Name_____
Date_____

Types of Minerals

There is a very large number of different minerals. However, minerals can be grouped so that learning about them is easier. In this course, the groupings that will be used are silicate minerals, carbonates, sulphates, phosphates, halides, hydroxides, and the ore minerals.

As is evident in the following table, by far the most common elements in the earth's crust are oxygen and silicon.

Average Composition of the earth's crust

Element	Weight %
oxygen	46.6
silicon	27.7
aluminum	8.1
iron	5.0
calcium	3.6
sodium	2.8
potassium	2.6
magnesium	2.1
total	98.5

Source: Montgomery, Carla W., *Physical Geology*, 3rd ed., p. 28

For this reason, minerals composed mostly of silicon and oxygen are the most common in crustal rocks. These minerals are called silicates. Silicates can be considered the common rock forming minerals.

Silicate minerals include:

- olivine and garnet - These minerals are quite susceptible to chemical weathering.
- pyroxenes and amphiboles -Weathering resistance is greater for these individual silicates.
- micas and clay minerals - These minerals are quite susceptible to chemical weathering.

NOTE: some of the above minerals are classified as Ferromagnesian silicates. These silicates are often dark in colour. Typical examples are olivine, pyroxenes, amphiboles, and the dark coloured micas like biotite.

- quartz - Resistant to weathering, thus its common occurrence in beach sand.
- feldspars - There are 2 types of feldspars - less resistant to weathering than quartz
  1. Plagioclase feldspar minerals (formulas: $(Na,Ca)(Al,Si)_2Si_2O_8$)
  2. Potassium feldspar (formula: $KAlSi_3O_8$)

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Carbonate minerals include: (contains carbonate - CO_3)

- Calcite ($CaCO_3$ - calcium carbonate) and dolomite (calcium-magnesium carbonate) are common minerals in this group. These minerals are susceptible to acid weathering.

Sulphate minerals include: (contains sulphate - SO_4)

- barite (barium sulphate) and gypsum (calcium sulphate, $CaSO_4 \cdot 2H_2O$)

Halides include: (contains a metal element plus a halogen)

- halite (sodium chloride) and fluorite (calcium fluoride)

Phosphates include: (contains a metal element plus PO_4)

- apatite ($Ca_5(PO_4)_3F$)

Hydroxides include: (contains a metal element plus OH)

- Gibbsite ($Al(OH)_3$)

Ore Minerals: An ore mineral is a mineral that contains a valuable metal and from which the metal can be refined. Ore minerals often (but not always!) show metallic lustre and they are usually dense.

Examples are:

- galena, PbS; pyrite, FeS_2 (**Sulphides**)
- magnetite, Fe_3O_4; hematite, Fe_2O_3; (**Oxides**)
- gold, and copper, (**native elements**)

Name_____
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Mineral Identification

What are Minerals?

A mineral is a naturally occurring inorganic solid that has a definite chemical composition or range of compositions, and a crystalline internal structure. Minerals may be pure elements or they may be compounds. Materials that are synthetically produced or produced by living things, however, are not minerals. Naturally occurring inorganic solids (like opal) that lack a regular crystal structure are called **mineraloids**.

How can Minerals be Identified?

Minerals can be identified by their properties. In most cases the physical properties are sufficient but sometimes a chemical property is also required.

The most important physical properties that are helpful in mineral identification are **colour**, **streak**, **lustre**, **hardness**, **cleavage**, **tenacity**, and **density**. Reaction to **dilute hydrochloric acid** is a chemical property that is useful for the identification of carbonate minerals. In addition there are some properties that are unique to just a few minerals. These properties are magnetism, phosphorescence, fluorescence, some optical properties of a transparent mineral, and radioactivity.

Colour: Although colour is usually a mineral's most noticeable property it can also be confusing because many minerals come in a variety of colours depending on the trace elements they contain. For example, one of the commonest minerals, quartz, can be colourless (crystal quartz) or purple (amethyst) and transparent, white (milky quartz), pink (rose quartz), red or brown (jasper), black (flint). grey (chert) or various shades of colour in agate. Fortunately colour can often be indicative of certain types of minerals and it can certainly narrow the choices. Some important copper containing minerals, for example, are blue or green and many of the metallic minerals are grey or brassy in appearance.

Streak: The streak is the colour of the finely powdered mineral and it often shows a much truer colour than is indicated by the specimen itself. To find the streak of a mineral the mineral is pressed firmly against a piece of unglazed porcelain (a streak plate) and then dragged across the

surface. The streak is the colour of the mark remaining after the excess powder and broken pieces are removed from the plate.

Lustre: This term describes the surface sheen of a mineral. All minerals are either metallic (which is shiny like a metal) or non-metallic. More specific terms for the non-metallic lustres are sometimes used - for example, earthy (like dirt), waxy, and vitreous (like glass).

Hardness: This is measured on a hardness scale of 10 called the Mohs scale after the German mineralogist who devised it. On this scale, talc, the softest, has a hardness of 1 and diamond, a hardness of 10. The complete Mohs scale and the hardness of some common materials are shown in the table below.

Hardness kits that include a sample of the mineral for each point on the scale are available, but usually a mineral can be tested for hardness with just a few common materials and the information gained will provide important clues for the identification the mineral. For example, only a few minerals are softer than a fingernail. These are gypsum, talc, molybdenite, and graphite, and the last two are soft enough to write on paper. Similarly, there are not many that are harder than a streak plate so if the mineral scratches the streak plate this narrows the possibilities very considerably.

The Mohs Hardness Scale and the hardness of some common items that are useful for determination of the hardness of mineral samples.

Mohs Scale	**Common Items**
1 talc	
2 gypsum	2.5 fingernail
3 calcite	3.5 penny
4 fluorite	4.5 steel nail
5 apatite	5.5 knife blade
6 orthoclase feldspar	6.5 streak plate
7 quartz	
8 topaz	
9 corundum	
10 diamond	

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Cleavage: Many minerals break evenly along certain preferred directions in one, two, or three dimensions. This breakage reflects underlying structure in the mineral. For example, mica cleaves beautifully to form very thin sheets. Mica is a silicate mineral with weak bonds in one direction between layers of atoms; therefore, it breaks as flat sheets. The mineral hornblende is also a silicate mineral but this mineral has weak bonds in two directions; therefore, this mineral has cleavage in two directions and cleaves or breaks into steps. Quartz is also a silicate mineral and it has strong bonds many directiosn and consequently quartz does not exhibit cleavage. Instead, quartz **fractures**. When it fractures, quartz produces smoothly curved surfaces called **conchoidal fractures**. Glass also produces conchoidal fractures when it breaks along the edge.

Light reflects well from the large parallel flat surfaces that are evident on minerals that have good cleavage. Minerals with poor cleavage have smaller flat surfaces from which light reflects. Consequently, the reflection is not so obvious.

Tenacity: Tenacity refers to the manner in which a mineral resists breakage. Terms that are used for tenacity are brittle, malleable, flexible, or splintery, for example.

Density: An object's density is its mass per unit volume. Density compared to that of water is called the **specific gravity**. Numerically it is the same as density but it has no units.

Reaction to Acid: Dilute hydrochloric acid (about 3%) is commonly used for the acid test for carbonate minerals - minerals that contain the carbonate radical. Such minerals will fizz when a few drops of the acid are placed on the surface (calcite) or on a small amount of the powdered mineral (dolomite).

Magnetism: The mineral magnetite (Fe_3O_4) is common and it is magnetic. This is a diagnostic test for magnetite.

Phosphorescence and Fluorescence: These can be checked with an ultra-violet light. A fluorescent mineral will glow while the light is turned on whereas a phosphorescent mineral will continue to glow after the light is turned off.

Optical Properties: Some transparent minerals show unusual optical properties. Calcite, for example, produces a double image of objects viewed through the crystal.

Name_____
Date_____

Types of Minerals

There is a very large number of different minerals. However, minerals can be grouped so that learning about them is easier. In this course, the groupings that will be used are _____, _____, _____, _____, _____, _____, and the _____.

As is evident in the following table, by far the most common elements in the earth's crust are _____ and _____.

Average Composition of the earth's crust

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oxygen	46.6
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Source: Montgomery, Carla W., *Physical Geology*, 3rd ed., p. 28

For this reason, minerals composed mostly of silicon and oxygen are the most common in crustal rocks. These minerals are called _____. Silicates can be considered the common _____.

Silicate minerals include:

- _____ and _____- These minerals are quite susceptible to chemical weathering.
- _____ and _____ -Weathering resistance is greater for these individual silicates.
- _____and _____- These minerals are quite susceptible to chemical weathering.

NOTE: some of the above minerals are classified as _____. These silicates are often _____in colour. Typical examples are olivine, pyroxenes, amphiboles, and the dark coloured micas like biotite.

Name_____
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- quartz - Resistant to weathering, thus its common occurrence in beach sand.
- feldspars - There are 2 types of feldspars - less resistant to weathering than quartz
  1. _____minerals (formulas: $(Na,Ca)(Al,Si)_2Si_2O_8$)
  2. _____ _____ (formula: $KAlSi_3O_8$)

Carbonate minerals include: (contains _____)

- _____ ($CaCO_3$ - _____) and _____ (calcium-magnesium carbonate) are common minerals in this group. These minerals are susceptible to _____.

Sulphate minerals include: (contains _____)

- _____ (barium sulphate) and _____ (calcium sulphate, $CaSO_4 \cdot 2H_2O$)

Halides include: (contains a _____)

- _____ (sodium chloride) and _____ (calcium fluoride)

Phosphates include: (contains a _____)

- _____ ($Ca_5(PO_4)_3F$)

Hydroxides include: (contains a _____)

- Gibbsite ($Al(OH)_3$)

Ore Minerals: An ore mineral is a mineral that contains a _____and from which the metal can be refined. Ore minerals often (but not always!) show _____and they are usually _____.

Examples are:

- _____, PbS; _____, FeS_2 (_____)
- _____, Fe_3O_4; _____, Fe_2O_3; (_____)
- _____, and _____, (_____)

Name_____
Date_____

Mineral Identification

What are Minerals?

A mineral is a _____that has a _____ or range of compositions, and a _____. Minerals may be _____or they may be _____. Materials that are synthetically produced or produced by living things, however, are not minerals. Naturally occurring inorganic solids (like opal) that lack a regular crystal structure are called _____.

How can Minerals be Identified?

Minerals can be identified by their _____. In most cases the _____properties are sufficient but sometimes a _____property is also required.

The most important physical properties that are helpful in mineral identification are _____, _____, _____, _____, _____, _____, and _____. Reaction to _____ is a chemical property that is useful for the identification of _____minerals. In addition there are some properties that are unique to just a few minerals. These properties are _____, _____, _____, some optical properties of a _____, and _____.

Colour: Although colour is usually a mineral's most noticeable property it can also be confusing because _____ _____. For example, one of the commonest minerals, quartz, can be colourless (crystal quartz) or purple (amethyst) and transparent, white (milky quartz), pink (rose quartz), red or brown (jasper), black (flint). grey (chert) or various shades of colour in agate. Fortunately colour can often be indicative of certain types of minerals and it can certainly narrow the choices. Some important copper containing minerals, for example, are blue or green and many of the metallic minerals are grey or brassy in appearance.

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