ES 104: Laboratory # 6 (Summer 2022)
PHYSICAL PROPERTIES OF MINERALS AND MINERAL IDENTIFICATION

Before start of the lab, watch a short 8-minute Youtube video on the basics of mineral identification:
https://www.youtube.com/watch?v=32NG9aeZ7_c

Introduction

Minerals are naturally occurring, usually inorganic, solids that possess a definite chemical composition and a specific, orderly arrangement of atoms. This lab will help you to develop the ability to identify common minerals found at the Earth's surface. Although there are literally thousands of minerals, there are only a small number of minerals that are common rock forming, ore, and industrial minerals. These constitute a large part of the Earth's crust. Identification is accomplished by testing and observing the physical properties studied in the first of part of this laboratory. The second part of the lab will focus on describing the physical properties of a mineral and on identifying minerals using the physical properties.

Objectives

- Recognize and describe the physical properties of minerals
- Develop and use a mineral identification key to name minerals
- Identify minerals using physical properties

Useful Websites

- http://www.rockhounds.com/rockshop/xtal/part2.html
- http://geology.csupomona.edu/alert/mineral/shape.htm
- http://mineral.galleries.com/minerals/property/physical.htm
- http://mineral.galleries.com/minerals/cleavage.htm
- http://webmineral.com/help/Luster.shtml

Name____________________________________
Lab day _______Lab Time______________________

Pre-lab Questions – Complete these questions before coming to lab.

Briefly define the following key words.

1. Element	7. Cleavage
2. Mineral	8. Fracture
3. Color	9. Crystal form
4. Streak	10. Density
5. Luster	11. Magnetism
6. Hardness	12. Effervescence

1. How is density calculated? (Show formula with units.)

2. What is the difference between a silicate and non-silicate mineral? Include some examples of each type of mineral.

Part A: Activities Focusing on Physical Properties

Minerals exhibit certain diagnostic properties, called physical properties, which can be tested and observed, thereby leading to the correct identification of the mineral. Many (but not all) of these properties are unique to a given mineral. One of the keys to identifying minerals is observing a combination of physical properties displayed by a mineral. You must be sure of the meaning of each of the physical properties. On the following pages, you will study these properties: luster, color, streak, heft, density, hardness, cleavage, fracture, crystal form, magnetism, and effervescence in dilute, cold hydrochloric acid (HCl).

STATION #1: Luster and Color

1. Study the various mineral specimens provided. Of the four specimens **in the luster box,** how many can be grouped into each of the following luster types?

   __________ Metallic __________ Nonmetallic-glassy

   Describe <u>Luster</u> in your own words.

2. Study the mineral specimens of quartz (Sample #3) provided in the **color** box. What is the reason for the variety of colors that quartz exhibits? (**HINT**: Think about what a single drop of food coloring does to a glass of water.)

3. Is color a reliable physical property to help identify a given mineral specimen? Keep in mind your observations in question 2 above. Explain your answer.

STATION #2: Other Physical Properties

In this station you will examine Streak, Magnetism, and Effervescence

1. Describe in your own words:

   Streak—

   Magnetism—

   Effervescence—

2. Examine the collection of samples provided and complete the data table by recording the following observations for each sample:

Sample Number	**Streak Color**	**Magnetic Character**	**Reaction to HCl**
#1			
#2			
#13			

STATION #3: Cleavage, Fracture, and Crystal Form

Study the collection of single mineral samples. Several samples exhibit cleavage (#5, #6, and #13), one shows fracture (#3), and one demonstrates crystal form (#4).

Cleavage and **Fracture** are related to how a mineral breaks apart. They are controlled by the internal atomic arrangement of the mineral.

1. Is cleavage or fracture (which one) controlled by planes of weak chemical bonding?

2. Briefly explain these in relation to crystal structure of the atoms.

Crystal Form is also controlled by the internal atomic structure but is not related to how a mineral breaks. With a magnifying lens, look at the crystal form shown by sample 4. **Sketch it** here ↓.

3. What is Crystal Form?

Study the minerals listed below, and complete the data table. For each, describe the cleavage in terms of the number of directions, or write 'none' if the mineral does not have cleavage, and **determine the angle between them *if* there is more than one direction of cleavage**. Also, provide a simple sketch of the sample emphasizing the cleavage, or lack of it.

Sample Number	# of Directions	Angle between cleavage planes (90º or not 90º)	Sketch showing cleavage angle
#3			
#5			
#6			
#13			

STATION #4: Density

The density of a mineral can be estimated by hefting the mineral in your hand. Some minerals will feel heavier than others for a given sample volume. This is a **subjective** determination. For mineral identification, it is **better to measure** the mineral sample's mass and volume and calculate the density. Any person doing the determination should get the same answer: **the answer is objective** and not subjective. The concept that anyone doing the experiment should get the same answer is fundamental to science.

Density can be calculated with a high degree of accuracy (although your measurement may not seem so because you are using a relatively primitive method). The density of any substance is the mass per volume, shown by the equation:

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

Step 1: Find the mass of your specimens using the balance. Record in the table on page 6.7, including units.

Step 2: Determine the volume of the specimens by displacement of water in a graduated cylinder. Record with units in the table on page 6.7.

Step 3: Use the equation to determine the density of the specimens.

Table for density measurements and calculations:

Sample number	1) Mass of sample	2)Volume of sample	3) Density of sample	*Show work here (include units):*

1. The density of quartz is 2.65 g/cm^3. If you have 2.65 grams of quartz, what is the volume of the specimen, in cm^3?

2. What would be the volume of 1 gram of quartz? Show work here. (Include units: they help you set up the equation.)

Specific gravity (S.G.) is a term quite similar to density. Specific gravity is a unitless comparison of a mineral's density to the density of liquid water. Water has a specific gravity of 1. Specific gravity can be thought of as the number of times the mineral is heavier than the same volume of water. For example, if a mineral has a specific gravity of 3.47, it is 3.47 times heavier than an equal volume of water.

3. If a substance had a specific gravity of 2.54, would it float or sink in water?

4. Is the specific gravity of ice greater or less than 1?

5. Is the specific gravity of oil greater or less than 1?

STATION #5: Hardness

Hardness is the resistance of a mineral to scratching. It is determined by comparing the ability of a mineral to scratch or be scratched by other minerals of known hardness. In 1812, Friedrich Mohs developed a non-linear scale of ten commonly available minerals as a standard for comparison. This scale is shown at the right.

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

Because you do not have samples of each of these minerals available, the following hardness guide is useful to bracket the hardness of an unknown sample.

Hardness Guide:

Hardness (H)	**'Code'**	**Description**
less than 2.5	<2.5	Mineral can be scratched by fingernail (H fingernail = 2.5).
2.5 to 3.5	2.5-3.5	Mineral cannot be scratched by fingernail, and mineral cannot scratch penny (H penny = 3.5).
3.5 to 5.5	3.5-5.5	Mineral can scratch penny, and cannot scratch glass (H glass = 5.5).
greater than 5.5	>5.5	Mineral can scratch glass.

Determine the hardness for the small group of minerals provided and complete the data table.

Sample	**Hardness (use <u>code</u> from table above)**
#3	
#7	
#13	
#14	

Describe how differences in hardness might be useful in mineral identification. Use some examples.

Part B: Activities focusing on Mineral Description and Mineral Identification

<u>Description</u>

You are now ready to collect a complete set of data of the physical properties useful in mineral identification. Determine the physical properties of each sample and record your observations in the data table provided on the following page. **Complete the table of specimen properties before trying to identify the minerals by name.** This is more important than the name! After listing the properties, use these and the 'Mineral Identification Key' on pages 6.11, 6.12 and 6.13 to determine which minerals you have. Be sure to notice the footnote information provided in the key.

<u>Identification</u>

Mineral identification is a process of elimination based on determinations of physical properties. In this activity, you will use an identification key for the minerals that you described. To use a key to identify minerals, you will be given a series of choices about the properties of a mineral. For most of the identification process, the choices will be "either this or that". Compare your determinations of mineral properties with the mineral identification tables in the following pages.

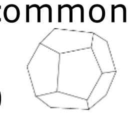
To identify the fifteen 'unknown' minerals, follow the divisions of the key tables: first choose the proper table by the luster of the mineral. Notice Table 2a is for identifying those minerals that have a metallic luster. Table 2b and 2c are for minerals that do not have metallic luster: Table 2b is for minerals that are light-colored, and 2c is for minerals that are dark colored. Each table for luster is divided into two sections: softer than glass, and harder than glass. These sections are further divided by the absence or presence of cleavage, and the characteristics of the cleavage if it is present.

After you have identified the minerals, you should concentrate on a small number (1-3) of properties for each mineral to help you remember how to identify it. These are considered "diagnostic properties" for that mineral. A particular mineral will have a set of properties that are diagnostic for it. Some properties that are diagnostic for certain minerals are of no significance for other minerals. This is especially true for color, or some special properties like magnetism or effervescence in hydrochloric acid.

Mineral Description Table

Sample #	**Luster:** Metallic/ Non-metallic/ Submetallic	**Hardness** Describe using range code in guide on pg. 6.8	**Cleavage:** # of planes and angle of intersection. **Crystal form** (if it shows)	**Streak** Color of it, or 'none' if H>6	**Color** and **Other properties** (if present)	**MINERAL NAME—** complete properties for all minerals before beginning to name any
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Table 2a: Mineral Identification Key—Metallic Luster

Hardness	Cleavage	Diagnostic Physical Properties	Mineral Name
Harder than glass	Absent	Brass yellow color, tarnishes brown to green; **greenish or brownish black streak**; cubic or pyritohedron crystals common;  **H = 6 – 6.5**, S.G.=5.0	**Pyrite** FeS_2
		Pale brass yellow to whitish gold color; dark gray streak; radiating masses and "cockscombs:" common; H = 6 – 6.5, S.G.=4.9	**Marcasite**[*] FeS_2
		Dark gray to black color, dark grey to black streak; **magnetic**; massive or "grainy"; may have 'submetallic' luster; H = 6[‡], S.G.=5.2	**Magnetite** Fe_3O_4
		Silver to gray color, **red-brown streak**; may be composed of glittery flakes; H=5-6.5, S.G.~5	**Hematite** Fe_2O_3
Softer than glass	Present	Silver gray color, **gray streak**; **cubic cleavage** (three directions at 90°), but may be distorted; H = 2.5 (cannot be scratched by fingernail); **S.G. = 7.4 – 7.6**	**Galena** PbS
	Absent	Golden yellow color, **tarnishes to purple**; Greenish black to dark gray streak; H = 3.5 – 4, S.G.=4.2	**Chalcopyrite**[*] $CuFeS_2$
		Copper to dark brown color, **tarnishes to green**; copper streak; H = 2.5 3; S.G. = 8.8–8.9	**Copper**[*] Cu
		Dark gray color; dark gray streaks; **marks paper easily**; greasy feel; H = 1; S.G. = 2.1-2.3	**Graphite**[*] C

[*] These minerals are not included with ES 104 lab specimens.
[‡] The hardness of some samples is less than this table indicates, due to alteration

Table 2b: Mineral Identification Key—Nonmetallic Luster, Light Colored

Hardness	Cleavage	Diagnostic Physical Properties	Mineral Name
Harder than glass	Present	White to pink color; **two directions of cleavage at 90°; H=6**‡, SG=2.55; subparallel banding (exsolution lamellae) may be present on cleavage faces	**Potassium Feldspar** † (Orthoclase) $KAlSi_3O_4$
		White to blue-gray color; **two directions of cleavage at nearly 90°; H=6**‡, S.G.=2.65; may have striations (parallel grooves) on cleavage faces	**Plagioclase Feldspar**† $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$
	Absent	White, gray, or pink color; usually massive; may have hexagonal prism with pyramid crystals; transparent to translucent; glassy luster; conchoidal fracture; **H=7**, S.G.=2.65	**Quartz** † SiO_2
		Olive green to yellow-**green color**; granular masses; grains glassy with conchoidal fracture; H=7‡, may be less from alteration, S.G.=3.3-4.4	**Olivine** † $(Fe,Mg)SiO_4$
Softer than glass	Present	Colorless, yellow, blue, green, or purple; four directions of cleavage **(octahedral)**; transparent to translucent; **H=4**, S.G.=3.2	**Fluorite*** CaF_2
		White, gray, or pink color; three directions of cleavage not at 90° (rhombohedral); fizzes in dilute HCl if powdered; H=3.5–4, S.G.=2.85	**Dolomite*** $CaMg(CO_3)_2$
		Colorless, white, yellow, or gray; rhombohedral cleavage (**three directions, not at 90°**); **fizzes** in dilute HCl; H = 3, S.G.=2.72	**Calcite** $CaCO_3$
		Colorless, white or gray; **cubic cleavage** (three directions at 90°); salty taste; dissolves in water; **H = 2.5**, S.G.=2.1-2.3	**Halite** NaCl
		Colorless, clear brownish or yellowish color; one direction of cleavage; usually **thin, elastic, transparent to translucent sheets;** H=2.5, S.G.=2.8. May be submetallic	**Muscovite**(mica)† $KAl_2(AlSi_3O_{10})(OH)_2$
		Colorless to white; massive, or one good direction of cleavage (and two poor) forming thick; nonelastic, translucent sheets; **H = 2**, S.G.=2.3	**Gypsum** $CaSO_4\ 2H_2O$
	Absent	White earthy masses resembling chalk; plastic and sticky when wet; H=1–1.5, S.G.=2.6	**Kaolinite*** $Al_4Si_4O_{10}(OH)_8$

*These minerals are not included with ES 104 lab specimens.

† Minerals important to formation of igneous rocks: study these carefully because they will be used to help identify igneous rocks in the next two labs.

‡ The hardness of some samples is less than this table indicates, due to alteration

Table 2c: Mineral ID Key—Nonmetallic Luster, Dark Colored

Hardness	Cleavage	Diagnostic Physical Properties	Mineral Name
Harder than glass	Present	Dark gray to blue-gray color; two directions of **cleavage at ~90º; H = 6**‡, SG=2.62-2.76; striations (parallel grooves) may be present on cleavage faces	**Plagioclase Feldspar**† $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$
		Black to dark green color; two directions of cleavage intersecting at 87º and 93º; often massive in appearance; **H = 5.5**‡, S.G.=3.1-3.5	**Augite** (Pyroxene)† Ca, Mg, Fe, Al Silicate
		Black to dark green color; two directions of **cleavage intersecting at 60º and 120º**; often massive or splintery in appearance; H=5.5‡, S.G.= 3.0-3.3	**Hornblende**† (Amphibole) Na, Ca, Mg, Fe, Al Silicate
	Absent	Dark gray to smoky brown color; usually massive; transparent to translucent; glassy luster; **conchoidal fracture; H = 7**. S.G.=2.65	**Quartz**† SiO_2
		Black, dark **green**, olive green color; granular masses; single grains are glassy with conchoidal fracture; H = 7‡, S.G.=3.27-4.37	**Olivine**† $(Fe,Mg)SiO_2$
		Dark red to brownish-red color; translucent; often has smooth, parallel fractures resembling cleavage; **H = 7**, S.G.=3.5-4.3	**Garnet*** Fe, Mg, Ca, Al Silicate
		Dark gray to black color, dark grey to black streak; **magnetic**; massive or "grainy"; may have 'submetallic' luster; H = 6‡, S.G.=5.2	**Magnetite** Fe_3O_4
		Grayish to dark brown to yellow-brown color; **yellow-brown streak**; amorphous; opaque, earthy appearance ; H = 1.5–5.5, S.G.=4.37	**Limonite*** $Fe_2O_3\ nH_2O$
Softer than glass	Present	**Dark brown to dark green color**; one direction of cleavage; usually in **thin, elastic, transparent to translucent sheets; H = 2.5–3**, S.G.=2.95-3.0. May be submetallic.	**Biotite** (Mica)† $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$
		Dark green to green color; one direction of cleavage; usually in thin, opaque, curved sheets; often massive with greasy feel; H=2.5, S.G.=2.6-2.9	**Chlorite*** Mg, Fe, Al Hydrous silicate
	Absent	Dull red to gray color; **reddish-brown streak**; opaque, earthy appearance; H=1.5–5.5, S.G.=5.2	**Hematite** Fe_2O_3
		Grayish or dark brown to yellow-brown color; **yellow-brown streak**; amorphous; opaque, earthy appearance; H = 1.5 – 5.5, S.G.=4.37	**Limonite** $Fe_2O_3\ nH_2O$

* These minerals are not included with ES 104 lab specimens.
† Minerals important to formation of igneous rocks
‡ The hardness of some samples is less than this table indicates, due to alteration

For your information... **Mineral uses and some mineral facts:**

Barite	principle source of barium and sulfate for chemical industry; used in petroleum industry as drilling mud
Calcite	used for manufacture of cement and lime for mortars, used as soil conditioner, used as flux for smelting metallic ores, building industry
Chalcopyrite	important ore of copper; oxidized surfaces show iridescence.
Feldspars	used in manufacture of porcelain; source of aluminum in glass industry
Fluorite	flux in making steel; used in chemical industry for hydrochloric acid; high-grade ore is used in making optical equipment
Galena	most important ore of lead; lead is used in batteries, in metal products as an alloy, in glass making; used to be the principal ingredient in paints. The Romans used lead for indoor plumbing, which may have resulted in lead poisoning of the higher, classes and contributed to the downfall of the Roman Empire.
Garnet	semi-precious gemstone, used in abrasive products (sand paper)
Graphite	this is the "lead" of pencils, also used in protective paints in foundries, batteries, and electrodes; in fine powder form, it is used as a lubricant
Gypsum	plaster (wall board, sheet rock); used in Portland cement; soil conditioner for fertilizer
Halite	table salt; source of Na and Cl for the chemical industry
Hematite	most important ore for steel making; used in pigments, some use as gemstone
Kaolinite	used for brick, paving brick, drain tile, ceramic products, and as filler in glossy paper
Magnetite	minor ore of iron
Olivine	some used as gem (peridot); used in casting industry because of refractory properties (means high melting temperature)
Quartz	some use as gemstone; in sand form, used in mortar, concrete, as flux, and for abrasive products. Artificial quartz is now used in radios and for optical instruments (quartz permits both the transmission and reception on a fixed frequency).
Sphalerite	most important ore of zinc; galvanized metals are covered with zinc to prevent rusting.
Talc	used in manufacture of paint, paper, roofing materials, rubber, cosmetic powders, and talcum powder; used as insulators in electrical industry

Name_______________________________________

Lab day _______Lab Time_______________________

POST-LAB ASSESSMENT

1. Describe the procedure you use for identifying a mineral and arriving at its name.

2. Name the physical property that is described by each of the following statements:
   a. Breaks along smooth planes: ____
   b. Scratches glass: ____
   c. A red-colored powder on unglazed porcelain: ____
3. **Describe** the shape **and sketch** a mineral that has three directions of cleavage that intersect at 90°.

4. How many directions of cleavage do the feldspar minerals (potassium feldspar and plagioclase) have? ___________________________________
5. How would you tell the difference between a crystal face and a cleavage plane?

6. Which would tell you more about a mineral's identity: luster or hardness? Why?