

## Minerals – Laboratory 2

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(name)

### Exercise 1

**Minerals** are naturally occurring inorganic substances with a definite chemical composition and crystalline structure. They are formed through chemical reactions that occur within and on the Earth. To understand minerals you need to understand some basic chemistry. The following is a list of elements and their short hand notations. You are responsible for knowing the short hand notation of all of these elements.

- (a) silicon – Si
- (b) aluminium – Al
- (c) oxygen – O
- (d) iron – Fe
- (e) magnesium – Mg
- (f) potassium – K
- (g) sodium – Na
- (h) calcium – Ca
- (i) carbon – C
- (j) hydrogen – H
- (k) chlorine – Cl

### Exercise 2

**Atoms** are the smallest particles of an element that retain all of their properties. As you well know all atoms are composed of a **nucleus** and surrounding **electrons**. The nucleus contains both **protons** and **neutrons**. Electrons are negatively charged particles while protons are positively charged. Electrons occupy a variety of **shells** or **orbitals** that are arranged about the nucleus. In general, electrons occupying the innermost shells are more tightly bound to the nucleus than are electrons occupying outer shells. The outermost shell is sometimes referred to as the **valence shell** because of its ability to release or accept electrons.

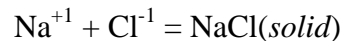
In a given atom, say oxygen, the number of protons is balanced by the number of electrons when it is in standard state. In contrast, when an atom is in **ionic state**, then the number of electrons and protons are unbalanced. This occurs when an atom gives up or accepts electrons from its outermost shell. Positively charged ions are called **cations** while those with a negative charge are termed **anions**. Cations result when the number of protons is greater than the number of electrons. In contrast, anions result when the number of electrons exceeds the number of protons. You are expected to know the common charges or **valance states** of the above elements. They are as follows:

- (l) Si = +4
- (m) Al = +3
- (n) O = -2
- (o) Fe = +2 or +3
- (p) Mg = +2
- (q) K = +1
- (r) Na = +1
- (s) Ca = +2
- (t) C = +4
- (u) H = +1
- (v) Cl = -1

The valence state of an atom is sometimes referred to as its **oxidation state**.

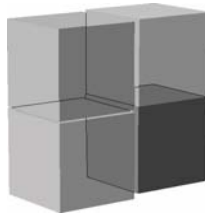
### Exercise 3

There are two major groups of minerals – **nonsilicate** and **silicate**. Let us look at a common nonsilicate mineral, halite. A common example of this mineral is table salt. The chemical formula for halite is NaCl. We can write an equation that expresses the way that halite forms as follows:



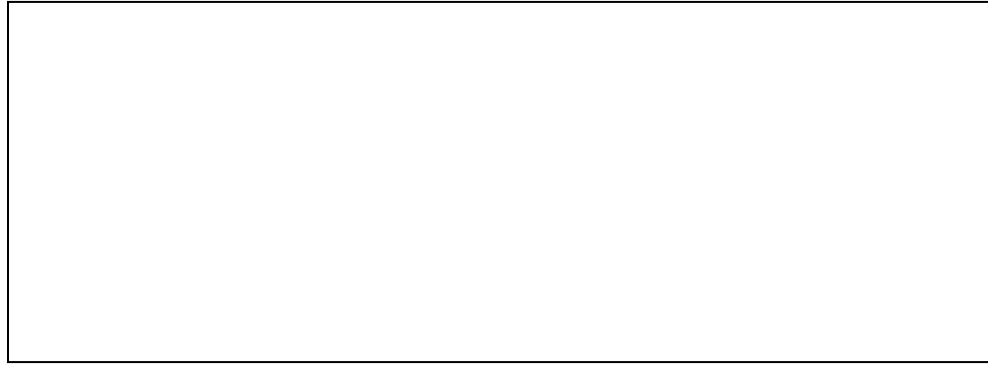
In the above equation note that in the solid, the charges of Na and Cl balance out and sum to zero. This is true for all minerals.

**Halite** is generally translucent, shaped like a cube, and is rather soft.



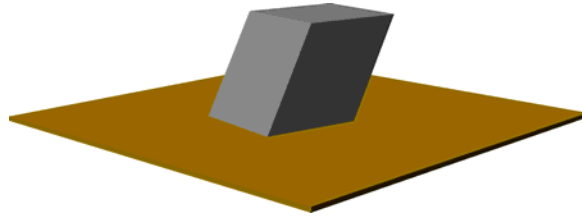
Schematic drawing of cubic halite crystals. Each crystal is  $\sim 5 \text{ mm}^3$  in size

In fact, you should be able to scratch halite with your finger nail. It is an evaporate mineral that forms as water in a salt lake or lagoon dries out. It should be in your box of minerals. See if you can find a mineral with these general characteristics. After finding it sketch an example below from your hand sample and list its key characteristics.



**Your sketch of halite goes here**

**Calcite** is  $\text{CaCO}_3$ . It too is typically translucent and soft but unlike halite it has a rhombic form as shown below. You can not scratch calcite with your finger nail, but you can scratch it with a copper penny.



*Sketch of a  $\sim 5 \text{ mm}^3$  rhombohedron of gray calcite lying on brown filter paper*

Calcite occurs in a variety of rocks but is most common in limestones and marbles. Now see if you can find calcite in your box of minerals. After finding it sketch an example below from your hand sample and list the characteristics that you would use to distinguish it from halite.



**Your sketch of calcite goes here**

Other common nonsilicate minerals include graphite (C), magnetite ( $\text{Fe}_3\text{O}_4$ ), galena (PbS), hematite ( $\text{Fe}_2\text{O}_3$ ), and pyrite ( $\text{FeS}_2$ ). **Graphite** is like the lead in your pencil. It

forms in metamorphic rocks such as slates and schists. **Magnetite** is the only mineral that we will study that is magnetic. It forms in igneous rocks and in veins. **Galena** forms in hydrothermal veins where hot fluids reach the upper parts of the Earth's crust. **Hematite** forms in hydrothermal veins and as a replacement product of other minerals. **Pyrite** forms as an accessory mineral in sedimentary, igneous, and metamorphic rocks. Can you guess why its common name is "fools gold"?



*Schematic illustration of cubes of pyrite. Each cube is  $\sim 5 \text{ mm}^3$  in size*

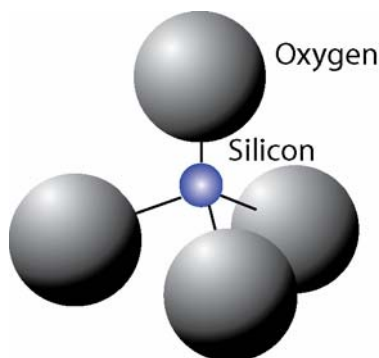
After finding pyrite sketch an example from your hand sample and list its key characteristics in the box below.

**Your sketch of pyrite goes here**

#### Exercise 4

The **silicate mineral group** consists of all minerals that are built from the so called **silicon tetrahedron**. The silicon (Si) atom has an atomic radius of 0.42 Å (Å = angstroms) while the oxygen (O) atom has a radius of 1.4 Å. One Å is equal to  $10^{-8}$  cm or 0.00000001 cm. The silicon tetrahedron looks like an Egyptian pyramid with the small silicon atom tucked in the middle of the pyramid and the huge oxygen atoms occupying each of the four corners of the pyramid.

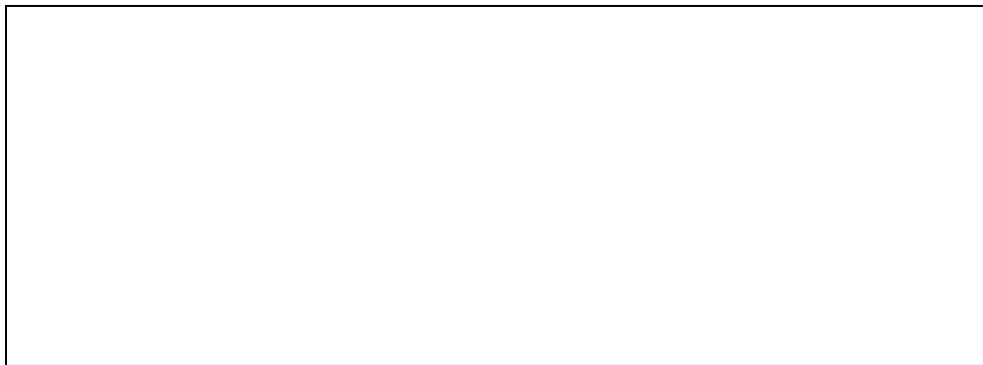
In order for you to gain a fundamental understanding of this geometry we will make a stick molecule of the silicon tetrahedron (see sketch below). As our silicon atom we will use a gum drop or jelly bean. Representing the bonds between the silicon and oxygen atoms will be tooth picks. Though we could use more gum drops for oxygen atoms we will assume their presence.



*A stick figure of the silicon tetrahedron. The large gray atoms are oxygen while the small central blue atom is silicon*

Silicon tetrahedron can be arranged to form 5 major groups of silicate minerals. Each arrangement is unique and specific to each of the 5 major groups. You will be asked to make 4 to 5 individual stick silicon tetrahedron. You will then arrange them into the 5 major groups following instructions provided by your lab instructor.

The 5 major silicate structures are (a) **independent**, (b) **single chain**, (c) **double chain**, (d) **sheet**, and (e) **framework**. As you complete each stick molecule of the silicate structure sketch and label its key parts below.



**Your sketch of the Independent Silicate Structure goes here.**

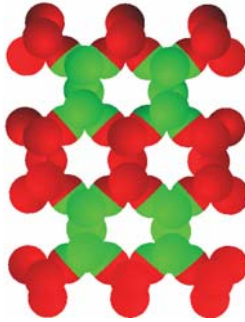


**Your sketch of the Single Chain Silicate Structure goes here**

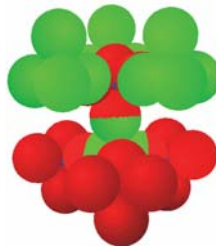


**Your sketch of the Double Chain Silicate Structure goes here**

The sheet and framework silicate structures are difficult to draw, and, as a result I have drawn them for you below.



*Sheet Silicate Structure* - Both green and red balls are oxygen atoms. Note that this is a birds-eye view; hence, the tiny silicon atoms are tucked beneath the topmost oxygen atom.



*Framework Silicate Structure* - Green and red balls are oxygen atoms while the small blue balls are silicon. In the framework silicate structure all oxygen atoms are shared.

### Exercise 5

Using the tools provided identify the major non-silicate mineral and note their characteristics as listed in Table 1 below.

**Table 1. Major non-silicate minerals**

<b>Non-silicate Mineral</b>	<b>Rock #</b>	<b>Metallic/Non-Metallic</b>	<b>Hardness</b>	<b>Cleavage</b>	<b>Color</b>	<b>Streak</b>	<b>Other Characteristics</b>
Graphite C							
Magnetite Fe <sub>3</sub> O <sub>4</sub>							
Galena PbS							
Hematite Fe <sub>3</sub> O <sub>2</sub>							
Pyrite FeS <sub>2</sub>							



## Exercise 6

Using the tools provided identify the major silicate minerals and note their characteristics as listed in Table 2 below.

**Table 2. Major silicate minerals**

Silicate Mineral	Silicate Structure	Rock #	Metallic/Non-Metallic	Hardness	Cleavage	Color	Streak	Other Characteristics
Olivine (Mg,Fe) <sub>2</sub> SiO <sub>4</sub>	Independent							
Pyroxene (Mg,Fe)Si <sub>2</sub> O <sub>6</sub>	Single chain							
Hornblende NaCa <sub>2</sub> (Mg,Fe,Al) <sub>5</sub> (Si,Al) <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>	Double chain							
Biotite K(Mg,Fe) <sub>3</sub> (AlSi <sub>3</sub> O <sub>10</sub> )(OH) <sub>2</sub>	Sheet							
Muscovite KAl <sub>2</sub> (AlSi <sub>3</sub> ) <sub>10</sub> (OH) <sub>2</sub>	Sheet							
Talc Mg <sub>3</sub> Si <sub>4</sub> O <sub>10</sub> (OH) <sub>2</sub>	Sheet							
Quartz SiO <sub>2</sub>	Framework							
Plagioclase (Ca,Na)(Al,Si)AlSi <sub>2</sub> O <sub>8</sub>	Framework							
K-feldspar KAlSi <sub>3</sub> O <sub>8</sub>	Framework							