

CHEM 221

Instrumental Analysis

EXAM #2

March 16, 2005

Name: _____

INSTRUCTIONS: Read through the entire exam before you begin. Answer all of the questions. For questions involving calculations, show **all** of your work -- **HOW** you arrived at a particular answer is **MORE** important than the answer itself!

The entire exam is worth a total of 200 points. Provided are a periodic table and a formula sheet jam-packed with useful stuff!

Good Luck!



2. a. (10 pts) Hmm, if I look up the wavelengths of the two aluminum lines mentioned in the previous problem, I find that the values that I have given are specified for "air" and that the corresponding wavelengths in a "vacuum" are 3093.680 and 3093.737 Å. Calculate the frequency of the aluminum line that is at the lower wavelength.

b. (10 pts) Based on this information, calculate the index of refraction for "air" (at the frequency of the lower wavelength aluminum line).

c. (15 pts) Let's assume that we have a light source that emits *only* at the lower wavelength (3092.71 Å) aluminum line and we are directing the beam into a Michelson interferometer. The moving mirror in the interferometer travels at a velocity of 0.50 cm/sec and moves a total distance of 1.0 cm (i.e., the mirror moves 1.0 cm before reversing its direction). Sketch the interferogram (intensity versus retardation (δ)) that would be obtained from this system using the light source described above.

d. (10 pts) Calculate the frequency of the resulting interferogram from the experiment described in **part c** on the previous page.

e. (15 pts) Would this interferometer be able to "barely resolve" the two aluminum emission lines at 3092.71 \AA and 3092.84 \AA ?

3. a. (15 pts) Carbon monoxide (CO) can be determined at trace levels using IR absorption spectrophotometry. Using a 10.0-cm pathlength gas cell, a standard containing 100.0 ppm CO gave an absorbance of 0.250 at 2170 cm^{-1} . Calculate the concentration (ppm) of a gas sample, analyzed using the same gas cell, which gives an absorbance of 0.010 at the same wavenumber. Assume the system obeys Beer's Law over the concentration range investigated.

b. (10 pts) Assuming that the readout uncertainty of the IR spectrophotometer is $\pm 0.10\%$ -T, what is the %-relative uncertainty in the concentration you determined in **part a** above?

c. (10 pts) Is the concentration determined in **part a** above or below the detection limit for this measurement? (No need to calculate the detection limit, just determine whether the signal from the sample is above or below the detection limit).

5. More QUICKIES - No more than 2 sentences!

- a. **(10 pts)** What is usually the most likely decay route to the ground state after a molecule or atom absorbs a photon of electromagnetic radiation (EMR)? Does this decay process result in the emission of a photon of EMR?
- b. **(10 pts)** Quantitative solution analyses in IR spectroscopy are often problematic. Give ONE (of the many) reasons for these difficulties and describe the problem(s) it introduces.
- c. **(5 pts)** Based on their relative electronegativities as well as their molecular orbital overlap integrals, determine the entropy change associated with a grizzled thickset marmot gnawing at the fibrous remains of large perennial plant having a single elongated main stem, assuming, of course, that this *marmota monax* was able to persistently bite at the hard fibrous substance (typically xylem).