Chemistry 447 Problem Set (Spectroscopy) Winter 2001

1. Why must the slit width of a prism-based monochromator be varied to provide a constant effective bandwidth whereas it can be nearly constant for a grating-based monochromator?

2. Interference filter can be used to develop a simple dual detector flame photometer for the detection of sodium and potassium in serum samples by atomic emission spectroscopy. Sketch what such a system might look like! Assuming that the dielectric material used to create the two required filters had a refractive index of 1.35, what thickness (between semi-transmitting plates) would the filters for the potassium and sodium channels need to be! (assume that emission lines are 589 nm for sodium and 766 nm for potassium).

3. For atomic emission of potassium using the 766 nm line, assume that the flame temperature was 1800 ^{o} C, what % of the atoms would be in the excited state that correspond to this wavelength of light?

4. A beam containing two separate wavelengths (400 nm and 700 nm) of radiation was passed through a thick glass plate (3 cm thick) with an incident angle of 30 degrees from normal to the plate. Assuming that the refractive index of the glass plate at 400 nm 1.53 and at 700 nm it was 1.32, and that the refractive index of air is 1.00, what would be the angle of refraction for each wavelength of radiation. How far apart (in mm) would these two different wavelengths be when then reach the other edge of the plate?

5. What determines the wavelength range that a given phototube or photomultiplier tube can be used in analytical spectroscopy?

6. When excited in a flame, sodium atoms exhibit a number of emission lines included two closely spaced weak lines at 2852.8 angstroms and 2853 angstoms (in UV region) corresponding to an electron transitions from the 5p → 3s orbital. If the temperature of the flame were 2200 ^{o}C what fraction of the total atoms would be in this excited state? What resolving power would be required for the monochromator in the emission instrument for you to see both emission lines? What type of dispersion element would be required to achieve such resolution?

7. Explain why atomic emission spectroscopy is more suitable for carrying out simultaneous multielemental determinations compared to atomic absorption.

8. With respect to atomic spectroscopy, what is a refractory compound and how can hydride sample introduction help improve the analytical sensitivity toward elements that readily form such materials.

9. Explain why matrix effects are uncommon in inductively-coupled plasma emission spectroscopy, but are usually encountered in furnace atomic absorption spectroscopy.

10. What is the primary advantage of constructing a laser that utilizes a 4 level energy system vs. one based on a three level system?

11. Magnesium was determined by flame atomic absorption using an appropriate hollow cathode lamp and setting the monochromator to 285.2 nm. Sketch the hollow cathode lamp, and briefly explain how it works? Based on Fig. 8-2 in your textbook, sketch the entire emission spectrum of this lamp. When a blank solution (w/o) magnesium was introduced into the flame, the current detected at the photomultiplier was 100 µA. In the presence of a given sample containing Mg, the current was 75 µA. A standard solution of Mg with a concentration of 20 µM yielded a photocurrent of 55 µA when aspirated into the flame. What was the concentration of Mg in the sample? (assume zero dark curent if a shutter was placed to block light from striking the detector).