

Mineral lectures

S = slide

S1

Why study minerals?

- Minerals present in a rock help to define the rock and how the rock formed
- Minerals and the rock cycle are used to determine conditions and processes in plate tectonics
- Minerals help to understand how the Earth and planets formed

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How to study minerals

- What makes a mineral – the chemistry of the mineral
- Mineral properties – how they are related to chemistry and how they are used to identify the mineral
- Classification and abundance on Earth

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Definition of a mineral

- A geologist defines a mineral as 'any naturally occurring inorganic solid that possesses an orderly crystalline structure and a well-defined chemical composition'.
- A rock is not a mineral but a mass of minerals or pre-existing rock that occurs naturally as part of the Earth. Some rocks may be composed of all one mineral such as limestone (calcite) and others of many minerals.

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- What is 'an orderly crystalline structure and a well-defined chemical composition'?
- Need to start with the elements that make up the mineral.

An element is a substance that cannot be broken down into simpler substances by physical or chemical means.

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Periodic Table of the Elements

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- In the Periodic Table the elements can be ordered into rows so that those elements with similar properties are in columns.
- An atom (a = not, tomos = cut) is the smallest particle of matter that retains the essential characteristics of an element.
- The atoms are combined to form chemical compounds.

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Atoms

- An atom is made up of three parts: protons, neutrons and electrons.
- The nucleus, or central region, contains the protons and neutrons. Both protons and neutrons have the same mass but protons have a positive charge and neutrons do not have a charge (neutral).
- Orbiting outside of the nucleus are the electrons. The electrons have a negative charge and very little mass (almost no mass). The electrons are often shown orbiting the nucleus like planets around the sun but they tend to move in regions called principal shells or energy levels. Each shell or energy level can hold a specific number of electrons. The outermost shell is the valence shell and these are the electrons involved in chemical bonding.

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Three parts of an atom

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Chemical Compounds

- When elements join together to form chemical compounds the forces holding them together are electrical. The chemical bonding changes the electron configuration of the bonded atoms.
- When the valence shell does not contain the maximum number of electrons the atom is likely to chemically bond with one or more atoms.

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Ionic bonds

- Ionic bonds; the transfer of electrons may be the easiest to visualize. Elements in column one transfer their single outer electron to elements in column seven to form stable outer shells for both elements.
- The electrically charged particles are called ions. Negative and positive charged particles attract, therefore, an ionic bond is the attraction of oppositely charged particles to form an electrically neutral compound.

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Covalent Bonds

- Covalent bonds are where two or more elements share electrons such as when chlorine shares an outer electron to form Cl_2 , a gas. The same bonds are found in H_2

and O₂, this bond consists of elements sharing an electron rather than transferring it. Another common covalent bond is SiO₂, where silica with 4 outer electrons, shares electrons with oxygen with 6 outer electrons. *Covalent bonds tend to be stronger than ionic bonds*

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Other bonds

- Some chemical bonds are hybrids of the ionic and covalent bonds and in some compounds both types of bonds are present. In the metallic bond the electrons from the outer shell tend to migrate between atoms of the same element. The bond creates the high electrical conductivity of metal and is responsible for some of the other properties such as tenacity.

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Ions & Isotopes

- The number of protons in the nucleus defines an element
- The outer electrons are involved in chemical reactions
- Neutrons have the same mass as protons
- The mass number of the element is the sum of the mass of protons and neutrons in the nucleus
- An isotope is an element with a different number of neutrons.

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Isotopes

- Isotopes are chemically similar within an element.
- Different isotopes can be found in the same mineral.
- The nuclei of most isotopes are stable but those that are not are called radioactive.
- Radioactive isotopes 'decay' to produce stable elements through a process called radioactive decay.
- During this process the unstable atom radiates energy and emits particles at a regular rate.
- The energy released includes heat and the rate can be measured to calculate the age of the mineral or rock.

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- The regular mineral structure is determined by how the chemical bonds, mainly ionic or covalent bonds

- The well-defined composition is determined by the elements the form the mineral. In some minerals there is often a substitution of ions, such as Mg and Fe or K and Na

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Bonding and Mineral Properties

- Ionic bonds tend to break easier than covalent bonds

- Cleavage – breakage along a plane
- Hardness – the resistance to breaking
- Tenacity – how the mineral breaks

S17
Hardness

S18
Cleavage planes

S19
Cleaved Mica

S20
Fracture

S21
Chemical composition and Mineral Properties

- Minerals that always have the same composition usually always have the same color and streak
- Minerals that tend to have trace amounts of another ion in their structure tend to have a variety of colors

S22
Streak

S23
Color

S24
Luster

S25
Abundance of elements on Earth

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•Oxygen is the most abundant element followed by silicon – most abundant mineral class is made of silicon and oxygen with varying amounts of the other abundant elements

•Silicon and 4 oxygen ions combine to form a tetrahedron and these tetrahedrons can combine with other ions or share an oxygen ion – silicate minerals

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Silica Tetrahedron

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Silica Polymerization

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Silicate minerals

- Silicate minerals can be found in all 3 rock groups. They are the most abundant type of mineral in igneous and metamorphic rocks.
- In sedimentary rocks silicate minerals are important but other mineral groups are as abundant.

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Mineral Groups

- Halides have ionic bonds between the first and seventh columns of the periodic table and are associated with sedimentary rocks
- Carbonates are composed of CO_3 groups that bond with Ca and can bond with Mg, Fe, and Mn and usually are sedimentary or metamorphic rocks
- Sulfates are composed of SO_4 groups that bond with Ca and other ions, they tend to be found sedimentary rocks

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Mineral Groups

- Oxides are minerals that have a bond with oxygen ions and can be found in all rock types
- Sulfides are minerals that have a bond with sulfur and are often associated with igneous rocks and ore bodies
- Native elements are composed of the same element such as gold, silver, or diamond

Important Concepts/Potential Questions

1. What is the definition of a mineral?
 2. What is an atom and what are the three main components of an atom?
 3. What is a silica tetrahedron?
 4. What is silica polymerization? Give examples.
- % What is the difference between a reserve and a resource?