GLY4200C Name_____
108 points November 30, 2012
17 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 -- FINAL 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)

2 T 1. X-rays are more energetic than visible light, and therefore have shorter wavelengths.

6 F 2. If 2Vz is 35 , then the mineral is uniaxial positive.

2 T 3. There are two circular sections in any biaxial indicatrix.

7 T 4. When the slow direction of the crystal is parallel to the slow direction of the compensator, addition will occur.

10 F 5. A eutectic point is the same thing as a minimum melting point in a binary phase diagram.

5 T 6. In orthoscopic observation, the greater the value of the numerical aperture the better the resolution.

0 T 7. As pressure increases, a liquid will eventually cross a phase boundary and become a solid, if other factors are held constant. This helps explain why the outer core is liquid and the inner core is solid.

5 T 8. In a system, if there is a stoichiometric relationship between two of the substances present in the system, the number of components is reduced by one.

3 F 9. The sublimation curve separates a solid phase from a liquid phase.

3 F 10. Melting of a substance directly to a liquid that is of the same composition as the solid is an example of incongruent melting.

8 T 11. For systems of fixed composition, as pressure increases the phase diagrams generally become simpler.

1 F 12. When light passes from a medium of low index of refraction to one of higher refractive index, the light will be refracted away from the normal.

1 T 13. The equation $(n_r/n_i) = \tan \triangle I$ gives the condition for maximum polarization, and is known as Brewster's Law.

6 F 14. For any angle greater than or equal to the critical angle there will be no reflected ray. Light will be totally refracted.

4 T 15. The more vibrations per second, the slower the light travels through the medium, if the dispersion is normal.

2 F 16. In the expression $I/I_0 = e^{-kt}$, t = temperature.

5 F 17. In an anisotropic medium, the ordinary (O) and extraordinary (E) rays will vibrate in the same plane.

0 T 18. The quarter λ plate is especially useful for examining specimens showing bright interference colors, because they are moved only a short distance along the scale.

2 T 19. Anisotropic crystals will show their most intense, or brightest, interference colors at a position 45 ° off extinction

9 F 20. When using an accessory plate in the subtraction position, interference colors will always be lower than they are without the accessory plate.

0 T 21. Oils higher than 1.8 often contain poly-chlorinated biphenyls (P.C.B.'s) and must be used with great caution because P.C.B.'s have been shown to be powerful carcinogens.

5 T 22. For a high power (40x) lens, the depth of focus is less than the thickness of the thin section, so the slide must be placed on the stage with the cover slip up, or it will be impossible to focus the microscope.

4 F 23. Parallel extinction is only possible in triclinic crystals.

3 T 24. Inclined extinction is only possible in biaxial crystals.

0 F 25. Natural color is measured in crossed-nicols.

2 T 26. The size of the indicatrix for an isotropic material will change, depending on the wavelength of light, but the shape will always be spherical.

12 F 27. The wave normal to the wave front is always in the direction of propagation of electromagnetic radiation.

6 F 28. The ellipsoid which represents the indicatrix of a biaxial mineral has two major axes.

11 F 29. X, Y, and Z are crystallographic axes.

5 F 30. For a biaxial mineral, $\beta = (\gamma + \alpha)/2$.

5 T 31. The circular sections of a biaxial indicatrix always include the Y axis.

9 F 32. If B_{x_a} is over X, the mineral is biaxial positive.

10 F 33. Ions with filled d orbitals have a strong contribution to magnetism from the d electrons.

1 F 34. In an atom, the number of neutrons must equal the number of electrons

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

4 C 1. The optic axis of a uniaxial crystal is coincident with which crystallographic direction?
A. X
B. Y
C. Z
D. It depends on whether the mineral is positive or negative

13 C 2. Which of the following X-ray methods is used for powder samples?
A. Laue
B. Precession
C. Hägg-Guinier
D. Weissenberg

5 C 3.What type of phase diagram is used to represent the silica system?
A. Ternary (composition)
B. Binary eutectic (temperature and composition)
C. Temperature and pressure
D. Binary solid solution (temperature and composition)

4 A 4. If a system has only temperature as a variable, and there are two components and three phases present, the number of degrees of freedom is:
A. 0
B. 1
C. 2
D. 3

3 C 5. A system contains quartz, albite, and melt. How many components are present?
A. 0
B. 1
C. 2
D. 3

8 D 6. The system in question 5 has how many phases present?
A. 0
B. 1
C. 2
D. 3

10 A 7. How many degrees of freedom does the system in question five have, assuming that temperature is the only variable?
A. 0
B. 1
C. 2
D. 3

3 C 8. What type of phase diagram is used to represent the olivine series?
A. Binary eutectic (temperature and composition)
B. Binary peritectic (temperature and composition)
C. Binary solid solution (temperature and composition)
D. Ternary (composition)

4 A 9. What type of phase diagram would be used to represent the system $CaSiO_3$, $MgSiO_3$, and $FeSiO_3$?
A. Ternary (composition)
B. Binary eutectic (temperature and composition)
C. Temperature and pressure
D. Binary solid solution (temperature and composition)

1 B 10. In order for extinction to occur, the privileged directions of two polaroids must be:
A. Parallel
B. Perpendicular
C. 45 to each other
D. The respective positions is irrelevant to extinction

4 B 11. The value of the index of refraction in a circular section of a biaxial indicatrix is:
A. α
B. β
C. γ
D. Any of the above

1 D 12. What is the maximum birefringence possible in a biaxial mineral.
A. $\beta' - \alpha$
B. $\gamma' - \beta$
C. $\gamma' - \alpha$
D. $\gamma - \alpha$

6 B 13. How many axes does a uniaxial indicatrix have?
A. 1
B. 2
C. 3
D. It depends on the optical sign of the mineral

4 C 14. The M shell in x-ray crystallography corresponds to a shell whose n value is what?
A. 1
B. 2
C. 3
D. 4

6 A 15. In biaxial crystals, how many high-order axes are present?
A. 0
B. 1
C. 2
D. 3

5 B 16. The biaxial anisotropic indicatrix has which of the following characteristics?
A. Prolate ellipsoid
B. Triaxial ellipsoid
C. Sphere
D. Oblate ellipsoid

0 B 17. How many components are present in a unary diagram?
A. Zero
B. One
C. Two
D. Three

6 C 18. In a unary system, what variables are typically plotted on a phase diagram?
A. Composition and pressure
B. Composition and temperature
C. Temperature and pressure
D. Three different composition ranges

10 D 19. In a binary system, which type of phase diagram may be plotted?
A. Temperature and composition
B. Pressure and temperature
C. Pressure and composition
D. All of the above

9 C 20. For the plagioclase feldspars, which type of phase diagram is appropriate?
A. Binary eutectic with congruent melting
B. Binary eutectic with incongruent melting
C. Binary solid solution
D. Binary minimum melting point

14 D 21. For the alkali feldspar (K-spar and albite) system, which type of phase diagram is appropriate?
A. Binary eutectic with congruent melting
B. Binary eutectic with incongruent melting
C. Binary solid solution
D. Binary minimum melting point

5 D 22. For a mineral classified as uniaxial positive, which of the following is true?
A. The ellipsoid that represents the indicatrix will have tow major axes, whose magnitudes are ε and ω
B. There will be one optical axis, whose direction will be along the direction of the unique high-order symmetry axis in the tetragonal or hexagonal systems
C. The indicatrix will be a prolate ellipsoid
D. All of the above

12 B 23. Which of the following powder X-ray methods has the advantage of using the least material?
A. Buerger precession
B. DeBye-Scherrer
C. Hägg-Guinier
D. Weissenberg rotation

8 D 24. Which region of the earth ranges from 2900 to 5100 kilometers below the surface of the earth?
A. Crust
B. Inner core
C. Mantle
D. Outer core

6 C 25. One centimeter is equivalent to how many nanometers?
A. 10^{-9}
B. 10^{-7}
C. 10^{7}
D. 10^{9}

2 A 26. The quantum number which determines the shape of the orbital is the:
A. Azimuthal quantum number
B. Magnetic quantum number
C. Principal quantum number
D. Spin quantum number

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

5 1. In a binary system, with temperature as the only variable, if two phases are present, how many degrees of freedom are there? ONE

9 2. The Hägg-Guinier method is superior to the Debye-Scheirer method in most respects. In what way is the Debye-Scheirer method superior?
IT REQUIRES FAR LESS SAMPLE

15.5 3. Why is the wavelength range of X-ray significant in mineralogy? X-RAYS HAVE WAVELENGTHS WHICH ARE COMPARABLE TO THE INTERATOMIC SPACING IN CRYSTALS. THEY INTERACT WITH THE CRYSTALS IN WAYS WHICH ALLOW US TO DETERMINE INFORMATION ABOUT THE ATOMIC ARRANGEMENT WITHIN THE CRYSTAL.

12 4. An ellipsoid whose surface is generated by the magnitude of the index of refraction vectors in every possible direction is called the OPTICAL INDICATRIX

12 5-7. If ε = 1.637 and ω = 1.572, and the mineral has a six-fold axis, what crystal system does the mineral belong to? 5) HEXAGONAL What is the optical class?

7, 6 6) UNIAXIAL 7) What is the optical sign? +

11 8. Isochromes are lines of equal COLOR . from Gk. khroma "color"

2 9. What do the letters OAP stand for? OPTIC AXIAL PLANE

0 10. A INTENSIVE property does not depend on the amount of materialp present.

16 11. What is a component?

ONE OF THE MINIMUM NUMBER OF SUBSTANCES, WHICH ARE CHEMICAL CONSTITUENTS THAT MUST BE SPECIFIED IN ORDER TO DEFINE ALL PHASES.

14 12. In the extended phase rule, f = c - p + x, what is x?

x IS THE NUMBER OF INTENSIVE VARIABLES, PRESSURE, TEMPERATURE, COMPOSITION, AND POSSIBLY MAGNETIC AND ELECTRIC FIELDS, THAT CAN BE CHANGED INDEPENDENTLY WITHOUT LOSS OF A PHASE

8.5 13. In a phase diagram in which pressure is NOT shown as a variable, at what pressure is the system, unless it is explicitly stated otherwise on the diagram? ONE ATMOSPHERE

4 14. Substances for which the index of refraction is the same in all directions are said to be ISOTROPIC.

8.5 15. List the faces which belong to {110} in the tetragonal system. (1 point)

(110) $(1\bar{1}0)$

$(\bar{1}10)$ $(\bar{1}\bar{1}0)$

9 16. The charge on the europic ion is +3.

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)

2 B 1. How many phases are present at point 1 in the diagram?
A. Zero
B. One
C. Two
D. Three

3 B 2. How many phases at present at point 3 in the diagram?
A. Zero
B. One
C. Two
D. Three

5 A 3. The diagram shown is an example of:
A. Binary eutectic with congruent melting
B. Binary eutectic with incongruent melting
C. Binary solid solution
D. Binary minimum melting point

6 B 4. The diagram shown is an example of:
A. Binary eutectic with congruent melting
B. Binary eutectic with incongruent melting
C. Binary solid solution
D. Binary minimum melting point

2 D 5. For the region labeled "2L", what phases are present?
A. Two solid phases, En and Qz
B. One solid phase, En, and a liquid phase
C. One solid phase, Qz, and a liquid phase
D. Two immiscible liquid phases

1 6. The diagram shown illustrates the principle of what rule? LEVER

4 7. Point 1 in the diagram has what percent of the "B" component? 20%

4 8. Point 4 has zero percent of which component? A

2 C 9. The formula shown in the lower portion of this diagram is known as _____'s Law.
A. Bragg
B. Brewster
C. Snell
D. Weissenburg

3 C 10. In the diagram shown, the rays illustrated by the solid blue and dashed orange lines are propagating from left to right, producing a resultant ray (pink). This is an example of:
A. Constructive interference
B. Destructive interference
C. Noise
D. All of the above

1 D 11. In the picture, the accessory plate on the right is the:
A. Full λ plate
B. Quarter λ plate
C. Quartz sensitive tint
D. Quartz wedge

Matching - Match the discovery in column one with the person 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	I 1. This German physicist discovered spectral lines in the spectrum of the sun. Today index of refractions oils are described using the letters he assigned to various wavelengths.	A. Roy G. Biv
		B. Sir William Henry Bragg
		C. Sir William Lawrence Bragg
4	F 2. An equation used to calculate dispersion in minerals is named after this French mathematician.	D. Sir David Brewster
		E. Martin J. Buerger
7	H 3. The representation of the spatial variation of the index of refraction as an indicatrix is due to this man. (Mentioned during the review)	F. Augustin Louis Cauchy
		G. Albert Einstein
		H. Sir Lazarus Fletcher
1	K 4. Produced a color chart which plots the thickness of an isotropic specimen, its birefringence and its retardation in nanometers	I. Joseph von Fraunhofer
		J. Josiah Willard Gibbs
		K. Michel Levy
5	O 5. This Austrian physicist developed a rotating-crystal method which also translated the film, allowing unambiguous index of each refraction	L. Wilhelm C. Roentgen
		M. Willebrod Snellius
		N. Max Theodore Felix von Laue
		O. Karl Weissenburg

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

Given: $c_{vacuum} = 2.998 \times 10^8$ m/s

13.5 1. If f = 4.76 x 10^{14} Hz, what is λ (expressed in nm)? (4 points)

$\lambda = c/f = (2.998 \times 10^8 m/sec)/(4.76 \times 10^{14} hz) = 6.30 \times 10^{-7} \times 1 \times 10^9 nm/m = 630 nm$

29.5 2. Use the Bragg equation to calculate d if = 0.150 nm and theta is 23.6 . Assume n = 2. (3 points)

$$n\lambda = 2d \sin\theta$$

$$d = \frac{n\lambda}{2 \sin\theta}$$

$$d = \frac{2 \times 0.150}{2 \sin 23.6°}$$

$$= \frac{0.300}{0.800} = 0.375\ nm$$

21 3. What is the index of refraction for eglestonite, Hg_4OCl_2, given that light travels with a velocity of 1.204 x 10^{17}nm/sec through eglestonite? (3 points)

$$1.204nm/\sec x10^{-9}\,m/nm = 1.204x10^{8}\,m/s$$

$$n = c_{vacuum} / c_{medium} =$$

$$2.998x10^{8} / 1.204x10^{8} = 2.490$$

12 4. The retardation may be calculated using the formula $\Delta = t(N - n)$. For a standard thin section (30 microns thick) of rhodocrosite, if N = 1.816 and n = 1.597, what is Δ, expressed in nm? Which is the fast direction, N or n? Will an interference figure of rhodocrosite show isochromes? (4 points)

$$(30\mu)x(1000nm/\mu) = 30{,}000nm$$

$$\Delta = 30{,}000(1.816 - 1.597) = 30{,}000(0.219) = 6{,}570nm$$

10,10 n is the fast direction. Rhodocrosite will show several sets of isochromes.

1,1 5. Use Figure 1 (next page) Outline the liquidus line in green, and the solidus line in brown. Start at 50% An and 1500°C. Assume the temperature is slowly decreased until the temperature
2.5 reaches 1100°C. Show the path followed by the solid in blue, and the path followed by the liquid
2.5 in red. (2 points) Then answer the following questions. (1 point each)

3.5 A. At what temperature does the first solid form? 1450°C

9 B. What is the composition of the first solid phase? An_{82}

8.5 C. At what temperature does the last liquid disappear? 1280°C

11.5 D. What is the composition of the final liquid? An_{13}

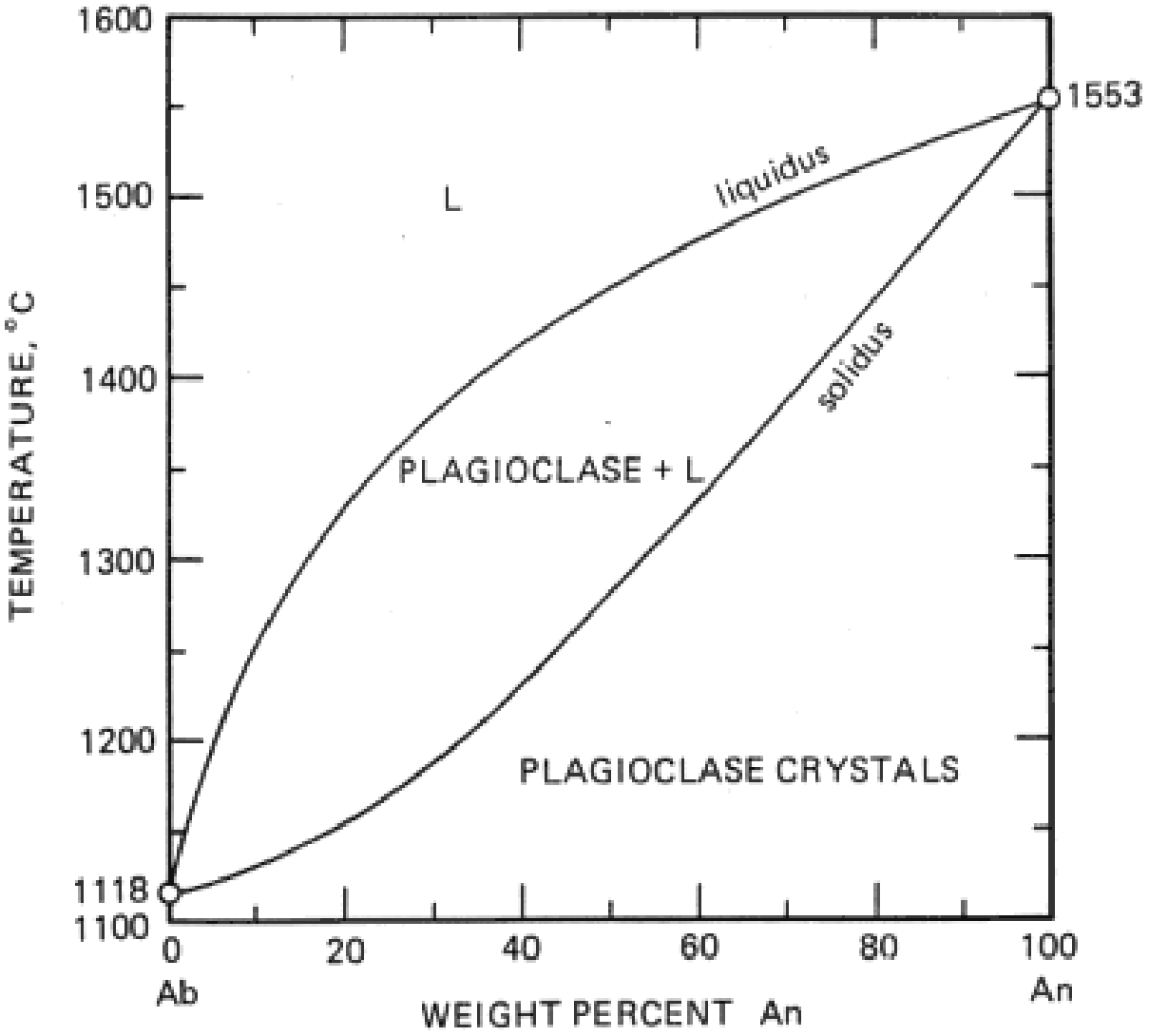

Figure 1

15 E. What phases (type and composition) are present at 1350°C? Melt + An_{63}

12.5 F. What is the percentage of each phase present at 1350°C? (Show calculations below)

32% Melt + 68% An_{68}

LF = 15.5 mm SF = 32.5 mm LF +SF = 48 mm

% Melt = 15.5/48 = 32% % An_{63} = 32.5/28 = 68%

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. 2 points each

5 1. What is the difference between the "angle of incidence" used in optical mineralogy and the "glancing angle of incidence" used in x-ray crystallography?

THE ANGLE OF INCIDENCE IS MEASURED FROM A NORMAL TO THE PLANE OF INCIDENCE. THE GLANCING ANGLE OF INCIDENCE IS MEASURED FROM THE PLANE OF INCIDENCE. THE TWO ANGLES ARE COMPLIMENTARY.

16 2. Why are the ports of X-ray tubes covered by beryllium windows?

THE INTERIOR OF THE X-RAY TUBE OPERATES IN VACUUM SO THE PORT MUST BE COVERED IN ORDER TO MAINTAIN THE VACUUM. X-RAYS ARE ABSORBED BY MATTER. THEREFORE THE PORTS SHOULD BE CONSTRUCTED OF SOME TYPE OF MATTER WHICH MINIMIZES X-RAY ABSORPTION. ELEMENTS WITH LOW ATOMIC NUMBER HAVE LOW X-RAY ABSORPTION. BERYLLIUM IS THE LOWEST ATOMIC NUMBER MATERIAL THAT IS SOLID AND NON-REACTIVE.

1 3. Why are X-ray tubes cooled with water?

X-RAY TUBES WORK BY HAVING HIGHLY ENERGETIC ELECTRONS HIT A METAL TARGET, WHICH GENERATES X-RADIATION. THE CONVERSION IS NOT 100% EFFICIENT. THE EXCESS ENERGY IS TRANSFORMED TO HEAT, WHICH WOULD QUICKLY MELT THE TARGET, DESTROYING THE TUBE, IF THE TARGET WERE NOT COOLED.

HAVE A GREAT VACATION AND
A VERY HAPPY AND SAFE NEW YEAR!

Final Exam results

97.5	A-	
94.0	B+	
88.5	B-	
86.0 - 2	C+	
83.0		
82.0		
81.5		
81.0		**MEDIAN = 81**
80.0		
79.5	C	**MEAN = 79.3 (73.4%, C)**
77.0	C-	
75.5	D+	
69.5	D	
65.5	D-	
62.5		
58.5	F	

Previous Years Results -Final Examination

Term, YearMean, %

Fall, 2012 73.4
Fall, 2011 76.1
Fall, 2010 70.0
Fall, 2009 68.8
Spring, 2009 75.6
Fall, 2007 73.9
Fall, 2006 73.7
Fall, 2005 69.0
Spring, 2004 89.7
Fall, 2002 73.2
Spring, 2001 69.7
Spring, 2000 87.2
Fall, 1998 66.8
Fall, 1997 76.8
Fall, 1996 71.5
Fall, 1995 76.1
Fall, 1994 69.6
Fall, 1993 79.6
Fall, 1992 73.2
Fall, 1991 73.8

Eleventh of out 20

TOTAL EXAMINATION RESULTS
(OUT OF 288; 48% OF FINAL GRADE)

263.5	A-	
245.5	B	
233.0		
232.5		
232.0		
230.5	B-	
228.0	C+	
220.5		**MEAN = 219.7 (76.3%, C)**
216.0		**MEDIAN = 216**
215.5		
213.5	C	
207.5		
206.0		
205.0	C-	
200.5		
199.5	D+	
186.5	D	

In 2011, the highest grade on the exams was 271.5.
The 2011 Mean was 219.3.