

DEPARTMENT OF GEOLOGY

MODULE CODE	GLG1B10
MODULE NAME	OPTICAL AND ANALYTICAL MINERALOGY
CAMPUS	APK
EXAM	JANUARY 2017 (Supplementary Exam)

Date	January 2017
Assessor(S)	Mrs Lauren Blignaut Prof Sebastian Tappe
Internal Moderator	Mr Mike Knoper
External Moderator	
Duration	180 minutes
Marks	180

Number of pages	5 (including front page)
Instructions	Answer all the questions

Section A: Optical Mineralogy (90 marks)

Question 1

- (a) Give the definition of a mineral **(5 marks)**
- (b) How many crystallographic axes are needed in order to define the directions of a crystal? **(1 mark)**
- (c) Which crystal systems do fluorite, turquoise, plagioclase and amphibole come from? Graphically explain these systems and clearly state what the relationships are between the lengths of the axes and the angles in-between them **(20 marks)**

Question 2

- (a) Give the equation for the refractive index, and state what each symbol represents **(5 marks)**
- (b) Give the definition of an optic axis **(3 marks)**
- (c) What are the vibration and propagation directions? **(2 marks)**

Question 3

- (a) With regards to bonding forces, how do isotropic and anisotropic minerals differ? **(2 marks)**
- (b) What is double refraction? **(3 marks)**
- (c) What is the gypsum plate? **(4 marks)**
- (d) Calcite has an epsilon value of 1.933 and an omega value of 1.990. The thickness of the thin section in μm is 25. Calculate the retardation value in nm, and explain what would happen if the gypsum plate was inserted and the colours increased **(5 marks)**

Question 4

- (a) What is an isogyre? **(1 mark)**
- (b) What are the steps for making an interference figure (must be in the correct order)? **(5 marks)**

Question 5

- (a) Draw the indicatrix of a 2V+ mineral. Indicate all the axes and the refractive indices, as well as the 2V angle. Indicate what BXO and BXA is **(5 marks)**
- (b) Mineral identification indicates that a mineral is 2V-. Draw the optic figure, indicating the 'quadrants', and respective colours and signs. Explain what is occurring in the figure in order for it to be a 2V+ mineral **(7 marks)**
- (c) What is zoning? Give a mineral example that contains zoning **(5 marks)**

Question 6

- (a) What is Albite twinning? Give 2 mineral examples (including their signs and angles) of this type of twinning **(7 marks)**

Question 7

- (a) What is the main difference between pyroxenes and amphiboles? **(2 marks)**
- (b) Which 2 pyroxene minerals have the highest pleochroism? **(2 marks)**
- (c) Name the two orthopyroxene minerals, and give their optic signs and angles **(6 marks)**

Section B: Analytical Mineralogy (90 marks)

Question 1

(10 marks)

- a) Define the term 'Mineral Polymorph' and provide 1 example from the Neso-/Orthosilicate Family including a chemical formula (i.e., mineral formula).
- b) Explain the differences in the mineral structure of your above example such as Coordination Numbers (i.e., numbers of nearest neighbors that surround a central cation and are bonded to it; Si-O, Al-O).

Question 2

(10 marks)

- a) Name 5 physical (mechanical) and chemical (compositional) properties of any naturally occurring mineral.
- b) Name 3 optical properties of any naturally occurring mineral.
- c) Name a typical unit in which the density or specific gravity of a mineral is reported.

Question 3

(10 marks)

- a) Name 9 mineral species that represent type examples of the 'Mohs Hardness Scale' from Level-1 to Level-9 (Level-10 is diamond).
- b) Above which hardness level does a knife not scratch?

Question 4

(10 marks)

- a) Name 3 (out of the 6 main) Families of the Silicate Class and provide the general structural formula for each named family (i.e., Si-O bonding).
- b) List a mineral example for each named silicate family (no formula required).

Question 5

(10 marks)

- a) Name the 2 end-member mineral species that form the continuous solid-solution series of the olivine group (with mineral formulas).
- b) Name the crystal system of the olivine group and state whether it is optically uniaxial or biaxial.
- c) What is the atomic Mg/Fe ratio above which the optical character of olivine changes from negative to positive?
- d) Why does the olivine group have a range in density (specific gravity) and not just a single value? Which of the 2 end-members has the highest density?
- e) Name 3 rock types in which olivine occurs as an important rock-forming silicate mineral.

Question 6

(10 marks)

- a) Name 3 end-member mineral species of the garnet group with their respective chemical formulas, and assign whether they belong to the Pyrope or Ugrandite Series.
- b) In which site of the garnet structure does Al^{3+} reside mainly, and by which other cations (name 2) is it typically substituted or replaced?
- c) Name 3 rock types in which garnet occurs as an important rock-forming silicate mineral.
- d) What is the most common group of rocks (or geologic environment, pressure-temperature conditions) in which garnet occurs?

Question 7

(10 marks)

- a) Which mineral species of the epidote group incorporates the economically important Rare-Earth Elements (e.g., La^{3+} and Ce^{3+})?
- b) For which divalent (2+) cation do the REEs substitute in the epidote group structure, and which other chemical element is involved in this 'coupled substitution' to facilitate 'charge balance' (or electrical neutrality).
- c) Name 3 geologic environments in which epidote group minerals can form as important rock-forming silicate minerals.

Question 8

(10 marks)

- a) Describe the fundamental structural unit common to all silicate minerals (you can prepare a sketch for illustration).
- b) What is the form of the 'coordination polyhedron' that describes the above structural unit best, and what is the Si-O coordination number?
- c) If a cation of a chemical element (e.g., Al^{3+}) is said to be in 'octahedral coordination' with its nearest neighbor O^{2-} anions, then how many Al-O bonds form this octahedral coordination polyhedron?
- d) Name 1 mineral example each for the Neso-, Ino-, and Tectosilicate Families, respectively. Describe briefly how the silicon tetrahedra are arranged (e.g., 'polymerization') in the mineral structures of your above examples.

Question 9

(10 marks)

- a) How abundant (in volume- or weight-%) are Tectosilicates in the Earth's crust, and which feldspar group is the most abundant on Earth?
- b) Name the 2 end-member mineral species that form the continuous solid-solution series of the plagioclase group (with mineral formulas).
- c) What is the name of the plagioclase mineral species with 50-to-70 molecular-% anorthite component, and what is its optical character?
- d) In which coordination(s) or structural site(s) does Al^{3+} occur in anorthite?
- e) In which coordination(s) or structural site(s) does Al^{3+} occur in albite?
- f) Name 2 optical properties that help to distinguish between the alkali feldspar group and the plagioclase feldspar group.