[1]Introduction to Crystal Structures: Bond Strength (Pauling's Rule #2)

1. **quartz** - ball and stick model

There are only two kinds of atoms in this model. Silicon is black and oxygen is red. For each, fill in the following table:

color	element	ion and charge	coordination #	bond strength

The formula is SiO_2. So, there are twice as many oxygen as silicon in this structure. Is the coordination number for oxygen equal to half the coordination number for silicon? Why or why not?

2. **calcite** - ball and stick model
Here we have black carbon, red oxygen and white calcium atoms. The CO_3 groups are tightly bonded complexes ("radicals") and act as an ionic group. So, treat them as one unit and fill in the following table:

color	element or radical	charge	coordination #	bond strength

3. **sphalerite** - clear plastic model
In this kind of model, the different ions have different sizes. This is more realistic than the standard ball and stick model. The little red balls represent zinc. The large white ones are sulfur. Assuming that sphalerite is ionic, you can determine coordination numbers and bond strengths just as you did for quartz. You, of course, realize that if there are equal numbers of Zn and S, then their ionic charge must be the same. So, fill

[1]The idea for this exercise came from: Mogk, D. (1997) Directed-Discovery of Crystal Structures Using Ball and Stick Models (*in* Brady, J.B., Mogk, D.W., and Perkins, D., eds., Teaching Mineralogy, The Mineralogical Society of America, p283-290)

in the following table. This is a bit more complicated than for quartz.

color	element	ion and charge	coordination #	bond strength

4. **<u>wurtzite</u>** - clear plastic model
In this model, the little red balls represent zinc. The large white ones are sulfur.
Wurtzite and sphalerite are *polymorphs*. <u>What does this mean?</u>

Assuming that wurtzite is ionic, you can determine coordination numbers and bond strengths just as you did for sphalerite.

color	element	ion and charge	coordination #	bond strength

<u>How do the coordination numbers, bond strengths, etc. compare between wurtzite and sphalerite?</u>

Sphalerite and wurtzite form different shaped crystals because they have different atomic arrangements, even if the same composition. <u>Look carefully at the models and explain the differences between the two structures.</u> They just do not look the same. Describe the differences.

Look in your mineralogy book and find out what crystal system sphalerite and wurtzite belong to. (The two belong to different systems.) If you know the system, then you know the shape of the unit cell, right? <u>Make a sketch of a unit cell of wurtzite, and also a sketch of a unit cell of sphalerite</u>. Show where the two kinds of atoms are located in each of the unit cells.

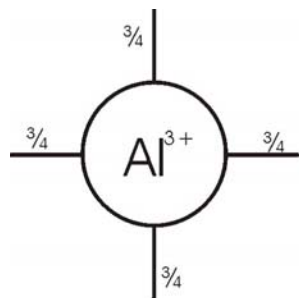
5. **<u>olivine</u>** - plastic model

In this olivine model, the large pinkish spheres are oxygen. The small brown marbles are magnesium. The white marbles are silicon. Fill in the following table. Note that the bond strength column has been changed to read average bond strength. The calculations are the same, however.

color	element	ion and charge	coordination #	average bond strength

Are the coordination numbers for the magnesium and the silicon the same? Why or why not? (i.e., What properties of Mg^{2+} and Si^{4+} account for the similar/different coordination numbers?)

Make a sketch of each of the cations in olivine, showing the correct number of bonds around each and the strength of each of the bonds.



For example, if you were depicting an Al ion in 4-fold coordination, you would have a drawing something like this.

Now, make a sketch of each of an oxygen anion, showing the correct number of bonds around each and the strength of the bonds. This is tough! If you do this correct you will see why we talked about average bond strength, in the first part of this question.

6. **albite** - ball and stick model
The red balls are oxygen, black are silicon, silver are aluminum, and gold are sodium.
For the cations only, fill in the following table:

color	element	ion and charge	coordination #	bond strength

Make a sketch of each of the cations, showing the correct number of bonds around each and the strength of the bonds.

Now, if you are masochist and want lots of extra credit, do the same sort of analysis for the oxygen anions! Good luck.