1. Please indicate whether the following statements are True (T) or False (F) (note: the entire statement must be true for the statement to be true!) (24 pts).

   a) In a Michelson interferometer, when the retardation ($\delta$) is equal to zero, this means that the minimum intensity of radiation from the source will strike the IR detector.

   b) The purpose of the laser beam within a Michelson interferometer is to determine the exact timing for sampling the signals from the IR detector, and this also provides a measure of the speed of the moving mirror.

   c) A tungsten lamp is an excellent source of radiation in the far IR region of the spectrum.

   d) In flame atomic absorption spectroscopy, a refractory compound is one that decreases the intensity of light striking the detector (appears as positive error in absorbance) owing to a significant change in the refractive index of the flame due to the presence of this species.

   e) The use of a more intense excitation source for molecular fluorescence will always lead to an increase in the fluorescence quantum yield of the molecule being excited, and hence better detection limits.

   f) Graphite furnace atomic absorption instruments will generally yield lower detection limits for a given element than corresponding flame instruments because the atomization efficiency of the sample is much greater.

   g) Use of a tunable laser source for UV-Vis spectrophotometry is always preferred, owing the improvements in detection limits that normally results in spectroscopy from using a more intense source.

   h) Electron impact and field desorption are both good examples of hard ionization methods used in mass spectrometry.

   i) Very high vacuums (very low pressures) are required in most mass spectrometry instruments to prevent contaminating the instruments with ambient species, and to also prevent collisions of the ions with high levels of atmospheric molecules, which would degrade the ability to separate these ionic species in the gas phase.

   j) The lower detection limits observed for elemental analysis by ICP vs. flames and other atomization sources (for nearly all elements) is mostly the result of the inert argon atmosphere, due to the large amount of argon gas used to create the plasma.
k) A hypsochromic shift in the $\lambda_{\text{max}}$ of a species when recording a UV-Vis absorption spectrum means that the $\lambda_{\text{max}}$ shifted to a higher wavelength or lower energy.

l) The purpose of a nebulizer in atomic spectroscopy is to create very small dried salt particles the analyte ion before the sample enters the flame or plasma region where actual atomization occurs.

2. Please indicate the correct answer to the following multiple choice questions (make sure you write correct letter answer next to question number in your blue exam book) (21 points)
3. Sketch the basic instrument components in their proper orientations of a conventional spectrofluorimeter (assume diffraction grating based). Briefly explain the purpose of each component and further explain why it would be possible that a interference filter-based fluorometer could actually yield lower detection limits for quantitating a given fluorescence molecule than the spectrofluorometer instrument that you have drawn. (15 points)

4. Lithium can be used as an antidepressant drug (usually in the form of lithium carbonate). If lithium was determined by flame emission spectroscopy using a resonant line at 671 nm, estimate the % change in intensity of the emission signal that would possibly result (for a given concentration of lithium ions) if the flame temperature was changed from 2200 to 2300 °C. Would such a change be positive or negative, and would you expect the detection limits to be lower or higher at the more elevated temperature. Explain! (hint: you need to do some calculations using the appropriate equation). (15)

5. Sketch a photomultiplier tube arrangement (top down view) and explain how it can be used to detect very low intensities of electromagnetic radiation in the UV and Visible ranges of the spectrum. Why is this detector not used modern FT-IR instruments that operate in the mid-IR region? Explain! (10)

6. Magnesium was determined by flame atomic absorption using an appropriate hollow cathode lamp and setting the monochromator to 285.2 nm. When a blank solution (w/o) magnesium was introduced into the flame, the current detected at the photomultiplier was 125 µA. In the presence of a given diluted serum sample containing Mg, the current was 75 µA (diluted with 0.12 M NaCl). A standard solution of 20 µM Mg in a solution containing physiological levels of NaCl (0.12 M) yielded a photocurrent of 80 µA when aspirated into the flame. What was the concentration of Mg in the sample based on these current measurements (assume zero current if a shutter was placed in front of the hollow cathode lamp to block light from the source from striking the detector). Given that the standard used to calibrate the instrument did not contain organic species (i.e., the 20 µM Mg standard), and that Mg was being detected using radiation in the UV region of the spectrum, do you believe that this measurement has a significant source of error? If so, is the error positive or negative and why? Also, what type of AA instrument would enable you to correct for this error? (15)
7. Briefly define the following terms (1-2 sentences!) (5 pt each):

   a) continuum source
   b) multiplex advantage
   c) incoherent source of radiation