   Example: Magnetite (Fe_3O_4), Limonite (Fe O)

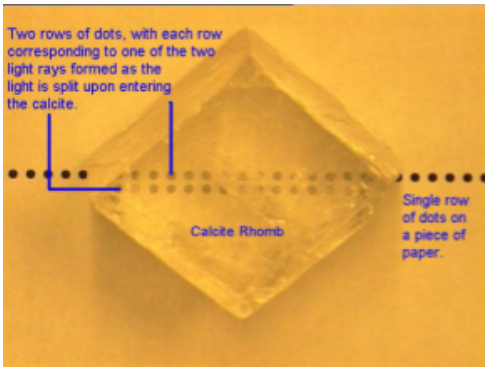
   b. **Sulfides-** Minerals made up of Sulfur (S) and some other element or elements excluding Oxygen (O), Silicon, Carbon (C), or Halide elements. (O).
   Example: Galena (PbS)

   c. **Halides-** Minerals made of combinations of Chlorine (Cl), Fluorine (F), and Bromine (Br) excluding Oxygen (O), Silicon (Si), Sulfur (S), or Carbon (C). Example: Halite (NaCl). Fluorite CaF_2

   d. **Sulfates-** Minerals made up of Sulfur (S) and four Oxygen atoms. Excluding Silicon, Carbon (C), or Halide elements.
   Example: Gypsum ($CaSO_4$) only one in your box

   e. **Carbonates-** Minerals made up of Carbon (C) and three Oxygen atoms. Excluding Silicon (Si), Sulfur(S) or Halide elements.
   Example: Calcite ($CaCO_3$) Dolomite $CaMgCO_3$

   f. **Native Elements-** Mineral that are made up of only a single element.
   Example: Gold (Au), Copper (Cu), Graphite (C). Sulfur - S


Two rows of dots, with each row corresponding to one of the two light rays formed as the light is split upon entering the calcite.
Calcite Rhomb
Single row of dots on a piece of paper.

Attachments

black_smoker.mov