

## CHEMISTRY 447

### Mass Spectrometry Problem Set (typical questions from past exams)

1. To enhance resolution in a magnet sector type mass spectrometer, why is it necessary to add an electrostatic analyzer to create a double focusing type instrument?
2. Briefly describe the processes and instrumentation involved in the following ionization techniques used in mass spectrometry: a) chemical ionization; b) field desorption; c) fast atom bombardment; d) therospray.
3. Explain how an MS-MS type of instrument (triple quadrupole) can be used to selectively detect one species in a complex sample, even when there are several species present with essentially the same molecular weight as the analyte.
4. For accurate quantitative work, why is it often necessary to use an internal standard method when using mass spectrometry as the analytical method?
5. Briefly explain why the ionization source of a time-of-flight mass spectrometer must be operated in a pulsed mode not continuously.
6. Briefly explain what the “image current” is in FTMS techniques and, assuming ions with only one  $m/z$  were within the instrument, what two characteristics of this current would provide the identification and quantitative information regarding these ions.
7. In an ICP-MS experiment, calculate the mass resolution required to resolve the following two species;  $^{116}\text{Sn}^{+1}$  (atomic weight = 115.90219) and  $^{232}\text{Th}^{++}$  (atomic weight = 232.038).
8. Name four types of ionization methods commonly used in Mass-Spectrometry and classify each as either a “hard” or “soft” ionization method.
9. typical true or false questions:
  - An electrospray LC-MS interface serves as both an interface and ionization source for mass spectrometry.
  - In FT-MS, increasing the size of the permanent magnetic field would decrease the frequency of the image current for an ion with a given  $m/z$  ratio.
  - In a time of flight MS, after a pulse of voltage is applied to the accelerator slits, the heaviest ions arrive at the detector first.
10. For the following sets of ions, determine the resolution required of a mass spectrometer to resolve both species and give an example of two different types of mass spectrometers that would be capable of achieving such resolution.
  - a)  $\text{C}_3\text{H}_7\text{N}_3^+$  (MW= 85.0641) and  $\text{C}_5\text{H}_9\text{O}^+$  (MW= 85.0653).
  - b)  $\text{NH}_3^+$  (MW= 17.0304) and  $\text{Mn}^{+3}$  (atomic weight = 54.938).

11. Briefly explain why an electrostatic analyzer must be employed in series (prior to) a magnetic sector mass analyzer to obtain high resolution mass spectra (i.e.,  $R_s = 50,000$ ). Why can't magnetic sector section alone yield such high resolution? (10) .

12. Electrospray MS and Fast Atom Bombardment (FAB) are two of the most popular methods to produce gas phase ions for mass spectrometry. Via appropriate figures and text, briefly explain how both of these ionization sources function, and explicitly state whether each is considered a "hard" or "soft" ionization method. (10 points).