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.