REMINDERS

Computer Resources

- Class website -- provides syllabus and power points
  - (http://www.uh.edu/~geos2j/physical.htm)
  - Username: geology
  - Password: geology
- Blackboard – provides streaming video of some lectures, sample quizzes, Geode guided learning exercises.. To access Blackboard, log into AccesUH using your Cougarnet ID and password!!!

UH Email

- I am required to use the UH email if I want to send a message to you about the class. Please log into AccessUH and forward your @uh.edu email to an email address you read daily.
- My class emails are often rejected as spam since they are sent to over 100 students, please add my email to your list of contacts.

Chapter 3
Matter and Minerals

What is a mineral?

By definition a mineral ____.

1. is naturally occurring

- does not include synthetic gems, cast iron, or cement

2. is solid

- does not include oil or liquid water

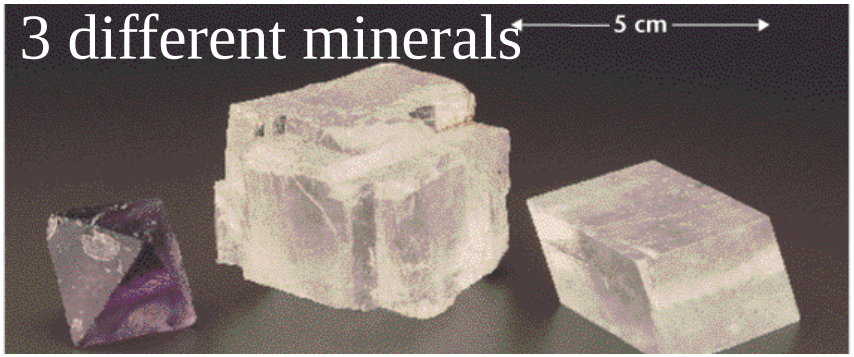
3. is generally inorganic

- includes the mineral calcite that composes shells and reefs secretions by marine life
- does not include coal which is composed of plant debris

4. has an orderly (crystalline) internal structure

- does not include amorphous phases so opal and glass not minerals

5. has a definite chemical composition

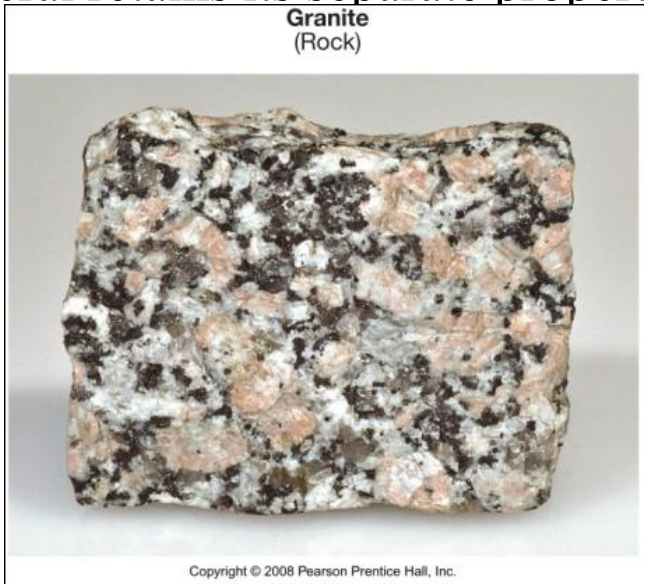


Minerals in a vitamin pill or cereal are different from geologic minerals

- Often in pills they are single elements (not minerals)
  - For example calcium (Ca), zinc (Zn), iron (Fe)
- Often elements in pills are chemically extracted from mineral and then added to the vitamin or cereal.
- Often the mineral calcite ($CaCO_3$) is added to cereal for calcium.

What is a rock?

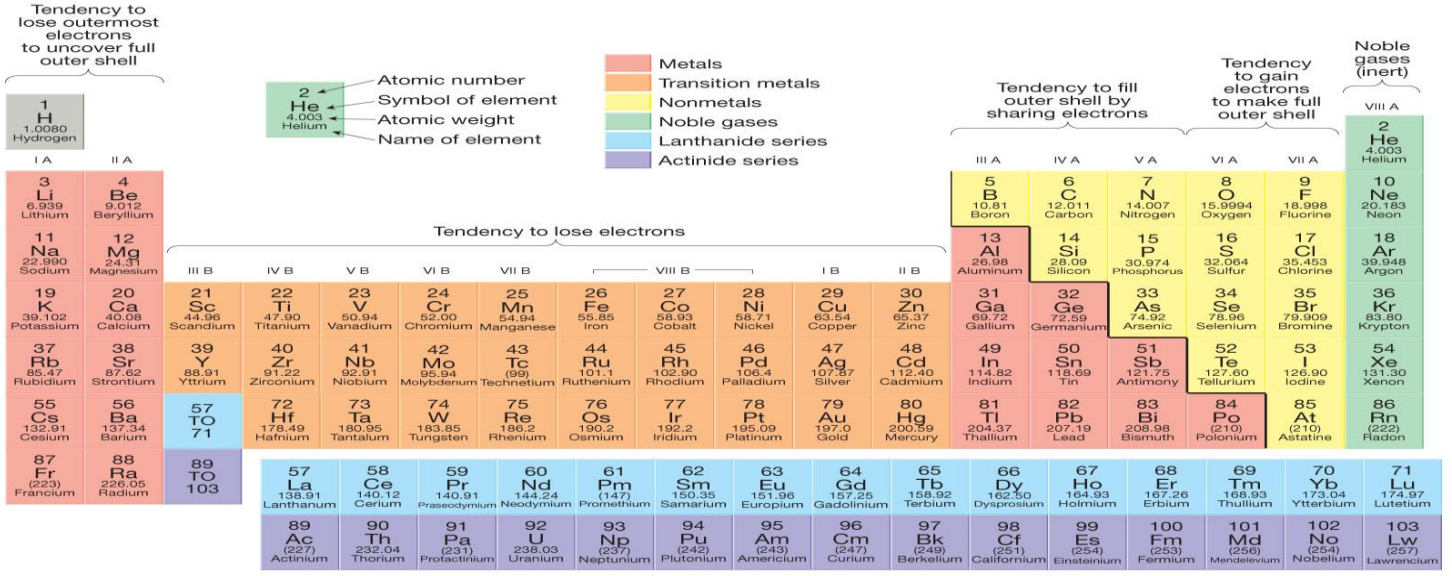
- A rock is a naturally occurring solid of mineral or mineral like matter
  - Not mine sledge or cement
  - Coal is a rock even though it is not a mineral
    - (composed of compacted plant material = mineral like matter)
- a rock can be composed of one mineral or an aggregate of mineral
    - (each mineral retains its separate properties)




Granite (rock)
Quartz (mineral)
Hornblende (mineral)
Feldspar (mineral)

Minerals are composed of elements

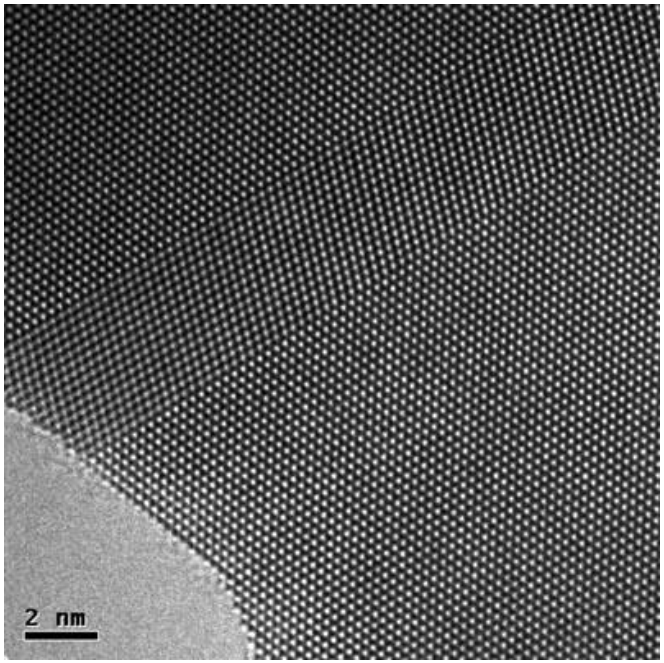
- **Elements**
  - **Basic building blocks of minerals**
  - **> 100 are known (92 naturally occurring)**



Elements are composed of atoms

Atoms

- **Smallest particles of matter that retains all the characteristics of an element**



Atoms of gold
(Electron microscope image)

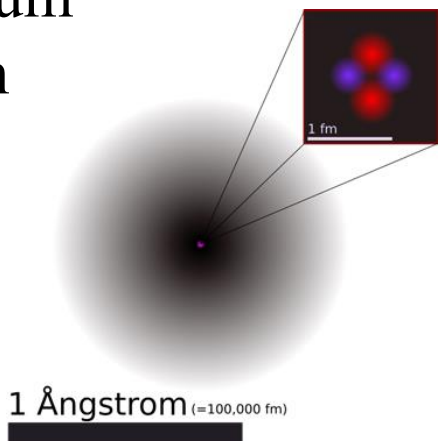
From http://www.nanotech-now.com/products/nanonewsnow/issues/034/034.htm

Atoms are composed of a

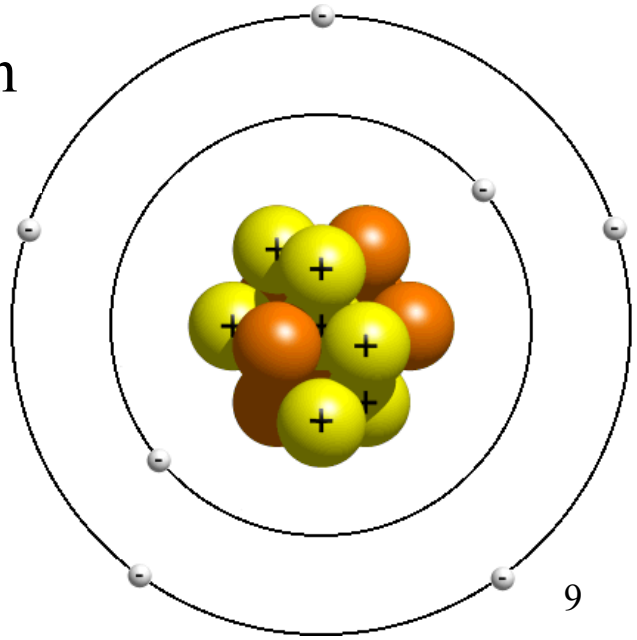
Central region called the nucleus consisting of protons (+ charge) and neutrons (no charge)

Electrons are negatively (-) charged particles that surround the nucleus and are located in discrete energy levels called shells

Helium atom



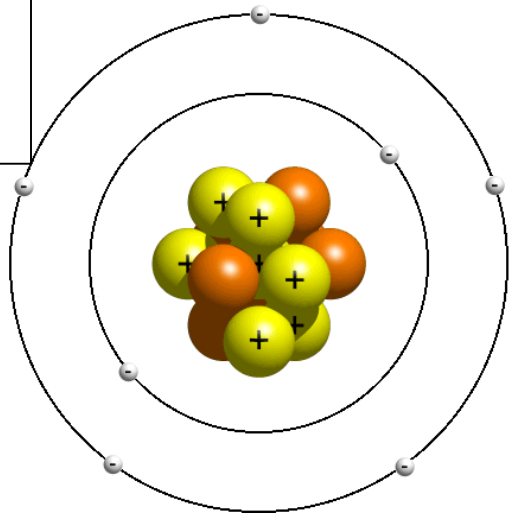
Nitrogen atom



What differentiates atoms of different elements?

- The number of protons is used to define an element.
  - The number of neutrons and electrons may change but the atom remain the same element if the number of protons does not change.

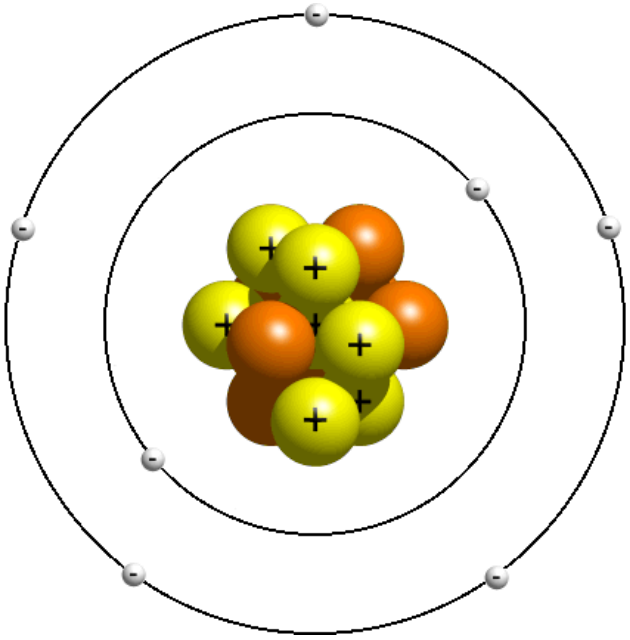
Nitrogen has 7 protons



Neutral atom

- An atom is neutral (has no charge) when it contain an equal number of electrons and protons.

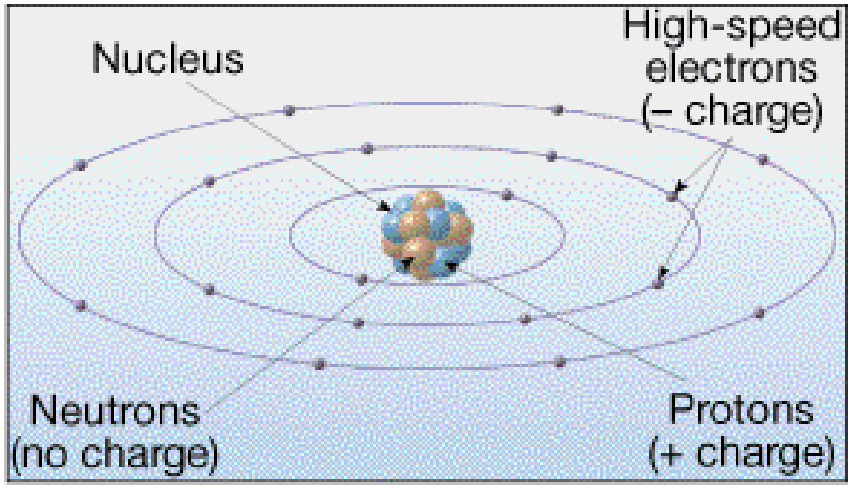
This neutral atom of nitrogen has 7 protons and 7 electrons



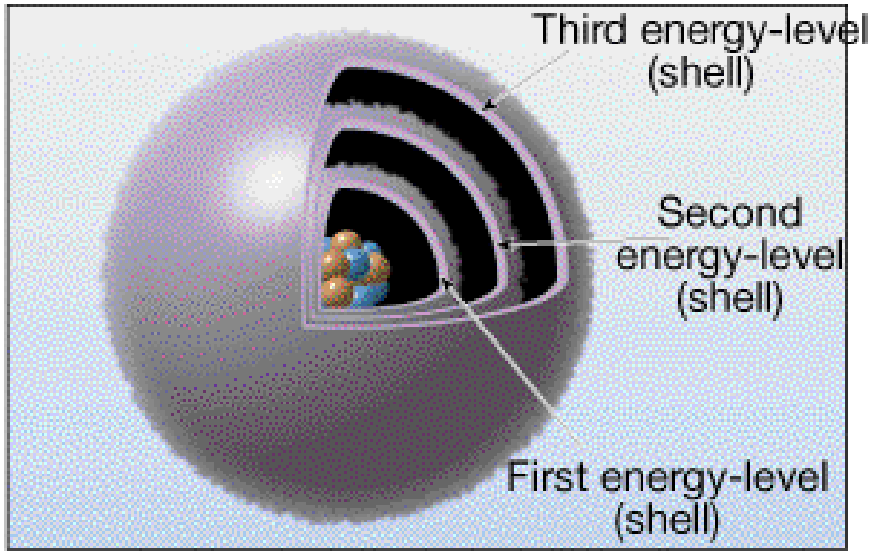
Each electron shell can hold up to 8 electrons, except for the inner most shell which holds 2 electrons.

Atoms tend to be most stable when their outer most shell contains 8 electrons (is full).

This is the octet rule.



A.

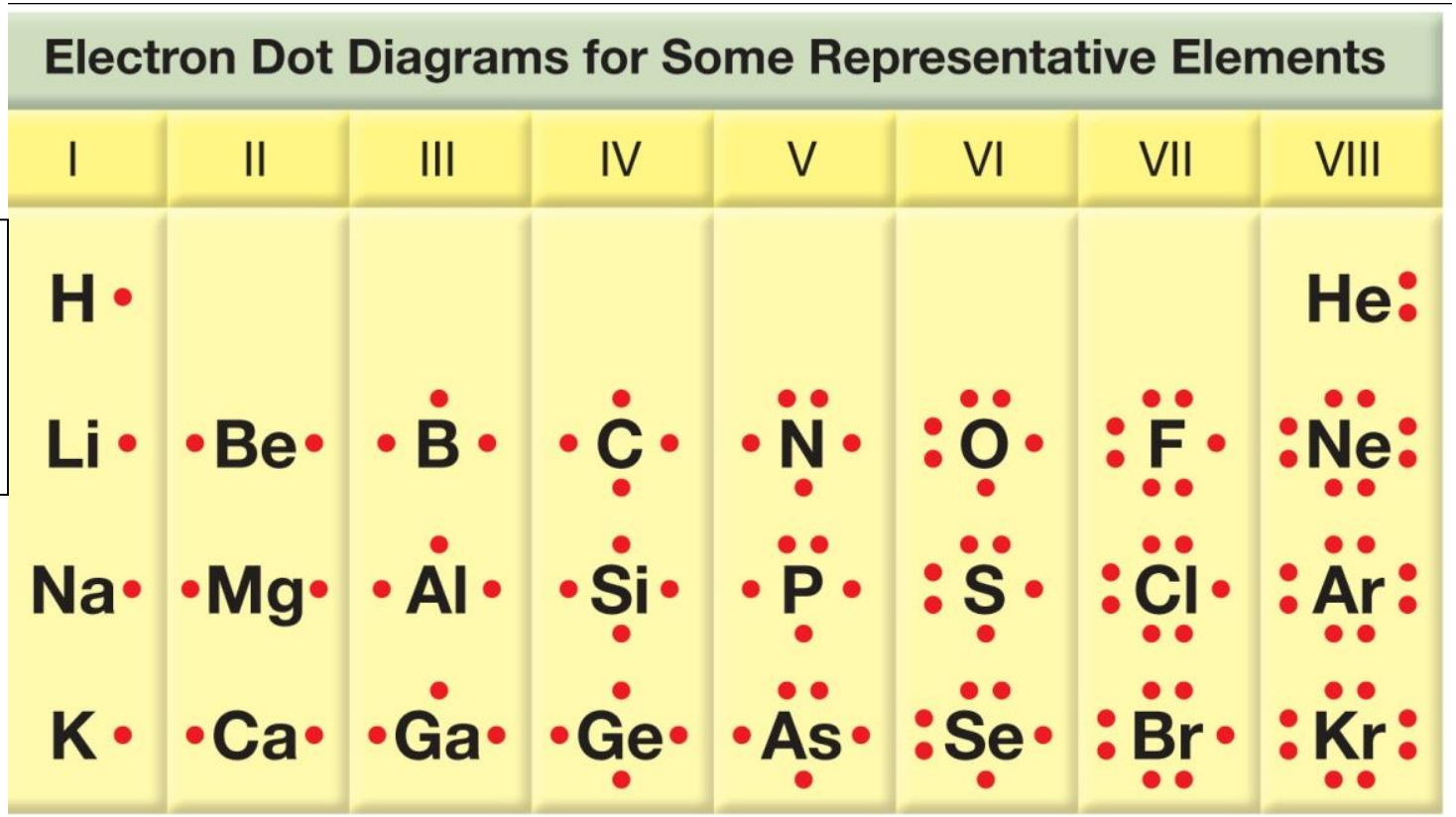


B.

Why do atoms chemically bond?

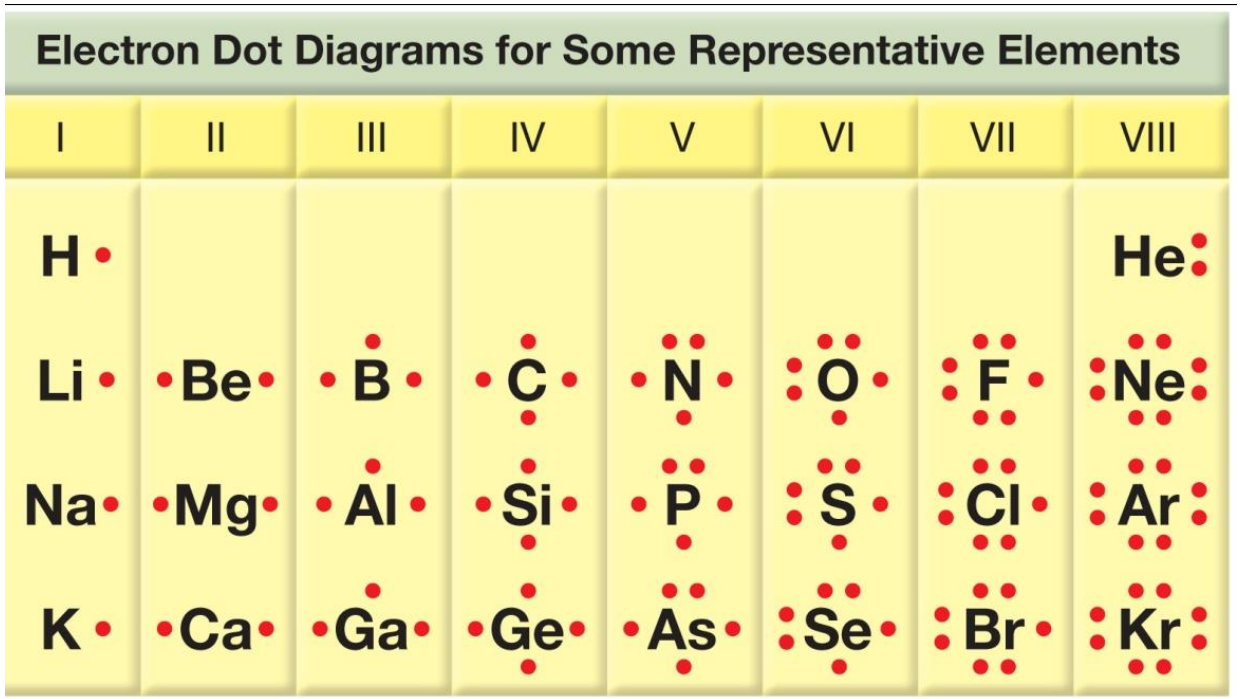
- They form compounds by sharing or transferring electrons to attain stable outer shells with 8 electrons

The red dots are the number of electrons in the outer shell.

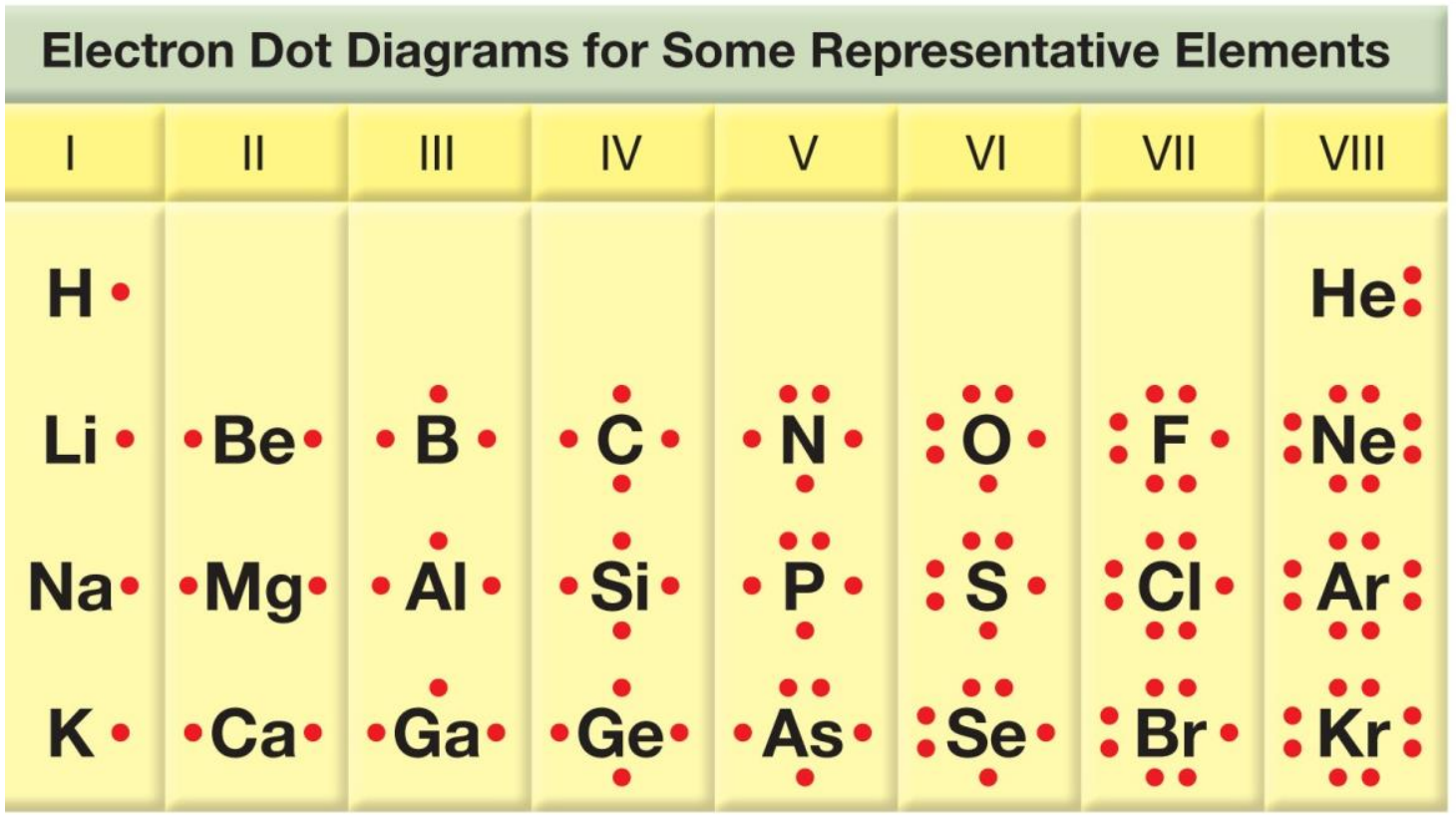


Atoms tend to combine so they each have 8 electrons in their outer shell

- An atom with 8 electrons in the outer shell is stable and will not gain or loose electrons.
  - Thus it is not involved in any chemical reactions and remains a neutral ion with no charge.



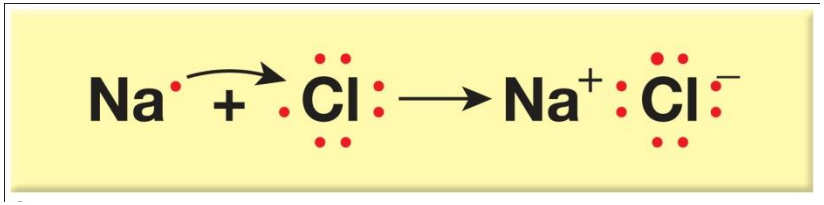
- An atom with an outer shell that contains 5 to 7 electrons will tend to gain electrons to fill to 8.
  - It becomes a negatively charged ion called an anion
- An atom with an outer shell that contains 4 or less electrons will tend to loose these electrons
  - It becomes a positively charged ion called a cation

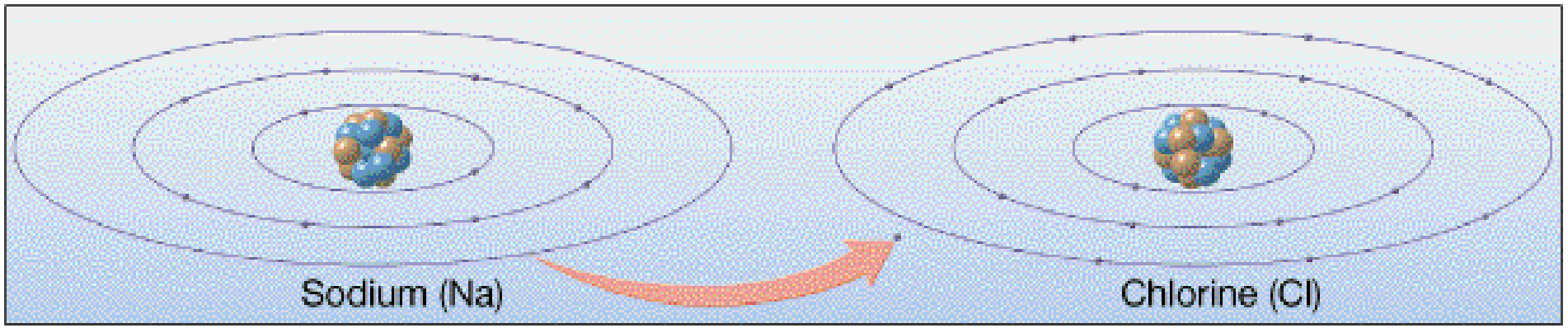


Two main types of bonds.

- **Ionic bonding**
  - **Atoms gain or lose an electron to form a stable outer shell.**
  - **These oppositely charged ions then bond together**
  - **This is a weak bond that dissolves more readily in water**
  - **Many non-silicate minerals are formed by ionic bonds**

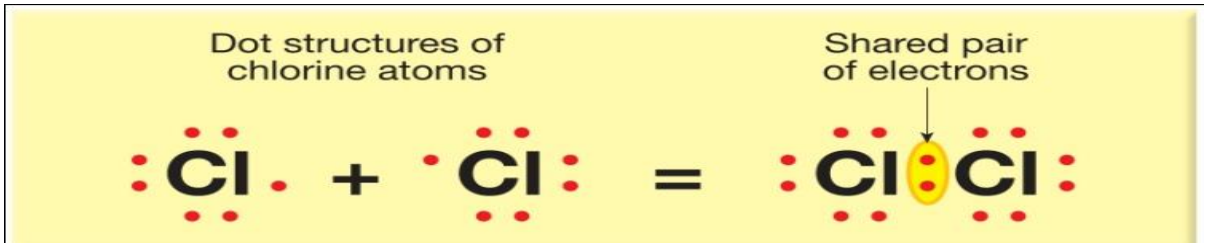
$$Na^+ + Cl^- \rightarrow NaCl$$

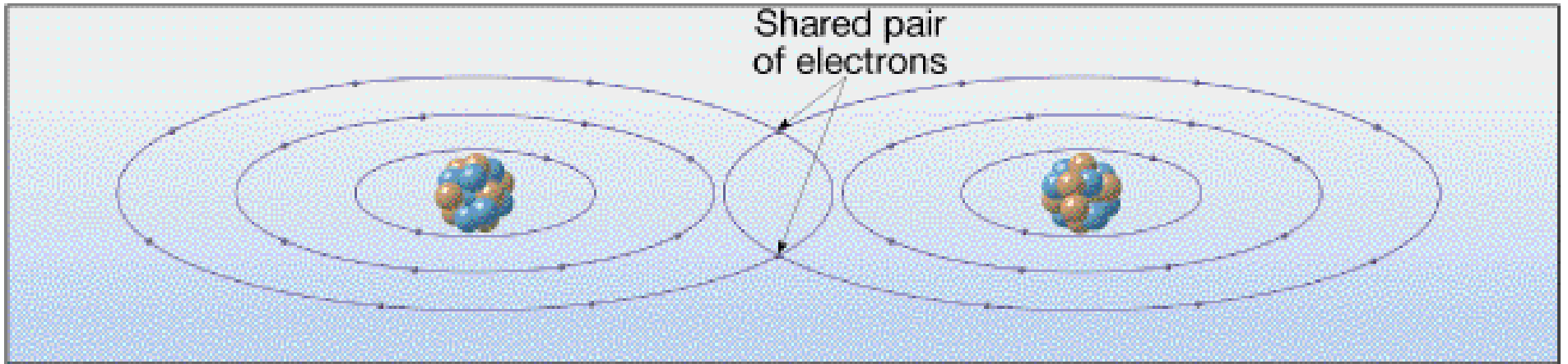




Two main types of bonds.

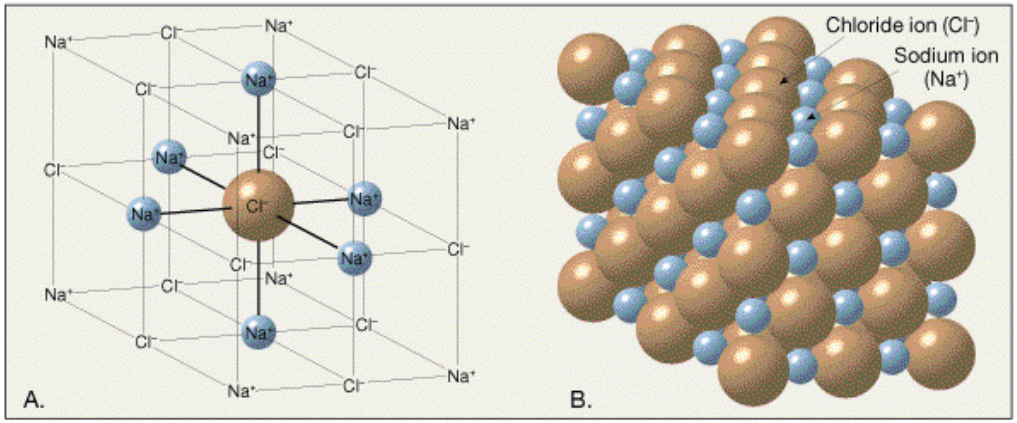
- **Covalent bonding**
  - Atoms combine by sharing electrons to achieve a stable outer shell
  - Covalent bonds are generally stronger than ionic bonds and dissolves less readily in water
  - Most silicate minerals are formed by covalent bonds

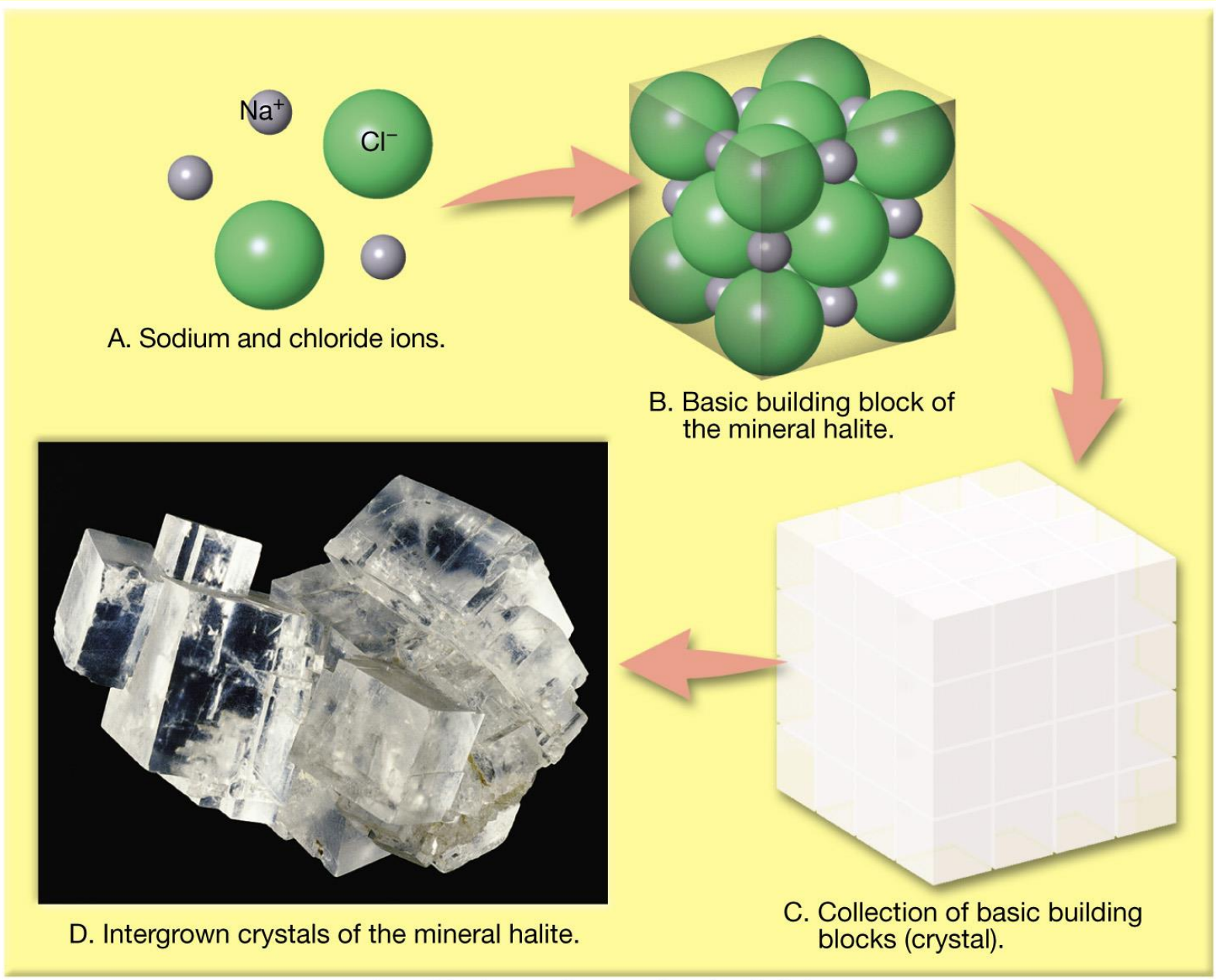




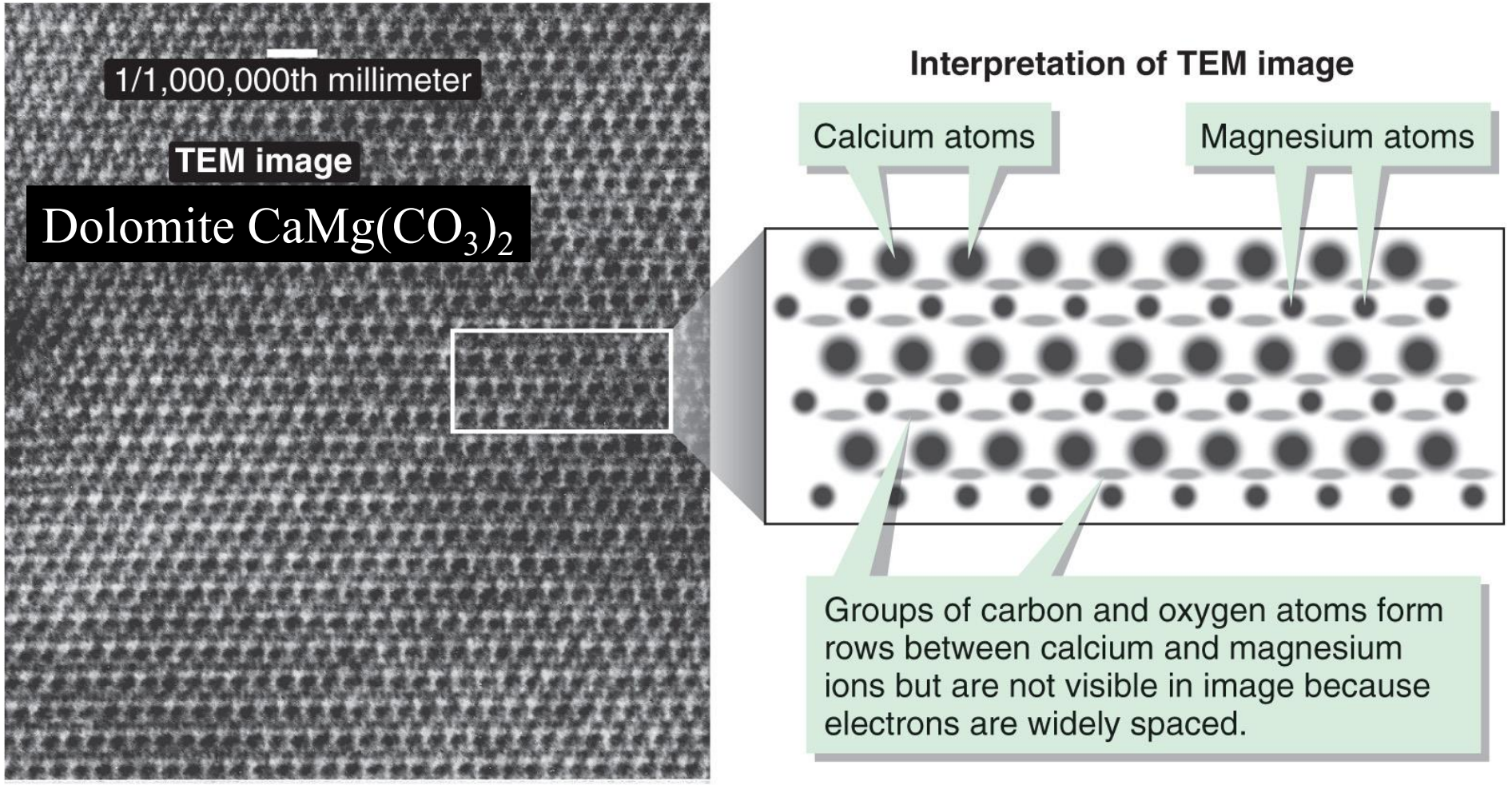
Structure of Minerals

- Minerals have an orderly internal structure
  - ordered array of atoms bonded together
  - Gives the mineral it crystal shape and cleavage.
- Example - Halite NaCl (table salt)
  - Na and Cl packed together into a cubic shape
  - halite grows into cube shaped crystals
  - halite breaks into cube shape



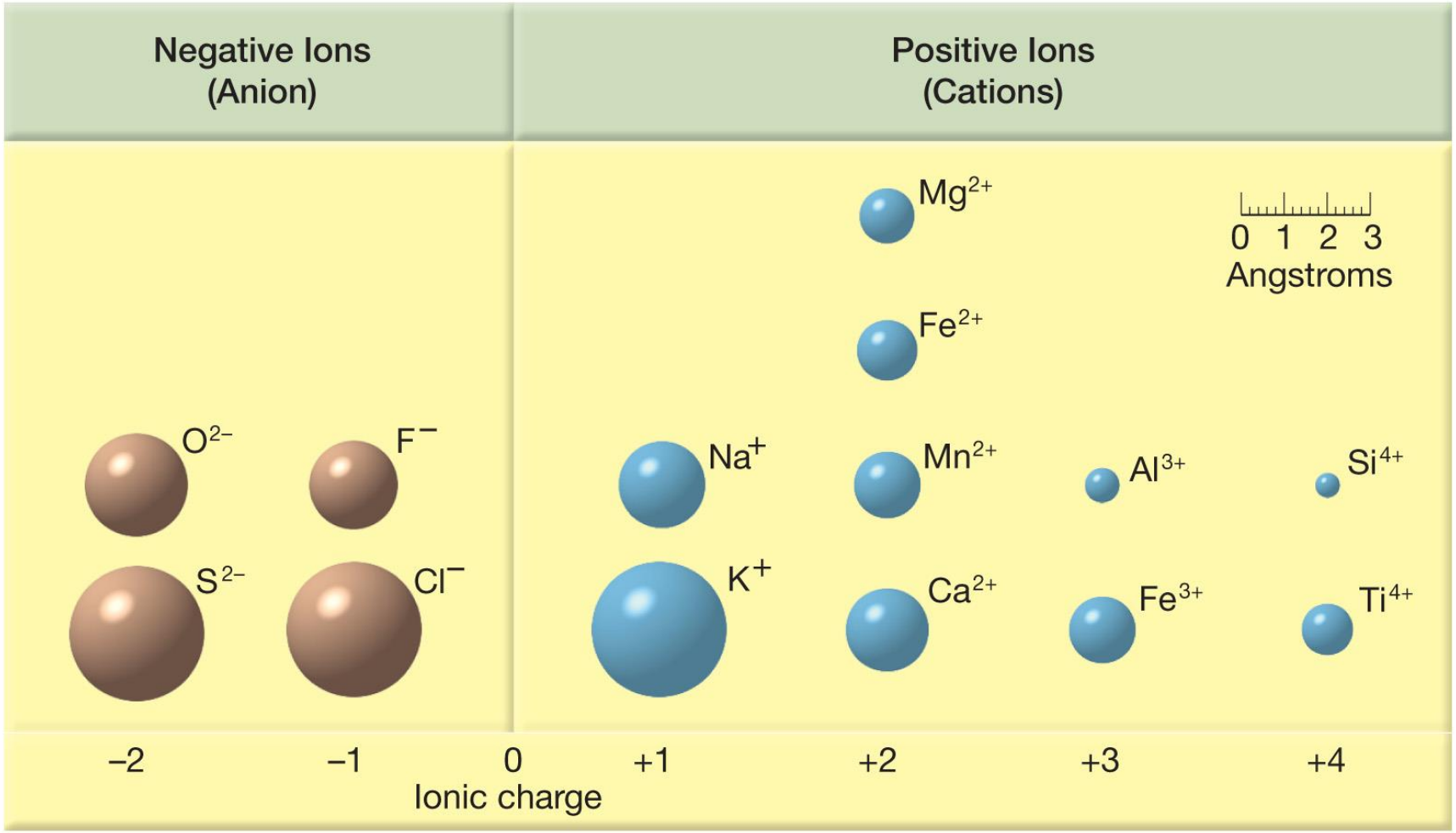


Visualizing atoms inside a mineral

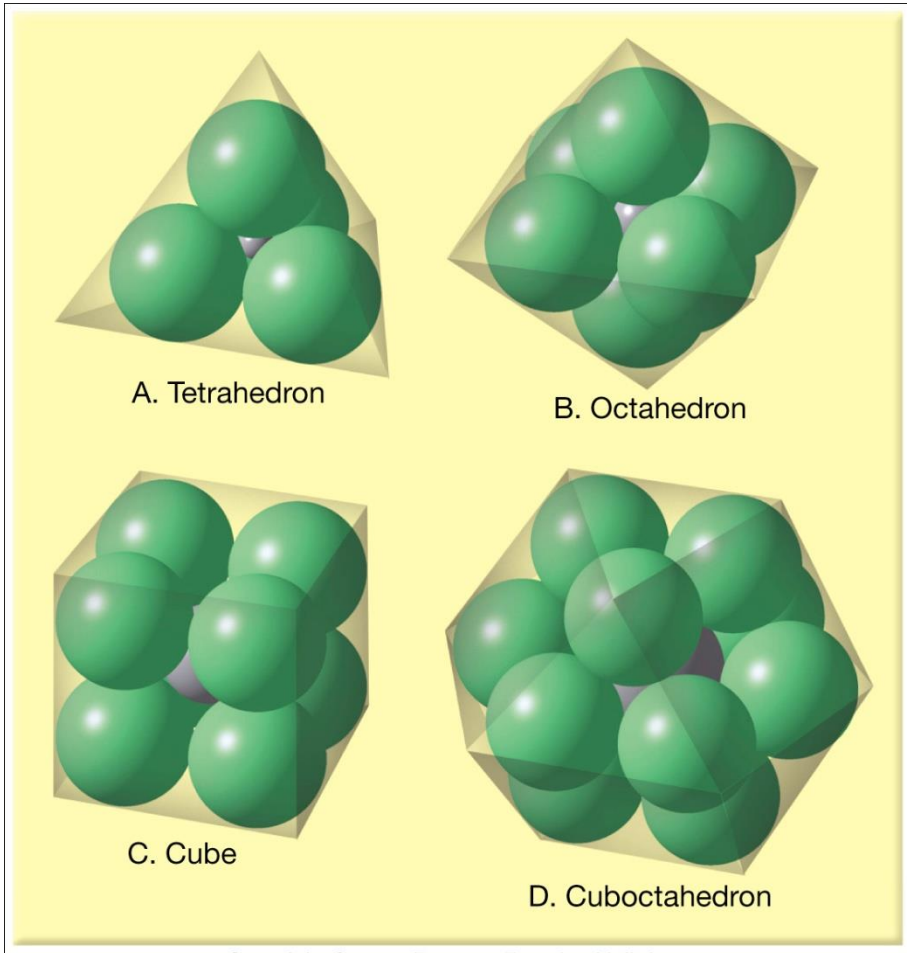


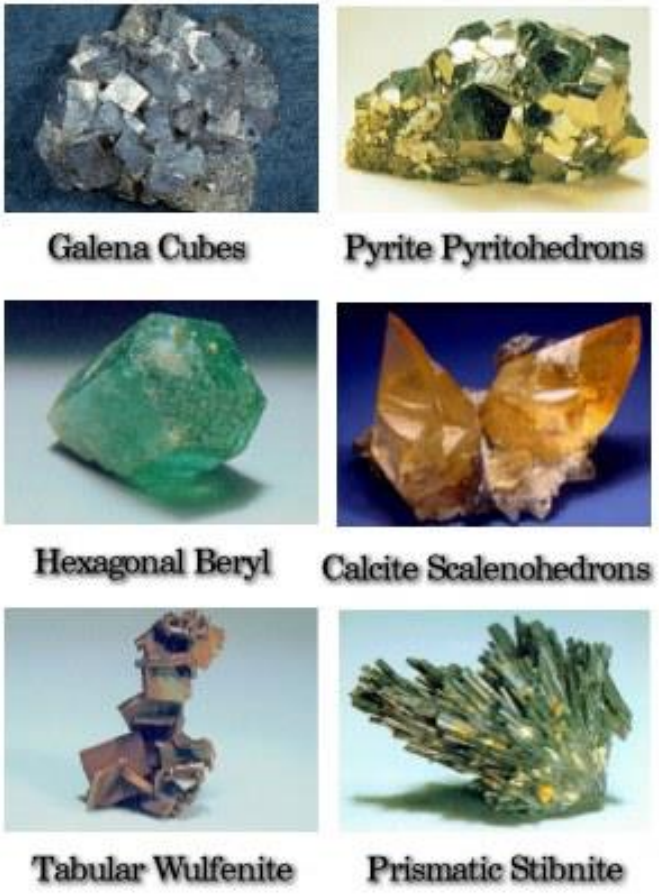
Why do different mineral compositions result in different shaped crystals?

- It is because ions are different sizes.
  - The different sizes result in different packing arrangements.



Different packing arrangements result in different shaped crystals?





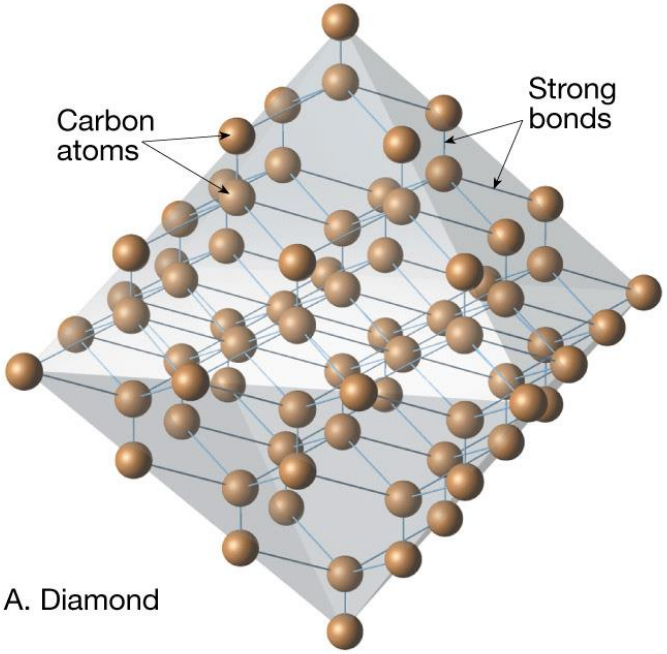
You will <u>not</u> be tested on the names of the different shapes

Many possible crystal shapes

Crystal Polymorphs

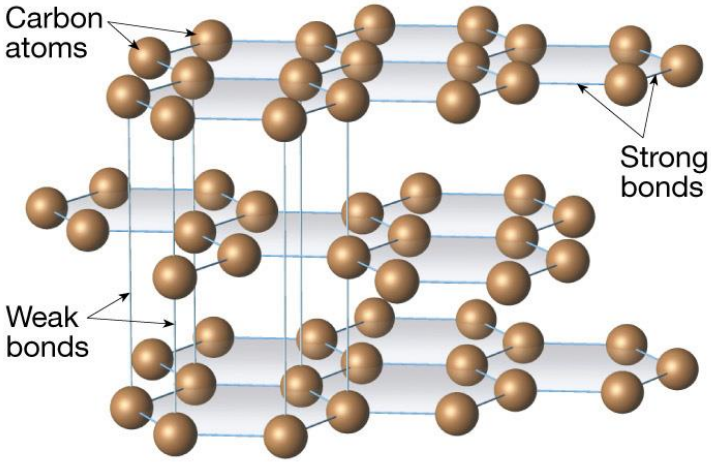
- Two minerals with exact the same chemical composition but with different crystal structures (arrangement of the atoms)
  - Polymorphs can have drastically different properties
- Example:
  - Graphite is carbon bonded into sheets
    - It is opaque, soft and slippery
  - Diamond is carbon bonded with strong covalent bonds
    - It is glassy in appearance and the hardest mineral

Crystal Polymorphs



A. Diamond

Diamond



B. Graphite

Graphite

Is pencil lead really made of lead?

- No, it is the mineral graphite (C)
- Graphite was originally identified as lead because it was soft and black like lead.
- Pencil lead is now a mixture of clay and graphite. The more clay the harder the lead in the pencil.

Mineral Identification using Physical Properties

- Crystal form
- Cleavage
- Fracture
- Luster
- Color
- Streak
- Hardness
- Density (Specific gravity)

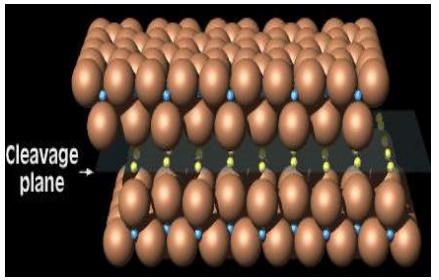
Crystal Faces, Cleavage and Fracture

Don't confuse these 3 properties

crystal faces– are the natural growth surface as a crystal forms from a liquid

Halite movie (NaCl)

cleavage – regular breakage along a molecular plane



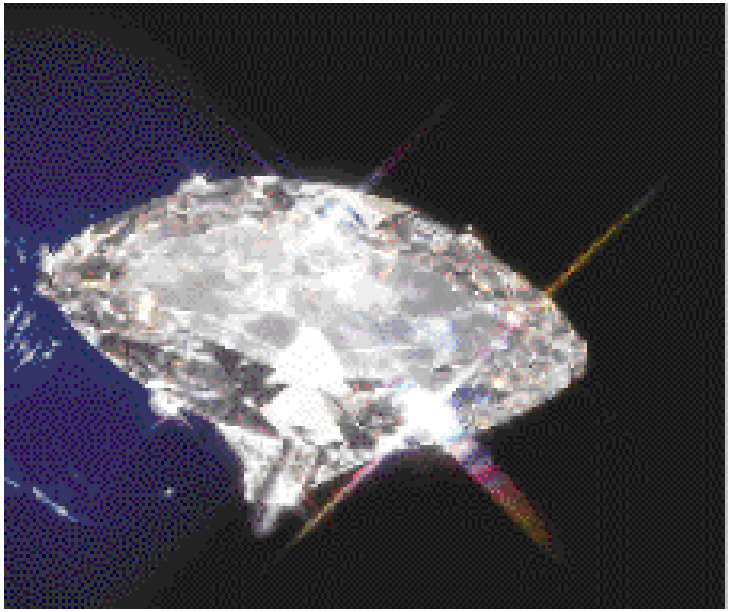
fracture – irregular breakage of a mineral in the absence of cleavage (for example conchoidal fracture in quartz)

A. Irregular fracture (Quartz)

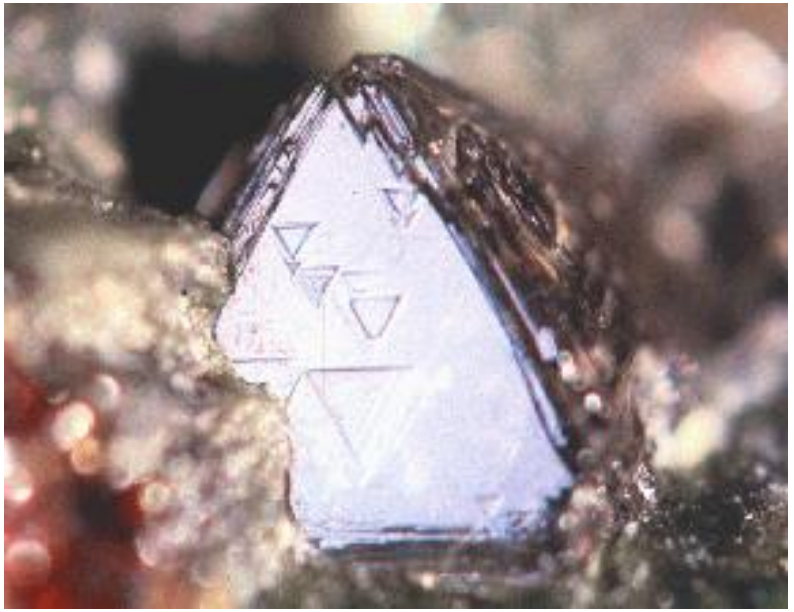
B. Conchoidal fracture (Quartz)

Crystal Face versus Cleavage Surface

Diamond gem stones in jewelry, are broken along cleavage surfaces

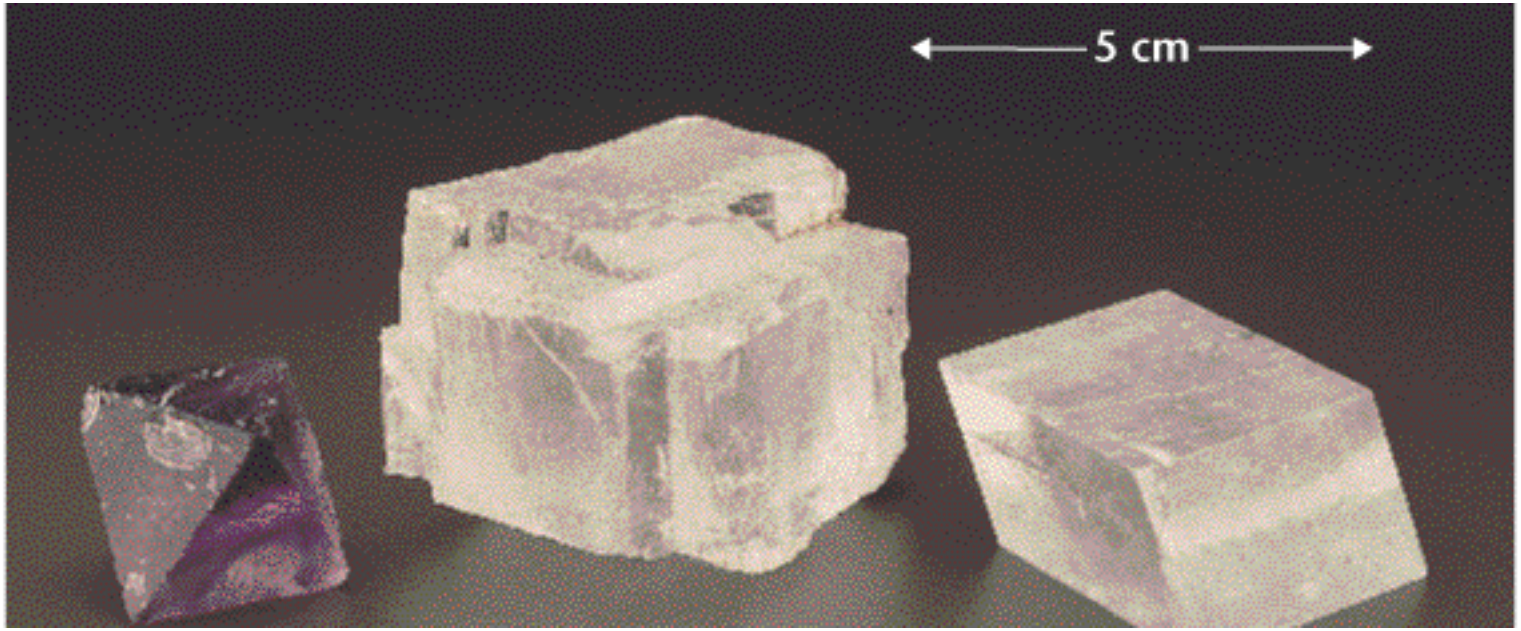


Diamond crystals in its original form is grown from a melt, and is not as attractive



Crystal Face versus Cleavage Surface

Smooth CLEAVAGE surfaces (breakage surfaces) shown below look like crystal faces, but they are not!



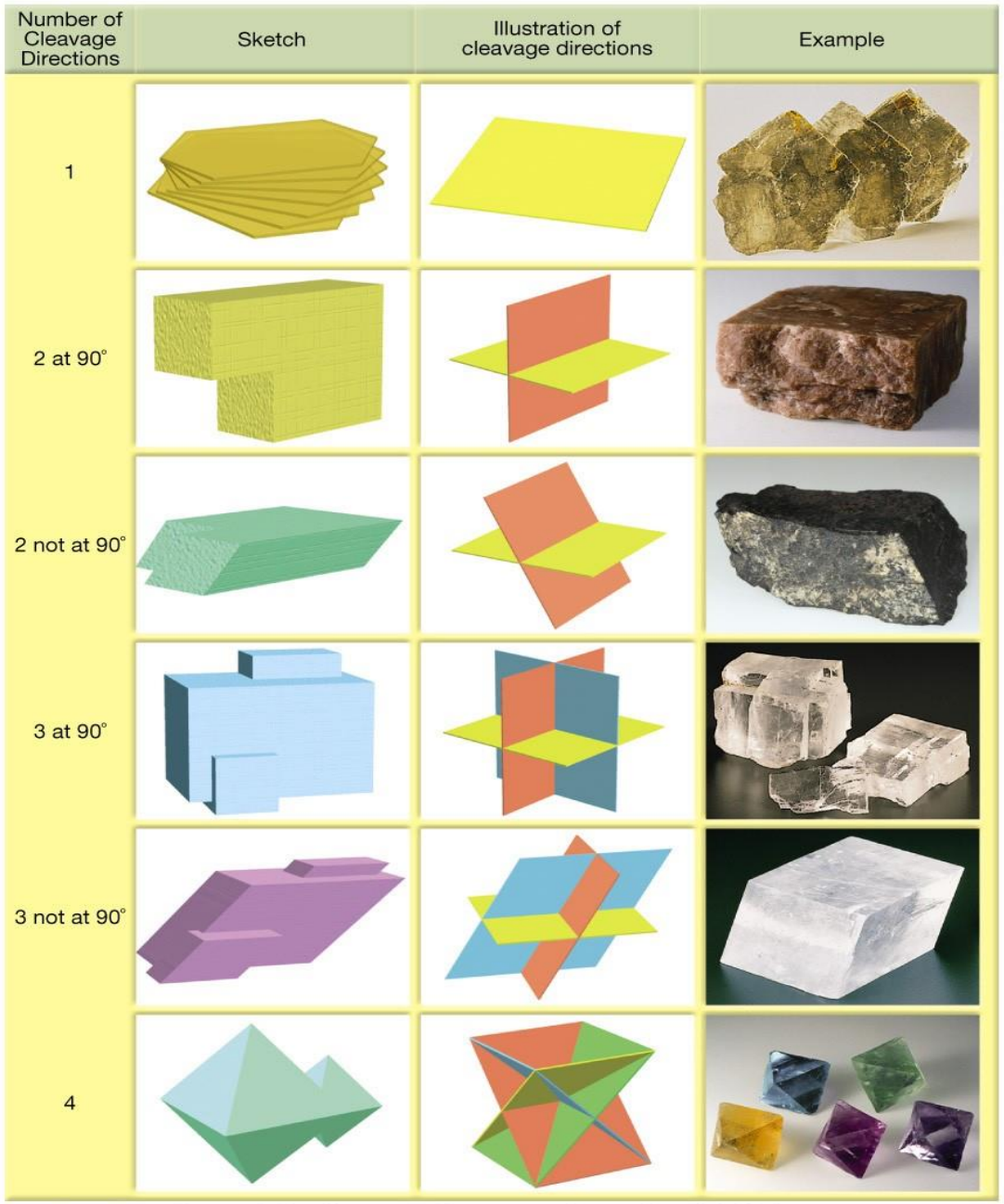
fluorite (CaF_2)

halite (NaCl)

calcite ($CaCO_3$)

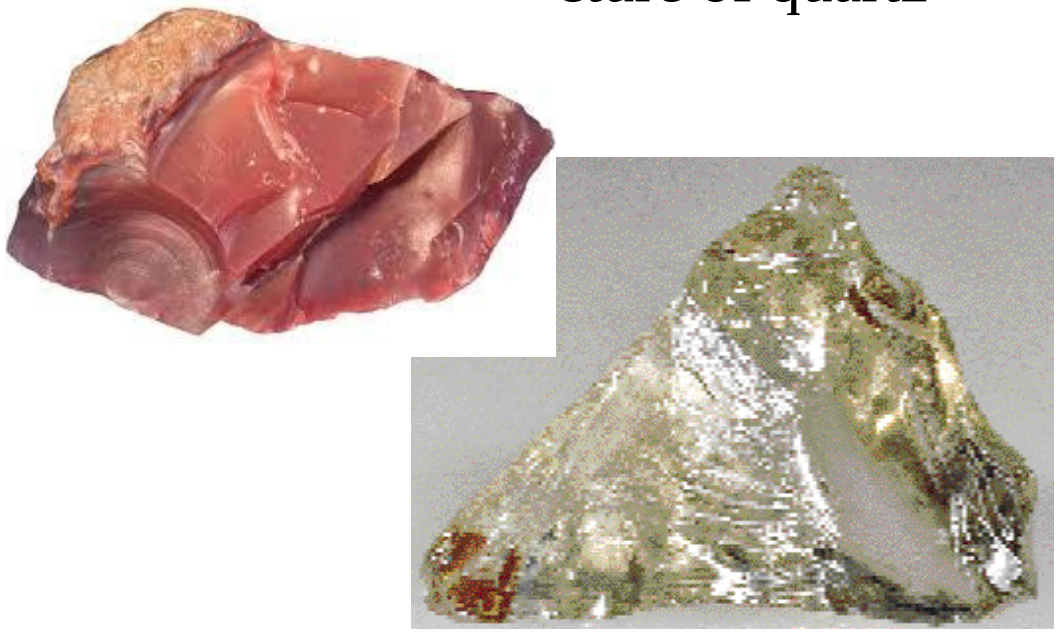
Common Cleavage Directions

(you will <u>not</u> be tested on these)



Fracture Surface versus Crystal Face

Conchoidal fracture of quartz



Crystals of quartz

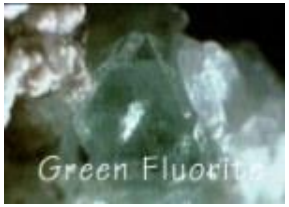
Quartz does not produce cleavage faces when it breaks, it fractures instead into conchoidal shaped fractures

Luster/Color/Streak

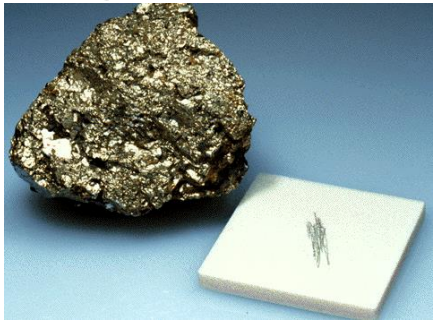
- luster- how light reflection on the surface
  - nonmetallic vs. metallic luster


- color – chemical impurities
  - Most unreliable method of identifying a mineral

The many colors of the mineral fluorite



- streak - powdered color on unglazed porcelain (streak plate)
  - streak color is reliable



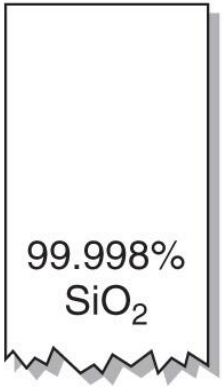
Example: Mineral color is from chemical impurities

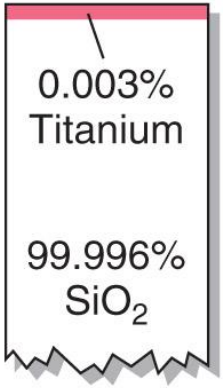
Three colors of quartz from chemical impurities

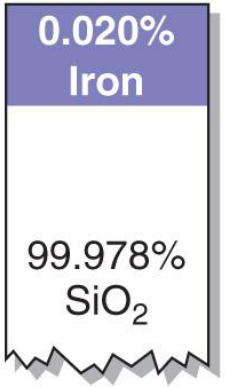
Colorless quartz

Rose quartz

Amethyst







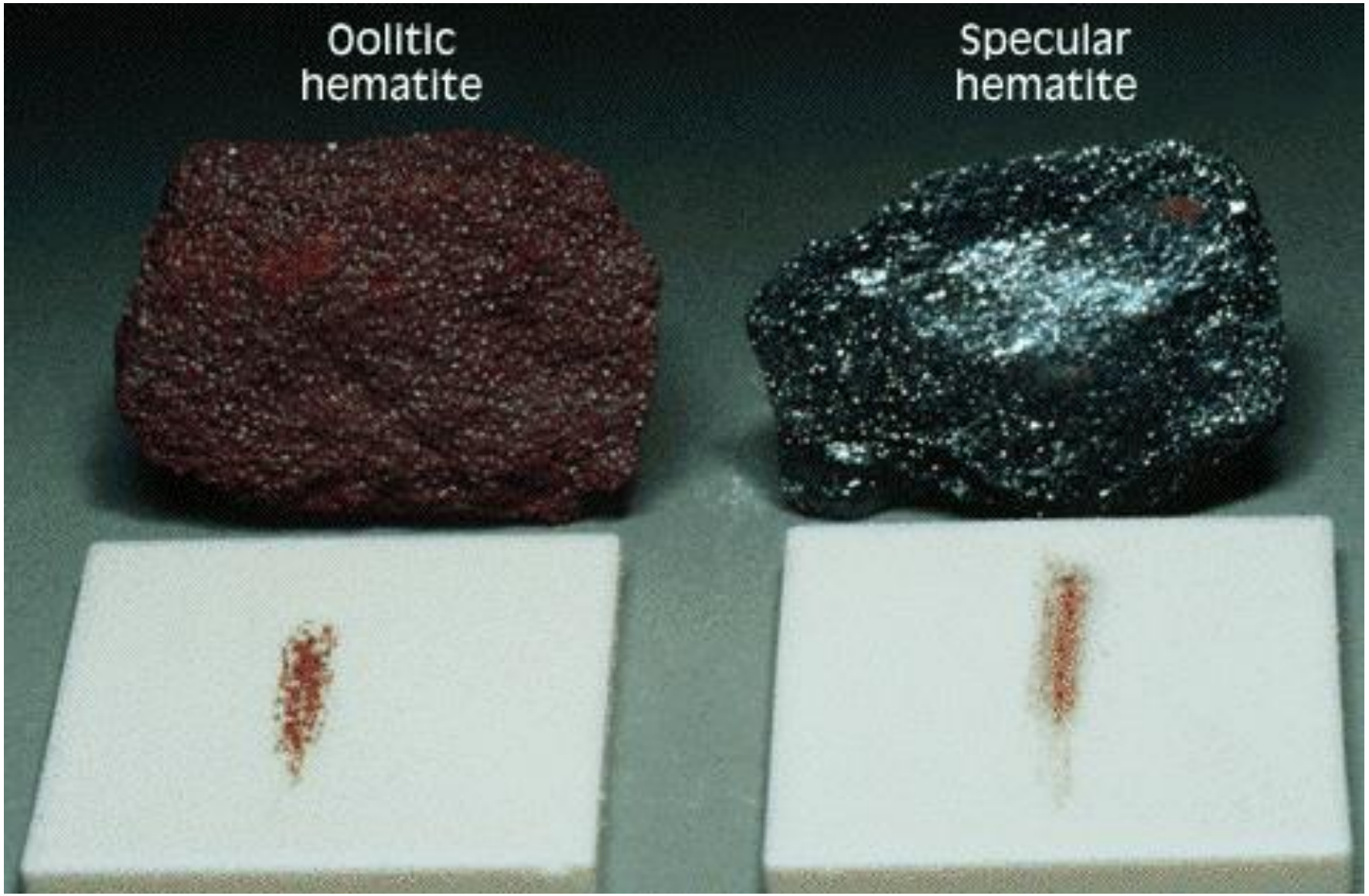
The Many Colors of Corundum

Ruby(Cr^{3+})

Sapphire (Fe^{3+} & Ti^{4+})

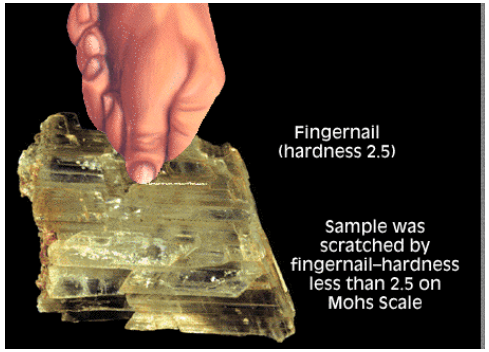
William Sacco

Example of streak not matching mineral color



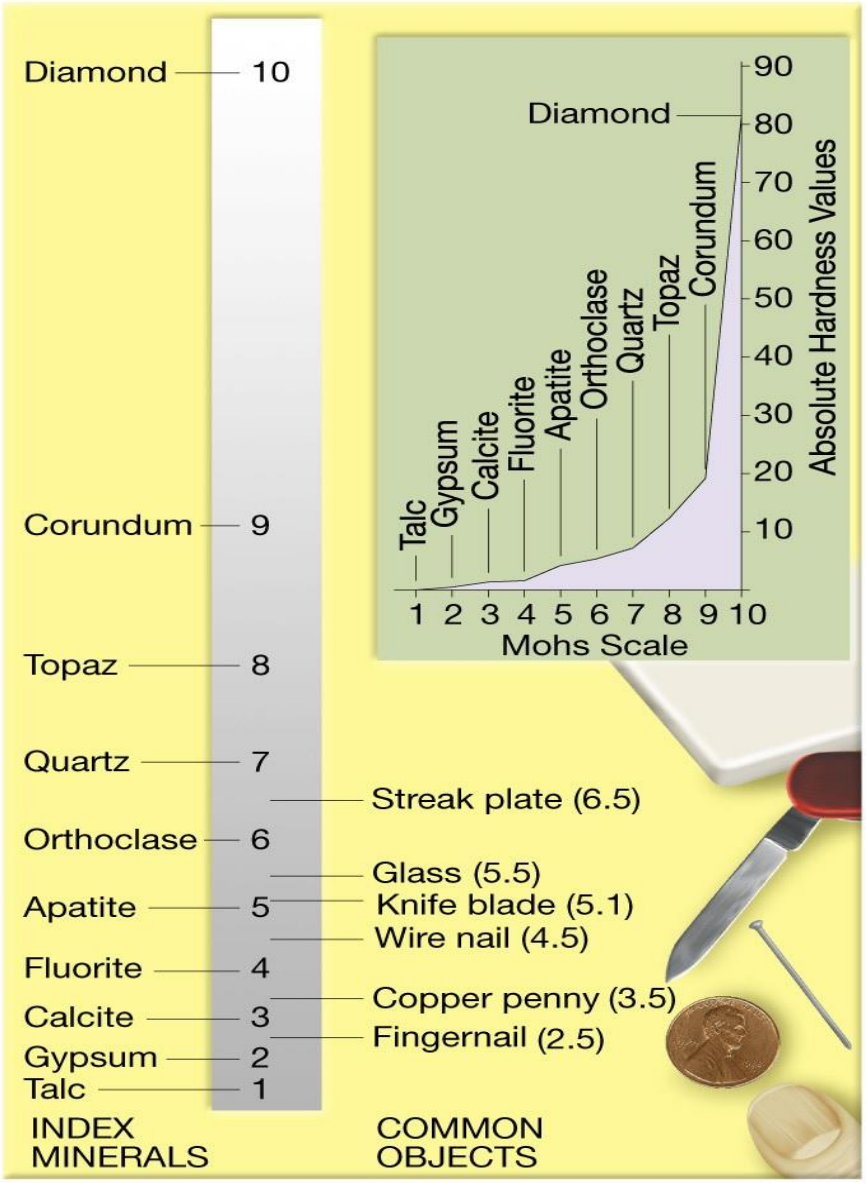
Hardness

- Hardness is a minerals resistance to scratching
  - It is the most reliable property for the identifying a mineral



- How to determine hardness:
  - rub a mineral or material of known hardness against unknown mineral
  - Mohs Hardness Scale (a relative hardness scale)

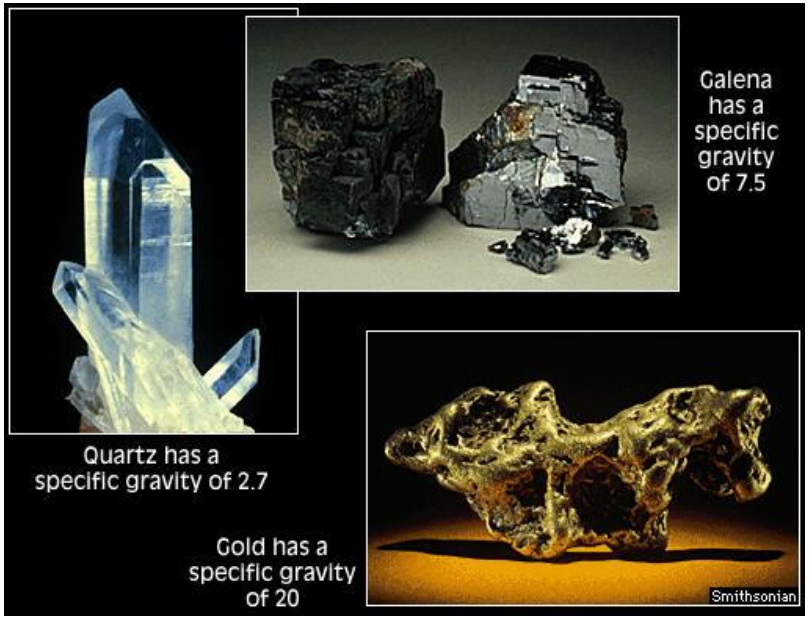
Mohs Hardness Scale



- You do not need to memorize this scale
- Make sure you know
  - Hardness is not measured with a hardness meter, it is a relative scale based on hardness relative to known items
  - that the silicate minerals you are required to memorize (see end of lecture for list) are generally harder than all the nonsilicate minerals
    - the main exception to this is diamond which is composed of only carbon and is the hardest of all minerals.

Density

- Density = mass per unit volume
- When a rock that is more dense than another rock, it means the same weight of rock takes up less volume.



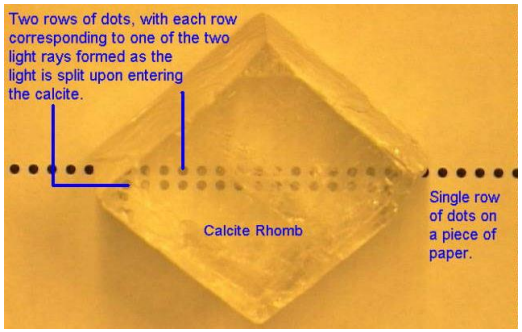
Other Physical Properties of Minerals

(you will not be tested on these properties)

- **Magnetic – magnetite (Fe_3O_4)**

- **Reacts to hydrochloric acid**
  - **calcite ($CaCO_3$) fizzes**

- **Double refraction - calcite**



- **Malleability - graphite**
- **Taste – halite (table salt) tastes salty**
- **Smell – (sulfur smells like rotten egg smell)**

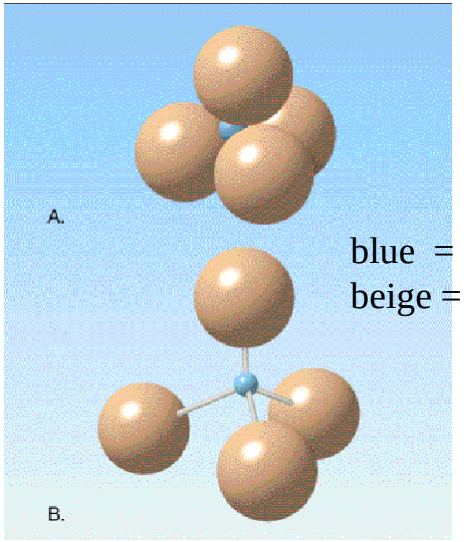
Common minerals you must know….

- **Silicate minerals** – are composed of Si and O
  - Si and O comprise 74% of crust so silicate minerals are the most common minerals on Earth
  - The form from crystallization of magma
    - (magma is a silicate melt)
  - Silicate minerals are divided into two groups
    - **Ferromagnesian silicate minerals**
    - **Nonferromagnesian silicate minerals**
- **Clay minerals:** are separate group of silicate minerals formed from the near-surface weathering of silicate minerals (clay minerals are not crystalized from a melt)
- **Nonsilicate minerals** – contain no silica (Si)

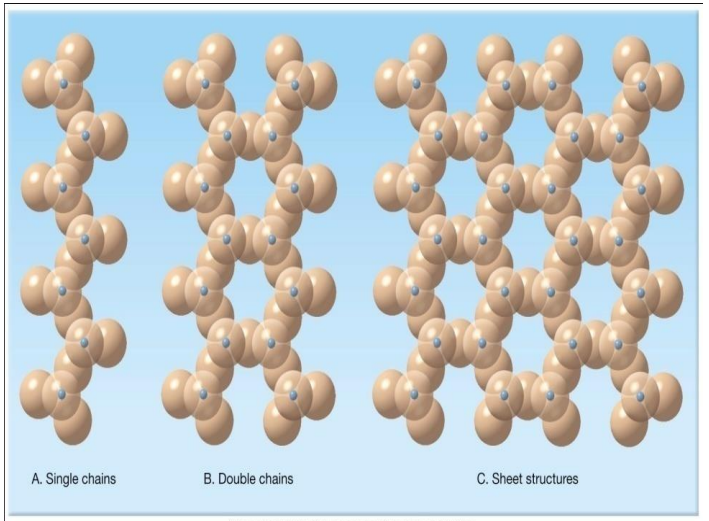
Silicate Minerals

- The basic building block of silicate minerals is the Si-O tetrahedron
- The Si-O tetrahedron are bonded to each other by cations
  - Predominantly Fe and Mg for ferromagnesian silicate minerals
  - Predominantly Al, Ca, Na and K for nonferromagnesian silicate minerals
- Silicate minerals are grouped based on how the silicate tetrahedrons are bonded together
  - single silica tetrahedra
  - single chain
  - double chain
  - sheets

Si-O tetrahedron



blue = silicon
beige = oxygen



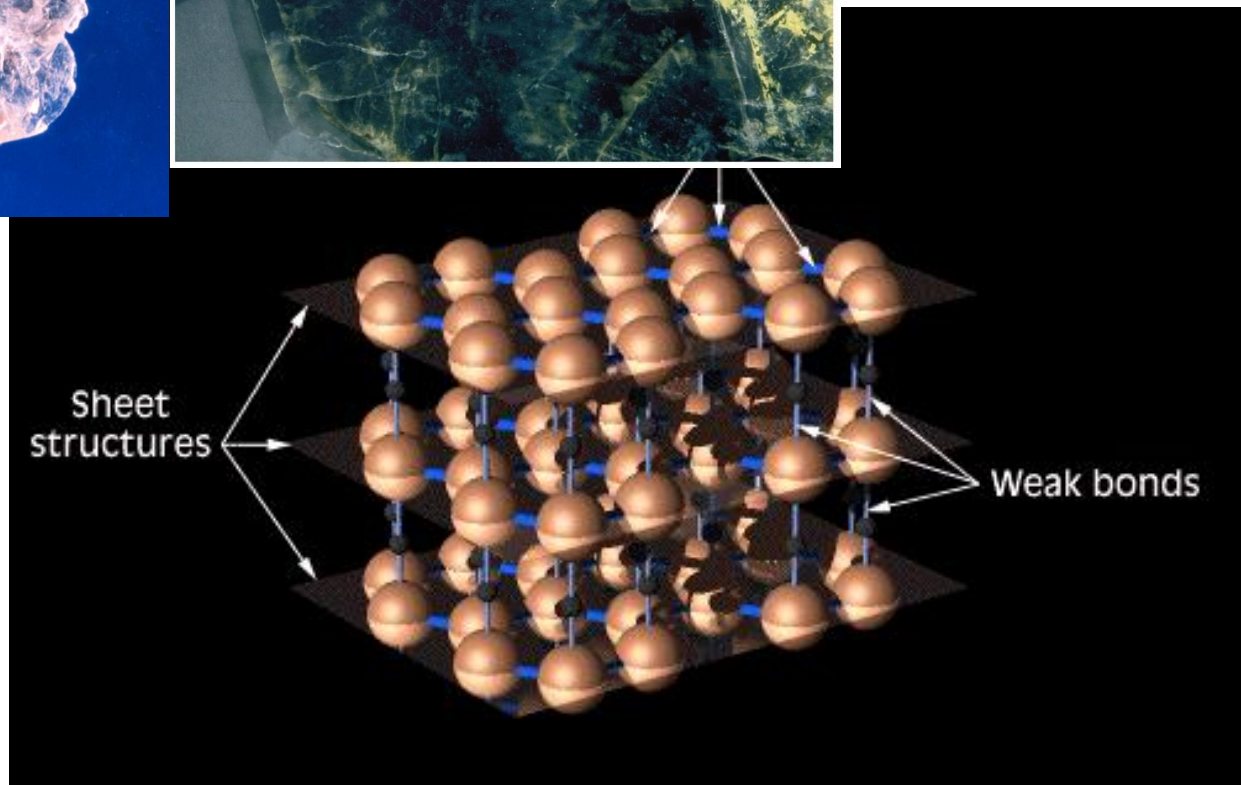
Ferromagnesian Silicate Minerals

Fe-Mg rich, mafic, dark colored

You must know that the following minerals are ferromagnesian silicate minerals

- olivine
- pyroxenes
- amphibole group (hornblende)
- biotite mica

Biotite mica: has an interesting sheet structure

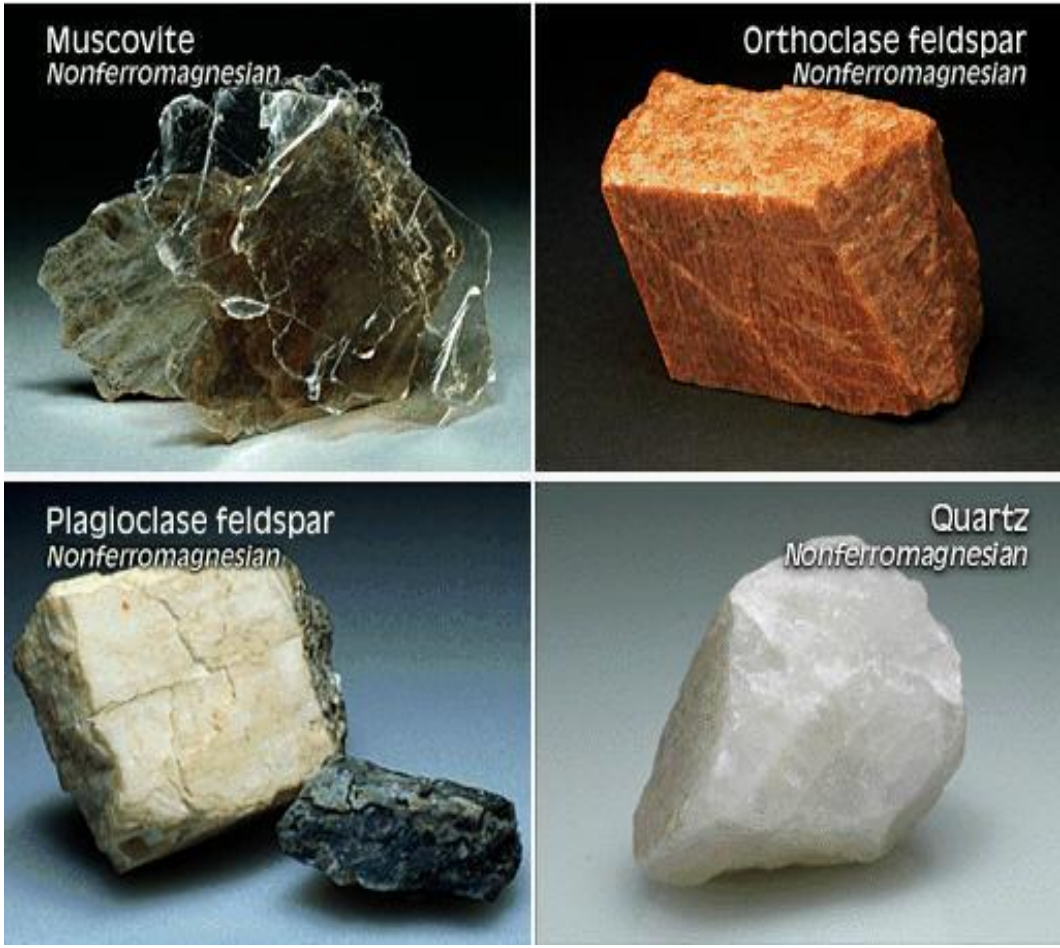


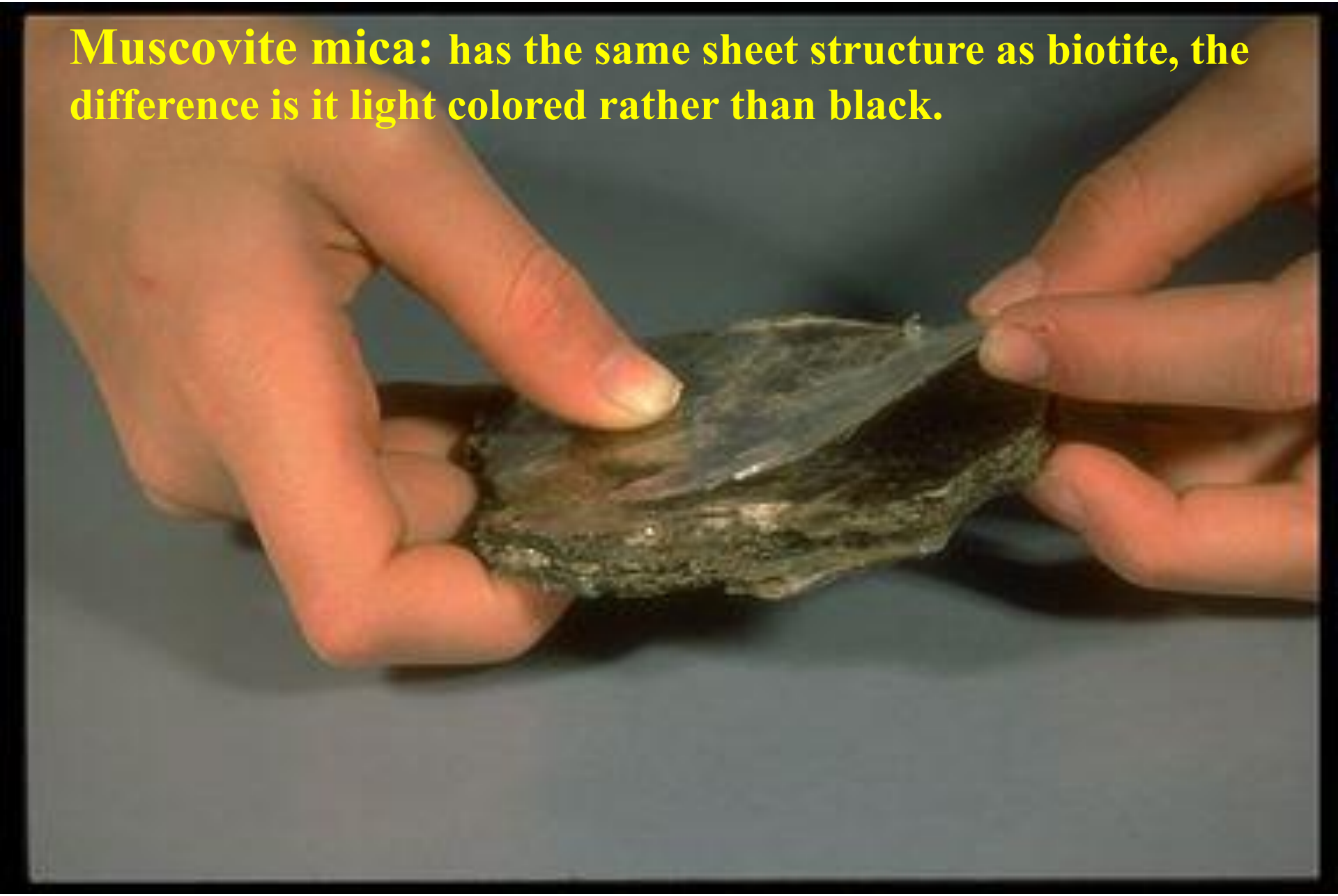
Nonferromagnesian Silicate Minerals

Ca – Na –K rich, felsic, light colored

You must know that the following minerals are nonferromagnesian silicate minerals

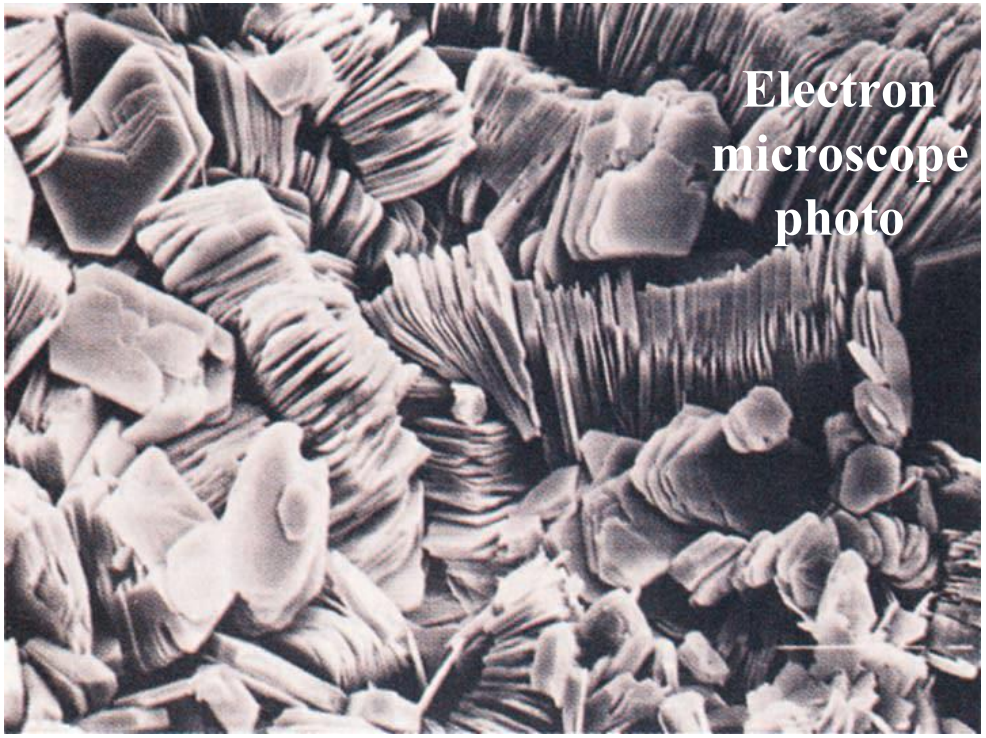
- muscovite mica
- Quartz (SiO_2)
- K-feldspar (orthoclase)
- Ca-Na plagioclase
- clay minerals




Muscovite mica: has the same sheet structure as biotite, the difference is it light colored rather than black.

Clay Minerals

- Clay sized minerals composed of Si-O and a wide range of elements, that are produce by the near surface weathering of silicate minerals.
- Clay-mineral crystals are flat sheets of microscopic size.
- (You do not need to know the name of any of the clay minerals, just the group as a whole.)



Nonsilicate Minerals

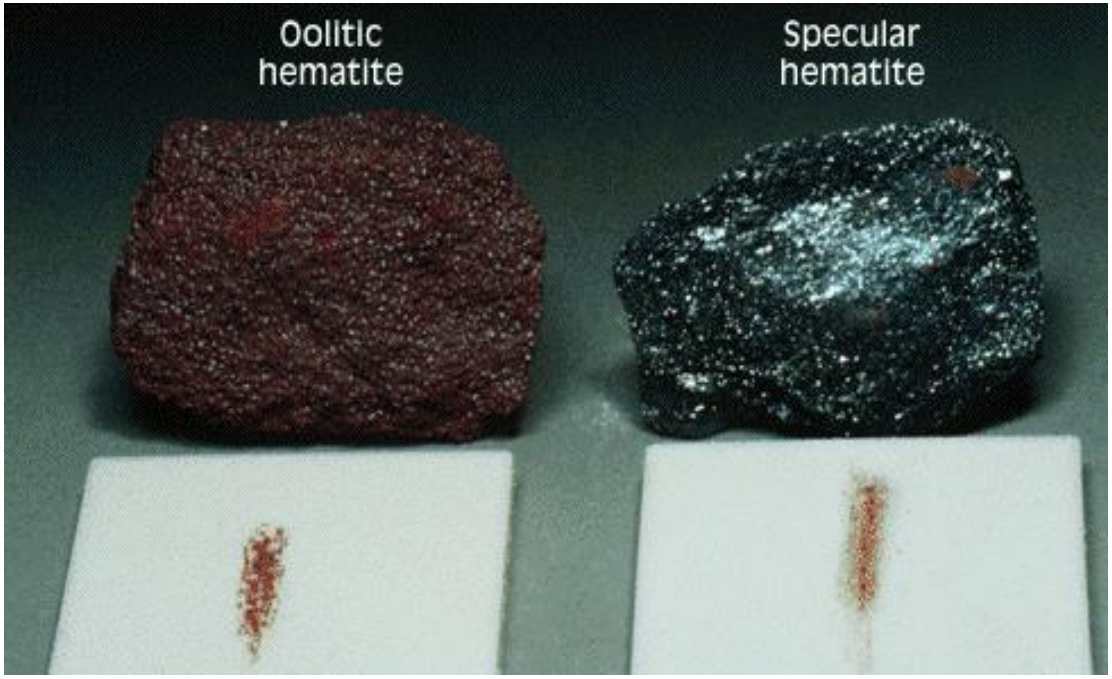
This group does not contain silica (Si)

- Nonsilicate minerals generally crystallize from water at near surface conditions.
- Nonsilicate minerals you must know

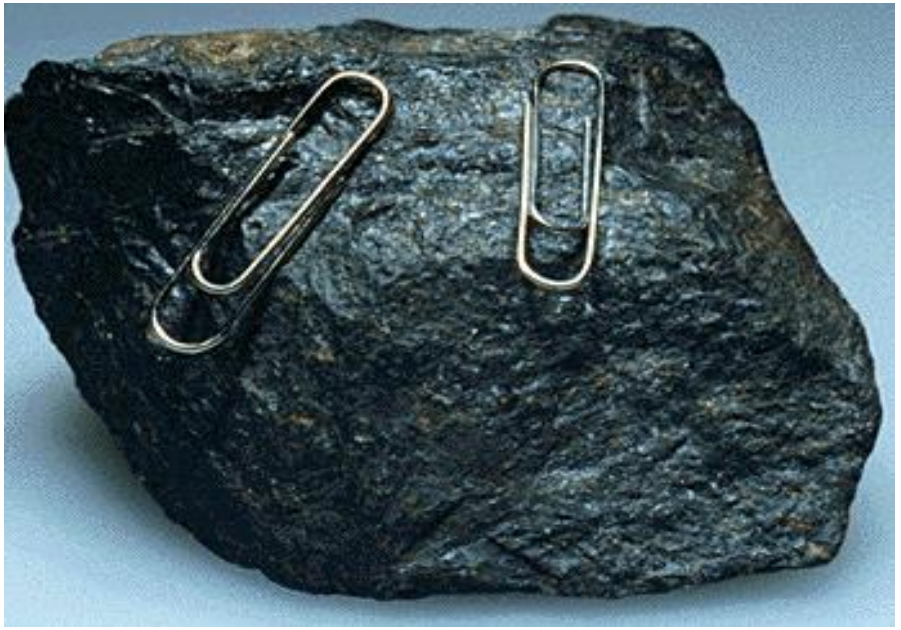
  (Be able to match these formula with the mineral name)

  - hematite Fe_2O_3
  - magnetite Fe_3O_4
  - gypsum $CaSO_4$
  - halite NaCl (memorize this mineral and formula)
  - calcite $CaCO_3$ (memorize this mineral and formula)
  - dolomite $CaMg(CO_3)_2$

Hematite (Fe_2O_3)



Magnetite (Fe_3O_4)



Gypsum
(Sulfate)
$CaSO_4 \cdot 2H_2O$

Halite
NaCl


Calcite
$CaCO_3$
Dolomite
$(Ca,Mg)CO_3$

Houston Gem and Mineral Society

http://www.hgms.org/

- For amateur collectors
- Teach mineral faceting, polishing etc.
- Hosts mineral collecting trips
- Hosts annual Gem and Mineral Show

End