Chemistry 620
Analytical Spectroscopy
PROBLEM SET 4: Due 03/13/08

1. The human eye is a lens that focuses images on the retina, the screen of the eye. Suppose that the normal focal length of this lens, that is the position in which far away objects are focused on the retina, is 3.5 cm. The eye is able to focus on nearby objects by changing the shape of the lens, and thus its focal length. Calculate the focal length the eye would need to adopt in order for an object 17.5 cm from the eye to be in focus on the retina?

2. A point source of radiant intensity 2.0 Wsr^{-1} is placed at the focal point of a 0.5 cm diameter, f/4.0 lens. What is the focal length of the lens? What is the solid angle collected by the lens? What is the collection efficiency of the lens? What is the irradiance of a beam on a sample placed 0.5 m from the lens?

3. Using a pair of lenses both having a focal length of 2" and an object position 5" from the first lens, calculate the position needed for the second lens if an overall magnification of 10 is needed. Use ray-tracing to confirm your calculation.

4. The objective and the eyepiece of a microscope each have a focal length of 2.0 cm. If an object is placed 2.2 cm from the objective, calculate (a) the distance between the lenses when the microscope is adjusted for minimum eyestrain, (b) the magnification of the microscope, and (c) the collection efficiency of the objective.

5. If you focus the beam from a 50 mW Ar+ laser with a 3 mm beam waist to a diffraction-limited spot using a lens with a 50 mm focal length, what would be the spot size and the irradiance of the beam on the spot?

6. Fiberoptics are replacing lenses in some spectroscopic instrumentation because they can transmit light over long and/or irregular paths. If a 40 mW source beam is launched down a 50 μm diameter fiber that has n_{core} and n_{clad} equal to 1.52 and 1.43 and the attenuation of the fiber is 0.25 dBm^{-1} what is radiant flux exiting a 2.0 m segment of fiber?

7. Compute the acceptance cone of the fiber described in question #5 and the radiant power exiting the 2 m fiber segment if the laser beam and lens in question 4 is focused on the end of the fiber.

8. One of the issues raised in *Chi* is the fact that placing a lens a focal length away from a source will collimate the light but collect only a small spot. On the other hand, placing the lens further away from the source images more of the source but with lower collection efficiency. Estimate the collection efficiency and image brightness of a broadband white light 0.25$Wsr^{-1}cm^{-2}$ extended source collected by

a 1.5 cm diameter lens with a focal length equal to 7.5 cm placed 15 cm away from the source. Compare this to the collection efficiency when the lens is moved to the its focal length, assuming the source area viewed is the size of a diffraction limited spot. Where is the source image in this case?