Due: Wednesday, Feb. 8, 2005 at 11:00 AM. Answer the multiple choice questions on the first page of the quiz and hand in the page along with your written solutions to problem numbers 6-8. Please make the multiple choice page the top sheet of the solution set. The assignment needs to be handed in at the start of class.

1. (3 pts) Figure 5-10 on page 109 of the text demonstrates the effect of ensemble averaging on the signal-to-noise (S/N) ratio of a data set. By what factor do you expect the S/N ratio is improved in the data by progressing from 1 scan to 200 averaged scans?
   a) 200  b) 14.1  c) 400  d) \(4 \times 10^4\)  e) \(7.1 \times 10^{-2}\)

2. (4 pts) For a laser emitting red light at a wavelength of 623.8 nm, what is the frequency of the light in units of Hz and the energy per photon in Joules?
   a) \(4.81 \times 10^{-4}\) Hz, \(3.19 \times 10^{-37}\) J  
   b) \(1.87 \times 10^{2}\) Hz, \(1.24 \times 10^{-31}\) J  
   c) \(1.87 \times 10^{11}\) Hz, \(1.24 \times 10^{-22}\) J  
   d) \(4.81 \times 10^{14}\) Hz, \(7.28 \times 10^{47}\) J  
   e) \(4.81 \times 10^{14}\) Hz, \(3.19 \times 10^{-19}\) J

3. (3 pts) Referring to Figs 7-1 and 7-2 (pgs 144-146) of the text, which of the following describes the optical layout of a spectrometer that could be used for the determination of Cu ions in water samples based on the emission spectra of Cu at visible wavelengths.
   a) Xe lamp source, glass filter, photoconductor  
   b) hollow cathode lamp source, grating monochromator, phototube detector  
   c) silica prism, sample holder, laser source, golay detector  
   d) sample holder, D2 lamp source, glass prism, photomultiplier tube

4. (2 pts) The plot to the right shows a calibration curve for the analysis of phenobarbital samples by the standard addition method. The plot shows the fluorescence intensity versus the mass of phenobarbital that was added to each flask containing a fixed quantity of the unknown. The equation of the line is: \(y = 1.58x + 3.25\). What is the expected mass of phenobarbital in the unknown?
   a) 2.06 \(\mu\)g  b) 1.58 \(\mu\)g  c) 3.25 \(\mu\)g  
   d) 0.49 \(\mu\)g  e) 5.14 \(\mu\)g

5. (3 pts) To improve S/N in the UV/visible absorption spectrum of a compound, which of the following approaches would be useful for removing the low frequency noise that arises from instrument drift.
   a) place a low pass filter after the detector amplifier  
   b) ensemble average spectra recorded with an instrument equipped with a diode array detector  
   c) modulate the source intensity and recover the analyte signal with a lock-in amplifier  
   e) a and b  f) b and c  f) all of the above
6. (3 pts) If a 16-bit ADC is used to digitize a signal in the range of \(-5.0\) V to \(+5.0\) V, what is the maximum resolution (mV/bit) possible?

7. (6 pts) Construct plots of a sine wave signal that has the following characteristics:
   
   (i) a peak amplitude of 5.0 V and a frequency of 0.1 Hz
   
   (ii) a peak amplitude of 1.0 V and a frequency of 1.0 kHz

   **Be sure to label the units on the x-axis and y-axis of the graphs.**

8. (6 pts) Write definitions for the angular dispersion and the linear dispersion of a grating monochromator. Use a sketch to illustrate the differences. Write an equation that expresses the linear dispersion in terms of basic grating properties, such as the groove spacing and the focal length.

**Bonus:**

(4 pts) For each signal in problem #7, calculate the peak-to-peak and root mean square amplitudes.