1. Define and explain the following terms: (25%)
   (a) Sensitivity
   (b) Precision *vs.* accuracy
   (c) Detection limit
   (d) Internal standard
   (e) Reversed-phase chromatography

2. Describe applications and working principles of the following devices (25%).
   (a) Photomultiplier
   (b) Electron capture detector
   (c) Quadrupole mass spectrometer
   (d) Chemical ionization source
   (e) Inductively coupled plasma

3. Explain: (20%)
   (a) Why do molecular absorption spectra usually appear as band spectra, in contrast to that atomic absorption spectra are line spectra?
   (b) Why are vacuum systems necessary for the operation of mass spectrometers?
   (c) Why are high pressure pumps necessary in high-performance liquid chromatography?
   (d) How is a standard addition method used to measure the concentration of the unknown solution?

4. Calculate: (10%)
   (a) The resolution required to resolve the mass spectral peaks for $^{116}Sn^{+}$ and $^{232}Th^{2+}$. Atomic weights: Sn (115.90219 Da) and Th (232.03800 Da).
   (b) The mass of a benzene molecule.

5. Use an energy diagram to describe how a fluorescence process occurs. Then draw a block diagram to illustrate the components of a fluorescence spectrometer and explain how the instrument works. (10%)

6. A solution containing the complex formed between Bi(III) and thiourea has a molar absorptivity of $9.32 \times 10^{3}$ L cm$^{-1}$ at 470 nm. (10%)
   (a) What is the absorbance of a $6.24 \times 10^{-5}$M solution of the complex at 470 nm in a 1.00-cm cell?
   (b) What is the percent transmittance of the solution described in (a)?
   (c) What is the molar concentration of the complex in a solution that has the absorbance described in (a) when measured at 470 nm in a 5.00-cm cell?