GLY4200C Name_____
90 points October 18, 2019
4 took exam - Numbers to the left of the question number in red are the number of incorrect responses. Instructor comments are in blue.

Florida Atlantic University
MINERALOGY -- MIDTERM 2 EXAMINATION KEY

True-False - Print the letter T or F in the blank to indicate if each of the following statements is true or false. Illegible answers are wrong. (1 point each)

1 T 1. In a plane, spheres of equal size are most densely packed (with the least amount of empty space) when each sphere touches six other spheres arranged in the form of a regular hexagon.

0 T 2. Iron has a larger abundance when reported in weight percent than in atom percent.

1 F 3. Elements with abundances less than 0.1% are called minor elements. Trace

0 T 4. In the lower mantle, pressures are so great that silicon becomes six coordinated (CN = VI).

1 F 5. The core is divided into two regions, the liquid inner core and the solid outer core.

0 F 6. Trace elements are not abundant enough to be ores.

0 T 7. If there is a small difference of ionic radius the smaller ion enters the crystal preferentially.

1 F 8. For ions of similar radius but different charges, the ion with the lower charge enters the crystal preferentially

0 T 9 Low spin ions enter the crystal ahead of high spin.

0 T 10. The ordering of elements in the sanidine-microcline transition reduces structural symmetry.

0 T 11. The same mineral my grow with more than one habit. For examples, fluorite may be cubic, octahedral, or dodecahedral.

1 F 12. All lattices are three dimensional.

Exams to date _____/180 _____% Grade_____

0 T 13. In a point group, at least one particular point in a pattern remains unmoved by any symmetry operation.

1 F 14. In a complex symmetry operation, consisting of a combination of two simple operations, it is necessary that both operations exist separately.

2 T 15. The operation denoted $\bar{3}$ is a roto-reflection operation.

Multiple-Choice - Choose the best response to each statement or question. Print the letter corresponding to your choice in the blank. (1 point each)

1 C 1. In the transition zone, which of the following occurs?
A. Mineral chemistry changes from silicates to metals
B. The phase changes from solid to liquid
C. Olivine transforms to denser phases wadsleyite and ringwoodite
D. All of the above

1 D 2. A tetragonal lattice meets which of the following requires?
A. $\mathbf{a = b \neq c}$
B. $\alpha = \beta \neq \gamma$
C. $\alpha = \beta = \gamma$
D. Both a and c

0 A 3. Which symmetry element is associated with the operation of rotation?
A. Axis
B. Plane
C. Point
D. None of the above

0 A 4. Which symmetry operation is associated with a center of symmetry?
A. Inversion
B. Reflection
C. Rotation
D. All of the above

1 B 5. A Miller Index is represented by which symbol?
A. 123
B. (hkl)
C. [uvw]
D. {111}

2 D 6. The symbol [231] represents what?
A. Form
B. Miller Index
C. Point
D. Zone axis

1 C 7. In the isometric system, the planes (100), (010), (001), ($\bar{1}$00), (0$\bar{1}$0), and (00$\bar{1}$) may be represented as:
A. (100)
B. [100]
C. {100}
D. 100

0 A 8. A class of planes in a crystal which are symmetrically equivalent is called a:
A. Form
B. Habit
C. Miller Index
D. All of the above

1 D 9. Which of the following is an example of a vectorial property.
A. Color banding in a mineral
B. Cleavage
C. Dendritic growth
D. All of the above

4 D 10. One of the most characteristic diagnostic properties for the identification of microcline is:
A. Albite twinning
B. Carlsbad twinning
C. Dauphiné twinning
D. Gridiron (a.k.a. tartan) twinning

2 C 11. Which of the following forms of electromagnetic energy is more energetic then visible light?
A. FM radio
B. Infrared
C. Ultraviolet
D. Television

3 C 12. What causes the blue color in halite?
A. Rayleigh scattering effect caused by tiny inclusions
B. Colored by embedded blue minerals, like dumortierite (fibrous variably colored aluminum boro-silicate mineral)
C. Atoms of Na metal which migrate to form colloidal sized aggregate of sodium metal
D. Any of the above (A and B produce color in blue quartz)

2 B 13. The term "magnetism" probably refers to the region Magnesia in which country?
A. China
B. Greece
C. Persia
D. Peru

3 C 14. Three d electrons have what types contributions to magnetic moments?
A. Low orbital and low spin
B. High orbital and low spin
C. Low orbital and large spin
D. High orbital and large spin

0 C 15. What crystal system does (111) belong to? This question had a typo. The plane was supposed to be (1111). Therefore the question was thrown out and not counted. As written A would be the best answer, so students answering "A" received one point extra credit.
A. Isometric
B. Tetragonal
C. Hexagonal
D. Triclinic

Fill-Ins - Write in the word or words which best completes each statement or answers each question. (1 point per blank)

3 1. The minerals halite (NaCl), MgO (periclase), KC1, (sylvite), and PbS (galena) may be said to be ISOSTRUCTURAL.

1, 1 2-3. The two most common elements on earth, in order, are: 2) OXYGEN and SILICON.

2 4. A substitution such as Ca^{2+} & $A1^{3+}$ ↔ Na^{+} and Si^{4+} is known as a COUPLED substitution.

1 5. There is a greater tolerance for ionic substitution at HIGHER temperature.

1 6. Kyanite, andalusite, and sillimanite are three minerals with the formula Al_2SiO_5, but different crystal structures. They are described as POLYMORPHOUS.

1 7. Certain minerals occasionally contain interstitial impurities of radioactive compounds, or are composed of radioactive elements. If the structure is nearly or completely destroyed then it is said to be ___METAMICT____.

0 8. The external appearance of a mineral is called the mineral __Habit__.

1 9. Any action which, when performed on an object, leaves the object in a manner indistinguishable from the original object is a __SYMMETRY___ operation.

0 10. Properties of crystals that depend on the direction in which they are measured are called __VECTORIAL__ properties.

2 11. During crystal growth, one crystalline substance may grow on a crystalline substance of different composition and structure. Such growths are known as __EPITAXIAL__ overgrowths.

1 12. Filled orbitals give a net contribution of __ZERO_____ to the magnetic moment.

Diagrams and Figures - A series of slides will be shown. Each of these is a photo or a diagram previously seen in class. Diagrams may have been altered to remove labels, etc. Answer each question as the slide is shown. (1 point each)

0 __F__ 1. (T-F) This diagram illustrates cubic closest packing. (HCP)

1 __B__ 2. (M-C) This diagram illustrates which of the following:
A. Corner sharing
B. Edge Sharing
C. Face Sharing
D./ None of the above

0 __F__ 3. (T-F) The defect shown here is a Schottky defect. (Frankel)

0 __C__ 4. (M-C) The diagram shows what type of lattice?
A. C
B. F
C. I
D. P

2 __B__ 5. (M-C) The axes shown represent which crystal system?
A. Isometric
B. Tetragonal **$a=b\neq c$**
C. Orthorhombic
D. Monoclinic

1 C 6. (M-C) The axes shown represent which crystal system?
A. Tetragonal
B. Hexagonal
C. Monoclinic
D. Triclinic

1 B 7. (M-C) The axes shown represent which crystal system?
A. Tetragonal
B. Hexagonal
C. Monoclinic
D. Triclinic

3 B 8. (M-C) The form pictured is a:
A. Dipyramid
B. Dome
B. Pinacoid
D. Sphenoid

1 T 9. (T-F) The form shown is an open form.

3 10. (Fill-In) What type of mineral habit is this? DENDRITIC .

0 F 11. (T-F) The diagram illustrates a type of penetration twinning.

3 12. (Fill-In - extra credit) Decide what color the mineral of the mineral is, and use that information to decide which variety of quartz this is a spectrum of?

Quartz, variety AMETHYST

0 ___ 13. (M-C - extra credit) The object shown here is called: (Take your pick)
A. The Great Pumpkin
B. Jack O'Lantern 2 Jack is making this look easy (9 years in a row)
C. Toothy 1
D. All of the above 1

Discussion questions - Write a complete, concise answer to each of the following questions. Diagrams (labeled) may be used to supplement your written answers, where appropriate. Points as shown

2.5 1. Describe three ways crystals can grow. (3 points) Describe means you need to write something about each response.

Crystals may grow by

1. Dehydration of a solution - as the solution evapoates, concentration increases, and the mineral precipitates
2. Growth from the molten state, either magma or lava - As temperature decreases, the mineral begins to crystallize and grow
3. Direct growth from the vapor state - As temperature decreases, the mineral nucleates and begins to grow.

1 2. Describe the two conditions that all lattices must meet. (2 points)

1. The environment about all lattice points must be identical.
2. The unit cell associated with the lattice must fill all space, with no "holes".

2.5 3. What does 4/m mean? (1 point)

4/m means a four-fold rotation with a mirror plane perpendicular to it.

1.5 4. What does 3m mean? (1 point)

3m means three-fold rotation with 3 parallel mirror planes

1 5. Nucleation usually requires supersaturation. What does supersaturation mean? There are three ways in which supersaturation might be achieved. Briefly describe them. (4 points)

Supersaturation is the state of a system which has gone beyond concentration value of a saturated solution. This is a thermodynamically unstable state. It may be achieved by:

Increasing concentration of a solution, either by adding solute or evaporating solvent.

Changing the temperature of a system so that the saturation value is exceeded

Changing the pressure of a system so that the saturation value is exceeded

2 6. How might a newly formed nuclei be destroyed? (1 point)

Nuclei have very large surface area/volume. Unsatisfied bonding on outer surfaces leads to dissolution.

11.5 7. What two things must the Twin Law define? What are the possible types of twin elements? (5 points)

A). The type of twin operation - reflection across a twin plane, rotation about a twin axis, or inversion through a twin center

B) The orientation of the twin element associated with the operation

10 8. What is Crystal Field Splitting (Δ) influenced by? (3 points)

A. Oxidation state of metal cation – Δ increases about 50% when oxidation state increases one unit

B. Nature of the metal ion – $\Delta_{3d} < \Delta_{4d} < \Delta_{5d}$

C. Number and geometry of ligands - Δ_o is about 50% larger than Δ_t

12 9. What is Intervalence Charge Transfer (IVCT)? Describe and give an example. What phenomena does it cause? (3 points)

Delocalized electrons hop between adjacent cations. The transition can produce color in minerals, such as the blue color in minerals such as kyanite, glaucophane, crocidolite, and sapphire. An example is:

$$Fe^{2+} + Fe^{3+} = Fe^{3+} + Fe^{2+}$$

7 10. Describe two ways in which electrons can generate magnetic forces. (2 points)

Moving electrical currents generate magnetic forces. This includes electrons:

a) Orbiting around a nucleus

b) Spinning around their own axis

Matching - Match the discovery in column one with the person(s) associated with the discovery in column two. Answers may be used once, more than one, or not at all (One point each)

	Column 1	**Column 2**
1	_J_ 1. He said, "In a stable ionic structure, the valence of each anion, with changed sign, is exactly or nearly equal to the sum of the strengths of the electrostatic bonds to it from the adjacent cations."	A. Auguste Bravais
1	_A_ 2. He published Études Crystallographiques in 1849, and described fourteen unique lattices that meet the requirements which lattices must satisfy.	B. Jacques Curie
1	_I_ 3. Antiferromagnetic materials show increasing magnetic susceptibility up to a transition temperature, after which they become paramagnetic. The transition temperature is named after whom?	C. Marie Curie
1	_A_ 4. He formulated the law which says, "The most likely crystal face to grow are those planes having the highest density of lattice points.	D. Pierre Curie
1	_F_ 5. He laid the foundation of inorganic crystal chemistry and founded modern geochemistry.	E. Yakov Frankel
2	_J_ 6. Who said, "The number of essentially different kinds of constituents in a crystal tends to be small?"	F. Victor M. Goldschmidt
		G. René J. Huay
		H. William Hallows Miller
		I. Louis E.F. Néel
		J. Linus Carl Pauling
		K. Walter H. Schottky
		L. Nicolaus Steno

Problems - Do each of the following problems. Show all work. Label answers, including units, if any. Express answers to the correct number of significant figures. List any formula used, and defined all symbols used in the formula. "Miraculous answers", unsupported by all necessary calculations, will receive little or no credit.

1. For each of the following minerals, determine the valance state of the indicated element in each mineral. (1 point each)

	Mineral or group	**Formula**	**Ion**	**Charge on ion** (List numerical charge)
4	Powellite	$CoMoO_4$	Mo	+6
4	Cobaltite	CoAsS	As	-1
1	Monticellite	$CaMgSiO_4$	Mg	+2

9 2. Calculate the zone axis of the following pair of planes. (4 points)

(402) $(\bar{2}3\bar{1})$

$$4 \mid 0\ 2\ 4\ 0 \mid 2$$

$$\bar{2} \mid 3\ \bar{1}\ \bar{2}\ 3 \mid \bar{1}$$

$$0 \cdot \bar{1} - 2 \cdot 3,\ \ 2 \cdot \bar{2} - 4 \cdot \bar{1},\ 4 \cdot 3 - 0 \cdot \bar{2}$$

$$\bar{6},\ 0,\ 12 = [\ \bar{1}\ 0\ 2\ ]$$

4 3. Calculate the Miller Index of the following plane of the mineral scheelite. (3 points)

a = 0.525 nm Tetragonal
c = 1.140 nm

x-intercept = 0.519 nm
y-intercept = ∞
z-intercept = 0.379 nm

$$\frac{0.519}{0.525} \cong 1 \qquad \frac{\infty}{0.525} \cong \infty \qquad \frac{0.379}{1.140} \cong \frac{1}{3}$$

$$\frac{1}{1} = 1 \qquad \frac{1}{\infty} = 0 \qquad \frac{1}{\frac{1}{3}} = 3$$

MILLER INDEX IS (1 0 3)

Average grade on this section was 45%. These problems were very similar to HW 3 and 4. When you do the HW you are expected to learn the method involved. Last year the class average on very similar material was 89^{+} %

Previous Years Results - Midterm 2

Term, Year	Mean, %
Fall, 2019	68.8
Fall, 2018	79.3
Fall, 2017	73.6
Fall, 2016	83.5
Fall. 2015	81.9
Fall, 2014	82.6
Fall, 2013	81.3
Fall, 2012	80.1
Fall, 2011	81.7
Fall, 2010	80.8
Fall, 2009	85.2
Spring, 2009	84.6
Fall, 2007	85.5
Fall, 2006	95.1
Fall, 2005	82.6
Spring, 2004	71.3
Fall, 2002	79.3
Spring, 2001	80.0
Spring, 2000	77.6
Fall, 1998	80.2
Fall, 1997	81.1
Fall, 1996	76.5
Fall, 1995	73.1
Fall, 1994	78.5
Fall, 1993	78.9
Fall, 1992	89.1
Fall, 1991	86.7