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89.301 - MINERALOGY
DETERMINATION OF SPECIFIC GRAVITY

The specific gravity ($G = \rho/\rho_{H2O}$) of a mineral is a function of how tightly the ions/atoms are packed (the packing index) and the chemical composition. The packing index is

$$PI = \frac{V_I}{V_C} \times 100$$

where PI is the packing index, V_I = the total volume of the ions in the unit cell based on their ionic radii, and V_C = the volume of the unit cell.

1. Calculate the packing index for cristobalite and stishovite, two polymorphs of SiO_2. The data for cristobalite is found on p. 207 of the textbook. Use the ionic radii corresponding to coordination number 4 for both Si and O. Calculate the volume of each of the ions using the appropriate ionic radii. The volume of a sphere is $4/3\pi r^3$. Multiply the volume of each ion by the number of atoms in the formula unit (1 for Si and 2 for O). Then multiply the volume of the formula unit by the number of formula units (Z) in the unit cell. For stishovite, Z = 2. Next calculate the volume of the unit cell. Both polymorphs are tetragonal. For stishovite, a = 4.179Å and c = 2.665Å. Ionic radii and unit cell lengths are reported in Angstrom units. One Angstrom = 1×10^{-10} m.

	V_I (m)	V_C (m)	PI
Cristobalite			
Stishovite			

Compare the calculated Packing Indices to the specific gravity for cristobalite (G = 2.32) and Stishovite (G = 4.29). Which mineral has the greater packing index? Which mineral has the greater specific gravity? Are the results what you would expect given the discussion in the textbook on the relationship between the packing index and specific gravity? Explain.

2. Calculate the packing index for forsterite and fayalite (the two end member compositions of the olivine series). The information needed to do these calculations is found on p. 306 of the textbook. You will first need to determine the coordination numbers for Mg, Fe, Si, and O in the olivine structure. Then calculate the volume of each of the ions using the appropriate ionic radii. Remember that the volume of a sphere is $4/3\pi r^3$. Multiply the volume of each ion by the appropriate number of ions as given in the formula for forsterite and fayalite. For olivine Z = 4 (the number of formula units in the unit cell). Hence, you will need to multiply the volume of the formula unit by 4. Next calculate the volume of the unit cell using the lengths of the unit cell axes as given on p. 306. Ionic radii and unit cell lengths are reported in Angstrom units. One Angstrom = 1×10^{-10} m.

	V_I (m)	V_C (m)	PI
Fayalite			
Forsterite			

Compare the calculated Packing Indices to the specific gravity for fayalite and forsterite. Which mineral has the greater packing index? Which mineral has the greater specific gravity? Are the results what you would expect given the discussion in the textbook on the relationship between the packing index and specific gravity? Might some other factor be more important than PI in determining the density of forsterite and fayalite? Consider the chemical formulas of the two end members. Discuss.

Specific gravity of a mineral can be determined by comparing the weight of the mineral in air to the weight of the mineral when suspended in a container of water. This measurement is made using a Joly balance. For small samples the specific gravity can be determined using a pychnometer (a small flask fitted with a ground-glass stopper with a hole).

3. Determine the specific gravity of an unknown mineral using a pychnometer. The procedure is as follows:

    1. Weigh the mineral grain(s). (m_A)

    2. Weigh the pychnometer (with the glass stopper) when it is completely filled with water. Fill the flask and insert the stopper (this should be done while the flask is sitting on a Chemwipe). Some water will spill out of the flask. Remove the water from the exterior of the flask (using a Chemwipe) and weigh the flask. (m_P)

    3. Remove the stopper and add the mineral grains (1) to the flask (the flask should be sitting on a Chemwipe). Reinsert the stopper. Remove the water from the exterior of the flask. Re-weigh the pychnometer. (m_{P+S})

    4. Calculate the specific gravity (G)

$$G = \frac{m_A}{m_A + m_P - m_{P+S}}$$

Report your results in the following table.

Unknown	m_A	m_P	m_{P+S}	G