name _____

MINERALOGY LABORATORY
Symmetry

objective: become familiar with basic symmetry elements; recognize symmetry in 3-D

instructions: Be sure to review pages 175-183. You should probably read the rest of Chapter 9, too.

A. General questions:

1a) Make (2-dimensional) drawings that show good examples of a 2-fold, 3-fold, 4-fold and 6-fold rotation axis.

1b) Make a 2-D drawing that shows a good example of a mirror plane. Does your drawing have a 2-fold axis ? Probably. Make another one that has a mirror without a 2-fold axis.

1c) Make (2-dimensional) drawings that shows a good example of an inversion center.

1d) Can you make a 2-dimensional drawing that has an inversion center but no 2-fold axis? Why do we need to distinguish both kinds of symmetry?

2a) Real objects are three dimensional. Name or describe two examples of real objects that have a mirror plane in 3-D.

2b) Name or describe two examples of real objects that have 2-fold axes in 3-D.

2c) Name or describe two examples of real objects that have 3-fold axes in 3-D.

2c) Name or describe two examples of real objects that have 4-fold axes in 3-D.

2d) Name or describe two examples of real objects that have 6-fold axes in 3-D.

2c) Name or describe two examples of real objects that have an inversion center in 3-D.

3) What are rotoinversion axes? Some of them are redundant because they are the same as other symmetry elements we have talked about. Which ones? What are they equivalent to?

4) Now let's think about symmetry of atomic structures. Consider the ball and stick models listed below. For each, indicate (with a check mark) which symmetry elements are present. This is not a trivial exercise! **Remember, these models are only parts of an entire atomic structure – the atoms go on to infinity in all directions.**

Ball and stick model	at least one mirror	at least one 2-fold	at least one 3-fold	at least one 4-fold	at least one 6-fold	at least one inversion center	at least one inversion center
halite							
calcite							
graphite							
olivine							
albite (good luck!)							

Wooden Blocks and Real Minerals

5. There are 5 wooden blocks in the tray. Fill out the Table 1 (table and instructions on attached page). Note that in the key, Hermann-Mauguin symbols designate the point groups (see Box 9.6, page 203 in text for an explanation).

6. There are five examples of real minerals. Fill out Table 1 as you did for question #5.

Table 1. Symmetry and Crystals

You have been given samples to look at. For each, fill in the following table by counting the different <u>kinds</u> of symmetry elements. The count should be the number of different type of, for example, mirror planes. (This means that four equivalent mirrors only count as one!) Not the actual number. Ask us to explain this if it is unclear. **<u>Make sure you know what all the symbols below mean!</u>**

I.D. #	i	m	2	3	4	5	6	3̄	3̄	9̄	2/m	4/m	6/m
8													
50													
86													
162													
187													
gypsum scalenohedron													
pyrite crystals from sediment													
apophyllite crystal - this is soft so treat it nicely													
zircon crystals													
magnetite crystals in a rock													

Key to Determine Point Groups (Crystal Classes)

| | Crystal system | Possible point groups |

Does it have a 6-fold axis? → Yes ────────────→ Hexagonal →
6
6/m
622
6mm
6/m2/m2/m

↓ No

Does it have at least one 3-fold axis? → Yes → Does it more than one 3-fold axis?

→ No → Hexagonal →
$\bar{6}$
$\bar{6}m2$
3
$\bar{3}$
32
3m
$\bar{3}2/m$

→ Yes → Cubic →
23
$2/m\bar{3}$
432
$\bar{4}3m$
$4/m\bar{3}2/m$

↓ No

Does it have one (only one) 4-fold axis?

(If it has more than one 4-fold, you made a mistake.) → Yes ────────────→ Tetragonal →
4
4/m
422
4mm
4/m2/m2/m

↓ No

Does it have three perpendicular 2-fold axes? → Yes ────────────→ Orthorhombic →
222
2/m2/m2/m

↓ No

Does it have one 2-fold axis? → Yes →

Does it have two different mirrors (perpendicular to each other and parallel to the 2-fold axis)? → Orthorhombic ────→ mm2

Does it have a 4 axis? → Tetragonal →
$\bar{4}$
$\bar{4}2m$

Is it lacking a 4 axis and also lacking mirror parallel to the 2-fold axis? → Monoclinic →
2
2/m

↓ No

Does it have a mirror? → Yes ────────────→ Monoclinic → m

↓ No ────────────→ Triclinic →
1
$\bar{1}$