1. Define and explain the following terms. (30%)
   (a) Chemiluminescence
   (b) Selected ion monitoring
   (c) Precision *vs.* accuracy
   (d) Mobile phase *vs.* stationary phase
   (e) Monoisotopic mass *vs.* average mass
   (f) Calibration sensitivity *vs.* analytical sensitivity

2. Describe applications and working principles of the following devices. (30%)
   (a) Electron multiplier with discrete dynodes
   (b) Flame ionization detector
   (c) Ion cyclotron resonance mass spectrometer
   (d) Electrospray ionization source
   (e) Negative ion chemical ionization source
   (f) Diffusion pump

3. Explain: (20%)
   (a) How is a standard addition method used to measure the concentration of the unknown solution?
   (b) How does a reflectron time-of-flight mass spectrometer focus ions of the same mass to charge ratios but with different velocities?
   (c) Why can bromine atom-containing ions be easily identified in a mass spectrum?
   (d) An electron impact ionization source generally induces large amount of fragment ions from an analyte molecule. What analytical advantages are provided by such fragmentation?

4. Draw: (10%)
   (a) The chemical structures for the stationary phases that are commonly used in GLC columns.
   (b) An energy diagram to describe how a fluorescence process occurs and a block diagram to explain how a fluorescence spectrometer works.

5. Derive the equation $N = 16\ Rs^2(\alpha/(\alpha-1))^2((1+k'_B)/k'_B)^2$ using the definitions of number of plates (N), resolution (Rs), selectivity factor (α), and retention factor (k'_B). (10%)