UNIVERSITY OF JOHANNESBURG

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| **FACULTY** | : Science |
| **DEPARTMENT** | : Geology |
| **CAMPUS** | : APK |
| **MODULE** | : GLG01B1<br>OPTICAL AND ANALYTICAL MINERALOGY |
| **SEMESTER** | : Second |
| **EXAM** | : **SSA** January 2020 (Supplementary Exam) |

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| **DATE** | : | 9 January 2020 | **SESSION** | : 11:30-14:30 |
| **ASSESSOR(S)** | : | DR T OWEN-SMITH<br>DR L BLIGNAUT | | |
| **MODERATOR** | : | PROF M ELBURG | | |
| **DURATION** | : | 3 HOURS | **MARKS** | : 180 |

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NUMBER OF PAGES: 5 PAGES

INSTRUCTIONS:

1. Answer ALL THE QUESTIONS.
2. Number your answers clearly
3. Answer section A and section B in separate books

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## SECTION A: OPTICAL MINERALOGY [90 marks]

### Question 1 [8 marks]

a) Compare and contrast the monoclinic crystal system and the triclinic crystal system. Use diagrams to support your answer. **[5 marks]**

b) Name one mineral for each of the crystal systems above. **[2 marks]**

c) Are the minerals in these systems uniaxial or biaxial? **[1 mark]**

### Question 2 [10 marks]

a) Use diagrams to explain the possible ways in which two light waves vibrating in the same plane can interfere. **[8 marks]**

b) Explain how changing the following properties of a light wave changes its appearance **[2 marks]**:

i) amplitude

ii) wavelength

### Question 3 [14 marks]

a) Explain how the behaviour of light changes between the time it is emitted by the light source of the microscope to the time it reaches your eye. Assume that there is no sample on the microscope stage and the analyser is inserted. What image would you see? **[7 marks]**

b) Now you place an anisotropic mineral on the microscope stage. What would you see and why? **[7 marks]**

### Question 4 [17 marks]

a) Explain step-by-step how you would determine the sign of elongation of a mineral under the microscope. **[11 marks]**

b) Is it possible for a uniaxial negative crystal that is elongated along the crystallographic *c*-axis to have a positive elongation? Explain your answer with a sketch. **[6 marks]**

**Question 5 [28 marks]**

The mineral *londekaite* (2V = 30°) has the following refractive indices and absorption colours:

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|---|---|
| $\gamma = 1.644$ | blue |
| $\beta = 1.643$ | yellow |
| $\alpha = 1.633$ | pink |

a) Is this mineral uniaxial or biaxial? Give a reason for your answer. **[2 marks]**

b) Is the mineral optically positive, negative or neutral? Give a reason for your answer. **[2 marks]**

c) Draw the optical indicatrix for *londekaite*. **[5 marks]**

d) Draw the perpendicular section through the indicatrix for light propagated down one of the optic axes. **[2 marks]**

e) What absorption colour(s) would you see for the section in (d) above? **[1 mark]**

f) What absorption colour(s) would you see for the section showing maximum interference colours? Give reasons for your answer. **[4 marks]**

g) Draw a centred optic axis figure for *londekaite* with the gypsum plate inserted. Use this diagram (and your indicatrix from part (c) above) to explain why the areas of colour appear where they do in the figure. **[12 marks]**

**Question 6 [13 marks]**

a) Name and briefly describe 3 types of twinning that occur in feldspars. **[9 marks]**

b) What optical properties could you use to distinguish the three types of K-feldspar? **[4 marks]**

## SECTION B: ANALYTICAL MINERALOGY [90 marks]

**Question 1 (8 marks)**

a) Provide a mineral example from the neso/orthosilicate family (including chemical formula) that is a polymorph. **(2 marks)**

b) With regards to the above example, explain the difference in the mineral structure (including bonding and substitution). **(3 marks)**

c) Give the definition of an isomorph and provide one example, including chemical formula. **(3 marks)**

**Question 2 (9 marks)**

a) Explain the three possible interactions of transparency, and give a mineral example of each. **(9 marks)**

**Question 3 (10 marks)**

a) Name the 2 other mineral species (apart from forsterite and fayalite) that form part of the olivine group and give their chemical formulae. **(4 marks)**

b) Forsterite is unstable under low P-T conditions. In the presence of hydrous fluids, what does forsterite react to form? Please provide the balanced chemical equation. **(6 marks)**

**Question 4 (5 marks)**

a) In which site of the garnet structure does $Ca^{2+}$ reside mainly, and by which other cations (name 2) is it typically substituted or replaced? **(3 marks)**

b) What is the most common group of rocks (or geologic environment, pressure-temperature conditions) in which garnet occurs? **(2 marks)**

**Question 5 (6 marks)**

a) Which mineral species of the epidote group incorporates the economically important rare earth elements (e.g., $La^{3+}$ and $Ce^{3+}$)? Please provide the chemical formula of this mineral and the typical occurrence. **(3 marks)**

b) Name 3 geologic environments in which epidote group minerals can form as important rock-forming silicate minerals. **(3 marks)**

**Question 6 (14 marks)**

a) Describe and sketch the 3 fundamental structural units common to the pyroxenoids, and provide the 3 minerals associated with these structures. **(6 marks)**

b) In which family and group do wollastonite and jade occur? Please provide the chemical formula of each, the Si:O ratio, as well as a rock example in which each mineral occurs. **(8 marks)**

**Question 7 (38 marks)**

a) Where do Na-amphiboles predominantly occur? And what facies is this occurrence known as? **(2 marks)**

b) Draw the phlogopite systematic structure and indicate which group it comes from, as well as the characteristics of that group. **(6 marks)**

c) Draw the schematic development of the trioctahedral phyllosilicate structures and give mineral examples. **(10 marks)**

d) In what stability range does chlorite occur? **(1 mark)**

e) Give the general characteristics of the tectosilicates. **(4 marks)**

f) Give the two structural feldspar states that are common in igneous rocks, and explain what the difference between the two is dependent on. **(5 marks)**

g) Briefly explain each step (from 1 to 5) from the diagram below. **(10 marks)**