Geology 306 Final Exam

This closed-book exam contains seven pages. No notes or calculators are allowed. This exam is designed to last 100 minutes, but you will have about 120. I encourage you to do the easy problems first, then come back and do the hard ones.

Mark answers on these sheets. Grades may depend on clarity as well as content of answers. Numbers in parentheses following question numbers are point values.

Atoms, Ions and Bonds

1.(5) Toughness is the resistance to breakage, and is different from hardness. Some types of jade (made of actinolite) are amorphous – they have no discernable crystal structure, although TEM shows them to be composed of tiny (maybe just a few unit cells in length) intergrown randomly oriented crystals of actinolite at the sub-microscopic scale. Would you expect jade such as this to have greater, lesser, or equal toughness compared to regular actinolite? Also, would you expect it to be harder than regular actinolite (on Moh's scale)? Why or why not? _____

_____

_____

_____

_____

Solid solution

2.(3) Give the *specific composition* that would result if you began with Daphnite ($Mg_6Si_4O_{10}(OH)_8$) and "added" 0.3 formula units of the Tschermak exchange vector. _____

_____

3.(3) Give the solid solution exchange vector that relates the end-member plagioclases, albite and anorthite. I am not asking for the generalized formula of the intermediate plagioclase compositions.

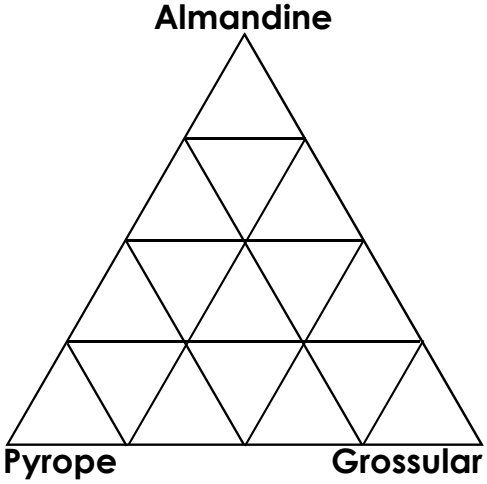
_____

Plotting Compositions

4.(6) Plot the location of the following garnets on the ternary diagram at right. Plot points only, labeled with letters a and b (Note that Almandine is the Fe end-member, Pyrope is the Mg end-member, and Grossular is the Ca end-member).

a.(3) $Alm_{60}Pyp_{10}Grs_{30}$

b.(3) $Mg_{0.5}Fe_{1.5}Mn_{1.0}Al_2Si_3O_{12}$



Pauling's Rules & Crystal Defects

5.(12) At very high pressure, silicon changes to octahedral coordination, and is believed to have a structure similar to perovskite. Assume that "westernite", a very-high-pressure silicate mineral obeys Pauling's Rules.

a.(3) How many oxygens would you expect two adjacent silicon ions in westernite to share in common? In other words, of the set of oxygens bonded to two neighboring silicons, how many are bonded to *both*? _____

b.(3) Use the principles of local charge balance to determine how many silicons are bonded to each oxygen in the above perovskite-like SiO_2 structure. Show your work below.

c.(3) If you found that adjacent silicons in westernite actually shared more oxygens in common than this, what would be noticeable about the atomic structure? _____

d.(3) What silicate structures are possible for that version of westernite (from part c)? (For example, island, bowtie, ring, single-chain, double-chain, sheet, or framework) _____

_____

Color / Fluorescence / Phosphorescence

6.(3) For a mineral to fluoresce, releasing a photon whose energy is 2.5 eV, which of the following is most likely to be true? (Circle a, b, or c)

a. It absorbed all the photons of other energies, leaving only those of energy 2.5 eV.

b. Each fluorescing ion absorbed two photons whose energies were 1.25 eV.

c. Each fluorescing ion absorbed one photon whose energy was 4 eV.

7.(3) If a new mineral were to be discovered that encompassed a solid solution between an Fe-rich end-member and an Mg-rich end-member, which end-member would we expect to be more strongly colored?_____

Polymorphs & Pseudomorphs

8.(6) Give a pair of polymorphs...

a.(2) ...with qualitatively different structures: _____

b.(2) ...with structures that differ only in their bond angles: _____

c.(2) ...that differ in cation ordering: _____

9.(3) Why would you need to very careful picking up a piece of beta-quartz? Explain. _____

_____

_____

_____

Miller Indices

10.(3) Assume that the c-axis is perpendicular to the page. Draw and label a (120) plane.

11.(3) Draw an adjacent plane and indicate the d-spacing (interplanar spacing).

12.(3) Give the Miller Indices for a set of planes that would have a larger d-spacing. _____

13.(3) Would such a plane be more or less likely to be a growth face than a (230) plane? _____

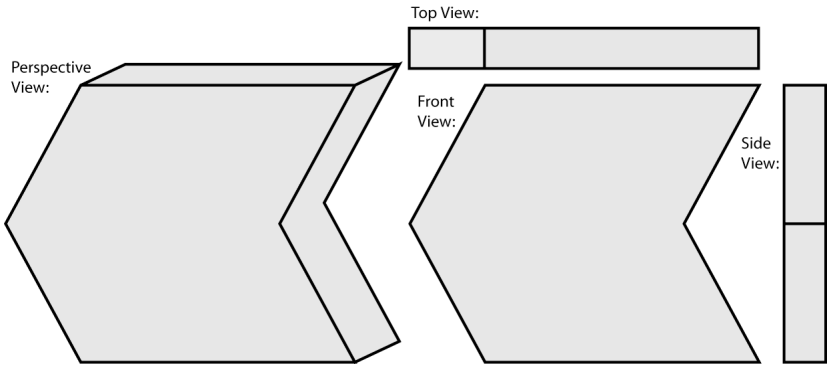
Crystal growth

14.(4) True or false: The critical radius is the size of crystal beyond which it is unstable, and will begin to form twins instead of growing a single crystal. _____

15.(4) List the three general ways crystals form. _____

_____

16.(6) Gypsum commonly forms "swallowtail twins," which look somewhat like the shape at right. Gypsum is monoclininc. Show where the twin boundary and the *b* axis are and explain how there can be a mirror plane parallel to the *b* axis here.



_____

_____

_____

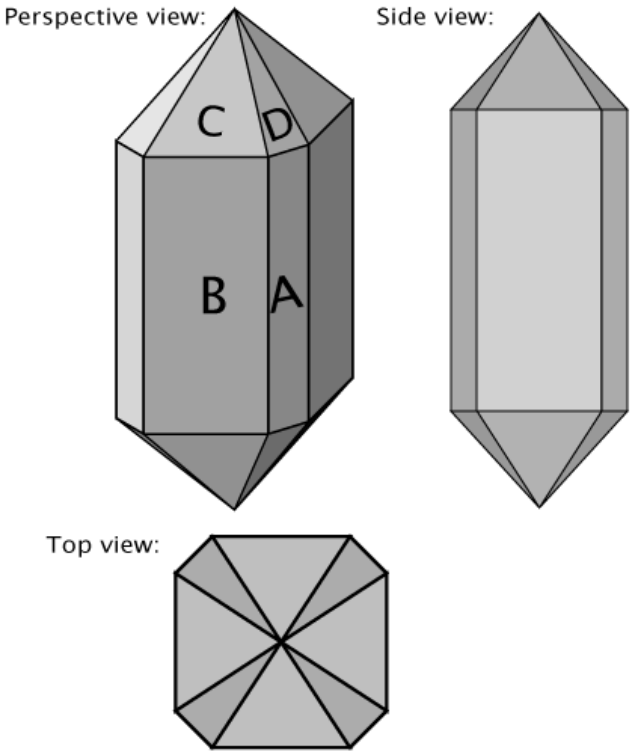
Crystal Forms

The next three questions refer to the crystal at right.

17.(3) What is the crystal system?_____

18.(3) How many crystal forms (not types of forms) are there in this crystal?_____

19.(9) For each form present, give the full name (in words), together with the form symbol (this has digits in it), and the number of faces the form contains. If there are lettered face(s) in the form, indicate which letter(s).



Lettered Face, if any	Name of Form	Form Symbol	Number of Faces

Systematic Mineralogy

20.(4) Spinel group minerals have the general formula XY_2O_4 (where X and Y are different cations), and have twice as many octahedral sites as tetrahedral.

a.(2) In magnetite (a spinel group mineral), what are the "X" cations? _____ and the "Y" cations? _____

b.(2) Describe where in the magnetite structure those cations are located (i.e., the coordination number for each cation)_____

_____

_____

21.(3) What is the key structural feature of zeolite minerals? (this feature is also shared by beryl and cordierite.) _____

22.(3) True or false: Halide minerals tend to have covalently bonded structures _____

23.(3) What site do micas and amphiboles have that pyroxenes lack? _____

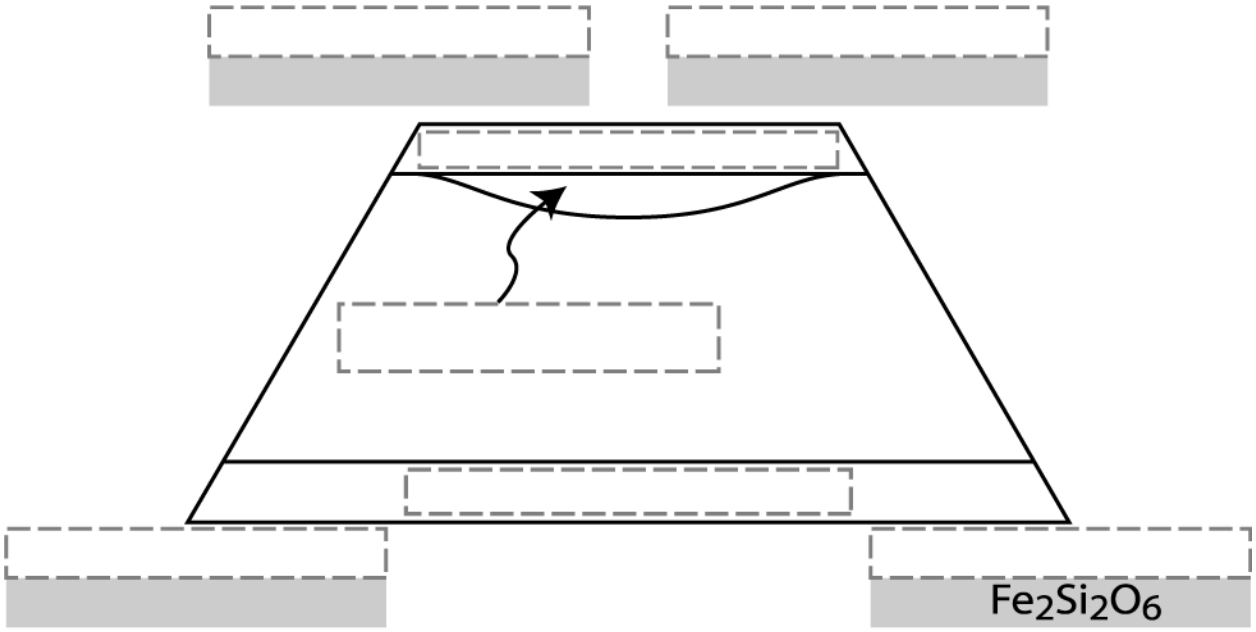
24.(6) What is the ratio of tetrahedral cations to oxygen in the following? (Answer as a ratio. Example: "7:13" meaning seven tetrahedral cations for every thirteen oxygens)

a.(3) A sheet silicate (phyllosilicate)? _____

b.(3) A bowtie silicate (disilicate)? _____

25.(10) Put the following mineral names in the correct places (dashed boxes) on the pyroxene quadrilateral below. Also give formulas for some pyroxenes (shaded boxes – one is done for you):

enstatite,ferrosilite (Fe-enst**),hedenbergite (**Fe-diop**),diopside,augite,orthopyroxene,clinopyroxene**



26.(7) Talc is $Mg_3Si_4O_{10}(OH)_2$.

a.(2) Is talc dioctahedral or trioctahedral? _____

b.(2) Describe the stacking of the sheets (e.g., O, T-O, etc.) _____

c.(3) Structurally and chemically, how does talc differ from phlogopite, the Mg end-member of biotite? You can use a sketch to aid your explanation, if you wish. _____

_____

_____

27.(3) True or false: Pure, end-member microcline could be perthitic on about a 1-mm scale. (Careful, this is tricky!) _____

28.(6) Sketch the amphibole structure, looking down (along) the chains (so the chains would be perpendicular to this paper). Include enough chains in your sketch to show the distinctive amphibole cleavage. Show all four types of cation sites as well as the cleavage planes (draw these as straight lines, and label the distinctive amphibole angle between them).

Crystal Systems & Axes

At right are three views of an idealized, perfect object for use in the following three questions. The shading and letter are to aid in the visualization – the colors are not meaningful.

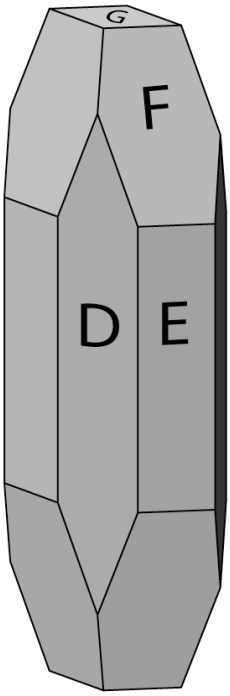
29.(4) Draw in and label all the symmetry elements, except for the center of symmetry (inversion point). Use any or all of the views, as long as you get the information across.

30.(4) Draw in and label all the crystal axes, obeying any rules for axis placement relative to symmetry elements that this crystal system requires. Use any or all of the views, as long as you get the information across.

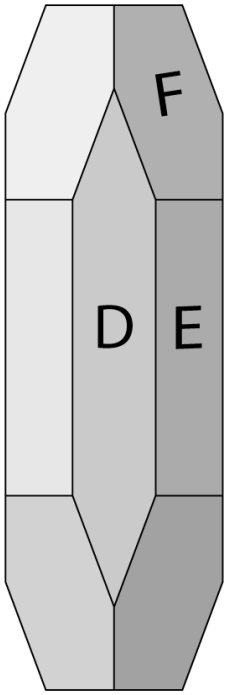
31.(3) What is the crystal system?

_____

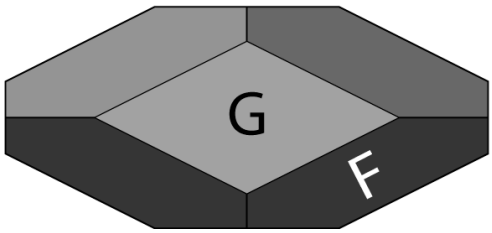
Perspective view:



Front view:



Top view:



Mineral formulas

Give the mineral group for each mineral, choosing from the following list:

Native element	Hydroxide	Sulfide	Single-chain silicate
Halide	Borate	Isolated Tetrahedra Silicate	Double-chain silicate
Carbonate	Phosphate	Bowtie silicate	Layer silicate
Oxide	Sulfate	Ring silicate	Framework silicate

32.(2) Sphalerite _____ 34.(2) Azurite _____ 36.(2) Sodalite _____

33.(2) Sillimanite _____ 35.(2) Topaz _____ 37.(2) Cordierite _____

38.(2) Which of the following would be a potential source of copper? (Circle one or more)

Pyrite	**Azurite**	**Actinolite**	**Chalcopyrite**

39.(2) Which of the following would be a potential source of boron? (Circle one or more)

Stilbite	**Phlogopite**	**Stibnite**	**Tourmaline**

Name the following minerals:

40.(2) $FeCr_2O_4$ _____ 43.(2) $Ca_2Si_2O_6$ _____

41.(2) $Ca_3Al_2Si_3O_{12}$ _____ 44.(2) $CaSO_4 \bullet 2H_2O$ _____

42.(2) $Na_2(Mg_3Al_2)Si_8O_{22}(OH)_2$ _____ 45.(2) $Ca_2Al_2(Al,Fe^{3+})OOH(Si_2O_7)(SiO_4)$ _____

Give the formulas for the following minerals:

46.(2) Beryl _____ 49.(2) Fluorite _____

47.(2) Corundum _____ 50.(2) Tremolite _____

48.(2) Dolomite _____ 51.(2) Biotite _____

52.(2) One of these minerals is not like the others (chemically); one of these minerals doesn't belong. Can you tell me which mineral is "doin' its own thing"? (i.e., 3 have some element in abundance, the other lacks that element).

Kaolinite	**Andalusite**	**Aragonite**	**Topaz**

53.(2) One of these minerals is not like the others (chemically); one of these minerals doesn't belong. Can you tell me which mineral is "doin' its own thing"? (i.e., 3 have some element in abundance, the other lacks that element).

Nepheline	**Apatite**	**Dolomite**	**Epidote**

54.(2) One of these minerals is not like the others (chemically); one of these minerals doesn't belong. Can you tell me which mineral is "doin' its own thing"? (i.e., 3 have some element in abundance, the other lacks that element).

Serpentine	**Enstatite**	**Olivine**	**Staurolite**