

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

Answers to Questions

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

color	element	ion and charge	coordination #	bond strength
<i>black</i>	<i>Si</i>	<i>Si 4+</i>	<i>4</i>	<i>1</i>
<i>oxygen</i>	<i>O</i>	<i>O 2-</i>	<i>2</i>	<i>1</i>

Is the coordination number for oxygen equal to half the coordination number for silicon? Why or why not?

Yes it is. It has to be in order to ensure that charge balances around both the cations and the anions.

2. **calcite** - ball and stick model

color	element or radical	charge	coordination #	bond strength
<i>white</i>	<i>Ca</i>	<i>+2</i>	<i>6</i>	<i>2/6 = 1/3</i>
<i>black/red</i>	<i>CO₃</i>	<i>-2</i>	<i>6</i>	<i>2/6 = 1/3</i>

3. **sphalerite** - clear plastic model

color	element	ion and charge	coordination #	bond strength
<i>red</i>	<i>Zn</i>	<i>Zn +2</i>	<i>4</i>	<i>2/4 = 1/2</i>
<i>white</i>	<i>S</i>	<i>S -2</i>	<i>4</i>	<i>2/4 = 1/2</i>

4. **wurtzite** - clear plastic model

Wurtzite and sphalerite are *polymorphs*. What does this mean?

Same composition but different arrangement of atoms and bonds in the structure.

color	element	ion and charge	coordination #	bond strength
red	Zn	Zn +2	4	$2/4 = 1/2$
white	S	S -2	4	$2/4 = 1/2$

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

All are the same.

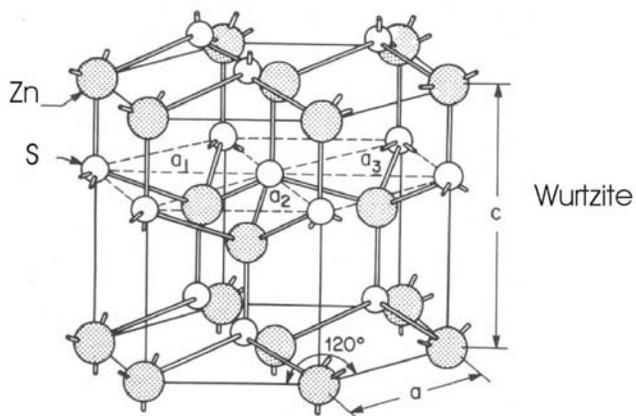
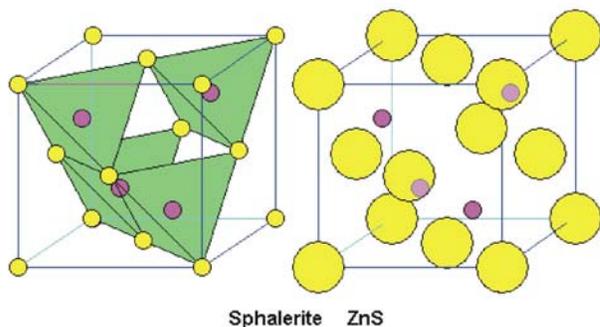
Look carefully at the models and explain the differences between the two structures. They just do not look the same. Describe the differences.

The structures are controlled by the way the S ions are stacked together. The small Zn cation just fit between. In sphalerite, the S ions are stacked so as to give an overall cubic arrangement. But, in wurtzite the arrangement is more hexagonal than cubic.

Make a sketch of a unit cell of wurtzite, and also a sketch of a unit cell of sphalerite. Show where the two kinds of atoms are located in each of the unit cells.

See drawings.

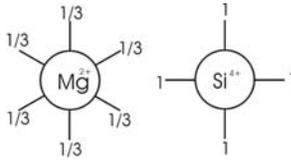
Two views of sphalerite's structure and one of wurtzite's



5. **olivine** - plastic model

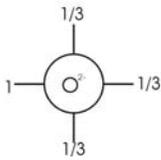
Note: Not mentioned in the handout is that the bonds to oxygen are not all the same!

color	element	ion and charge	coordination #	average bond strength
pink	O	O 2-	4	average is 1/2
brown	Mg	Mg 2+	6	1/3
white	Si	Si 4+	4	1



Are the coordination numbers for the magnesium and the silicon the same? Why or why not?

No. They are different due to the ions having different ionic size.



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.

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!

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
gold	sodium	Na +	6	1/6
black	silicon	Si 4+	4	1
silver	aluminum	Al 3+	4	3/4

The sketches will be similar but not identical to those above shown for olivine. There is a bit of a complication with albite – Na is not in exactly 6-fold coordination. But all ball and stick models show it in 6-fold, so that is the answer here.