Unit 3:

Earth Materials

Earth Systems 3209 - Unit 3 Lesson 1 – Building Blocks of Minerals

To fully understand Rocks and Minerals you must consider the chemistry behind them.

These things include:

A) Atoms (and the parts)
B) Elements
C) Molecules
D) Compounds

A) Atoms

Definition: the smallest unit of matter.

> ***Note****: If an atom is not neutrally charged (equal numbers of protons and electrons) they become ions.*

Sub-atomic particles that make up an atom include:

1) Proton - positively charged particle located in the nucleus.
2) Neutron - particle located in the nucleus with no charge.
3) Nucleus - central portion of an atom that comprises the majority of the atoms mass. It has both protons and neutrons.
4) Electron - negatively charged particle located in the surrounding energy levels.
5) Energy Level - shells that surround the nucleus that contain the electrons.

***Remember: Atoms make up Elements*

B) Elements

Definition: any material made up of one type of atom.

There are over 100 known elements, but only 8 of them make up over 98.5% of the earths crust by mass.

1) **O**xygen (46.6%)	2) **S**ilicon (27.7%)	3) **A**luminum (8.1%)
4) **I**ron (5.0%)	5) **C**alcium (3.6%)	6) **S**odium (2.8%)
7) **P**otassium (2.6%)	8) **M**agnesium (2.1%)	

> <u>*Rhyme to Remember*</u>*:* **Over S**eas **A**merican **I**ndians **C**an't **S**wim **P**ast **M**exico

***Remember: Elements make up Minerals*

Names and symbols of elements found in common minerals:

1) Chlorine (Cl)	2) Calcium (Ca)	3) Carbon (C)	4) Aluminum (Al)
5) Copper (Cu)	6) Cobalt (Co)	7) Fluorine (F)	8) Gold (Au)
9) Hydrogen (H)	10) Iron (Fe)	11) Lead (Pb)	12) Magnesium (Mg)
3) Oxygen (O)	14) Nitrogen (N)	15) Nickel (Ni)	16) Manganese (Mn)
17) Silicon (Si)	18) Sodium (Na)	19) Silver (Ag)	20) Potassium (K)
21) Sulfur (S)	22) Tin (Sn)	23) Zinc (Zn)	

For Example:

Halite - NaCl
Galena - PbS
Hematite - Fe_2O_3
Magnetite - Fe_3O_4

C) Compound

Definition: A substance that contains two or more elements chemically combined. A compound can have properties entirely different than the elements its made of.

Example: *Halite* (NaCl) is commonly called *salt*, or *Table Salt*. Table Salt can be eaten, but sodium (Na) and chlorine (Cl) are poisonous by themselves.

D) Molecule

Definition: The smallest part of a compound that still has all the properties of that compound.

Example: Water molecule - H_2O

***Remember: Atoms form Molecules and Compounds.*

Minerals

Definition: A naturally occurring inorganic solid that has a definite chemical composition and molecular structure.

They can consist of elements or compounds, but are usually Compounds. Some examples are: PbS is Galena, FeS_2 is Pyrite

Native minerals consist of only one type of element, like: gold, silver, sulfur, and diamond

To be a mineral, a substance must be ALL of these:

1) Naturally occurring
2) Inorganic
3) Definite chemical composition
4) Solid
5) Definite molecular structure

Questions to Answer:

1. What are the 5 parts of an atom? ______________________________________

____

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2. What are 3 of the major elements in the earths crust? ______________________

____

3. What are the chemical formulas for the following minerals?

   Halite - Galena - Hematite - Magnetite -

4. What is the definition of a compound? ____________________________________

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5. What are the 5 things that need to happen in order to have a mineral?

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Earth Systems 3209 - Unit 3a Lesson 2 – Mineral Groups in the Earths Crust

When we talk about minerals that belong to the Earths Crust, we must understand that they belong to 7 main groups:

1. Silicates
2. Sulfates
3. Carbonates
4. Oxides
5. Halides
6. Sulfides
7. Native

Hints on Classifying Mineral Groups

A) Mineral groups that end with **"ate"** and have an oxygen group in its chemical formula are one of the following;

i) Silicates = Si + O_x; example **Olivine - $(Mg,Fe)_2SiO_4$**

ii) Sulfates = S + O_x; example **Barite - $BaSO_4$**

iii) Carbonates = C + O_x; example **Calcite - $CaCO_3$**

B) Minerals that end with 'ide' and have a metal (ie Na, K) in it's chemical formula are one of the following:

i) Oxides = Metal + O; example **Hematite -** Fe_2O_3

ii) Sulfides = Metal + S; example **Pyrite** - FeS_2

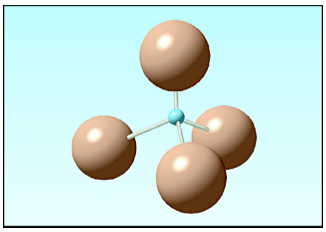
iii) Halides = Metal + Cl, Br, F; example **Fluorite -** CaF_2

Mineral Groups

1. Silicates
A mineral group that has silicon and oxygen as part of the atomic structure and makes up more than 96% of the earths crust

HINT: Look for SiO_x

Silicates that form rocks are split into 2 groups:



The Silica Terahedron

a) <u>Sialic Silicates (Aluminosilicates)</u>

These are rich in silicon and aluminum, and are the main rock type in continents. Generally these kinds of rocks make up 85% of the crust. Also, they are light in color.

HINT: Light = Less Dense = Continental Crust (kind of "floats")

b) <u>Simatic Silicates</u>

These are rich in silicon and magnesium, and are the main rock type in the ocean floor. Generally these rocks make up less than 15% of the earths crust. Also, the minerals are dark in color

HINT: Dark = More Dense = Ocean Crust (kind of "sinks")

The picture to the left shows "Aluminosilicates". We'd commonly call this "quartz rock". Notice that it looks a little like a glue stick.

2. Sulfates
A mineral group where there are compounds consisting of an atomic structure of one Sulfur and four Oxygen. Gypsum ($CaSO_4 \cdot 2H_2O$) is an example of a sulfate.

HINT: Look for SO_x

3. Carbonates
This is a mineral group where there are compounds consisting of an atomic structure of one carbon and 3 oxygens (CO_3). The most common Carbonate is Calcite, which makes up the rock Limestone ($CaCO_3$)

HINT: Look for CO_3

4. Oxides
This is a mineral group where there are compounds consisting of an atomic structure of oxygen combined with one or more metals. The most common oxides are those of iron (Fe_2O_3) and aluminum (Al_2O_3), referred to as <u>Ore – Minerals</u> (You will see more of this in Unit 5)

HINT: Look for Oxygen plus Metal

This is hematite – commonly known as Iron Ore

5. Halides
This is a mineral group where there are compounds consisting of an atomic structure of chlorine or fluorine with sodium, potassium, or calcium. Halite (NaCl) is the most common halide. This is often referred to as table salt.

HINT: Look for Cl, Fl, Na, K, Ca

Notice how the Halite breaks into cubes

6. Sulfides
This is a mineral group where there are compounds consisting of an atomic structure of one or more metals combined with sulfur. This is a common ore mineral (Unit 5 Spoilers!). Some examples are: Pyrite (FeS_2), Galena (PbS), Sphalerite (ZnS).

HINT: Look for S

Identify the mineral to the left.

7. Native Elements
This is a mineral group where there are <u>elements</u> that occur uncombined in nature. These are commonly called native elements. Some common examples are: Gold (Au), Silver (Ag), Copper (Cu), & Sulfur (S)

HINT: These 'stand alone'

A piece of native copper

Sample Problems

1. Which is an example of a halide?

(A) barite ($BaSO_4$) (B) calcite ($CaCO_3$) (C) fluorite (CaF_2) (D) hematite (Fe_2O_3)

2. What are the 7 main groups in the earth's crust, with an example of each?

3. What are the two types of silicates in the crust?

DO STSE #3 Next

Earth Systems 3209 - Unit 3a Lesson 3 – Mineral Properties

Each Mineral has properties that depend on:

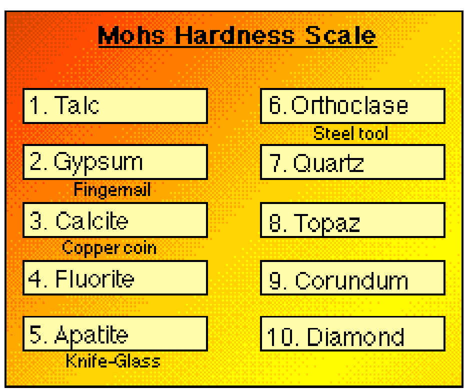
I. The type of minerals present
II. The arrangement of atoms
III. The strength of bonding

Text Book Reference: p 21 - 24

The following is a list of properties used to identify minerals that you need to know:
1. Hardness
2. Cleavage
3. Streak
4. Lustre
5. Color
6. Other - Taste, feel, magnetism, acid test, fluorescence
7. Specific Gravity – This will be its own lesson. Its THAT important.

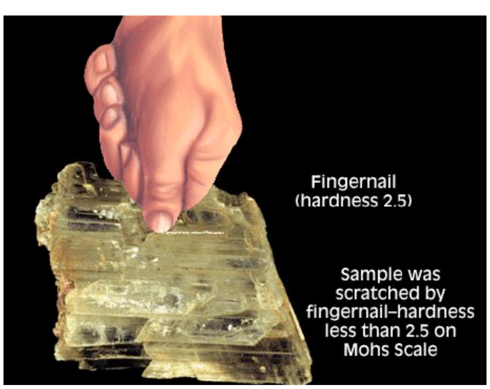
1. Hardness

This is the resistance of a mineral to scratching. Hardness is expressed in terms of **Moh's Hardness Scale** that ranks relative hardness from 1 – 10.



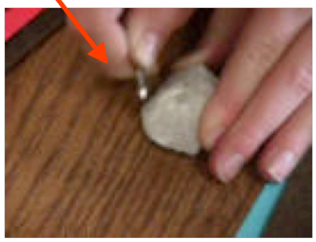
HINT: You could use a rhyme to remember the hardness scale:
Tonight Gypsies Come From Africa On Quads To Catch Dinosaurs

The following objects can be used when trying to determine the hardness of different minerals. If the object scratches the mineral then it is harder than the mineral.



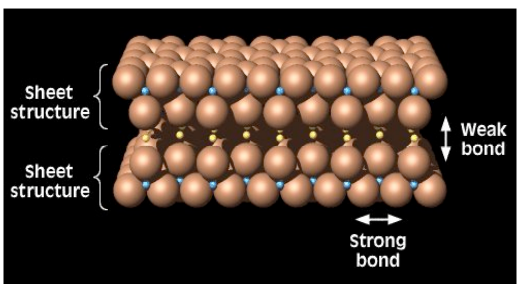
Approximate Hardness of Common Objects	
Fingernail	2.5
Copper penny	3.5
Iron nail	4.5
Glass	5.5
Steel file	6.5

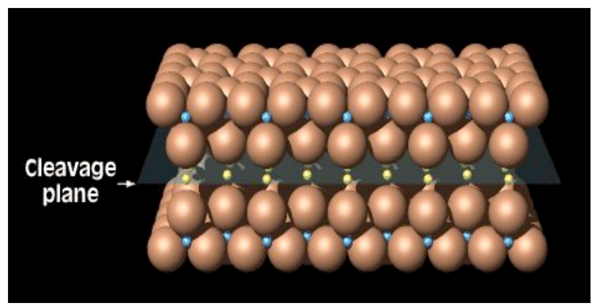
Nail, hardness of 4.5 scratches a mineral.



2. Cleavage

This is the tendency of some minerals to break along smooth, flat, parallel surfaces. Cleavage directions are determined by atomic structure and strength of bonding**.** The diagrams below illustrate this concept perfectly. They show that **Cleavage follows areas of weak bonding.**

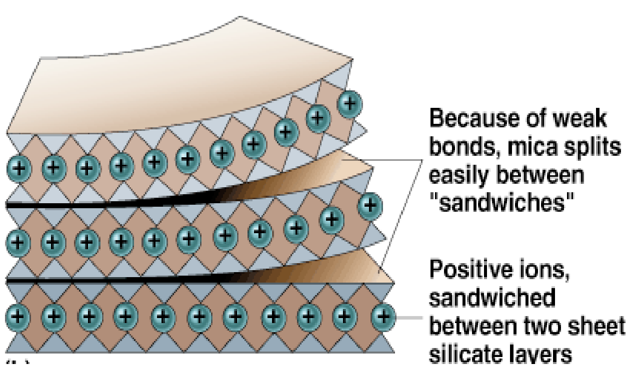




<u>Cleavage Plane Directions</u>

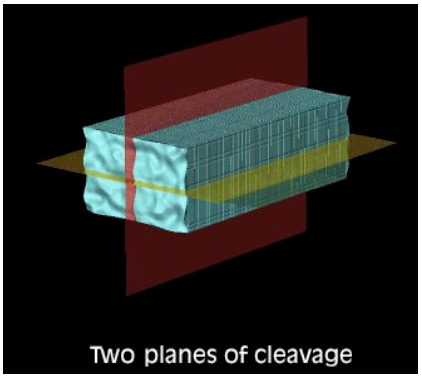
Minerals show cleavage in many different directions, but most common are in planes of one, two, and three directions.

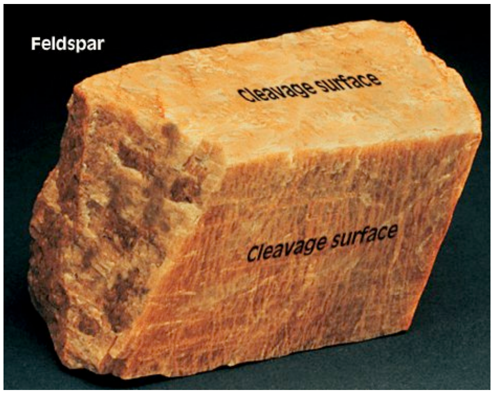
i) Cleavage in one direction (Basal Cleavage). An example: Mica displays this type of cleavage.



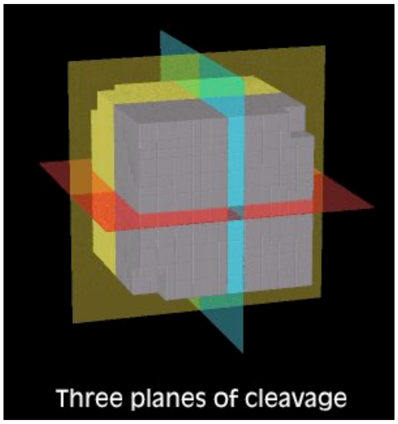
A sample of Mica

ii) Cleavage in two directions. An example: Orthoclase feldspar displays this type of cleavage.

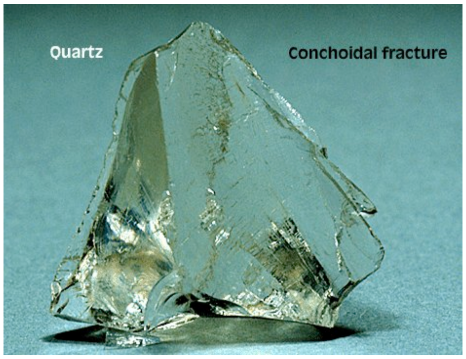


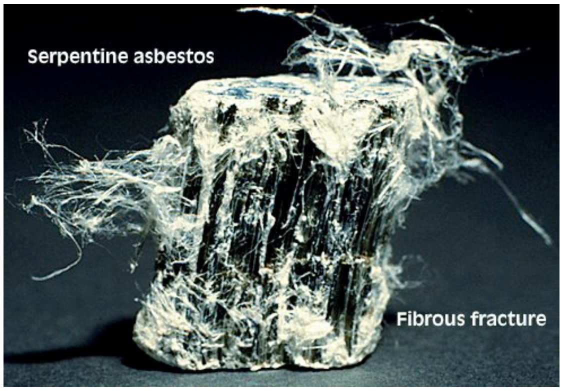


iii) Cleavage in three directions. An example: Halite displays this type of cleavage.
Fracture



NOTE: A mineral that does not have any cleavage planes is said to break by <u>"Fracture"</u>. An example is glass or the mineral quartz that is said to have <u>*Conchoidal Fracture*</u>. This is seen in the left diagram below.





Another example of a mineral that fractures is Asbestos. This mineral displays a <u>*Fibrous Fracture*</u>. This is seen in the right diagram above.

3. Streak

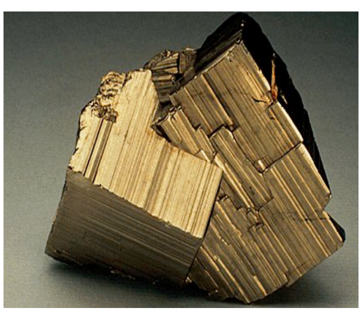
This is the true color of the mineral in its powdered form. To find the streak of a mineral, you perform a streak test. To do this you scratch a mineral across an unglazed porcelain tile and the powder streak left on the tile is the true color of the mineral.

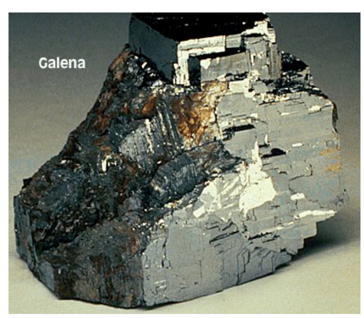
4. Luster

This is the appearance of the mineral in reflected light. Most minerals can be described as;

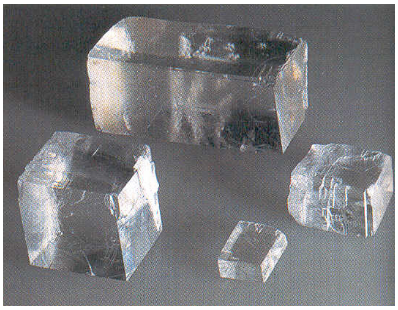
- A) Metallic
- B) Non - Metallic
    - i) Glassy
    - ii) Greasy
    - iii) Earthy or Dull
    - iv) Pearly

A) Metallic – Has a very metal glean (look) to it. The examples below are pyrite and galena. You can tell they have metallic luster because they look metallic.





B) Non-Metallic – Essentially, this is everything else. Can you identify each?



5. Color

This is the actual color of the mineral you see It is less distinctive and less reliable than the others. This is because:

i) Different minerals can have the same color.

ii) Some minerals may have impurities that cause a single mineral to have many different colors.

6. Other Properties

These physical properties can be helpful to identify minerals that are similar:

i) Taste - what the actual mineral taste like. *Ex. Halite (rock salt) taste salty.*

ii) Magnetism - if a mineral is magnetic or not. *Ex. Magnetite (Loadstone).*

iii) Acid Test - drop acid on the sample to see if the mineral reacts (fizzes). Used to test the Carbonate group. *Ex. Calcite (Limestone)*

iv) Feel - what the mineral feels like. *Ex. Graphite - greasy*

Earth Systems 3209 **(/35)** **Name:**
Minerals Review Sheet **Section:**

1. In the space provided, draw a pie-graph representing the top 8 minerals by abundance, in the earths crust. (5 marks)

2. In the chart, list any 10 minerals from your class notes and their chemical compositions. (5 marks)

Mineral Name	Chemical Composition

3. List 5 things a substance must be to be considered a mineral: (5 marks)

4. What are the two groups of silicates, and what is the difference between them? (2 marks)

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____

5. What are the properties used to identify minerals? (2 marks)

____

____

____

6. What are the 7 mineral groups? Give an example of each. (7 marks)

Group	Example

7. Make a list from 1 – 10 of Mohs Hardness scale. Where would everyday items, such as glass, a fingernail, steel and a penny fit on this scale? (5 marks)

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

8. What is the difference between cleavage and fracture? (2 marks)

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9. Explain why color is NOT a reliable property for identifying minerals. (2 marks)

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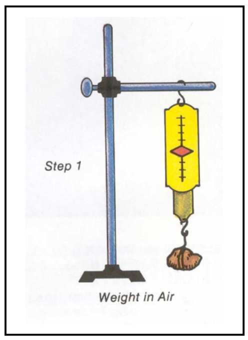
Earth Systems 3209 - Unit 3a Lesson 4 – Specific Gravity

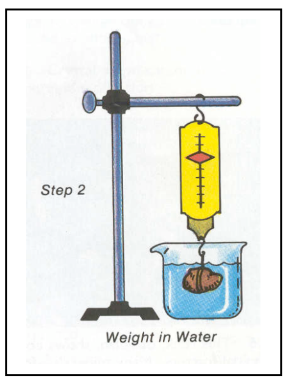
This lesson will show you how to calculate and solve problems based on specific gravity. At the end you will have to do questions based on the calculation, and a couple of assignments. There is a small amount of math involved here, but don't panic!

Essentially, Specific Gravity is the mass of a mineral compared to that of an equal volume of water. To determine specific gravity you need to carry out the following three steps:

1. Weigh the specimen in air and record the weight.



2. Weigh the specimen submerged in water and record the weight.



3. Calculate specific gravity (S.G.) using the following formula:

$$\textit{Specific Gravity} = \frac{\textit{weight in air}}{\textit{weight in air - weight in water}}$$

Specific Gravity = Density

It is important to note that because pure water has a density of 1 g/cm^3, the specific gravity is equal to its density. Thus, Specific gravity = Density.

Note: Pure water is pretty awesome. Always remember that when dealing with pure water, 1 g = 1 ml = 1 c.c. - or - cm^3

Density

To get Density you must:

1. Use a scale to measure the mass of the mineral sample.

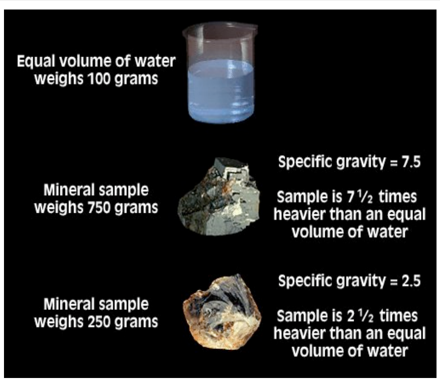
2. Find the volume of the mineral sample.

3. Calculate density (which equals specific gravity). You can use the following equation:

$$\text{Density} = \frac{\text{Mass}_{(\text{mineral})}}{\text{Volume}_{(\text{mineral})}} = \text{Specific Gravity}$$

For example:

Given that 1mL = $1cm^3$ = 1g, we know the weight of an equal volume of water in grams. We can then use our formula for the following question to calculate Specific Gravity:



Try it on your own. Your values should match those given in the picture to the right:

$$\text{S.G.} = \frac{\text{Mass of Mineral Sample}}{\text{Volume of Water}}$$

One final thing you should know about Specific Gravity is that there is no unit assigned to it, but with density there is (g/ cm^3). When you answer these questions, most times you can use the density equation, but ***remember that unless it specifically asks for density, there will be NO UNITS in your answer***.

Questions:

1. Why is pure water “pretty awesome”? ____

____

2. Explain how the specific gravity of a mineral is determined. ______________________

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Earth Systems 3209 **(/20)** **Name:**

Specific Gravity Assignment #1 **Section:**

Always remember: Water – $1cm^3$ = 1 g = 1 mL; S.G. = D = m/V; *V = L x W x H*

Example:

A mineral with a mass of 150 grams displaces 60 milliliters of water.

- **specific gravity (S.G.)** = mass of mineral divided by mass of water displaced by the mineral
- mass of mineral = 150 g
- volume of displaced water = 60 ml
- 1 ml of water has a mass of 1 g so the mass of displaced water = 60 g

S.G. = 150g ÷ 60g
= 2.5

Results

The specific gravity of the mineral in the example is 2.5.

Why?

Specific gravity is the ratio of the mass of a substance, such as a mineral, in air compared to the mass of an equal volume of water. To calculate specific gravity, divide the mass of the mineral by the mass of the water displaced by the mineral. The answer tells you how many times heavier the mineral is than water. The mineral in the example is 2.5 times as heavy as water. Most minerals have a specific gravity greater than 1, meaning that they are heavier than water. Every mineral has a certain specific gravity, thus the specific gravity of a mineral can be used as a clue to its identity.

<u>Calculating densities of rocks and minerals</u>

1. You have a rock with a volume of $15cm^3$ and a mass of 45 g. What is its density?

2. You have a different rock with a volume of $30cm^3$ and a mass of 60g. What is its density?

3. In the above two examples which rock is heavier? Which is lighter?

4. In the above two examples which rock is more dense? Which is less dense?

5. You decide you want to carry a boulder home from the beach. It is 30 centimeters on each side, and so has a volume of 27,000 cm^3. It is made of granite, which has a typical density of 2.8 g/cm^3. How much will this boulder weigh?

6. Rocks are sometimes used along coasts to prevent erosion. If a rock needs to weigh 2,000 kilograms (about 2 tons) in order not to be shifted by waves, how big (what volume) does it need to be? You are using basalt, which has a typical density of 3200 kg/m^3

7. A golden-colored cube is handed to you. The person wants you to buy it for $100, saying that is a gold nugget. You pull out your old geology text and look up gold in the mineral table, and read that its density is 19.3 g/cm^3. You measure the cube and find that it is 2 cm on each side, and weighs 40 g. What is its density? Is it gold? Should you buy it?

Calculating Specific Gravity of Rocks and Minerals

8. You have a sample of granite with density 2.8 g/cm^3. The density of water is 1.0 g/cm^3. What is the specific gravity of your granite?

9. You have a sample of granite with density 174.8 lbs/ft^3. The density of water is 62.4 lbs/ft^3. What is the specific gravity of the granite now?

Earth Systems 3209 **(/30)** **Name:**
Specific Gravity Assignment #2 **Section:**

Remember: *Specific Gravity = Density*

Water – 1cm^3 = 1 g = 1 mL

$$S.G. = \frac{\text{weight of mineral in air}}{(\text{weight in air}) - (\text{weight in } H_2O)}$$

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

Volume = Length x Width x Height

1. Mineral Sample A has a weight of 420 grams in air and a weight of 380 grams while it is submerged in water. What is its specific gravity? ______________
Show your workings.

2. Mineral Sample B has a weight in air of 850 grams and a volume of 100 cubic centimeters. What is its weight in water? _______________
What is its specific gravity? _______________
Show your workings.

3. Mineral Sample C has a volume of 250 cubic centimeters and a weight in water of 1500 grams. What is its weight in air? ________________
What is its specific gravity? _______________
Show your workings.

4. Mineral Sample D has a weight in air of 42 grams and a volume of 210 cubic centimeters. What is its specific gravity? ______________
Show your workings.

5. a) Gold has a specific gravity of 19.3. What is the weight of a block of gold that is 10 cm long, 10 cm wide and 25 cm high?
In grams _________________
In kilograms ______________

Show your workings.

b) There are approximately 2.2 pounds in 1 kilogram and there are 12 Troy ounces *(a Troy ounce is a measure of value for gold)* in 1 pound. If Gold is worth about $420 per Troy ounce, about how much is the block of gold worth? $_____________
Show your workings.

Earth Systems 3209 Unit 3a Test Review

Please answer the following completely and on your own paper. You may type them, or handwrite them legibly.

Definitions (Terms to know)

Atom	ion	element	compound
Molecule	ionic	molecular	metallic
Mineral	silicates	carbonates	halides
Sulfides	sulfates	oxides	native elements
Silicates	carbonates	halides	sulfides
Sulfates	oxides	native elements	
Silica tetrahedron	crystal shape (form)	cleavage	fracture
Hardness	specific gravity	colour	streak
Luster	acid test	taste	magnetism
double refraction	fluorescence	mineralogy	crystallography
geochemistry	gemology		

3. A pencil lead contains the mineral graphite that is composed of pure carbon. A diamond is also composed of pure carbon.
a) How do their values for hardness compare on Moh's Scale?
b) Explain why the difference in hardness exists between diamond and graphite.
4. Based on the definition of a mineral, ice would be considered a mineral and coal would not. Explain why this is true.
5. a) Explain how the specific gravity of a mineral is determined.
b) A mineral sample was studied and the following data obtained. Using the data, determine the mineral's specific gravity.
Mass of Mineral Sample 129.6g
Volume of Water Displaced 18.0 cm3