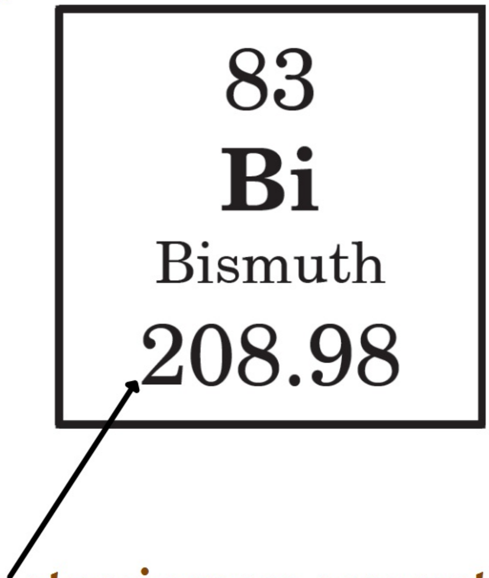
Unit 3 Lesson II (3.2)
Average Atomic Mass & Mass Spectrometry

Objective: The student will be able to calculate the average atomic mass of an element and (2) interpret mass spectra to determine percent abundances of isotopes.

Isotopic Abundance and Average Atomic Mass

The atomic weight of an element is the relative atomic mass of that element. It is actually a weighted mass of the elements isotopes (if any) and their relative abundance.



There is no known stable isotope of Bi. Bismuth has 35+ isotopes.

Its average atomic mass accounts for all of these isotopes.

Example 1

Naturally occurring chlorine is 75.78% ^{35}Cl (atomic mass 34.969 amu) and 24.22% ^{37}Cl (atomic mass 36.966 amu). Calculate the atomic weight of chlorine.

Example 2

Silver (Atomic weight 107.868) has two naturally-occurring isotopes with isotopic weights of 106.90509 and 108.90470. What is the percentage abundance of the lighter isotope?

Spectroscopy

The study of the interaction of matter and the electromagnetic spectrum.

These techniques allow chemists to study the amount, the mass, or the identity of a pure substance or even a mixture of substances.

Spectroscopy vs. Spectrometry

Spectroscopy: sorting a beam of light to amass different frequencies

Spectrometry: sorting a beam of atoms, molecules, or molecule fragments

Mass Spectrometry

How are the masses of these small particles known when calculating average atomic masses?

Mass Spectrometry is a powerful analytical tool used to determine the following information.

1. The elemental composition of a sample

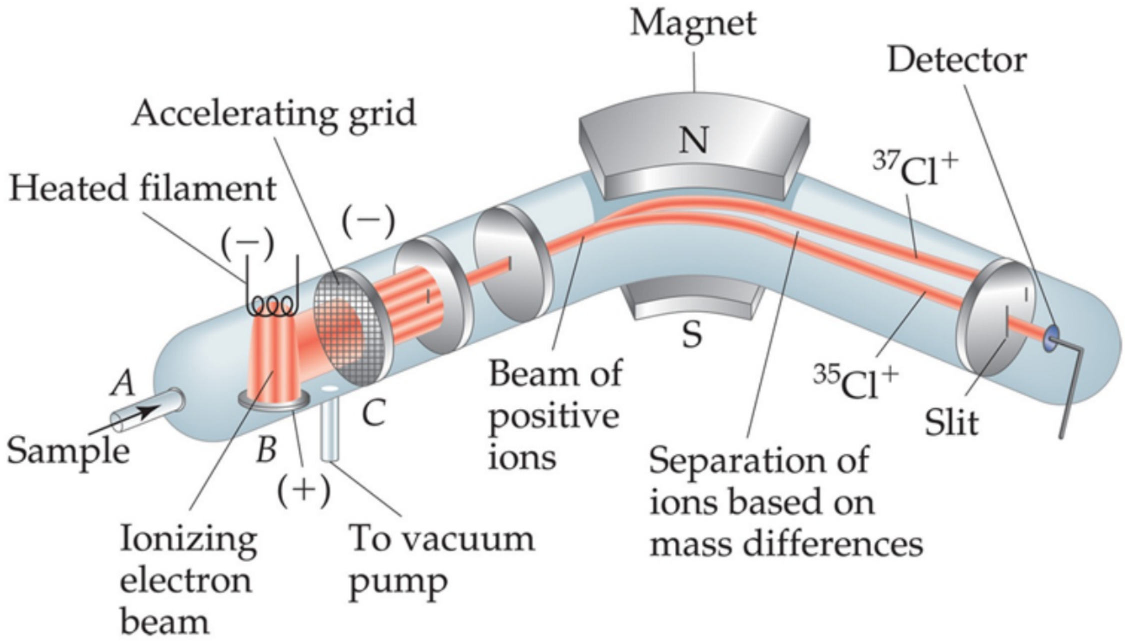
2. The masses of particles and of molecules

3. Potential chemical structures of molecules by analyzing the fragments

4. The identity of unknown compounds by determining mass and matching to known spectra

5. The isotopic composition of elements in a sample

Mass Spectrometry



The main mechanism of Mass Spec is to ionize substance so it can be separated by a magnet based on mass.

Mass Spectrometry

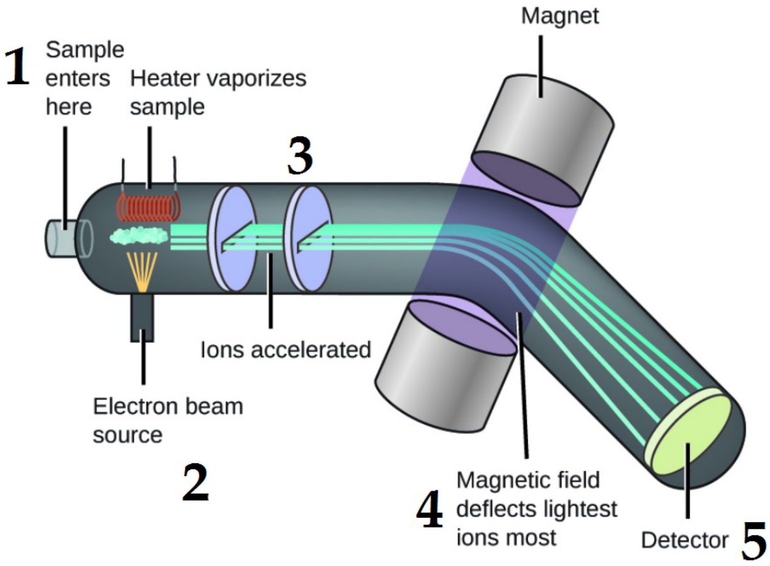
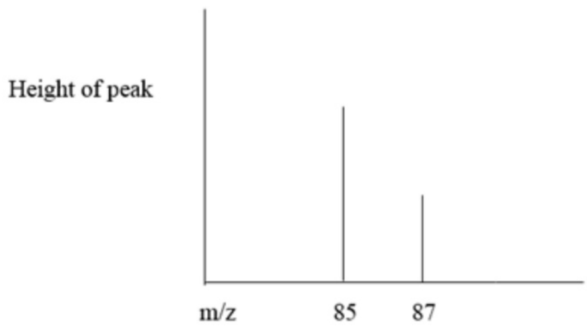


Image #	Step	What Happens
1	Inject and vaporize	Molecules/ atoms separate from each other
2	Ionize	Fast moving electrons hit the atoms and cause an electron to come off
3	Accelerate	Particles move faster.
4	Deflection	Magnetic field – heavier isotopes get deflected less than lighter isotopes.
5	Detection	Counts how many of each mass come through

Interpreting Mass Spectra



Example Spectrum

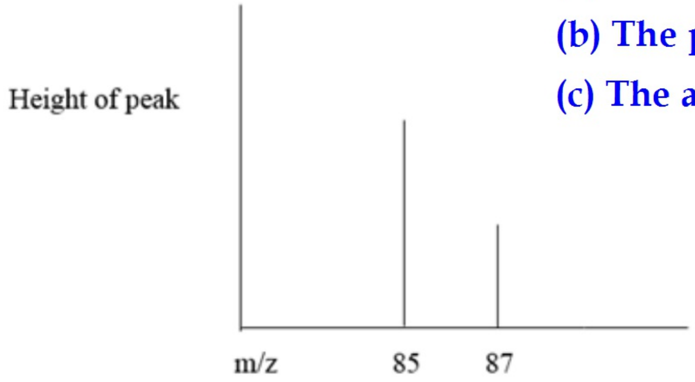
1. Each peak represents a different isotope of the element being analyzed.

2. The height of each peak is proportional to the amount of each isotope present (i.e. it's relative abundance).

3. The m/z ratio for each peak is found from the accelerating voltage for each peak. Many ions have a +1 charge so that the m/z ratio is numerically equal to mass m of the ion. That will be true for all the isotopes analyzed in the course.

Example #1

Consider the Mass Spectrum of Rubidium below to answer the following questions:

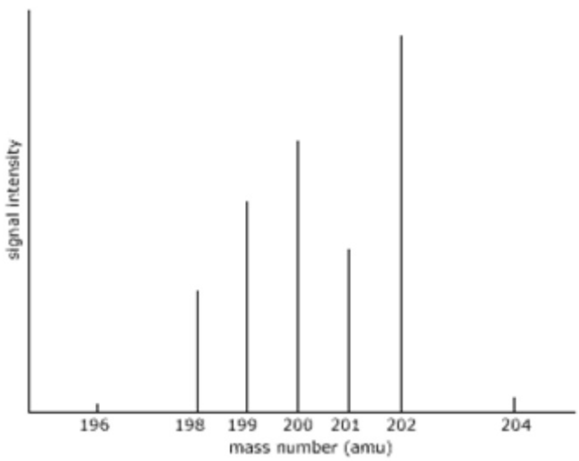


(a) The relative amount of each isotope.

(b) The percentage abundance for each isotope.

(c) The average atomic mass of rubidium.

Example #2



Consider the mass spectrum below for the following prompts:

(a) How many isotopes exist for this element?

(b) What is the percent abundance of each isotope?

(c) Calculate the average atomic mass and identify this element.