Houston Gem and Mineral Society's Home Scavenger Hunt for Economic Minerals and Rocks

The Houston Gem and Mineral Society assembles Economic Mineral and Rock sets for distribution free to teachers and homeschool groups (information on the set and how to request it are at https://hgms.org/education/mineral-and-fossil-sets/). This set consists of samples of minerals and some rocks that are important economically in our society. The set is a helpful teaching aid, but you do not have to have one to complete this scavenger hunt, which is specifically designed with activities that can be easily done at home or in the classroom with common school supplies and other ordinary objects. The activities are labeled for the grades they align to in the Texas Essential Knowledge and Skills for Science (TEKS).

All activities in this scavenger hunt should be conducted with adult supervision.

Minerals are defined as naturally occurring, inorganic solids with a definite chemical composition and an ordered internal structure. Minerals are the ingredients that make up rocks, and economic minerals and rocks are used to make things—whatever doesn't come from plants was made from economic minerals and rocks. This scavenger hunt will help you learn how economic minerals and rocks are used in our everyday life in our communities.

Minerals are dug from the Earth's crust within an ore deposit. Most of an ore consists of rock of no economic value, called "gangue." An ore is not mined from the Earth unless either the quantity or quality or both of its mineral content are sufficiently high to make a profit from extracting it, either by shaft or open-pit mining.

An economic mineral can be a metal or nonmetallic. Most ore minerals belong to three groups of nonsilicate minerals:

1. Native elements (examples: gold, silver, copper, sulfur, and graphite)
2. Sulfides (examples: galena, pyrite, chalcopyrite, and stibnite)
3. Oxides (examples: hematite, magnetite, rutile, cuprite, and corundum)

The native elements are each a single element, such as gold, which has the chemical symbol Au. The sulfides and oxides are represented by a chemical formula, such as galena, which is lead sulfide (PbS), and rutile, which is titanium dioxide (TiO_2). Nonsilicate minerals are much less abundant in the Earth's crust than its major component of silicate (SiO_4^{2-}) minerals.

Contents

1. Galena (lead sulfide or PbS)

Galena is the most important ore mineral of lead (Pb). Notice the lead-gray color, high specific gravity (it feels heavy when you pick it up compared with a same-size piece of most other minerals), and metallic surface luster. If you rub galena on a streak plate (which is an unglazed ceramic tile), it has a gray streak.

Lead was used in making paint, for making water pipes because it is easy to shape, and as an additive to gasoline to improve engine performance. It is no longer used in these products because it can be toxic, even in small amounts. Lead pollution is documented as the cause of learning disabilities in children. It is still used in car and other types of batteries and lead crystal glass. Lead-lined aprons keep us safe from stray X-rays at the dentist's office or in the hospital.

Activities:

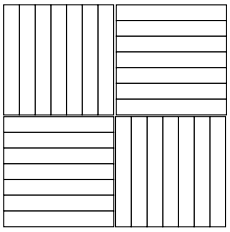
K-5: Galena is composed of lead and sulfur and is one of the heaviest minerals. It has a density of 7.6 gram/cm^3. That means that it is about 8 times denser than water, which has a density of 1 g/cm^3. A typical rock is about 2.5 times denser than water. To demonstrate how density can be used to identify minerals, take two 500-mL plastic water bottles. Leave one bottle full but take the cap off the second bottle and use a graduated liquid measuring cup to pour 335 mL of water out of it, leaving 165 mL in the bottle. Put the cap back on the second bottle and put each bottle into a clean sock so that you cannot see which is the full bottle. Now, compare the weight of the two bottles. One bottle is noticeably heavier, even though both bottles are the same size. Remove the bottles from the socks to see which bottle is heavier. Circle the answer:

Full bottle

165-mL bottle

1. Galena continued

2-4: The definition of a mineral includes that it has a definite chemical composition and an ordered internal structure, which determines the shape of the mineral's crystals. One of the ways that galena can be easily identified is by its cubic crystal structure, which means that galena crystals grow as cubes if they are forming in a roomy enough environment. Galena can also be identified by the way that it breaks along surfaces parallel to the cubic crystal faces. This is called cubic cleavage. To demonstrate this, stack some cubic dice or cubic wooden blocks together into a larger cubic block structure. Notice how the surfaces of the component dice or wooden block cubes are parallel to the outside surfaces of the larger block structure. Gently nudge the block structure with your hand to slightly separate the dice or wooden blocks. As they come apart, are the "fracture" surfaces of separation parallel to the outside faces of the larger block structure? Circle the correct answer:



Parallel

Nonparallel

All grade levels: Some metallic minerals are magnetic. If you have the Economic Rocks and Minerals set, use a magnet from your refrigerator to see if it is attracted to the galena sample. The property of magnetism can be used to identify minerals. Is galena magnetic? Circle your answer: Yes No

5+: What is the symbol for lead on the periodic table of the elements? _____
What element is in the same column, but one row higher than lead? _____

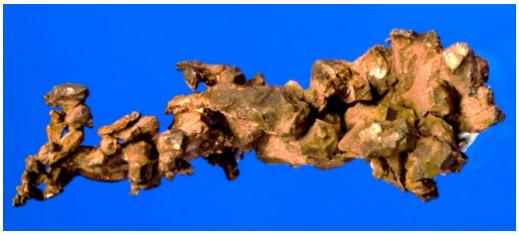
8+: What group is lead in on the table: _____. What does this position tell you about the characteristics of lead?

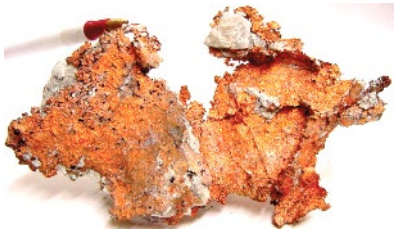
_____

_____

_____

2. Copper (Cu)





Copper is an important economic metal because it is a good conductor of electricity, so it is used in the power lines that bring electricity to your home, the wiring in your walls to the light switches and outlets, and the cords we plug in to the outlets. Copper is used in many industries besides for conducting electricity. Currently, copper is of interest because of its biocidal properties, which means that it can be used for disinfection purposes. Copper is used for the US penny coin—before 1982, it formed 95% of the penny, but to save money, the US Mint now manufactures pennies that contain only 2.6% copper as a coating on a zinc alloy coin. Copper is often alloyed with other metals to produce harder composites such as brass and bronze. Copper can be mined even in low concentrations that would not be economic with conventional mining methods by using solution mining, which uses water or dilute acid to leach the copper from the ore body.

Activities:

K: Find a penny coin and make a rubbing of it by putting the coin under this paper and rubbing the side of your pencil point over it:

K-3: Copper is useful because it is a good conductor of heat and electricity. Look at the cooking pots in your kitchen or at a store or online retailer. Do any of the pots have copper on the bottom of the pot? Circle your answer: Yes No

Why do you think that copper is on the bottom of cooking pots? _____

_____.

2-5: One of the ways that elemental copper is identified is by a property called malleability. All true metals are malleable. That means that when they are pounded with a hammer, they bend instead of break. The opposite of malleability is brittleness. Most nonmetallic minerals are brittle, which means they easily break or form a powder where scratched. First, to demonstrate brittle fracture, put on safety glasses, place a dried macaroni noodle on a concrete or asphalt sidewalk or driveway, and lightly tap it with a hammer. Then, make a small ball of aluminum foil and tap it the same way with a hammer. Label which one broke and which one flattened out without breaking? Circle the answer for each one:

2. Copper continued

Dried noodle: Brittle or malleable?

Aluminum foil ball: Brittle or malleable?

5+: When the atoms of copper join with oxygen in the air, they form the molecule copper oxide (CO). This formation on the surface of pennies makes them look dirty. Assemble the following materials:

- 10 dirty pennies
- 4 tablespoons lemon juice
- 8 tablespoons vinegar
- 1 teaspoon salt
- Small bowl (not made of metal)
- Spoon (not made of metal)
- Paper towels

1. Mix the lemon juice, vinegar, and salt in the bowl with the spoon until dissolved.
2. Dip a penny hallway into the mixture for 20 seconds. Take it out and describe what happened: _____.
3. Put the other nine pennies into the mixture. Watch carefully and describe what happens: _____ _____
4. After 5 minutes, remove four of the pennies from the mixture and lay them on a paper towel to dry. Take the remaining pennies out and rinse them thoroughly under running water. Lay them to dry on a paper towel. What is different between the pennies that weren't rinsed and those that were?

   _____

   The acidic mixture of lemon juice, vinegar, and salt dissolved the copper oxide on the surface of the pennies, but when that coating was removed from the pennies it was easier for the copper atoms to bond with oxygen and chlorine in the salt, forming a new mineral compound called malachite on the pennies that weren't rinsed.

6-8: Copper has antimicrobial properties, which means that it kills bacteria. You may have seen this mentioned in the news or on TV or online advertising of copper-infused products? Why do you think companies would want to put copper into products? _____

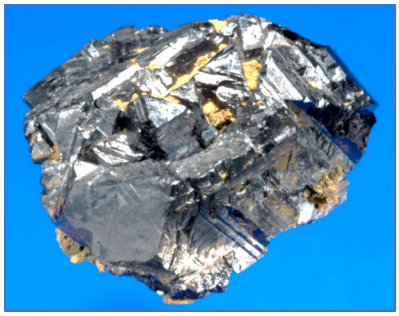
_____.

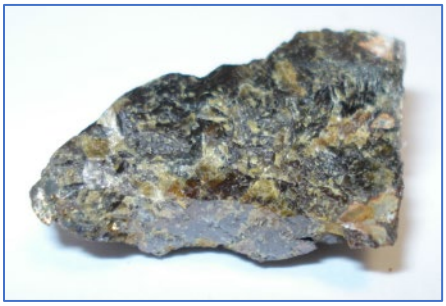
9+: An alloy is a metal made by combining two or more metallic elements, typically to give greater strength or resistance to corrosion. The two most common alloys using copper (there are more than 400!) are brass and bronze. Research what is the primary metal combined with copper for each and list some properties of these alloys.

Brass: Copper combined with _____. Properties: _____.

Bronze: Copper combined with _____. Properties: _____.

3. Sphalerite (zinc sulfide or ZnS)





Sphalerite is the most important ore mineral of the metal zinc. Its name comes from the Greek word *sphaleros,* which means deceiving, because sphalerite has a wide variety of appearances and can be difficult to identify in hand specimen. Its luster can range from submetallic to resinous, which means that the surface has the same appearance as resin (such as amber, which is fossilized resin) or a smooth-surfaced plastic. The zinc component can also be substituted for by variable amounts of iron, and the streak of sphalerite when rubbed on an unglazed ceramic streak plate can range from black to yellow. Nicknames of sphalerite are zinc blende and blackjack.

The metal zinc is silvery white in color and has many industrial uses. Adding a protective layer of zinc to steel and iron is called “galvanizing” and protects from rust and corrosion. Zinc oxide (ZnO) is commonly used as a paint pigment, in batteries, and for topically treating a variety of skin conditions, including itching, diaper rash, and dandruff. Zinc oxide is also used in sunscreen to physically block the damaging UV rays, and unlike chemical sunscreens, it is reef-safe, which means that the nanoparticles do not pose a danger to marine ecosystems. In US penny coins made after 1982, the center of the coin is made from a zinc alloy. Zinc chloride (ZnCl) is used for preserving wood.

Activities:

1-3: Check the date on a penny coin. Write the date here: _____ From what you read about the US penny (see 2. Copper), circle whether the penny has a zinc alloy center: Yes No

K-4: Look at some different types of nails at home or at a hardware store. Do they have a rough, silvery coating? Circle your answer: Yes No If yes, they are galvanized, which means they have a coating of zinc that helps prevent rust. If the package for the nails is available, check it to confirm your answer.

5+: The first commercial dry batteries were zinc-carbon batteries. Because these batteries work in any position, they enable portability of the devices they power. Check the batteries you have at your home or look at some in a store or online retailer. Do you find any zinc-carbon or zinc-chloride batteries (Hint: they are usually labeled “heavy duty”). Research why alkaline batteries were developed to substitute for zinc-carbon batteries in primary (nonrechargable) applications:

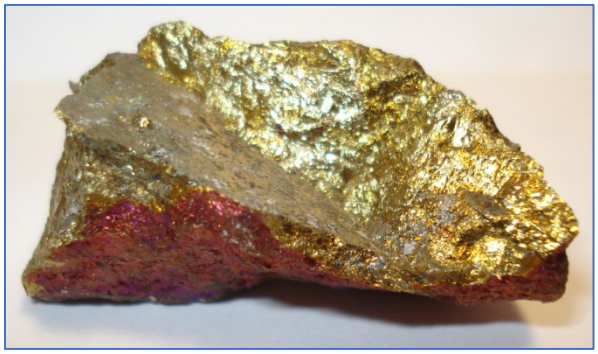
_____
_____.

3. Sphalerite continued

8+: Find zinc on the periodic table of the elements. Which would be heavier, a cubic centimeter of pure copper or a cubic centimeter of pure zinc? Explain how you know by the arrangement of the elements on the table: _____

_____.

4. Chalcopyrite (copper iron sulfide or $CuFeS_2$)



Chalcopyrite is the most important ore mineral of copper. It loses its metallic luster and tarnishes from a brassy yellow color upon weathering to a dull gray-green color. The streak on an unglazed ceramic plate is greenish black. Copper is used in many industries (read more at 2. Copper). The electrical power industry relies on copper wires to conduct electricity. Copper was formerly used for the US penny coin, but now is only a coating on the penny. It is often alloyed with other metals to produce harder composites such as brass and bronze. Copper is also widely used in analytical chemistry.

Chalcopyrite is often associated with bornite (Cu_5FeS_4), which is also a mixture of copper, iron, and sulfur. Bornite has a copper-red color on fresh broken surfaces but tarnishes to multiple iridescent colors, earning it the nickname peacock ore.

Activities:

K-1: Do you have any doorknobs or lamps in your home that have a bright, shiny gold-colored finish? This is brass, which is an alloy (mixture) of copper and zinc. Write or draw what you found that is made of brass: _____

_____.

1-4: Chalcopyrite crystals are in the tetragonal crystal system, which means that the crystal looks like a square if you look at it from the top and like a rectangle from the side. Draw what is called an "exploded view" of the crystal as a square and a rectangle that share one short side of the rectangle:

5-8: Draw a 3D rectangular prism to represent the chalcopyrite crystal in the tetragonal crystal system. Put the square on top and size the rectangular sides as 1.5 cm wide, 1.5 cm deep, and 5 cm in height.

4. Chalcopyrite continued

9+: The composition of chalcopyrite is $CuFeS_2$, bornite is Cu_5FeS_4, and pyrite, which is often confused with chalcopyrite, is FeS_2. These minerals are often found associated with each other. Copper is the most valuable element of the three that make up these minerals. Iron and sulfur are typically waste byproducts of mining copper minerals. Answer which of the three minerals would produce the most copper if you mined 100 kg of each and explain how you determined the answer:

_____

_____.

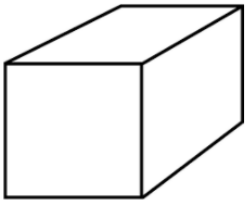
5. Halite (sodium chloride or NaCl)

Halite is the mineral name for what we know as table salt. Halite crystallizes as cubes and is usually white, but can be gray or pink. Halite is found in certain sedimentary environments as a result of evaporation of briny (salty) water and can accumulate in large beds that can be mined commercially. It is also extracted by evaporation from seawater in many places around the world.

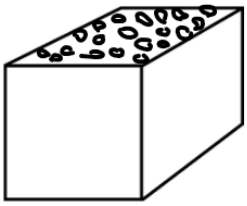
Halite is necessary in the human diet. In fact, your body contains about 100 cm^3 (20 teaspoons) of salt, which is stored in your bones and bodily fluids, such as blood and sweat. But too little or too much salt is not good for you. In addition to flavoring and preserving food, salt is used to tan leather and to make glass and ceramics. The biggest industrial use of salt is in the chemical industry to produce chlorine for chemical processes and also soda ash (sodium). In northern climates "rock salt" is used to melt ice and snow on highways. The halite sample in the economic rocks and minerals set comes from Hockley, in Waller County, Texas, where an underground operation mines a salt dome near the surface.

Activities:

K-3: Take two ice cubes and put each in a bowl. Heavily sprinkle one ice cube with salt. Check the ice cubes every 5 minutes for a total of 15 or 30 minutes. Circle which ice cube melted faster:



Ice cube



Ice cube with salt on it

As the ice cube starts to melt, the water dissolves the salt, and the component ions of the salt interfere with the chemical structure of the water to lower the freezing point (usually 0°C or 32°F). This is why salt is put on icy roads to speed the ice melting and delay any refreezing to make driving safer.

2-4: Halite is soluble in water. Put a teaspoon of salt in a glass of water. Stir the mixture of salt crystals and water and watch the salt crystals. What happens to the salt crystals?

_____

Now take a tiny sip of the water in the glass. Although you cannot see the salt crystals because they dissolved in the water, can you taste them? Circle your answer: Yes No

5. Halite continued

3-4: The mineral halite is in the cubic crystal system, which means that all three sides of the crystal look like a square. Draw a cubic crystal:

5-6: Put a small amount of table salt (not flaky finishing salt) onto a dark surface. Look at the crystals with a magnifying lens or with a cell phone camera. What shape are the crystals? _____

Crystal shapes are used to identify minerals because the atoms that make up the mineral crystals have a repeated orderly pattern.

5+: Halite forms when seawater evaporates, leaving the salt crystals behind. Put about 120 mL (half a liquid measuring cup) of water in a cooking pot and warm it (boiling is not necessary). Keep adding salt and stirring it until no more salt dissolves in the water. Let it cool and then pour the water into a clean bowl. Let it sit uncovered for a few days without disturbing it and look for crystals forming around the edge of the bowl. What shape are the crystals: _____. To make the crystals more interesting, add some food coloring to the mixture of salt and water while you are stirring it.

Where did the crystals first start forming? _____.

Why do you think they formed there? _____

_____.

8+: Adding salt to water changes the density of the water as the salt dissolves in it. Pour water into a tall clear glass until it is half full. Stir in about 6 tablespoons of salt. Wait for the water to stop swirling and pour in plain water without disturbing or mixing with the salty water until the glass is nearly full. Gently lower an egg into the water. Describe what happens:

_____

_____.

Is the salt solution more or less dense than the fresh tap water layer? Circle your answer:

More dense Less dense

How do you know? _____

_____

6. Gypsum (calcium sulfate dihydrate or $CaSO_4 \cdot 2H_2O$)

Gypsum is a common sedimentary mineral that is the same chemically as anhydrite ($CaSO_4$) with the addition of water in its crystal structure. It forms in large deposits where ocean and other waters with a high content of sulfate and calcium were concentrated and dried up to deposit the sulfate and calcium. Gypsum is usually white but can be clear also. Its monoclinic crystal system (three unequal axes with two of them perpendicular to each other) makes it easy to break gypsum into flat sheets along one direction, similar to the mineral mica. There are large gypsum mines in West Texas.

You live surrounded by gypsum: it is ground up and used to make the drywall or sheetrock on the walls of your home and other buildings. It is used as a fertilizer and soil conditioner for agriculture. Plaster of Paris is made from gypsum and is used in surgical splints for broken bones and casting molds. Gypsum is a very soft mineral that you can scratch with your fingernail. Likewise, the sheetrock made from it on the walls is also easily scratched or dented.

Activities:

K-2: Gypsum is commonly used in sidewalk chalk because it is so soft. Take some sidewalk chalk and draw a picture of a monoclinic crystal on the sidewalk, driveway, or chalk board:

K-2: Can you find a dent or a scratch in the sheetrock in your home? Circle one: Yes No

Do you know how it happened? _____.
If you don't find dents and scratches, you do a good job treating it gently to keep it in good shape.

4-7: Gypsum is one of the softest minerals, rated at 2 on the Moh's hardness scale of 1 for the softest (talc) to 10 for the hardest (diamond). Collect a bar of soap, a penny, and a nail to demonstrate relative hardness testing by scratching something soft with something hard. Try to scratch the soap with the nail, then try to scratch the penny with the nail.

Was it easy to scratch the soap with the nail? Circle your answer: Yes No

Was it easier or harder to scratch the penny with the nail? Circle your answer: Easier Harder

6. Gypsum continued

8+: Find calcium on the periodic table of the elements. What is its element number? _____ How many protons are in each atom of calcium? _____ What else do you know about calcium from its position on the table? _____

_____.

9+: One way of identifying gypsum is by its crystal system shape. It crystalizes in the monoclinic crystal system, which has a parallelogram for one of the faces. The description of a monoclinic crystal is that it has three unequal axes with two of them perpendicular to each other. Draw the three axes for this monoclinic crystal:

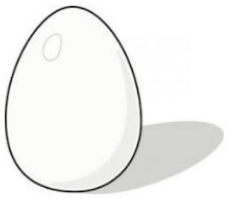
7. Sulfur (S)

Sulfur is a nonmetallic element found usually as deposits from gases at volcano vents or produced by anaerobic bacteria. Sulfur itself has no odor, but sulfur minerals easily weather in the presence of oxygen to form compounds that have a very distinctive annoying smell, like a skunk or a rotten egg! Sulfur is unusual because not only is it the only common mineral that is yellow but it is bright yellow. It is in the orthorhombic crystal system, which has three axes at 90° to each other that are unequal in length.

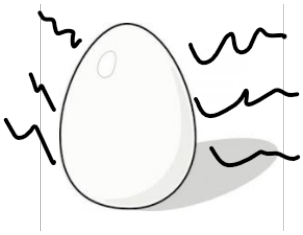
Sulfur is used to make many chemicals, including sulfuric acid, which is important for making fertilizer to help plants grow and as a highly effective electrolyte in car batteries. Sulfur is commonly used as a bleaching agent and for food preservation, in pesticides and fungicides, and to vulcanize rubber, which improves the hardness, elasticity, and durability. Sulfur is an essential component of the antimicrobial medicines developed in the early 20th century called sulfa drugs.

Activities:

K-2: If you have eggs in the refrigerator, give them a sniff to make sure one hasn't gone bad, which you would detect by the sulfurous smell. If you have boiled eggs in the refrigerator, give them a sniff, because the sulfur and iron in the egg can react to have a sulfurous odor (this does not mean that the boiled egg is rotten). Did you find an egg with a sulfur smell? Circle your answer:



No sulfur odor



Sulfur smell

3-5: Sulfur can be recognized by its bright yellow color. Draw a picture of what you think a sulfur crystal might look like, using a bright yellow color. Remember it is in the orthorhombic crystal system, so all the sides are rectangles of different sizes:

7. Sulfur continued

6+: Sulfur crystallizes in the orthorhombic crystal system. The most common crystal pattern has the shape of a trapezoidal prism. Make a 2D view by drawing two trapezoidal prisms, one on top of the other, with the widest parts of the trapezoids sharing the same border (one trapezoid is right side up, the other is upside down, touching each other). Color it yellow.

8+: Find sulfur on the periodic table of the elements. What is its atomic number? _____. What element is above it on the periodic table? _____. What else do you know about sulfur from its position on the table? _____
_____.

8. Hematite (iron oxide or Fe_2O_3)

Hematite is one of the common ore minerals of iron. Hematite is found in large sedimentary beds of Precambrian age, where it is mined by open pit methods. It also occurs in other environments, but not usually in quantities large enough for commercial mining. It can be reddish and earthy in appearance or have silver-like reflective flaky crystals (called specular or micaceous hematite), but all varieties give a reddish-brown streak on an unglazed ceramic tile streak plate. Hematite has a hardness that is close to that of glass and has a density that is twice as high as granite or sandstone.

As one of the primary ores of iron, hematite is used in the manufacture of wrought iron and the alloy steel. Steel is used in our economy for many essential tasks, from structural supports in buildings to ships and automobiles, furniture, and household tools. Hematite is also used to make red pigments for paint and cosmetics.

The other common ore mineral of iron is magnetite. They can be readily distinguished because hematite is nonmagnetic whereas magnetite is magnetic and has a black streak.

Hematite is a truly out-of-this-world mineral: NASA discovered that hematite is one of the most abundant minerals on the surface of Mars. This is what gives the planet a reddish brown color in the night sky, earning it the nickname “red planet.”

Activities:

K-3: Find a steel nail and put it in a cup of water for a few days. Did a reddish-brownish coating form on the nail. Circle your answer: Yes No

The coating is rust, which is caused by the iron in the nail combining with oxygen to form an iron oxide like hematite. However, many nails are coated with zinc to prevent rusting. This is called “galvanizing” and it typically like a bumpy, silvery gray–colored coating. If your nail didn’t rust, it must be galvanized.

K-5: Try to scratch the surface of a copper penny with a steel nail. Then try to scratch the nail with the penny. This is done to determine the relative hardness of one material to another. If the nail cannot scratch the penny, then the penny is harder. If the nail can scratch the penny, then the nail is harder. Circle which is harder (next page):

8. Hematite continued

Penny

Steel nail

5: Research the Mohs hardness scale for minerals. Would the steel nail scratch hematite? Yes No

5-8: If you have a strong magnet and the hematite sample from the HGMS rock set, check if the hematite is magnetic. Circle your answer: Magnetic Nonmagnetic

Does a weaker refrigerator magnet attract the sample? Circle your answer: Yes No. What does the weaker magnet's behavior tell you about how strongly magnetic the hematite is? _____

_____.

9+: Research whether Mars is visible in the night sky tonight. If it is, look to see if it deserves the nickname "red planet" compared with the other planets and stars. If Mars is not visible tonight, find an online image of it and check the planet's color. Is Mars red in the night sky: Yes No

9. Garnet ($X_3Y_2(SiO_4)_3$ in which X can be Ca, Mg, Fe^{2+}, or Mn^{2+} and Y can be Al, Fe^{3+}, Mn^{3+}, V^{3+}, or Cr^{3+})

The garnet group consists primarily of aluminum silicates with calcium, magnesium, iron, or manganese as part of the composition. Each of these chemical compositions, called species, has its own mineral name but their physical properties and crystal form are similar. Garnet is found in metamorphic deposits but it is usually not concentrated enough to be economic. Alluvial garnet sands are mined in some parts of the world. Most people think of garnets as red gemstones, and they have a wide range of colors, with the most common brown to red to yellow and green. With its hardness ranging between 6.5 and 7.5 depending on the species, garnet is used as an abrasive, such as on sandpaper and for the optical and plate glass-grinding industries.

Activities:

K-1: Garnets used as gemstones have a very reflective surface that makes them sparkle in the light. This physical property is called a vitreous luster (from the Latin word *vitrum* for glass). Look at a wax candle or wax crayon and compare how shiny is it compared to window glass or a gemstone in a ring. Circle which one has a shinier surface:

Wax (waxy luster)

Window glass (vitreous luster)

2-4: Garnets can be many different colors. They can be red, brown, orange, green, black, gray, pink, or purple. Draw a circle and divide it into 8 even slices, like a pizza. Color each slice of the circle to represent the different colors of garnets. If you don't have all these colors, then use any colors that you have, because garnets can be just about any color!

9. Garnet continued

3-5: Garnets are very hard, which makes them good gemstones because they are hard to scratch. Garnets are harder than steel, so they can scratch steel. Collect a glass jar (one that you are going to recycle), a steel nail, and sandpaper, if you have that handy. Try to scratch the glass jar with the nail. Try to scratch the nail with the sandpaper. Examine the nail closely—you will see grains of the abrasive from the sandpaper on the nail, but that does not mean the abrasive is relatively softer, only that they came loose. List the materials you compared for relative hardness from softest to hardest:

Softest _____ _____ _____ Hardest

6-8: Garnets are unusual for gemstones because some of them respond to a strong N52 magnet. The chemical formula for garnet species is different for each color. For the five most common garnet species, circle which ones have a metal component that would be attracted to a magnet?

Almandine garnet, $Fe_3Al_2Si_3O_{12}$, is bright red colored

Pyrope garnet, $Mg_3Al_2Si_3O_{12}$, is deep red colored.

Spessartine garnet, $Mn_3Al_2Si_3O_{12}$, is bright orange.

Grossular garnet, $Ca_3Al_2Si_3O_{12}$, can be multicolored, depending on impurities.

Uvarovite garnet, $Ca_3Cr_2Si_3O_{12}$, is rare and forms bright emerald green crystals.

9+: Garnets crystalize in the isometric system, which means that the crystal axes are perpendicular to each other and same length in each of the three directions, like a cube. Many garnets crystallize in the dodecahedral (12 faces) and trapezohedron (24 faces) crystal habits. Draw a dodecahedron, which is essentially a 12-sided crystal with diamond-shaped faces on each side. Some dodecahedrons are 12-sided with a pentagon on each side, known as pentagonal dodecahedrons.

10. Magnetite (ferrous ferric iron oxide or Fe_3O_4)

Magnetite occurs in all types of depositional environments in the Earth, from igneous to metamorphic to sedimentary. Its distinguishing characteristic is its attraction to a magnet. Magnetite itself is used as an abrasive, pigment in paints, and heavy media in specific gravity operations used in mining and other industries to separate less dense materials, which rise to the top. It is a primary ore of iron. Iron is one of the most common elements on the Earth's surface, but must be found in high concentrations such as large deposits of magnetite ore to make it economically favorable to mine. Iron is an important industrial metal used to make wrought iron and steel, as mentioned previously for the other common ore of iron, hematite. Iron is used to make and build everything from the nails and screws that hold buildings together, to cars, to major appliances in your home. Iron is almost always mixed with other elements to make it into the alloy steel. The other added elements, such as vanadium, chrome, and molybdenum, give the steel higher strength and help reduce corrosion.

Activities:

K-2: Magnets attract metals that have iron in them. Take a refrigerator magnet and find some things around your home that the magnet is attracted to. Things made of metal or with metal parts that you can test include paper clips, aluminum foil, nails, pots and pans, different parts of a car, and cans with food and drinks in them. Draw or write the things the magnet was and was not attracted to:

_____Attracted to the magnet_____

_____Not attracted to the magnet_____

3-5: Some metals can be turned into magnets. Take a screwdriver or a metal nail file and touch it to some small pieces of steel, such as paperclips or staples. If the screwdriver magnetically picks up these things, it is because it was already magnetized to prevent the annoyance of dropping a screw. If your screwdriver is not magnetized, rub a strong magnet (a refrigerator magnetic will not work for this) several times on the screwdriver in the same direction. Now try to pick up the same small pieces of steel. Did the screwdriver behave magnetically: Yes No

10. Magnetite continued

Rubbing the magnet along the screwdriver in one direction aligned the magnetic elements in it to behave as magnets. This effect will last about three months. If you were able to magnetize the screwdriver, try demagnetizing it by rubbing with the strong magnet in the opposite direction from before. Is the screwdriver demagnetized now: Yes No

6+: Some foods are naturally rich in iron and others are enriched or fortified with iron, which is used by the body to produce red blood cells. You carry enough iron in your body to make two small nails! To find evidence of this added iron take a few pieces of Cheerios (12.6 mg/serving) or Total breakfast cereal—or some other cereal that has a high iron content as listed on the nutrition label, typically providing 100% of the recommended daily intake of iron—and float them in a bowl of water. Get a strong magnet and move it close to the floating piece of cereal. What is the effect on the cereal:

_____.

If you don't have a strong enough magnet, search for "magnetic Cheerios" on YouTube and watch what happens to answer.

8+: Take a bowl of Cheerios or Total or another iron-fortified dry breakfast cereal and crunch the cereal up with a potato masher or rolling pin until it is a fine, even powder. Put the powdered cereal into a gallon-sized self-sealing plastic food storage bag, and add some water to make it the consistency of soup. Lay the bag flat on the table and push a strong magnet around on top of the bag, without lifting if at all. Finally, move the magnet to one corner of the plastic bag and then lift the magnet. If you are using a sufficiently strong magnet, describe anything unusual that you see where the magnet was:

_____.

Any dark eyelash-like objects that you see attracted to the magnet are iron filings!

8+: Lodestone is a type of magnetite with a distinct north-south polarity. The Chinese were the first to make a magnetic compass using lodestone, not for determining the cardinal directions of north, south, east, and west for navigation but initially for harmonizing the organization of their buildings and objects by using the principles of feng shui. Research how you could construct a simple compass using a lodestone, a piece of wood, water, and bowl: Sketch and briefly describe your answer:

Is the lodestone aligning with the north geographic pole or the north magnetic pole. What is the difference between the two? _____

_____

_____.

11. Fluorite (calcium fluoride or CaF)

Fluorite, commercially called fluorspar, is mined from deposits in sedimentary rocks around the world. The US and England had considerable reserves, but most world production comes now from enormous deposits in China. Fluorite has a very important commercial use as a flux in the making of steel and aluminum. Flux is used as a flowing and impurity-cleaning agent. This use consumes the majority of world production. The remainder is used in the chemical industry to produce fluorine, which is then used to produce hydrofluoric acid (HF) for industrial purposes and also to fluoridate water, which prevents cavity formation in teeth.

Activities:

K-1: Fluorite is usually blue, green, yellow, or clear. It makes cubic crystals, the six sides of which look like squares, like a dice cube or a wooden toy block. Draw four squares, and color them different colors like fluorite.

2-4: Many communities add fluoride to the water that comes out of the tap. When you drink that fluoridated water or eat food cooked with it, the fluoride content helps prevent cavities. For the same reason, there is also fluoride in many brands of toothpaste. Look at a tube of toothpaste in your home or at a store or online retailer. Do you see the word fluoride on your toothpaste tube or box? Circle your answer: Yes No

K-5: Fluorite is transparent. Minerals demonstrate three types of light transmission:

- Opaque means that light does not pass through it. A piece of steel is opaque because no light passes through it.
- Translucent means that light passes through but not detailed shapes. Wax paper and a single layer of facial tissue or tissue paper allow light to pass through, but you cannot see images from the other side.
- Transparent allows light to pass through and you can see images from the other side. Ordinary window glass and water are transparent.

11. Fluorite continued

Find one example of each type of light transmission in your home and write or draw your answers:

Opaque Translucent Transparent

6-8: Fluorite is used in some optical microscopes because of its index of refraction, which is the ability of a material to change the direction of a beam of light. The higher the index of refraction, the more a beam of light changes direction. You can demonstrate the index of refraction with a glass pitcher or vase full of water and a pencil. Hold the pencil halfway into the water. Look through the pitcher from the side at the pencil above and below the water. Describe anything unusual you notice about the pencil:

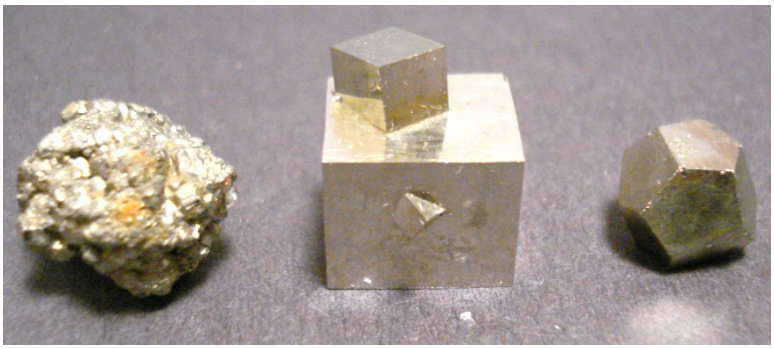
_____.

9+: Fluorite crystallizes in the isometric crystal system, which means that all three axes (X, Y, and Z) are perpendicular to each other and they are all the same length. This makes fluorite crystallize in cubes or octahedrons, which look like two four-sided pyramids joined at the base. Sketch this structure in 3D:

For a crystal with an octahedron structure of two four-sided pyramids joined at the base, how many crystal faces are there? _____.

What is the shape of the crystal faces on the octahedron? _____.

12. Pyrite (iron sulfide or FeS_2)



The mineral pyrite is common in all environments—sedimentary, igneous, and metamorphic—and is a common constituent of ore deposits. Deep-sea oceanic vents have been found to eject fine particles of pyrite-generated iron that provide trace nutrients to bacteria, plankton, and other sea life. When it is shiny and brass-yellow it can be mistaken for gold and hence is called fool's gold. However, pyrite does not have a gold streak but a black one of an unglazed ceramic streak plate. It is rarely mined for its iron content because the sulfur in the mineral is a contaminant that makes the resulting iron weak and brittle. It is mainly used today to produce sulfur dioxide (SiO_2), which is used in the paper industry as a whitener and for the production of sulfuric acid, which has a great many uses in the chemical industry.

Activities:

K-3: Pyrite can be identified by its metallic luster. That means that it is very shiny, usually silver or gold colored and reflects light. Non-metallic luster is usually not as reflective and can be dull or waxy or even vitreous, like glass. Find some things around the house that have a metallic and non-metallic luster.

Metallic: _____. Non-metallic: _____.

K+: Pyrite is also known as "fool's gold" because it has a yellowish color like gold, but it is not quite the same. If you have the Economic Rock and Mineral set, compare the color of pyrite against a piece of gold jewelry. Do you see a difference in the color? Circle your answer: Yes No

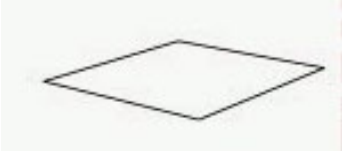
K-5: Pyrite is very hard, about the same hardness as steel. Try to scratch the copper surface of a US penny coin with a steel nail. Then try to scratch the nail with the penny. This is done to determine the relative hardness of one material to another. If the nail cannot scratch the penny, then the penny is harder. If the nail can scratch the penny, then the nail is harder. Circle which is harder:

Penny

Steel nail

12. Pyrite continued

K-5: When pyrite breaks, it breaks along curved surfaces, which is called a conchoidal fracture. This behavior is very different from that of some other metallic minerals, such as galena, that break along flat surfaces. To show the difference between a conchoidal fracture breaking along cleavage surfaces, stack some same-size cubic objects such as dice or wooden blocks into a larger 3D block structure. When you gently nudge the block structure, it separates into smaller pieces along smooth, parallel surfaces. To demonstrate conchoidal fracture, put on safety glasses and put an ice cube on the driveway or sidewalk outside and gently tap it with a hammer until it breaks. Are the broken surfaces flat and smooth (like breaking along cleave surfaces) or curved and jagged? Circle your answer:



Smooth cleavage face

Conchoidal fracture

1-3: Pyrite crystallizes in the isometric crystal system. Some of the best-formed crystals of pyrite in the world come from Spain and form perfect cubes. Find some things around your home that are also cubes. Write or draw your answers:

4-5: Look at the driveway or sidewalk for some concrete with pebbles embedded in it. Use a steel nail to try to scratch a pebble. The pebbles are usually made up of quartz, which is rated 7 out of 1–10 on the Mohs relative hardness scale. Pyrite is about the same hardness as a steel nail. Is the pebble harder than the nail? Circle your answer: Yes No On the basis of your result, which is relatively harder, pyrite represented by steel or quartz represented by the pebble? _____

6-8: Pyrite is made from iron and sulfur. Find iron on the periodic table of the elements. What is its atomic number? _____. What is the atomic number of sulfur? _____. How many atoms of sulfur are there per atom of iron in pyrite? _____.

9+: Research the physical properties of pyrite and gold before you go mining to avoid being fooled by fool's gold. Summarize how to distinguish them: _____

_____

_____.

13. Barite (barium sulfate or $BaSO_4$)

Barite occurs in sedimentary rocks as veins or lenses, and where these form sufficiently large deposits, they are mined commercially. It is also a by-product of metal ore mining, because it is a common gangue mineral in sulfide veins (see 1. Galena, 3. Sphalerite, and 4. Chalcopyrite). Barite is an unusual mineral in that it is very dense for a nonmetallic mineral. Barite is usually white or clear but can be brownish yellow or pale blue.

Barite is primarily used in industry as a weighting agent in drilling fluid (called "mud") for oil and gas well drilling. The density of the mud is increased to control the higher pressures that occur with depth in underground reservoirs. Other uses of barite are as a pigment in paints and as weighted filler for paper and cloth. Because it is a strong absorber of X-rays, barite is used in the medical field to picture the digestive system by contrast.

Activities:

K-1: Barite is usually white or clear, but can have many colors. Its pure crystals are in the orthorhombic system and look like rectangular boxes: Color the one on the left light blue, one of barite's colors. Barite can also form flatter crystals in a circle pattern to look like the petals on a flower. When this form is colored red by iron stains, it is called "desert roses." Color the barite rose on the right red.

Blue barite crystal

Red desert rose

K-5: With a high density for a nonmetallic mineral of 4.5 g/cm^3, a piece of barite would weigh about twice as much as a same-size piece of a typical silicate rock. To demonstrate how density can be used to identify minerals, take two 500-mL plastic water bottles. Leave one bottle full but take the cap off the second bottle and use a graduated liquid measuring cup to pour 250 mL of water out of it, leaving 250 mL in the bottle. Put the cap back on the second bottle and put each bottle into a clean sock so that you cannot see which is the full bottle. Now, compare the weight of the two bottles. One bottle is noticeably heavier, even though both bottles are the same size. Remove the bottles from the socks to see which bottle is heavier. Circle the answer:

13. Barite continued

Full 500-mL bottle

250-mL bottle

5-6: Barite is a very useful mineral because of its high density. Although elemental barium and all soluble salts of barium are highly toxic, barium sulfate is nontoxic because it is extremely insoluble in water. To examine solubility, which is the ability to dissolve in water, take two glasses of water and add one teaspoon of salt to one and one teaspoon of pepper into the other. Stir each glass for about 30 seconds. What do you see that is different between the two? _____

_____.

Which is soluble in water, salt or pepper? _____ Which is not soluble in water? _____

6+: Barite crystallizes in the orthorhombic crystal system. The most common crystal pattern has the shape of a trapezoidal prism. Make a 2D view by drawing two trapezoidal prisms, one on top of the other, with the widest parts of the trapezoids sharing the same border (one trapezoid is right side up, the other is upside down, touching each other). Color it yellow.

7+: Just from your current knowledge, which do you think is heavier, iron or barium? _____. Now, look at the periodic table of the elements and find both elements. What is the atomic weight of each: Barium: _____. Iron: _____. Now that you know their atomic weights, which one is heavier? _____.

9+: Barite strongly absorbs X-rays and gamma rays. Although it is notably dense for a nonmetallic mineral, it is also less dense than the lead conventionally used for X-ray shielding in medical applications, such as the apron you wear at the dentist. Barite has a density of 4.5 g/cm^3 and lead has a density of 7.6 g/cm^3. X-ray imaging of the digestive tract may require the patient to drink a solution of barite and crushed barite. Lead absorbs X-rays better than barite, so research why barite would be used for radiology instead (see 1. Galena): _____

_____.

14. Limestone (calcium carbonate or $CaCO_3$)

Limestone is a common sedimentary rock. Water may dissolve lots of holes in it. The caverns of West Texas were created by water dissolving large open areas below the surface of the Earth. If there is not enough support for the land surface above a cavern, it can collapse to create a sinkhole.

Limestone is one of the most important economic materials obtained by quarrying in the US. The limestone rock is ground to powder and used in the production of cement, which is an essential ingredient of concrete. Concrete is widely used in buildings, for the foundation, and for roadbeds, driveways, and airport runways. Many quarries are dug for limestone rock to use only in cement manufacture. Limestone is also used to make the "lime" used in the mortar that holds building materials such as brick and stone together and for manufacturing paper, plastics, steel, glass, and paint. It can be quarried for road gravel and as a dimension stone—many important buildings have facings of limestone, including the Empire State Building.

Limestone consists of calcium carbonate ($CaCO_3$) with various impurities. The mineral name for $CaCO_3$ is calcite. One variety of calcite is called Iceland Spar, which looks like clear blocks of ice. It is used for prisms in some microscopes. The element calcium (Ca) in calcite and limestone is the fifth most abundant metal in the Earth's crust, but it does not occur as pure deposits in nature, only in combination. In our bodies, calcium is mainly stored in our bones and teeth, but your body does not make its own calcium. If you do not get enough calcium in your diet or from nutritional supplements, your bones and teeth will not grow properly and weaken. Calcite has many uses as a neutralizer for acids. Crushed limestone is applied to soil to neutralize acid. High-purity calcite is used as an acid neutralizer in the chemical industry and in over-the-counter antacids such as Tums. It reacts with acid in your stomach to neutralizes some of it, which produces carbon dioxide (CO_2) as a byproduct.

Activities:

K-5: Get some vinegar and baking soda. Take 1 teaspoon of baking soda and put it into a bowl. Pour 1 teaspoon of vinegar on top of the baking soda. Draw or write what happened:

The bubbles that form when you add vinegar (acetic acid or CH_3COOH diluted in water) to baking soda (sodium bicarbonate or $NaHCO_3$) is carbon dioxide (CO_2), the same gas that is used in soda pop to give it fizz. You can also use a crushed Tums tablet, which is made from calcite, instead of baking soda.

14. Limestone continued

K-5: Get a small amount of vinegar, about 1 teaspoon. Find some concrete in a non-conspicuous location. Place a few drops of the vinegar on the concrete and observe the results. Did small bubbles come up from the concrete where you dropped the acid? Circle your answer: Yes No

This is a similar chemical reaction as in the previous activity, liberating carbon dioxide from the carbonate ion (CO_3^{2-}) in both the baking soda and the calcite in the concrete.

9+: Read through the two previous activities (you are welcome to conduct them also!) Write the chemical reaction that occurred for each one:

3-8: Calcium carbonate is commonly used as an abrasive in toothpaste to help remove debris, plaque, and surface stains from teeth in combination with the scrubbing motion of brushing. Collect the following ingredients to make your own toothpaste:

- Calcium carbonate antacid tablets, such as Tums
- Baking soda (sodium bicarbonate or $NaCO_2$)
- Artificial sweetener of your choice
- Liquid food colorings
- Liquid food flavorings, such as peppermint

Combine ½ teaspoon calcium carbonate and ¼ teaspoon sodium bicarbonate in a small bowl or cup. Add just enough water (ideally, use an eye dropper to add about a dozen drops of water) to make a paste. Then add about 1/8 teaspoon of powdered artificial sweetener or 1–2 drops of liquid sweetener.

Taste test your toothpaste by putting a small amount on a spoon tip. Then, experiment with mixing in different amounts of sweetener and/or small amounts of coloring and flavoring (again, use a dropper if available) to make two or more varieties. Record the different ingredients added to the basic paste in each toothpaste variety. Have other family members or classmates taste test your different toothpastes. Make a bar or pie chart displaying how many people picked each toothpaste as their favorite:

Variety 1 added ingredients: _____

Variety 2 added ingredients: _____

Variety 3 added ingredients: _____

(list more as necessary)

Draw your chart here:

14. Limestone continued

5-8: Calcite crystallizes in the hexagonal crystal system, usually forming large masses of small crystals, but sometimes it forms clear blocks that look like ice. It breaks on smooth surfaces called cleavage surfaces, with rhombohedron shape for the resulting crystals. Unlike a cube, which has rectangular faces, the six sides are parallelograms, with each pair of opposite sides parallel to each other. Draw this 3D crystal shape:

6+: Acid rain can form from mixing moisture in the air with carbon dioxide emitted from the burning of fossil fuels. Review the first two activities for limestone. What effect would acid in the rain have on buildings and roads that are made from concrete or limestone: _____

_____

_____

What do you think the effects on your teeth would be from drinking a lot of acidic beverages, such as most soda pops, or prolonged sucking on highly sour candies (note that “sour” candies decrease the pH in your mouth to form an acidic environment): _____

_____

_____

15. Granite

Granite is an igneous rock that consists primarily of quartz, potassium feldspar, and muscovite mica in varying percentages. Small amounts of dark-colored silicate minerals can be mixed in. Quartz has a hardness of 7 and feldspar has a hardness of 6 on the Mohs hardness scale, which makes granite a hard rock, ideal for high-use and weather-exposed surfaces. The Mount Rushmore National Memorial is carved in a granite mountain. Igneous rocks form from magma (molten rock) cooling and hardening beneath the surface of the Earth. They can be exposed later as a result of tectonic activity, such as mountain building and continental drift. Where accessible deposits of granite are found in sufficient quantity and quality, it are quarried as dimension stone, which is rock cut and finished to specific size and shape for many uses: monuments for cemeteries and public places, building facing (including the Texas Capitol building), and, most recently, countertops and tabletops in homes, restaurants, and other buildings. Rough blocks of granite are used as riprap to protect coastlines by preventing erosion, such as forming the jetties at Galveston Island of the Texas coast. Crushed granite gravel is often used on trails, such as in the Houston area.

Activities:

K-3: The Texas State Capitol building is constructed with Texas pink granite that is mined in central Texas. The pink or red color comes from the large amounts of potassium feldspar among the other minerals in the granite. Draw a picture of pink granite by drawing nine rectangles at different angles and different sizes. Each rectangle should touch edges of the other rectangles around it. Color two-thirds (2 of every 3) of the rectangles in a pinkish tan color, and color the remaining 1/3 of them in a light gray color. Then, take a black crayon or marker and put a bunch of black dots mixed in with the other two colors. You have drawn a Texas pink granite! The pinkish tan is the feldspar, gray is quartz, and black dots are biotite and other mafic minerals, which are rich in magnesium and iron.

4-5: Two common building stones are granite and limestone. Granite is a mixture of minerals. The two most common are feldspar and quartz. Quartz is the most common mineral on the surface of the earth and is harder than steel with a rating of 7 on the Mohs hardness scale of 1–10, with 1 being talc and diamond being 10. Limestone (calcite) has a hardness of 3 on the hardness scale. Could calcite scratch quartz? Yes No. Could quartz scratch calcite? Yes No.

15. Granite continued

6+: Although granite is a hard rock, over many thousands of years, granite exposed at or near to the Earth's surface can decompose due to a process called weathering. Feldspar alters into tiny pieces of clay and quartz decomposes into pieces of quartz that are much larger than the clay, eventually reducing to the size of beach sand.

Fill a glass jar about ¾ full, add some sand and some muddy or clayey dirt. Shake it up and watch as the particles settle to the bottom of the jar. Which settles faster in water: the sand or the fine pieces of clay in the mud? _____

(In answering the following questions related to the jar experiment, you can conduct research online.)

If a river carrying clay and sand empties into the ocean, which settles faster next to the beach?

_____

How does the energy introduced by wave action on the beach influence settling:

_____

_____

_____.

Is the sand or clay carried farther out into the ocean before it settles? _____.

16. Basalt and Diabase (plagioclase feldspars or $(Na,Ca)(Si,Al)_4O_8$ and hornblende series minerals or $(Ca,Na)_{2–3}(Mg,Fe,Al)_5(Al,Si_8O_{22}(OH,F)_2)$



Basalt and diabase are dark-colored rocks consisting of plagioclase feldspars and hornblende series minerals in various percentages. They contain the same minerals but differ in crystal size. Basalt is an extrusive igneous rock with microscopic crystals that did not have much time to form when the source lava was extruded in an eruption and cooled relatively quickly. Diabase has a similar mineral composition to basalt but richer in silica and with visible crystals because they could grow during relatively slower cooling within intrusions such as filled fractures or dikes extending away from the magma body but not exposed to the Earth's surface.

Igneous Rocks: Crystallization Environment and Composition

	Intrusive	Extrusive	Composition
Ultramafic rocks	Peridotite	None	Silica poor
Mafic rocks	Gabbro	Basalt	↕
Intermediate rocks	Diorite/Diabase	Andesite	
Felsic rocks	Granite	Rhyolite	Silica rich

Basalt flows are common in many areas around the world. One of the largest of these hardened lava flows is the Deccan Traps in India. Where basalt flows can be readily accessed, they are quarried for the superior hard, tough gravel they make when crushed to various sizes. This gravel is used in constructing asphalt, concrete, and gravel roads. Large pieces are used as riprap along some coastlines to protect from erosion. Where diabase is exposed at the surface it can be quarried for the same uses as basalt. A famous diabase exposure is the Palisades Cliffs along parts of the Hudson River in New York and New Jersey. The diabase has the appearance of columns, and the name "Palisades" means a fence of stakes, derived from the Latin word *palus* meaning stake.

Activities:

K-3: Draw a picture of a volcano with red lava being erupted from the top and flowing down one side of the volcano. The crater at the top and any flows down the volcano are where you find basalt after the lava cools to form rock.

16. Basalt and diabase continued

K-3: Basalt is called an extrusive igneous rock because it was extruded or came out to the Earth's surface and cooled quickly. The crystals that form are very small because they didn't have much time to grow before hardening to rock. You may not even be able to see them without magnification. Rocks that form below the surface of the Earth cool slowly and form larger crystals. Compare different individual grain sizes by putting a little salt in one bowl, dried rice in another bowl, and dried beans (or something of similar size) in another. Compare them side by side.

Circle which one has the finest (smallest) grain size: Salt Rice Beans

Circle which one has the coarsest (largest) grain size: Salt Rice Beans

4-6: Read the preceding activity comparing grain size for salt, rice, and beans. Research the density (total mass divided by total volume in units of g/cm^3) of these three substances. Write the order from least to most dense: Least dense = _____ < _____ < _____ = Most dense

Does this differ from the individual grain size order of salt < rice < bean? Circle your answer: Yes No

5-7: Mt. Everest is the tallest mountain in the world above sea level at 8,848 m. The Empire State Building in New York is 443 m. The height above the ocean floor of the Mauna Kea volcano in Hawaii, which is made from basaltic lava flows, is 10,210 m high. The tallest mountain in our solar system is Olympus Mons on Mars, which is also a volcano made from basaltic lava flows. It has a height of 21,229 m. Draw an illustration, to scale, comparing these four things. Label the scale you used.

7+: Basalt is the most common volcanic rock on the surface of the Earth and makes up most of the ocean floor. Most of the basalt on the ocean floor erupts from cracks and is rapidly cooled by the cold ocean water surrounding the lava to form pillow basalts. They are called pillow basalts because the large basalt rock bubbles look like pillows up to 1 m across. Research the thermal conductivity of water and of air and explain why water cools erupted lava to basalt more rapidly than air:

_____

_____

_____.

17. Potassium Feldspar (potassium aluminum silicate or $KAlSi_3O_8$)

Potassium feldspar (also called K-feldspar) is a primary constituent of light-colored igneous rocks, such as granite and rhyolite. Feldspars are the most common minerals in the Earth's crust, forming more than half of it (quartz is the most common mineral on the surface of the continents). The three principle varieties of K-feldspar are microcline, orthoclase, and sanidine, which form at low, medium, and high temperatures, respectively. They have the same chemical composition but different crystal structures. K-feldspar is common in many rocks used as building stones. In some massive deposits of the igneous intrusive rock pegmatite, the amount of K-feldspar may be large enough to be commercially exploitable. Potassium feldspar is used for aggregate in concrete and asphalt, and in the manufacture of glass and ceramics, primarily porcelain, such as for sinks, bathtubs, and toilets. It is also used in the manufacture of fiberglass.

Activities:

K-5: When feldspar decomposes, it forms clay. There are a lot of other minerals that also decompose to form clay. Clay particles are very small and hold water in the soil better than sand because the smaller clay particles have more surface area and fit tightly together. Having the right amount of clay is important to growing crops, and too much clay would not drain well. You can demonstrate this by filling two self-sealing sandwich or snack bags with water. Take scissors and cut a tiny piece of a bottom corner off one bag and a larger piece off the other bag. Circle which bag empties out faster:

Small opening in the bag

Large opening in the bag

So, could water flow faster through a rock with large openings between the grains (sand) or small openings (clay)? Circle your answer (on the next page):

17. Potassium feldspar continued

Water flows faster though clay grains

Water flows faster through sand grains

4-5: The mineral halite (salt) has a chemical formula of NaCl. Salt is used to season and preserve food, but too much salt can cause a person's blood pressure to increase and cause health problems. Potassium is also a vital nutrient for our diet, and potassium chloride (KCl) is used by some people as a substitute for NaCl for table salt. Most people know that bananas are high in potassium, but there are many foods that are better sources of potassium. Research how much potassium is in a serving of banana and find four other foods that are higher in potassium to complete this table. Circle which of these would be your favorite for consuming potassium in your diet:

Food	Potassium (mg)
Banana	

6-8: Some potassium feldspar occurs in rocks called pegmatites, which can contain extremely large crystals up to several inches or even feet across, along with many gemstones such as tourmaline and beryl. One of the feldspar gemstones is moonstone. Research why moonstones have the property of adularescence and explain here: _____

_____

_____

_____.

8+: The name potassium feldspar reflects this mineral's large content of potassium. Find potassium on the periodic table of the elements. What is its atomic number? _____. What element sits above it on the periodic table? _____. What group is potassium in and what does that tell you about its properties? _____

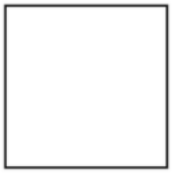
_____.

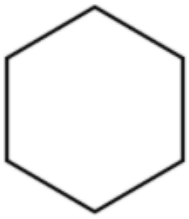
18. Quartz (silicon dioxide, SiO_2)

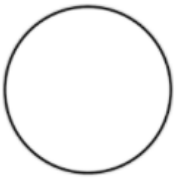
Quartz is the most common mineral on land and the Earth's surface. It is so common because it consists of silicon and oxygen, the most important chemical elements in the Earth's crust. It is a constituent of most light-colored igneous rocks, many metamorphic rocks such as gneiss, and sedimentary rocks such as sandstone. Beach sand is usually made up mostly of small, rounded pieces of quartz. Quartz is one of the most important economic minerals as a major component of cement and glass in the form of sand. Quartz is used commercially as an abrasive because it is the most common mineral that has a hardness of 7 or more on the Mohs hardness scale for minerals, which means it is harder than glass or steel. Quartz crystals are a piezoelectric material, so if an alternating voltage is applied to them, it causes the crystals to create mechanical vibrations or electronic oscillations at a constant frequency. This signal is extremely stable across a wide range of temperatures and environmental conditions. Thus, billions of quartz crystals are used as components in watches, video games, computers, cell phones, and other electronic equipment.

Activities:

K-2: Quartz crystals are often used as gemstones because they are very hard, so they resist scratching, and they come in a variety of colors depending on the impurities they contain. The crystals form as hexagonal prisms. The most popular is amethyst, which is the purple variety of quartz. Circle which shape is a hexagon (six-sided polygon) and color it purple, like one face of an amethyst crystal.







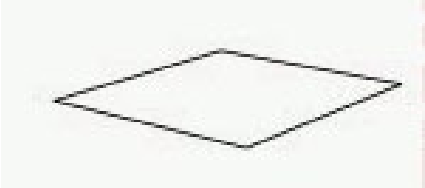
3-5: Because quartz sand is very hard, it makes good sandpaper. It is harder than most minerals and is harder than steel. Examine some sandpaper at your house, a hardware store, or an online retailer. Is the sandpaper labeled "flint" on the paper side or on the package? Yes No. If so, this means that it is made from quartz.

(continued next page)

18. Quartz continued

If it is not labeled "flint," is there another label on the back or on the package? Circle the one that you find: Garnet Silicon carbide Ceramic Aluminum oxide (the synthetic form of the mineral corundum, which is 9 on the Mohs hardness scale of 1–10. Some forms of corundum are the gemstones of ruby and sapphire.)

K-5: When many minerals break, they crack along very smooth, straight sides called cleavage planes that are determined by the crystalline structure. Quartz does not have any perfect cleavage faces, so when it breaks, the fracture surfaces look like broken glass, forming a concave (bowl-shaped) conchoidal fracture. Take an ice cube outside, put it in a clear plastic bag, and hit it softly with a hammer until it breaks. Does ice break along smooth, even faces or does it break along curved surfaces? Circle what you find:



Smooth cleavage face

Conchoidal fracture

6-8: Quartz gemstones come in many colors depending on what impurities are in the quartz molecular structure. Iron is the source of purple in amethyst and yellow in citrine, and titanium or manganese produce the pink in rose quartz. Agates are very fine-grained quartz crystals with impurities such as iron and manganese that give the individual bands in the rock the wide range of colors. When quartz crystals are being cut and polished to make finished gemstones, the person doing the grinding always drips water on the crystal to capture dust, because the quartz dust, also known as silica, can cause damage to a person's lungs. Because quartz is such a common commercially used mineral, there are many construction and industrial activities that produce these very small particles of respirable crystalline silica. Research activities that could expose workers to silica dust and list some of them:

_____

_____.

8+: A geode is a hollow subspherical stone nodule. Quartz crystals are a common lining of the internal cavity of geodes. Research how geodes form in areas of volcanic activity or by sedimentary processes and explain how the quartz crystals got inside of a hollow rock: _____

_____

_____

_____.

19. Bauxite

Formed by weathering, bauxite is a group of aluminum oxides and is the main ore that we get aluminum from. Aluminum is the most abundant metal element in the Earth's crust and the third most abundant element in the crust, trailing only oxygen and silicon. Because aluminum reacts with water and air to form various oxides and hydroxides, aluminum metal is never found in its pure form in nature. Bauxite is formed when aluminum-bearing rocks (typically those with a high content of the mineral feldspar) lose their silica by the weathering process of leaching. Using aluminum instead of steel for some parts of cars and trucks makes them lighter, which saves fuel and reduces polluting emissions.

Activities:

K-1: Aluminum is very malleable, which means that it can bend without breaking. Take a piece of aluminum foil and try bending it. Did it crack and break when you tried to bend it? Circle your answer: Yes No

K-4: Collect an aluminum drink can and a steel food can that are about the same size. Empty both cans. Which can is heavier? [circle one]

Aluminum pop-top can

Steel can

Aluminum has a lower density than steel, so it is lighter. However, steel is stronger than aluminum. You can easily dent or flatten an aluminum can compared with a steel one.

3-5: Aluminum metal is very soft and can be easily scratched with a steel nail. However, when aluminum is processed by calcining in high heat to reduce and oxidize it to Al_2O_3, it makes a synthetic form of the second hardest mineral, corundum, which is also known as the gemstones ruby and sapphire. Examine some sandpaper at your house, a hardware store, or an online retailer. Is the sandpaper labeled "aluminum oxide": Yes No

19. Bauxite continued

What is the advantage of using sandpaper that is made from minerals that are rated 9 on Mohs compared with sandpaper made with quartz, which is 7 on hardness scale of 1–10, with 10 representing the hardest mineral, diamond? _____

_____.

6-8: Aluminum is one of the lightest metals. Which would weight more, a cubic centimeter of aluminum, which has an atomic number of 13 on the periodic table of the elements, or a cubic centimeter of iron with an atomic number of 26? _____.

8+: Research the density of aluminum and steel. Modern commercial aircraft are about 80% aluminum by weight. Approximately how much weight was saved by using aluminum instead of steel for an average-size airplane that weighs 41,000 kg: _____

_____

_____.

8+: Some metals are permanently magnetic (ferromagnetic), which means they are attracted to a magnet. Check if an aluminum drink can is magnetic by applying a refrigerator magnet to it and circle your answer:

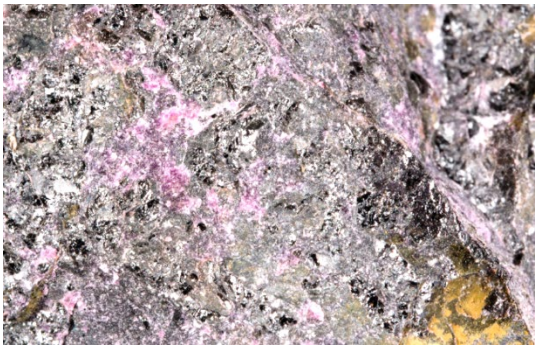
Magnetic Nonmagnetic

Find aluminum on the periodic table of the elements. What is its atomic number? _____. What group is aluminum in and what does that tell you about its properties, including whether ferromagnetism is a property of the group: _____

_____

_____.

20. Chromite ($FeCr_2O_4$)



Chromite is the only mineral containing chromium that is common enough to be mined. Chromium is an important economic mineral that is in common use around the world, such as an additive in making steel to give it resistance to corrosion. Stainless steel contains at least 10.5% chromium. It is also used as a plating on steel to prevent rust and gives it a very shiny, mirror-like finish. Most of the world's production of chromium is from South Africa, Turkey, and Kazakhstan. The USA must import almost all its chromium because it has no chromite concentrations large enough to mine.

Activities:

K-1: Look around your home or school for items that you think are made with stainless steel. If they are not coated or painted, they probably have a shiny silver color that looks like aluminum foil. Kitchen appliances such as refrigerators, ovens, dishwashers, and toasters or toaster ovens are likely made out of stainless steel that has chromium in it so they won't rust easily. Check whether you correctly identified steel items by applying a refrigerator magnet to them—most stainless steel is magnetic (unless it has a high content of the metal nickel) and will attract the magnet, even if the steel is coated or painted. Draw some of the things you found that are made from steel:

K-3: Chrome-coated steel and stainless steel containing chromium are much heavier than aluminum or plastic. Apply a refrigerator magnet to your flatware (knives, forks, and spoons) to see if they are magnetic, which indicates they are made with stainless steel. Find a plastic fork or spoon and hold it in one hand. Hold a similar-size stainless steel fork or spoon in your other hand. Circle which is heavier of the same-size utensils:

20. Chromite continued

Plastic utensil

Stainless steel utensil

4-5: Chromium is very hard at 8.5 on the Mohs hardness scale from 1 to 10. Steel is about 6.5. What advantage would be provided by coating drill bits with chrome? _____

_____.

6+: For many years, the impact-absorbing bumpers on cars were chrome-plated steel for both function and style. Starting in the 1970s, automobile manufacturers began replacing chrome bumpers with plastic covers over steel or aluminum bumper bars to reduce vehicle weight and thus improve fuel economy. If the two chrome steel bumpers on a car weigh 68 kg each and are replaced with aluminum-construction bumpers that weigh 9 kg each, how much weight is saved: _____.

The average car weighs 1,800 kg. What percentage of the weight was saved by replacing the bumpers: _____.

The US EPA says that for every 45 kg a vehicle's weight is reduced, the fuel economy is increased by about 1.5%. How much was the fuel economy improved by replacing the bumpers: _____.