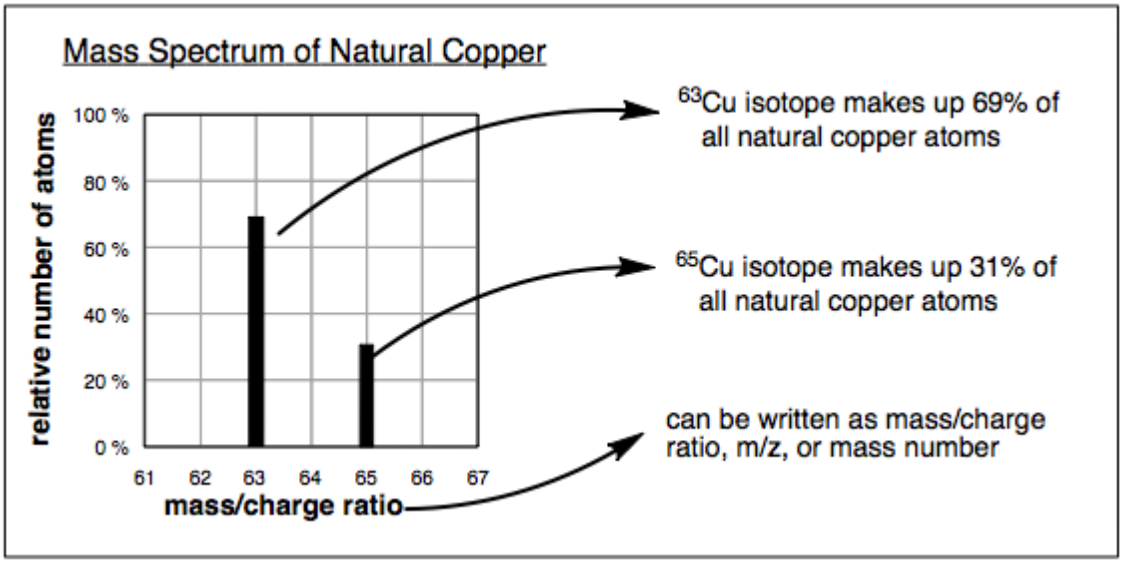
# Mass Spectrometry in AP Chemistry

The AP Chemistry curriculum for 2014 has added mass spectrometry (mass spec) under Big Idea 1, as it relates to atomic structure, the neutron, and isotopes.

## Background Information

Mass Spectrometry is a technique used to determine the molecular mass of atoms/molecules in a sample. High-energy electrons bombard a sample, which ionizes the atoms by ejecting electrons. An electric field is used to separate the ions based on their mass to charge ratio (m/z), and the number of atoms at each m/z value is compiled into a mass spectrum.

Mass spec. of some pure elements shows the existence of elemental atoms with different masses (isotopes), which supports the existence of neutrons. Ex. natural copper is made up of two isotopes: $^{63}$Cu and $^{65}$Cu. Mass spec. can determine the ratio of these isotopes, or identify a sample containing copper based on this ratio.




## How is Mass Spectrometry incorporated into the AP Chemistry curriculum?

There is a focus is on interpreting mass spectra, and being able to relate data from the spectrum to isotopes and average atomic masses of elements. Additionally, students should be able to explain how mass spectrometry data contributes to our current model of the atom and existence of the neutron.

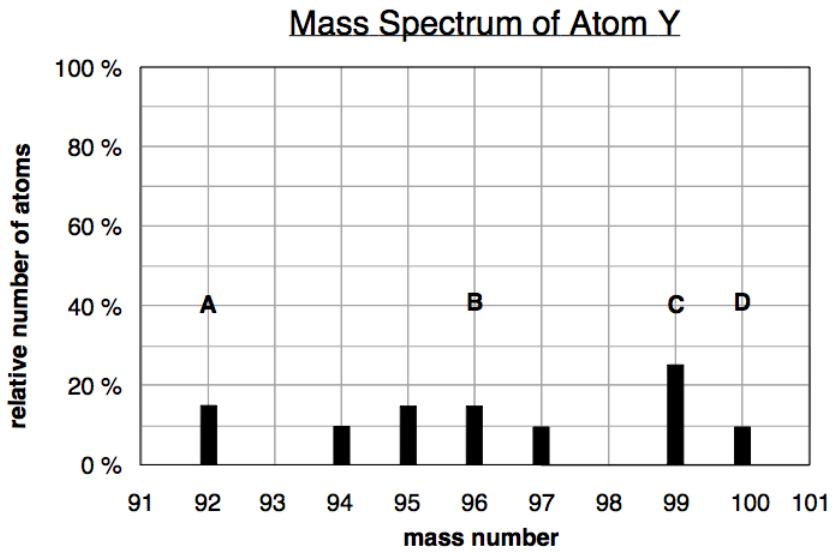
**Enduring Understanding 1.D** Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms. (The modern use of mass spectrometry provides another example of how experimental data can be used to test or reject a scientific model.)

**Essential knowledge 1.D.2**: An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model.

- **a**. Data from mass spectrometry demonstrate evidence that an early model of the atom (Dalton's model) is incorrect; these data then require a modification of that model.
- **b**. Data from mass spectrometry also demonstrate direct evidence of different isotopes from the same element.
- **c**. The average atomic mass can be estimated from mass spectra.

**Learning Objective 1.14** The student is able to use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element.

**Example:** The following 3 questions refer to the mass spectrum of Compound Y as shown below:




*1. Based on the mass spectrum of atom Y, which of the following statements is false?*

a. peak A and peak D come from atoms that have the same number of electrons
b. there are seven isotopes of atom Y
c. peak C comes from the most abundant isotope of atom Y
d. peak D comes from an atom with 4 more protons than the atom that gave peak B

*2. The identity of compound Y is:*

a. zirconium
b. molybdenum
c. americium
d. einsteinium

*3. Which peak comes from an atom with the greatest number of neutrons?*

a. A
b. all peaks in the spectrum have the same number of neutrons
c. C
d. D

**Answers:** 1 (d), 2 (b), 3 (d)

**Sample Question:** AP Chemistry Practice Exam and Notes, Fall 2013 #10

## Resources:

Zumdahl, Stephen, S. Chemical Principles. 6th Edition. Belmont: Brooks/Cole. 2011. Pg. 55

*This textbook contains examples of mass spectra, along with their relationship to isotopic abundance at the first-year undergraduate level. Useful for teacher or student reference.*

www.chem.ualberta.ca/~massspec/atomic_mass_abund.pdf Table of Isotopic Masses and Natural Abundance, from the University of Alberta, Department of Chemistry.

*A table of isotopic abundances of all elements. Useful as a student/teacher resource, and to construct questions using authentic data.*