

GEOL 103 Writing Assignment 1. Minerals Key

1. What's a cation? Anion?

A cation is a charged atom that has lost electron(s) in order to have a full valence shell, which is a stable electronic configuration. An anion is a charged atom that has gained electron(s) in order to have a full valence shell. More generally, both can be called ions, which means that they are electrically charged atoms.

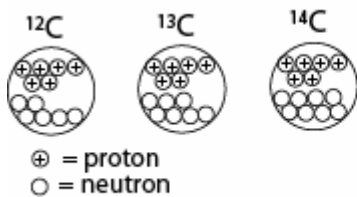
2. What is atomic mass? Atomic number?

Atomic number is the number of protons that an element has in its nucleus; this number does not vary for a particular element. Atomic mass is the sum of electrons and protons in the nucleus for an isotope.

3. What is in the nucleus of any atom? Of a carbon atom?

All nuclei have the number of protons appropriate for that element. Most nuclei also have neutrons (Most H atom are ^1H , only have a proton and no neutrons. ^2H and ^3H have 1 and 2 neutrons, respectively). A carbon atom has 6 protons and 6, 7, or 8 neutrons, depending on the isotope (see also question 4).

4. Draw a schematic diagram of the 3 most common carbon isotopes. Include correct # of protons & neutrons in each drawing. Assume 6 electrons. Answer these questions:



Note: protons and neutrons are not physically arranged as sketched. Only the nucleus is shown.

- How many protons does C always have? 6 What about H? 1 What are their atomic numbers? C 6; H 6
- What are the atomic masses of each carbon isotope? 12, 13, 14
- The average atomic number of C is 12.011 on the periodic table. What does this tell us about the abundance of each carbon isotope? The atomic mass that one can find on the periodic table is an average of the atomic masses for all isotopes, so ^{12}C has an atomic mass of 12, ^{13}C has an atomic mass of 13, ^{14}C has an atomic mass of 14; however, in a sample with lots of C, the average atomic mass = 12.011.
- Which carbon isotope have you heard the most about? Why? ^{14}C or carbon-14 because it is radioactive and used for radiocarbon dating of fairly recent organic material.

5. What kinds of evidence tell us about the internal structure of minerals? How does the cleavage of a mica relate to its internal structure?

Crystal growth faces are external evidence of internal structure (see Fig. 3.8), as are cleavage planes. X-ray diffraction and scanning tunneling microscopy (see Fig. 3.6 in lab book) are two methods not available to introductory students that provide evidence of internal structure.

Cleavage planes in minerals are *planes of relatively weaker bonds* that allow minerals to preferentially break along those planes in the internal structure. In micas, due to weak bonds in one particular plane, there is one excellent cleavage plane along which the mineral clearly breaks most easily.

6. What are polymorphs? Give an example.

Polymorphs are minerals that have the same chemical composition, but different internal structures, physical properties, and mineral names. Diamond and graphite are both pure carbon, but are dramatically different in physical properties. Quartz, stishovite, and coesite are all SiO_2 polymorphs. Calcite (common), aragonite (less common), and vaterite (rare) are all CaCO_3 polymorphs.

7. What can you say about the calcium and magnesium in the mineral diopside, $(Ca, Mg)_2Si_2O_4$? Why are Ca and Mg in parentheses?

A pure diopside “end-member” would be either $Ca_2Si_2O_4$ or $Mg_2Si_2O_4$. There’s an atomic site in the mineral lattice that can accommodate either Ca or Mg because they are similar in size and charge (both 2+). So $(Ca, Mg)_2Si_2O_4$ is the formula for a diopside that has a mixture of Ca and Mg in one atomic site (a **cationic substitution** of Ca for Mg (or *vice-versa*)).

8. What is a silica tetrahedron? How does it help us understand silicate minerals?

A silica tetrahedron has a central Si bonded to 4 O atoms. It’s called a tetrahedron because the imaginary planes between atoms form a four-sided (tetra) structure. It is the basic atomic building block for silicate minerals, which compose most of the minerals on Earth, including quartz, feldspars, micas, amphiboles, pyroxenes, and olivines. The arrangement of the tetrahedral (isolated, single chains, double chains, sheets, framework) help determine physical properties such as cleavage.

9. Some mineral crystals are very large, some are very small? Why?

For igneous rocks, slower cooling leads to larger crystals. The presence of open space available for crystal growth can also lead to larger crystals; e.g., as quartz crystals in a geode like the one you saw in lab.

10. Why is calcite a poor gemstone? Why is diamond a good gemstone?

Calcite is attacked easily by acid, it’s soft, and it cleaves easily. Diamond is very chemically resistant, and it’s very hard, making it long-lasting. Most diamond also interacts with light (brilliant luster) in more beautiful ways than calcite.

11. Quartz (SiO_2) has a specific gravity of 2.65. Coesite and stishovite (both SiO_2) were found in meteor craters in Arizona, and they have specific gravities of 3.01 and 4.35, respectively. Why? How is their occurrence related to the crater?

Because all of these minerals have the same chemical composition, they are **polymorphs** of each other.

The coesite and stishovite almost certainly formed from the transformation of quartz, which is very commonly in rocks and soil, due to the high pressures associated with the impact. Their higher densities suggest that the atoms are more closely packed than those in quartz. All three are SiO_2 polymorphs.

12. Why are the physical properties of diamond and graphite so different?

These polymorphs of carbon have very different internal structure and bonding. Diamonds bonds are much stronger.

13. What’s the difference between crystal faces and cleavage faces?

Crystal faces are the outer layers at which minerals **grow**, and they are an expression of a mineral’s internal structure. There may not be room for growth as minerals “bump into” each other during crystallization, so faces are not always well expressed. Cleavage faces result due to breakage along planes of weak bonds (for some minerals, not all); they should be expressed any time a mineral with cleavage is **broken**.

14. Why do quartz and olivine (for example) exhibit no cleavage?

They have no particularly weaker bonds in any particular direction. Both are hard, so strong bonds predominate in all directions.

15. How would you tell a quartz crystal from glass cut to look like a quartz crystal?

The quartz crystal would have an X-ray diffraction pattern; the glass would not (if you happen to have a handy X-ray diffraction instrument). The quartz should scratch the glass. Both would have conchoidal fracture, so breaking them wouldn’t help.