**Answer Key: Applying Density to Earth**

**Background**
Humans don't live in the oceans. Humans on the continents. If the entire Earth was covered by water, humans probably would not have evolved as they have. So what has provided us with continents on Earth?

1. Earth as we see it has ocean areas and land areas. But, what would a completely dry Earth look like if all the water was gone? The map image below shows elevations on Earth with all the water removed - note these elevations exist whether there are oceans or not.

   ![Map Image]

   a. Are elevations evenly distributed from high to low, or does it seem like there is a lot of high (red) and a lot of low (green), but not as much in the middle (yellow)?
   b. Also, looking at the yellow around the red, does it seem like there is relatively small amount of land in the transition from red to green?

   It seems like there is a lot of red and green but less yellow. And the yellow areas around the red are narrow, so it goes from high (red) to low (green) fairly quickly with not much in between.

2. The two main elevations in image above exist regardless of water on the planet.
   a. However, why are we not usually aware of the lower land that is green in this map?
   b. What happens to water when it rains, especially on the red elevations, that makes this so?

Most of the green areas are covered with water, that is, the oceans. When it rains on the red areas, water runs downhill to the green areas due to gravity, so all the water collects in the depressions shown by the green areas, and these are Earth's ocean basins. The water even covers some orange areas, such as the North Sea, around Indonesia, and north of Australia.
3.  
a. Knowing this fact about the Earth, what questions would you have?  
b. If you wanted to answer those questions, what other questions might you need to  
   ask to get enough data to come up with an explanation?

Questions might include (students might not get all of these at once):  
Guiding question: Why does Earth have 2 main elevations?  
Other questions:  
  • What is the crust of the Earth made of?  
  • What rocks are in the red and green areas?  
  • How could the different rocks relate to or cause the elevations?  
  • Could chemical properties affect this?  
  • What chemical properties could affect this?

Note further and more specific questions arise as earlier questions are answered, so this  
part of the exercise can be repeated as this exercise progresses.

4. As a basic concept, *elements* combine to make *minerals* as naturally occurring  
   compounds, and minerals then aggregate together physically to make *rocks*. There  
   are three major classes (groups) of rocks, do you remember what they are from  
   previous science classes?

**Igneous** - Rocks solidified from a melted mixture of elements called magma.  
**Sedimentary** - Rocks made from material broken down by weathering of other rocks.  
**Metamorphic** - Rocks changed by heat and/or pressure to a new form or composition.  
This is also the answer to question 1 in the answer to #3 above.

5. We can characterize the composition of much of Earth's crust by the names of the  
   igneous rocks that match the crustal composition. In the map image, the red areas  
   and nearby yellow areas generally are the composition of the igneous rock *granite*,  
   while the green areas and enclosed (mid-ocean) yellow areas are generally the  
   composition of the igneous rock *basalt*. You can find these rock names outlined in  
   red in the chart below. The areas within the red outline shows mineral names and  
   relative amounts of the mineral composition of these rocks.

   a. What minerals do you find in granite?  
   b. What minerals in basalt?

**Granite:** orthoclase, quartz, Na-rich plagioclase, muscovite, lesser amounts of biotite and  
    amphibole.

**Basalt:** pyroxene, olivine, lesser amounts of Ca-rich plagioclase.
6. The mineral compositions you found in the previous question affect the chemical properties of these rocks. One property you have studied, density, is important here, along with the understanding that lower density materials can float on higher density materials. For Earth, there is a layer under the crust called the asthenosphere that is solid but deformable (peanut butter is a similar deformable solid but the layer in the Earth is much more solid), so less-dense layers of the crust can float on this moveable solid layer. So then the densities of the granite and basalt crust become important because that will determine how these areas float on the asthenosphere.

a. Examine the data in the table below. Note that the minerals, their densities and percent abundance are presented and use to calculate overall densities for granite and basalt.

b. Which rock is more dense, granite or basalt?

c. If both are floating on the deformable asthenosphere, which will float higher?

Granite is less dense than basalt, so granite should float higher on the asthenosphere.
7. It's also true that granite crust is usually thicker than basalt crust. Putting all these facts together, draw your conclusion about why Earth has two main levels of elevation, and state your evidence and reasoning. Why is this chemistry important to life on Earth?

Earth has two main elevations because the crust comes in two different general compositions, granite and basalt, both of which float on the deformable asthenosphere. Evidence comes from the density measurements of the 2 rocks, and since granite is less dense than basalt, it will float higher than basalt crust. The extra thickness of granite crust also makes it higher. When we add the water on Earth, water collects over the lower basalt crust to make the oceans, while the higher granite crust remains dry land. This makes both water and land environments that allow for the diversity of life, and it is the chemical property of the density of the rocks that is a significant contributor to this condition of Earth. Particularly, the existence of dry land above the ocean levels - which needs the lower density of granite to float higher than the basalt ocean basins - is vital to human existence.
8. We have looked at density of the outer layers of rock on Earth. Expanding our view, examine the image below and look for a pattern.
   a. How do the densities of major Earth materials vary from the center of the planet to the atmosphere?
   b. Does this help you see why you have studied density in chemistry class?

The density of Earth materials decreases all the way from the center of Earth to the atmosphere - a regular arrangement though in irregular steps. This shows that density can be important not only in small objects and materials, but is relevant for the nature of the entire planet.