Chem 310

2nd Homework Set

Due Date: Feb. 3, 2004

Note: for the discussion questions, write your answer in your own words; do not copy the Required Notes or the text. This is an opportunity for you to get the concepts organized in your mind.

1. What is the near IR range in expressed in wavenumbers? What optical materials are suitable for use in this spectral domain?

2. 25000 cm^{-1} lies in what spectral domain? What wavelength in nm corresponds to 25000 cm^{-1}?

3. Calculate the transmittance (%T) of an empty quartz cell. The index of refraction of quartz is 1.55. Note that there are 4 air-quartz interfaces in the beam path.

4. Here is a practical application of Snell s Law. When I fish for trout, I don t want the trout to see me as I approach it. This is especially difficult in calm clear water. If I stay at a low enough angle with respect to the trout, then Snell s Law proves that the trout won t be able to see me. Draw a trout suspended a foot below the surface of the water. Draw a line representing a beam of light traveling from the trouts eye to the air-water interface. The angle of incidence of the beam on the water side of the air-water interface is angle θ. Calculate the angle of the beam ϕ on the air side of the interface. At what angle θ will the angle ϕ become 90 degrees (parallel to the air-water interface)? Assume that the index of refraction of water is 1.34.

5. What is chromatic aberration, and why is a mirror superior to a lens with respect to this aberration? Given that mirrors are superior, why aren t mirrors used as the main optical elements in cameras?

6. (a) A camera lens has a f.l. of 35 mm and a f# of 1.8. What is the diameter of the lens?
(b) If the f# of the lens is changed from 1.8 to 2.8, does it gather more light or less light?

7. What light sources are suitable as continuum sources of UV and VIS light? What light sources are suitable as continuum sources for near IR and IR light?

8. Briefly explain how the photoelectric effect yields a signal in a vacuum phototube. Include in your explanation why a vacuum phototube or photomultiplier is blind to IR light.

9. Sketch a diagram of a PMT and briefly explain how it works.

10. Sketch the transmission curve (T vs λ) for a low pass optical filter with a cutoff wavelength of 450 nm. What color would the filter be?

11. An interference filter is constructed with a MgF_2 dielectric (index of refraction = 1.36). What are the first, second and third order wavelengths transmitted by the filter if the dielectric layer is 500 nm thick?

12. Sketch the Czerny-Turner monochromator with a planar grating. How is the wavelength scanned? How is stray light reduced?

13. Harris, Exercise 20-A.

14. Harris, Problem 20-8.

15. Calculate the linear dispersion of a monochromator for the second-order wavelength if the grating has 800 lines/mm and the focal length of the monochromator is 100 mm. What is the bandpass if the slitwidths are set to 0.25 mm?

16. What is the difference between an echelle grating and an echellete grating? Show a sketch of each type of grating and indicate the surface that diffracts the light.

17. Generally, a single grating can be used for a monochromator that operates in the UV/VIS domain. However, a monochromator operating in the IR domain usually has 2 gratings, and switches them at about 2000 cm^{-1}. Why?

18. Why are cutoff filters often used in combination with grating monochromators?

19. If stray light is coming out of a monochromator, passing through a sample, and reaching the detector, will the measured transmittance be higher or lower than the true transmittance? Hint: see p. 471 of Harris.