1. Explain ionic bonding and describe how the structure and properties of ionically-bonded materials result from the characteristics of ionic bonding.

2. Explain covalent bonding and describe how the structure and properties of covalently-bonded materials result from the characteristics of covalent bonding.

3. Use the dot product to calculate the angle between [123] and [4\( \bar{1} \)0] directions in a cubic crystal.
4. Use the cross-product to calculate the *direction* which is perpendicular to both [111] and [8\(\bar{1}0\)] in an orthorhombic crystal with \(a = 1\), \(b = 2\), \(c = 3\) Å.

5. What is the *magnitude* of the direction vector [123] in a tetragonal crystal with lattice constants \(a = b = 5\) Å, \(c = 7\) Å?

6. What is the *angle* between the [123] and [23\(\bar{1}\)] directions in an orthorhombic unit cell with lattice constants \(a = 5\) Å, \(b = 7\) Å, \(c = 9\) Å?
7. Consider the diamond cubic C allotrope with $a = 3.56 \, \text{Å}$. Atomic positions are at 000, $\frac{1}{2}\frac{1}{2}0$, $\frac{1}{2}0\frac{1}{2}$, $0\frac{1}{2}\frac{1}{2}$, $\frac{3}{4}\frac{3}{4}\frac{3}{4}$, $\frac{1}{4}\frac{1}{4}\frac{1}{4}$, $\frac{3}{4}\frac{3}{4}\frac{1}{4}$. Calculate its theoretical density, the C-C bond length, and the C-C-C tetrahedral bond angle. Show all your work, but you may want to check your results with Crystallographica, Crystal Maker, Vesta, or another software package.

Note: $\rho_{th} = \frac{ZM}{AV}$ where $Z =$ number of formula units per unit cell
$M =$ molar weight of formula unit
$A =$ Avagadro's number
$V =$ volume of unit cell