GEL 3050 - Mineralogy - Optical Mineralogy

Disclaimer: These reviews are courtesy of the instructor. While care has been taken to include everything that might be tested, omissions or oversights may have occurred. The instructor shall NOT be liable for any missed answer on your part just because the topic is not explicitly mentioned. It is still the STUDENT'S RESPONSIBILITY to know and be able to use concepts addressed during lectures, labs, or required texts.

Optical & XRD Review Sheet: ***(Things I need to know....)***

BE ABLE TO IDENTIFY THE FOLLOWING MINERALS IN ACTUAL THIN SECTIONS WITHOUT THE AID OF ANY WRITTEN MATERIALS:

Mineral Name	Key Features in Thin Section	Optical Data
Andalusite	hi relief, euhedral, cloudy; XPL: max. 1st order yellow, penetration twin cross	RI: 1.629-1.650 Biaxial - Biref: 0.009 2V: 48-68°
Augite (Pyroxene)	clear - subtle pink, slight pleochroic (Ti), 90° cleavage; XPL: 2nd order colors; inclined sometimes parallel extinction	RI: 1.680-1.729 Biaxial + Biref: 0.026 2V: 40-52°
Biotite (Mica)	mica cleav., green, brown, pleo., zircon halos; XPL: little color change, bark tex.	RI: 1.565-1.675 Biaxial - Biref: 0.04-0.05 2V: 0-25°
Calcite	high relief; XPL: very hi order pastel colors, rainbow cross-hatches	RI: 1.486-1.660 Uniaxial - Biref: 0.154-0.174
Chlorite	slight green, slight pleo.,matted felt; XPL: 1st order grey, few grains color anom.	RI: 1.571-1.599 Biaxial + Biref: 0.005-0.011 2V: 0-40°
Epidote	hi relief, colorless - pale yellow grn, XPL: up to 3rd order	RI: 1.723-1.797 Biaxial - Biref: 0.013-0.046 2V: 64-89°
Garnet Group	med relief, clear to very slight pink, dust inclusions; XPL: isotropic	RI: ~1.7-1.8 Isotropic
Hornblende (Amphibole)	greenish, pleochroic, 60° cleavage; XPL: 1st - 2nd order colors; symmetrical extinction	RI: 1.614-1.701 Biaxial - Biref: 0.019-0.026 2V: 52-85°
Kyanite	hi relief, cleavage, clear to pale blue, rare pleo.; XPL: 1st order, largest extinction	RI: 1.712-1.734 Biaxial - Biref: 0.015-0.016 2V: 82°
Muscovite (Mica)	low relief, mica cleavage; XPL: 1st order colors	RI: 1.552-1.616 Biaxial ± Biref: 0.034-0.042 2V: 30-47°
Olivine *Fosterite* - *Fayalite*	no cleavage; XPL: colorful stained glass window appearance, 2nd - 3rd order	RI: 1.630-1.690 Biaxial + Biref: 0.04 2V: 46-98°
Orthoclase (Feldspar)	low relief; XPL: 1st order greys, cross hatch tartan twinning	RI: 1.518-1.524 Biaxial - Biref: 0.005-0.006 2V: 65-75°

Plagioclase (Feldspar)	low relief; XPL: 1st order greys, Albite / Carlsbad parallel tiger stripe twinning	Albite: RI: 1.528-1.542 Biaxial + Biref: 0.009-0.01 2V: 45° Labradorite: RI: 1.554-1.573 Biaxial + Biref: 0.008-0.01 2V: 85° Anorthite: RI: 1.572-1.588 Biaxial - Biref: 0.011-0.012 2V: 78°
Quartz	low relief; XPL: 1st order greys, undulose extinction	RI: 1.553-1.544 Uniaxial + Biref: 0.009
Sillimanite	hi relief, needle - blades, clear, square x-sec.; XPL: upper 2nd order	RI: 1.653-1.684 Biaxial + Biref: 0.016-0.023 2V: 20-30°
Sphene / Titanite	sub- euhedral brown - pink wedges, hi relief; XPL: little color change (hi whites)	RI: 1.840-2.11 Biaxial + Biref: 0.103-0.160 2V: 20-56°
Staurolite	honey yellow, pleo., poikiloblastic; XPL: little color change (low biref.)	RI: 1.736-1.762 Biaxial + Biref: 0.009-0.015 2V: 88°
Tourmaline	high relief, needles, triangles, very pleochroic; XPL: high order colors; longitudinal parallel extinction	RI: 1.610-1.698 Uniaxial - Biref: 0.035
Zircon	clear, euhedral very hi relief; XPL: high 3rd to 4th order colors	RI: 1.920-2.015 Uniaxial - Biref: 0.047-0.055

Additional Requirements:

1. Be able to identify mineral extinctions under the PLM (Polarized Light Microscope), such as parallel, inclined, symmetrical and asymmetrical extinctions.
   Sample question: *You view a mineral in thinsection under crossed polars while slowly rotating the stage as indicate by the graphic or animation. What type of extinction is most likely pictured?*
2. Be able to calculate refractive indices from refractory data:
   Sample question: *You use a laser beam to measure refractive angles in an unknown material. The measured incident angle is 31.0°, the corresponding refractive angle equals 25.4°. What is the refractive index of the unknown material?*
   Sample question: *You use a laser beam to measure refractive angles in an unknown material. The measured critical angle in the material is 62.1°. What is the refractive index of the unknown material?*
3. Be able to identify light beam propagation and refraction through materials of various optical densities:
   Sample question: *A laser beam propagates to two materials of different optical densities as depicted. Which of the two materials has the higher "n"?*
4. Be able to calculate critical angles from refractory index data!
5. Be familiar with the Becke Line method to assess refractory indices, including the use of immersion oils in the process!
6. Be familiar with optic axis and acute bisectrix interference figures to identify biaxial and uniaxial minerals with the PLM. Be familiar with the use of the accessory plate to determine the optic sign using the indicated figures.
7. Be able to use Bragg's law and associate calculations in XRD analysis:
   Sample question: *You measure a high intensity XRD peak at goniometer angle 14.3° (2θ) using a regular Cu X-ray tube. What is the corresponding d-spacing within your crystal lattice responsible for this particular peak?*

   Some helpful equations and other parameters:

   $K_\alpha=1.5418$ $K_\beta=1.3922$

   $s=h^2+k^2+l^2$ $n\lambda=2d\sin(\theta)$ $a/d=[h^2+k^2+l^2]^{-½}$

$\lambda/2sin(\theta)=a/[h^2+k^2+l^2]^{-½}$ $sin^2(\theta)=(h^2+k^2+l^2)\lambda^2/4a^2$

Sample question: *You are running an isometric mineral powder sample in the XRD unit using a regular Cu X-ray tube. You know from previous investigations that your mineral has a unit cell dimension of 3.615Å. A defined peak appears at a 2θ angle of 25.3°. What is the most likely h,k,l designation of the crystal face causing this particular peak?*

Some helpful equations and other parameters:

$K_\alpha=1.5418$ $K_\beta=1.3922$

$s=h^2+k^2+l^2$ $n\lambda=2dsin(\theta)$ $a/d=[h^2+k^2+l^2]^{-½}$

$\lambda/2sin(\theta)=a/[h^2+k^2+l^2]^{-½}$ $sin^2(\theta)=(h^2+k^2+l^2)\lambda^2/4a^2$

8. Be able to assign hkl indices to XRD peaks as well as XRD peak position for isometric unit cells.
   Sample question: *X-ray diffraction analysis is performed on a mineral with a face centered, isometric unit cell and the a pictured x-ray pattern is received. Which h,k,l crystal face would you predict at an indicated position (arrow) in a graphic?*
   Sample question: *In the isometric system the 321 crystal face or crystal plane would cause what number peak on an XRD chart?*
9. Be able to define refractive index, relief, interference figure, X-ray diffraction, optic axis, optic sign, optic plane, optic normal, optical extinction, and pleochroism.
10. Be able to practically estimate the 2V angle of a biaxial mineral in thin section. Be able to practically determine the optic sign of a mineral in thin section using the accessory plate of the PLM.
11. Be able to estimate the thickness of a thin section. You may use the birefringence charts hanging up in SI2012.