**GEOL 110**

**Exam #1**

**Spring, 2011**

1. (15 points) For the following crystal classes and forms, give the Miller Indices of the faces that are in that form:

**Crystal Class Form Faces**

 2/m {101} **(101), (**$\overline{1}$**0**$\overline{1}$**)**

$6/m$ {10$\overbar{1}$1} **(10**$\overline{1}$**1)(01**$\overline{1}$**1)(**$ \overline{1}101)$**(**$ \overline{1}011)$**(0**$\overline{1}11)($**1**$\overline{1}01)$

 **(10**$\overline{1}\overline{1}$**)(01**$\overline{1}\overline{1}$**)(**$ \overline{1}10\overline{1})$**(**$ \overline{1}01\overline{1})$**(0**$\overline{1}1\overline{1})($**1**$\overline{1}0\overline{1})$

2. (15 points) One technique to determine the chemical composition of a mineral is X-Ray Fluorescence (XRF). Describe what happens when an X-ray is directed at a mineral and why this can give you information about the elements in the mineral (you can fill out and use the figure below to aid in your description).

Incoming X-ray radiation interact with inner-shell electrons, causing an excitation to a higher level. These excitations relax back down to a lower, possibly not ground state, energy level – the energy difference is emitted as an emission particle with X-ray energy lower than the incident but specific to the excitation. Every element has different possible transitions between ground and higher energy states that are at very specific (i.e. unique) energy levels, these unique transitions provide unique emission X-rays that, if gathered quantitatively, can provide quantitative data on the amount of each element in the sample.

3. (15 points) A crystal is isometric, with *a* = 5.67. What is the *d* value for the (111) reflection? (Show calcs).

***d = a / (h2 + k2 + ℓ2)1/2*; *d* = 5.67 / (1.732) = 3.27Å**

4. (15 points) Just as ice cream water crystals form differently at liquid nitrogen temperatures v. freezer temperatures, FeOOH minerals form differently in solution. Very small crystals of ferrihydrite (an FeOOH) mineral form where acidic, iron-rich waters are quickly neutralized to more basic pH – using the ice cream analogy, why are the crystals so small? (hint – temperature affects a basic property of crystallization, in FeOOH it is not temperature, it is pH).

Points – 5 for idea od growth rate vs nucleation rate, 5 points for idea that small crystals form when nucleation rate is higher, 5 for idea that pH closer to pH of equilibrium/crystallization analogous to condition closer to freezing temp and hence where growth rate is higher

5. (10 points) A stoichiometric formula represents a relative number of atoms in mineral. Suppose you perform an analysis and find the formula Mg4Fe8Si6O24, normalize this formula to 6 oxygens.

MgFe2Si1.5O6

6. (20 points) Halite is an isometric mineral, *a* = 5.6404Å. Using our diffractometer with Cu radiation, λ = 1.54178Å, at what value of 2θ would we find the (200) peak? (Show calcs)

***d = a / (h2 + k2 + ℓ2)1/2; d =* 5.6404 / 2 = 2.8202Å.**

***λ = 2 d sin θ*; 1.54178 = 5.6404 *sin θ; sin-1* (1.54178/5.6404) = 15.86°; 2 *θ =* 31.72°**

7. (15 points) Give the axial requirements, in terms of a, b, c, α, β, γ, for the following crystal systems.

Isometric: ***a = b = c; α = β = γ* = 90°**

Monoclinic: ***a* ≠ *b* ≠ *c; α = γ* = 90°; *β* ≠ 90°**

Tetragonal: ***a = b* ≠ *c; α = β = γ* = 90°**

8. (10 points) Give the symmetry content of the following crystal classes:

4/m 2/m 2/m **1A4, 4A2, 5m, i**

6/m 2/m 2/m **1A6, 6A2, 7m, i**

9. (15 points) Given the following ions and ionic radii, determine the coordination for each and calculate the Pauling bond strength.

|  |  |  |
| --- | --- | --- |
| **Rc/Ra** | **Expected coordination** | **C.N.** |
| <0.15 | 2-fold coordination | 2 |
| 0.15 | Ideal triangular | 3 |
| 0.15-0.22 | Triangular | 3 |
| 0.22 | Ideal tetrahedral | 4 |
| 0.22-0.41 | Tetrahedral | 4 |
| 0.41 | Ideal octahedral | 6 |
| 0.41-0.73 | Octahedral | 6 |
| 0.73 | Ideal cubic | 8 |
| 0.73-1.0 | Cubic | 8 |
| 1.0 | Ideal dodecahedral | 12 |
| >1.0 | dodecahedral | 12 |

4+=0.42 Å; O2-=1.40 Å; Fe2+=0.74 Å; Al3+=0.67; Pb2+=1.41 Å;

|  |  |  |
| --- | --- | --- |
| Complex | Coordination number | Bond strength |
| Si4+ and O2- | 4 | 1 |
| Al3+ and O2- | 6 | 1/3 |
| Pb2+ and O2- | 12 | 1/6 |

10. (15 points) How well a particular element can substitute into a mineral lattice is dependent on several properties of the molecules, list them and discuss if As- or Au+ substitutes better into pyrite.

size + charge, bonding type, As- is isoelectronic with S- and Au+ is huge in comparison,