Homework Solutions for Chem 422

Chapter 11

1. Three types of mass spectrometers are used in atomic mass spectrometry: (1) quadrupole mass analyzers, (2) time-of-flight mass spectrometers, and (3) double-focusing mass spectrometers. The quadrupole mass spectrometer separates ions of different mass based on selective filtering of ions during their passage through four parallel rods that serve as electrodes. One pair of rods is attached to a positive dc voltage and the other to a negative dc voltage. In addition, variable radio frequency ac voltages that are 180° out of phase are applied to each pair of rods . The ions to be separated are then accelerated between the rods. Only ions having a limited range of m/z values are able to pass through the rods. All others are annihilated by striking the rods. By varying the dc and ac voltages simultaneously, separation of ions of different masses occurs.

   In the time-of-flight mass spectrometer, ions are accelerated periodically into a field-free drift tube. Their velocity in the tube is determined by their mass-to-charge ratio so that they arrive at a detector at different times depending on their mass.

   In a double-focusing mass spectrometer, ions are accelerated into a curved electrostatic field and then into an electromagnetic field. The lightest ions are deflected to a greater extent than are heavier ions, and thus are dispersed on a plane where they are detected.

2. The ICP torch in an ICP-MS instrument causes atomization and ionization of the species which can then be separated by the mass spectrometer.

3. The ordinate (y-axis) in a mass spectrum is usually the relative abundances or intensities of the ions. The abscissa (x-axis) is usually the mass-to-charge ratio.

4. ICP-MS has become an important tool for elemental analysis because of its high sensitivity, its high degree of selectivity, and its good precision for determining many elements in the periodic table.

5. The interface consists of a water-cooled metal cone with a tiny orifice in its center. The region behind the cone is maintained at a pressure of about 1 torr by pumping. The hot gases from the ICP impinge on the cone, and a fraction of these gases pass through the orifice where they are cooled by expansion. A fraction of the cooled gas then passes through a second orifice into a region that is maintained at the pressure of the mass spectrometer. Here, the positive analyte ions are separated from electrons and negative ions by a suitable field and are accelerated into the mass spectrometer itself.

Homework Solutions for Chem 422

Chapter 11

6. Lasers are used for sampling in ICP-MS by exposing a solid sample to an intense, pulsed laser beam, which rapidly vaporizes (ablates) the sample. The resulting vapor is carried into the ICP torch where atomization and ionization occur. The resulting gaseous mixture then enters the mass spectrometer for ion analysis.

7. Isobaric interferences are encountered when the isotopes of two elements have the same mass. A second type of spectroscopic interference occurs from molecular species that have the same mass as that of an analyte ion. A third type of interference is from matrix species that combine with the analyte and reduce the analyte signal as a result.

8. An internal standard is often used in preparing calibration curves for ICP-MS in order to compensate for random error from instrument drift and noise, torch instabilities, and some matrix effects. The internal standard chosen should be an element that is normally absent from the sample, but one that has an atomic mass and ionization potential close to that of the analyte.