

Mineralogy Study Guide

Symmetry

- Know the 7 crystal systems, including relative axial lengths and angles between axes.
- Know the symmetry operators involved in the 32 crystal classes: center of symmetry, axes of rotation, mirror planes, and rotary inversion axes.
- Given a block model, be able to identify the crystal class while using the crystal class handout.
- Know the Bravais lattices: primitive, body-centered, face-centered, end-centered. Rhombohedral and hexagonal cells are special kinds of primitive cells.
- Know how the new symmetry operators of the 230 space groups work: glide planes, screw axes.
- Be able to find mirrors, rotation axes, centers of symmetry, screw axes, and a, b, and c glides in a crystal structural model, if you are told that they are there.
- Be able to pick out the unit cell (lattice equivalent points at 8 corners) from a structure model.
- Be able to calculate Miller indices from axial intercepts. Be able to assign reasonable Miller indices to simple faces in block models.

Atoms and bonding

- Know the basic differences between the various types of chemical bonds: covalent, ionic, metallic, hydrogen, and Van der Waals.
- Know the general relationships between ionic radius and charge of a single element.
- Know the regular coordination polyhedra: triangle, tetrahedron, octahedron, cube, dodecahedron. Know that there are other less-regular and non-regular coordination polyhedra, such as: square plane, triangular dipyramid, square antiprism, triangular prism, hexagonal prism, etc.
- Be able to identify the two types of closest packed arrays of spheres: hexagonal closest packed and cubic closest packed.
- In a crystal structure model, be able to identify the coordination numbers of various atoms in the structure, regardless of whether or not the bonds are shown with metal rods.
- Understand that sulfides and other non-oxygen, nitrogen, fluorine, and chlorine compounds are not ionic compounds, and so the ionic model of bonding and prediction can't be applied.

Ionic model crystal chemistry

- Know the approximate, or at least relative, ionic radii and common coordination numbers of the most common ions in silicate and other oxygen-rich structures: B, C, Si, Al, Ti, Fe²⁺, Fe³⁺, Mn²⁺, Mg, Ca, Na, K, P⁵⁺, S⁶⁺.
- Understand how simple and coupled substitutions work. Be able to apply substitutions in a known structure, such as a pyroxene.
- Be able to pick out multi-atom substructures in structure models, especially coordination polyhedra and shared polyhedral elements: corners, edges, and faces.
- Given ion proportions, be able to put them into a structural formula in a reasonable way.
- Know common chemical substitutions in feldspars, olivine, amphibolies, micas, pyroxenes, and garnets.

Twinning, exsolution, inversion, etc.

- Know what twinning is and how growth twins differ from transformation twins.
- Understand how exsolution in a binary solid solution works.
- Be able to give some examples of polymorphs and pseudomorphs.
- Be able to give some examples of isostructural minerals.

Silicate structures

- Know the differences between, and be able to identify in structure models, the different silicate mineral types: nesosilicates (isolated tetrahedral), sorosilicates (pairs), cyclosilicates (rings), inosilicates (chains), phyllosilicates (sheets), and tectosilicates (3-d frameworks).
- Understand the layer types in 1-, 2-, 3-, and 4-layer sheet structures, and know mineral examples of all of these.
- Understand the stacking vector concept in the common sheet silicates, and be able to find the stacking vectors in models.

Color in minerals

Understand the concepts behind the various origins of color in minerals:

- Mineral particle contaminants.
- Conduction band transitions.
- Other atomic energy level transitions (e.g., d-orbital transitions).
- Charge transfer absorption.
- Reflection interference.
- Diffraction interference.
- Color centers.
- Be able to give at least one example of minerals that show each color mechanism, and the colors these minerals have.

X-ray diffraction

- Know Bragg's law. Be able to rearrange Bragg's law to solve for either of the two usual variables (2θ , d-spacing), and to plug numbers in to do so.
- Understand the origins of the continuum and line spectra generated in an X-ray tube.
- Know what an absorption edge is and how filters work to reduce the $K\beta$ interference in X-ray diffraction work.

Immersion oils and interference figures

- Be able to explain the origin of Becke lines, and how to use them to determine relative refractive index.
- Understand the three optical indicatrix type shapes: isotropic, uniaxial, and biaxial.
- Be able to identify these centered optic figures: uniaxial optic axis, biaxial optic axis, flash figure, and biaxial BXA (isogyres remain in the field of view).
- Be able to measure: optic sign, sign of dispersion of the $2V$ (biaxial minerals only), the sign of elongation of any elongate grain, and extinction angle on any grain that is elongate or has a parallel set of cleavage cracks. Note that the first three are the so-called "blue rules."
- Be able to find optic axis figures in grains in a grain mount or thin section.

Mineral properties

- Be able to accurately use all common mineral tests and features: habit, cleavage, hardness, luster, color, streak, ferromagnetism, dilute HCl fizzing, fluorescence, taste, density, hand lens, stereo microscope.
- Be able to distinguish between crystal faces and cleavage planes.
- Be able to identify on sight the common minerals in puzzle boxes.

Albite	Chalcopyrite	Hematite	Magnetite	Pyrite
Almandine garnet	Copper	Kaolinite	Microcline perthite	Rose quartz
Apatite	Fluorite	Kyanite	Muscovite	Sodalite
Biotite	Graphite	Labradorite	Olivine	Talc
Calcite	Gypsum	Lepidolite	Epidote	Tourmaline

Mineral chemical formulae

Know chemical formulae for minerals in the puzzle boxes.

Actinolite	Chalcopyrite	Fluorite	Hematite	Olivine
Albite	Copper	Garnet	Kyanite	Pyrite
Anorthite	Diopside	Gold	Magnetite	Quartz
Arsenic	Dolomite	Graphite	Marcasite	Silver
Biotite	Enstatite	Gypsum	Microcline	Talc
Calcite	Epidote	Halite	Muscovite	Zircon