1) Diffraction gratings are usually used with a small angle of diffraction. Give the most significant advantage and the most significant disadvantage of using a small angle.

2) Michelson Interferometer - The two Fe emission lines are at 3099.90 and 3099.97 angstroms. If the moving mirror in the interferometer travels at a velocity of 2.50 cm/s, how long does it take to obtain a single interferogram capable of resolving the two Fe lines (hint: first need to calculate the distance that the moving mirror needs to travel in order to "barely resolve" the two Fe emission lines).

- Explain why fourier transform instruments are much less common for ultraviolet, visible, and near-infrared regions. ---> To make the question worth more, I guess you could add what are the advantages of FT spectrometry.

- Draw and label the axis of an interferogram for monochromatic radiation. Explain why the shape of the curve is a particle way.

Question 1

We have discussed the advantages of Fourier transform spectroscopy at length. In light of these advantages (particularly the multiplex advantage), why are Fourier transform instruments commonly utilized only for infrared spectroscopy and seldom utilized for UV-visible spectroscopy?

Question 2

Increasing the number of resolution elements utilized to obtain a spectrum should generally improve the quality of that spectrum. Explain, then, why decreasing the width of the resolution elements degrades the signal-to-noise ratio appreciably for a typical infrared detector.

Question 3

Suppose that 1.5 mW of 400-nm light is incident upon the metal surface within a photoelectric cell. If only 0.10% of the incident photons produce photoelectrons, calculate the current generated in the cell.

Q) You have a monochromator with 140 gratings/mm with the center 2 cm filled. Your's systems focal length is 1.0 m and your measurements take place in the second order. Your boss been asked to resolve two spectral features in a sample at 5000 A and 5001 A by this afternoon.

A). Given this information, would your spectrometer by able to distinguish the two features? Show why.

B). Calculate what the slit width would need to be on your setup.

draw a very general schematic of an optical spectrometer. what does a chopper do, why is it located where it is in the schematic, and how does it improve the overall signal-to-noise ratio of the instrument?

Professor Petrucci decided that it was too nice a day to stay inside and study instrumental analysis so he took the class down to North Beach. While there, one of his students drank a large amount of the lake water and got dreadfully sick. Expecting there to be some arsenic in the water, Petrucci tested the water. Finding that his signal was buried in noise due to a power line neighboring the lab, a)what could he use to retrieve his signal from the noise? b)Where would he place it in the instrument and why? c)What does he need to do to the resulting signal after it is treated by this method?

a) He should use a chopper.
b) He should place it after his light source and before his sample so that the signal is modulated but not the noise.
c) The signal needs to be demodulated to return it to its original frequency using a lock in amplifier.

What is an advantage of CIDs over CCDs? What is an advantage of CCDs over CIDs?

A 5.00-mL sample of blood was treated with thrichloroacetic acid to precipitate proteins. After centrifugation, the resulting solution was brought to a pH of 3 and was extracted with two 5-mL portions of methyl isobutyl ketone containing APCD (A lead complexing agent). The extract was aspirated directly into an air-acetylene flame yielding an absorbance of 0.555 at 283.3 nm. 5-mL aliquots of standard solutions containing 0.250 and 0.450 ppm Pb were treated in the same way and yielded absorbances of 0.389 and 0.599, respectively. Calculate the concentration Pb (ppm) in the sample.

The frequency response of an analytical instrument to an input signal acquired at a sampling frequency (fs) of 100 Hz contained significant peaks at 10 Hz, 25 Hz, 30 Hz, 40 Hz, 70 Hz, 160 Hz and 510 Hz. Assuming that ?folding? or ?aliasing? has occurred, explain this phenomenon and devise with a clear/succinct explanation a modification to the sampling process that would allow you to identify which signals are real (i.e. not aliases).

The answer I have in mind would explain what aliasing is, what the Nyquist frequency is, and would suggest sampling at a different sampling frequency so that alias signals would shift while the real signals would remain at their same frequencies.

Explain a situation in which modulation of a signal would be useful in reducing signal to noise. Describe one common method of modulation, and how it works to selectively amplify a signal without amplifying noise.

A group of atmospheric scientists are studying the ozone layer and they determine they need to design a spectrophotometer with a 2nd order Fabry-Perot Etalon interference filter that has a peak transmittance of 305 nm. The magnesium fluoride dielectric has a refractve index of 1.38. What is the thickness of the dielectric in micrometers?

Answer: 0.221 um

This question was derived from the following journal article: Basher & Matthews (1977) Problems in the Use of Interference Filters for Spectrophotometric Determination of Total Ozone. Journal of Applied Meterology (16) 795 - 802.

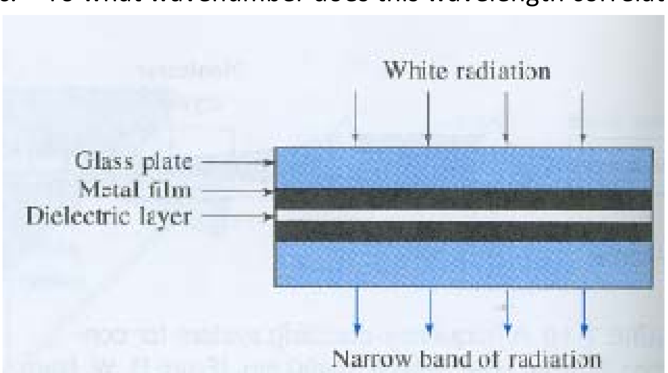
What is the concentration of atoms analyzed by AAS if you know the absorption coefficient (sigma), the path length (b), and the absorbance (A)? What would be the intensity of the signal (P) if given the initial power (Po)?

One way to increase the signal to noise ratio of a spectrometer is to have the radiant energy that reaches the detector be as large as possible. For a monochrometer lens that has a focal length of 10mm, and a diameter of 5mm. What is the F-Number if you were using the entire lens? What must be done to achieve an F-Number of f/5? Has the resolution increased or decreased?

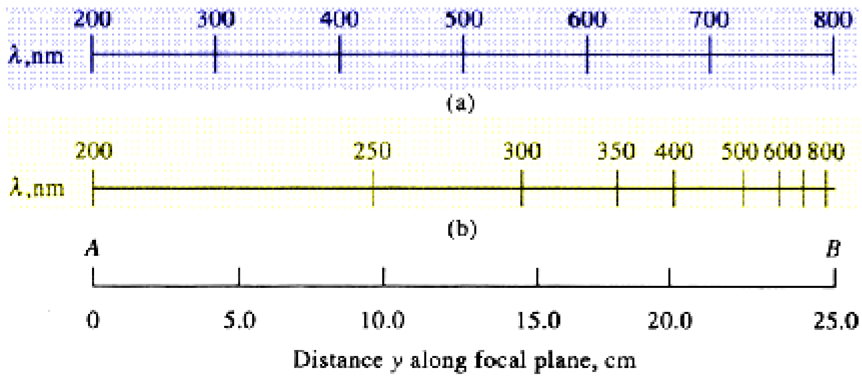
You are busy studying for an Instrumental Analysis Midterm, when a fellow classmate runs into the chem library and says that she cannot remember which of two chemicals, benzene and acetic acid, she put in two unlabeled containers (one chemical in each container). How could you qualitatively discover which chemical is in each waste bottle? If used, what would be the most likely interaction of radiation and sample? What type of spectrum would be seen? Draw a possible diagram for the appropriate type of spectra seen including axis labels. What type of diagram is this?

1. a. By using a cooled detector the thermal noise is reduced. What type of random noise becomes dominant in this condition?
   b. A filter is used to improve the s/n of the system described above. This filter has a bandwidth (Δf) of 100 kHz and is has center frequency (fc) at 1MHz. What is the finesse of this filter?

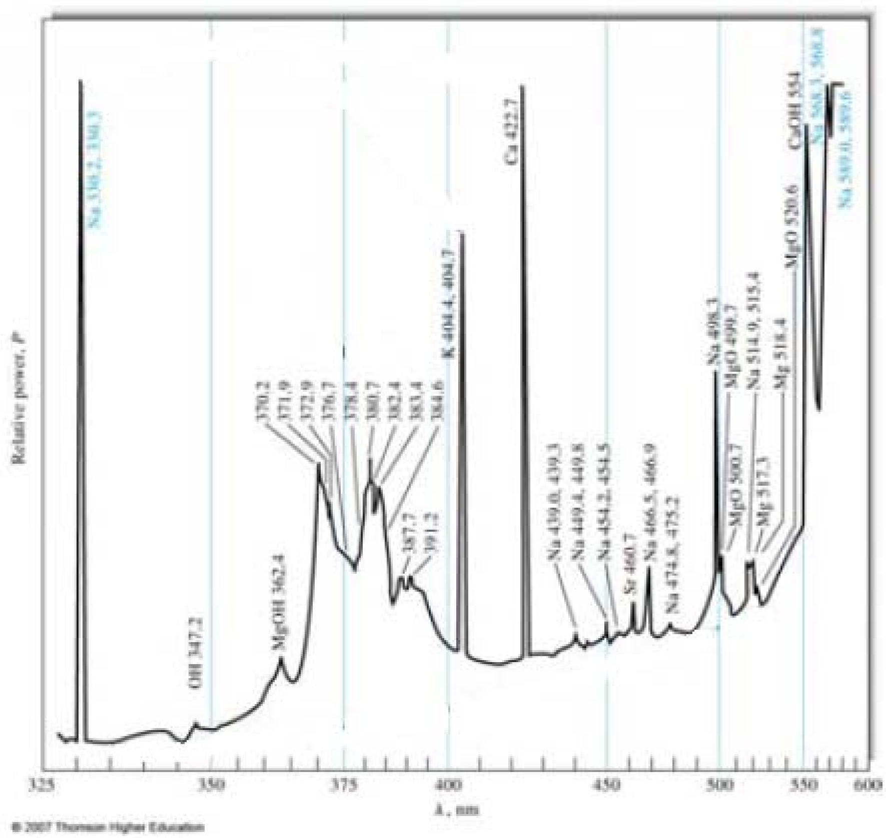
2. A transmission interference filter is shown below. The incident radiation is orthogonal to the surface of the filter. The dielectric layer has a refractive index of 2 and a thickness of 300nm. Assume first order interference.
   a. What purpose do the glass plates serve in the diagram below?
   b. What is the center wavelength transmitted to the air upon exiting the filter?
   c. To what wavenumber does this wavelength correlate?



3. The two plots of wavelength dispersion along the y axis of the focal plane below were each created by one of the two readily available dispersive elements used in spectroscopy. Which of these dispersive elements created each of the plots below? Explain your reasoning.



4. Identify lines, bands, and the continuum, in the emission spectrum below and give a short description of the primary source of each.



Solutions:

1a. Shot noise is dominate when thermal noise is minimized by cooling the detector.

b. The finesse of a filter is Q = Δf/fc therefore Q = (100kHz/1MHz) = 0.1

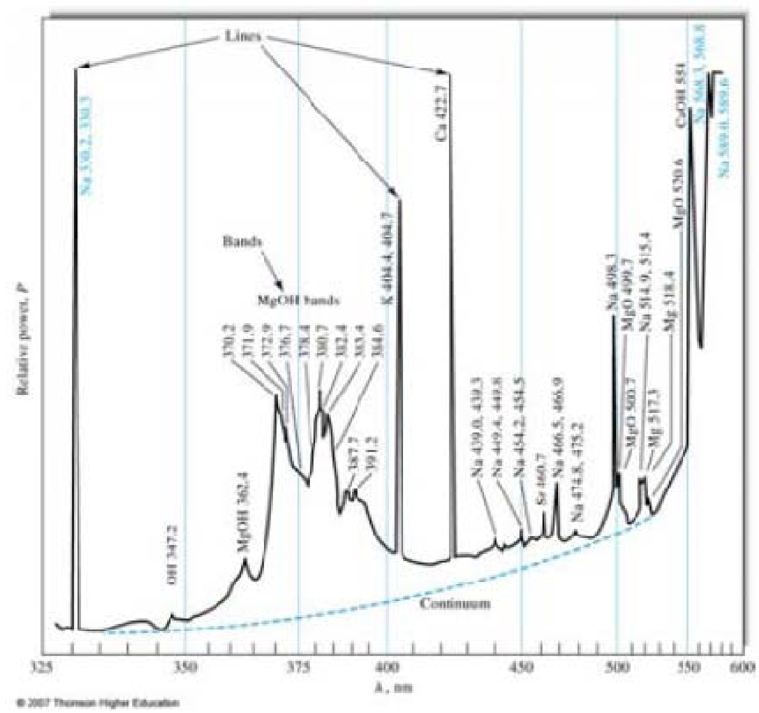
2a. The purpose of the glass is simply to support the thin metal and dielectric layers of the filter.

b. $\lambda = (2dn)/n = (2 * 3\times10^{-7} * 2) / 1 = 1200$nm

c. $\tilde{\nu} = 1/\lambda$ = 1/(1.2x10^{-4} cm) = 8333 cm^{-1}

3a. The plot in figure (a) was created by a grating because the inverse linear dispersion is constant with respect to λ. The plot in figure (b) was created by a prism because the inverse linear dispersion varies with respect to λ.

4.



- Line spectra
  - Primarily for atomic analytes/sources
- Band spectra
  - Primarily for molecular analytes/sources
- Continuum spectra
  - Primarily for thermal emitters (i.e., blackbodies)