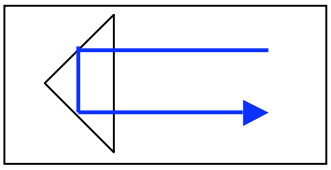
Chemistry 620
Analytical Spectroscopy
PROBLEM SET 3: Due 03/06/08

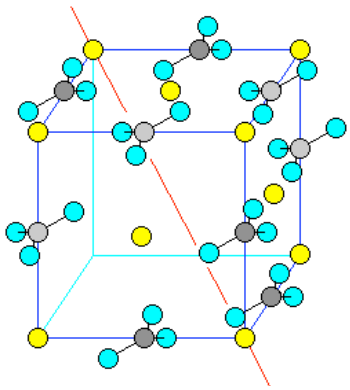
1. Derive an expression for the transmittance of a monochromatic beam propagating normal to dielectric interface from the expression for the reflectance. Assume neither of the media absorbs the radiation. Use the expression to compute the transmittance of a normal beam across an air/glass (nglass = 1.55) interface.

2. By what angles are the two highest gain lines of the Ar+ laser (λ_{blgr} = 488.0 nm & λ_{gr} = 514.5 nm) refracted upon entering (from air) a dielectric medium that has a number density equal to 7×10^{38} m^{-3} and natural (resonance) frequency equal to 5.4×10^{15} Hz at an incident angle of 20^{o}?

3. A 45-45-90 prism is used to totally reflect light as shown in the figure on the right. What is the minimum index of refraction of the prism needed for this to work (assuming the prism is used in air)? Illustrate (Draw) and compute what would happen if this device were used to point the dual wavelength Ar+ laser beam described in question #1.



4. Calcite has a large birefringence because the carbonate groups lie in parallel planes normal to the optic axis. Explain why the polarization of the carbonate group will be less when the electric field is polarized parallel to the optic axis than perpendicular to it. What does this imply about a wave's speed in calcite when its electric field is linearly polarized parallel or perpendicular to the optic axis. Figure source: http://www.uwgb.edu /DutchS/GRAPHIC0/ROCKMIN/ATOM-STRUCT/Calcite-NaCl.gif



5. One cheap way to make a polarizer is to use a stack of N microscope slides. The problem is that even assuming negligible absorption the transmitted light is dim. Use conservation laws to show that the total transmittance of a stack of N slides is $T=(1-\rho)^{2N}$ for normal incidence. Derive an expression for transmission through the stack inclined at Brewster's angle. Derive an expression for the extincition ratio for the stack at Brewster's angle

6. Suppose n_{fast}=1.47 and n_{slow}=1.51. Calculate the smallest thickness that a crystal could be cut to make a quarter wave plate for 532 nm light.

7. Compute the irradiance of a randomly polarized beam transmitted by a system composed of a perfect linear polarizer with its transmission axis set at 20^{o} to vertical placed between a pair of crossed polarizers (perpendicular transmission axes) if the source power is 50 mW and the beam diameter at the source, 25 mm, is smaller than the diameter of any of the polarizers. (You should assume that the polarizers have no effect on the beam size.) How much light would be observed if the perfect linear polarizer were a quarter-wave plate instead?

8. Suppose you were given only a linear polarizer and a half-wave plate. How would you determine which was which, assuming you all you have is a source of natural (unpolarized) light.