

## Isotopes Exercise

In this lab you will analyze mass spectrometer data for a series of atoms and molecules. Although atoms have only one atomic number, they may have more than one atomic weight. *Isotopes* are atoms that have the same atomic number but different mass numbers. The atomic weight of an element is the weighted average of the exact masses of the naturally occurring isotopes. Each isotopic mass is multiplied by the fractional abundance of the isotope, and each result must be added to the others.

### Example:

Atomic weight of B =

$$\begin{aligned} &(\text{Mass of } ^{10}\text{B}) \times (\text{Abundance of } ^{10}\text{B}) + (\text{Mass of } ^{11}\text{B}) \times (\text{Abundance of } ^{11}\text{B}) \\ &\text{or} \\ &(10.01) \times (0.199) + (11.01) \times (0.801) = 10.81 \text{ Atomic Mass Units (Amu)} \end{aligned}$$

Answer the following questions.

1. Suppose the mass spectrum of a hypothetical monatomic element X contains a signal at mass number 14 and another at mass number 16.
  - a. Sketch the mass spectrum assuming the signal at mass number 14 is three times the height of the signal at 16.
  - b. How many isotopes are present? Why?
  - c. What are the fractional abundances of the isotopes?
2. Consider the mass spectrum of neon, Figure 1.

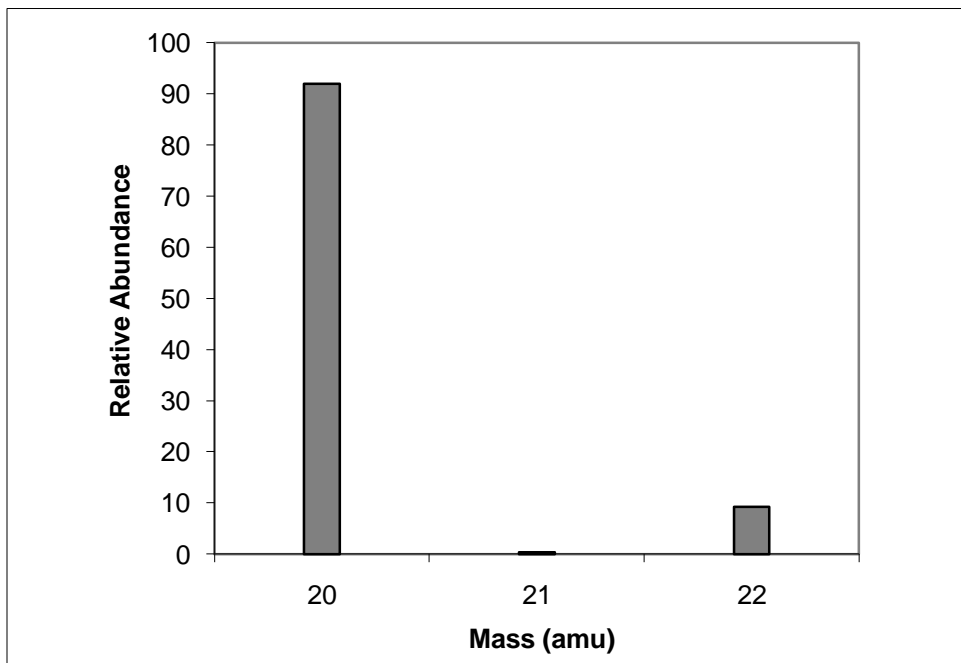


Figure 1. Mass spectrum of neon.

The mass spectrum consists of a signal a major signal at 20 amu, a low abundance signal at 21 amu, and another signal at 22. The heights of these signals are proportional to the number of counts of each mass number and represent the natural abundances of the isotopes. Determine the fractional abundance of each neon isotope from the mass spectrum in Figure 1 and calculate the atomic mass for this element.

Mass Number	Measurement with Units	Abundance
_____	_____	_____
_____	_____	_____
_____	_____	_____

Atomic Mass (Calculated) \_\_\_\_\_ Atomic Mass (Periodic Table) \_\_\_\_\_

**Procedure**

Using a metric ruler, measure the peak height of each isotope and calculate the abundance of each atomic isotope for mercury, molybdenum, and bromine.

*Make sure to include units with all measurements and the correct precision of the measuring device.*

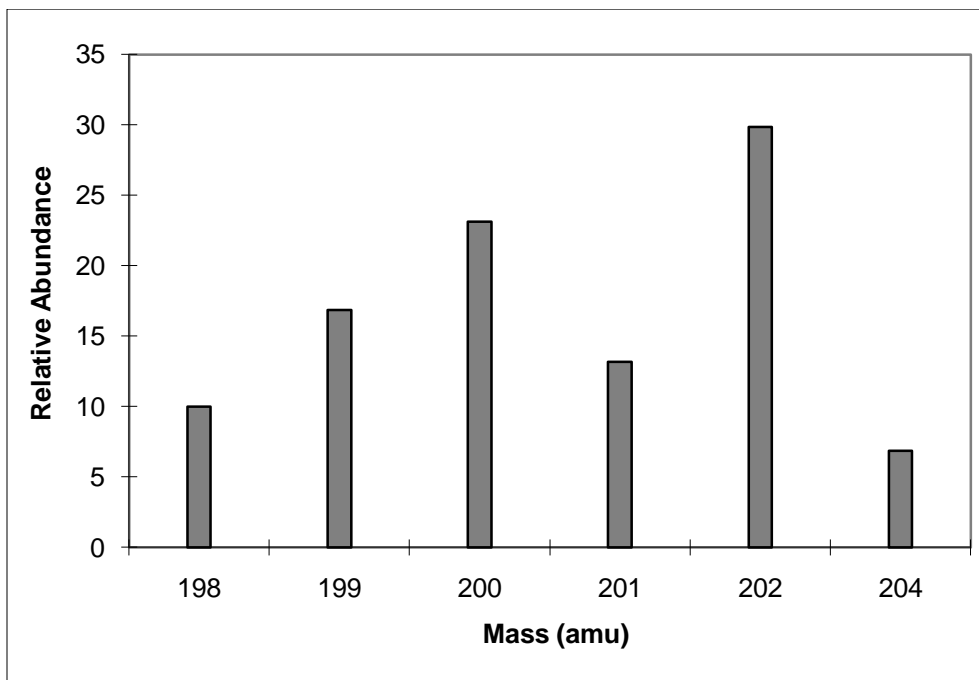


Figure 2. Mass spectrum of mercury.

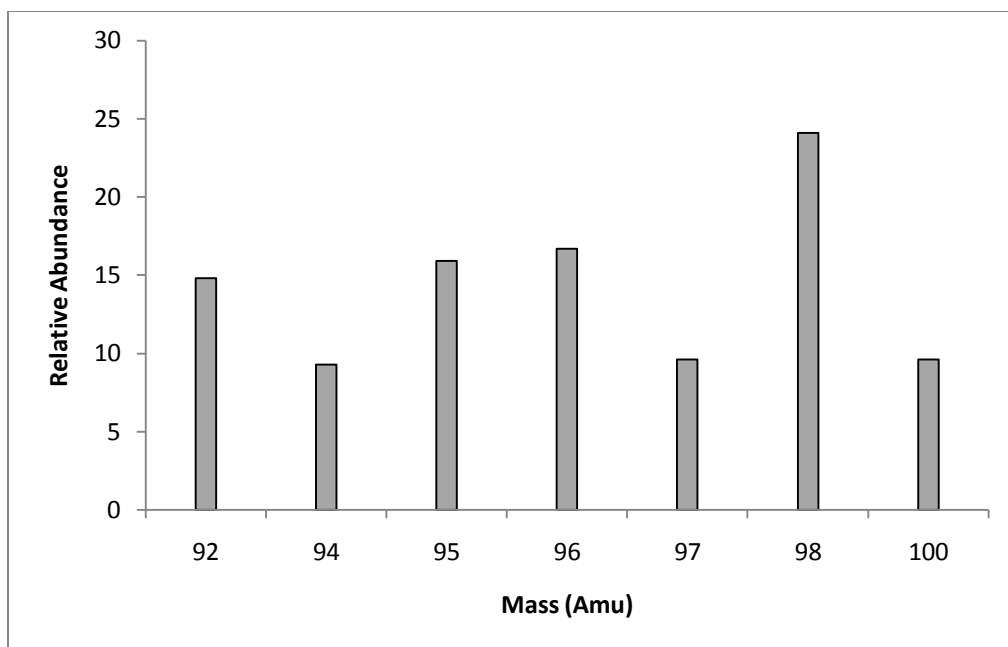


Figure 3. Mass spectrum of Molybdenum.

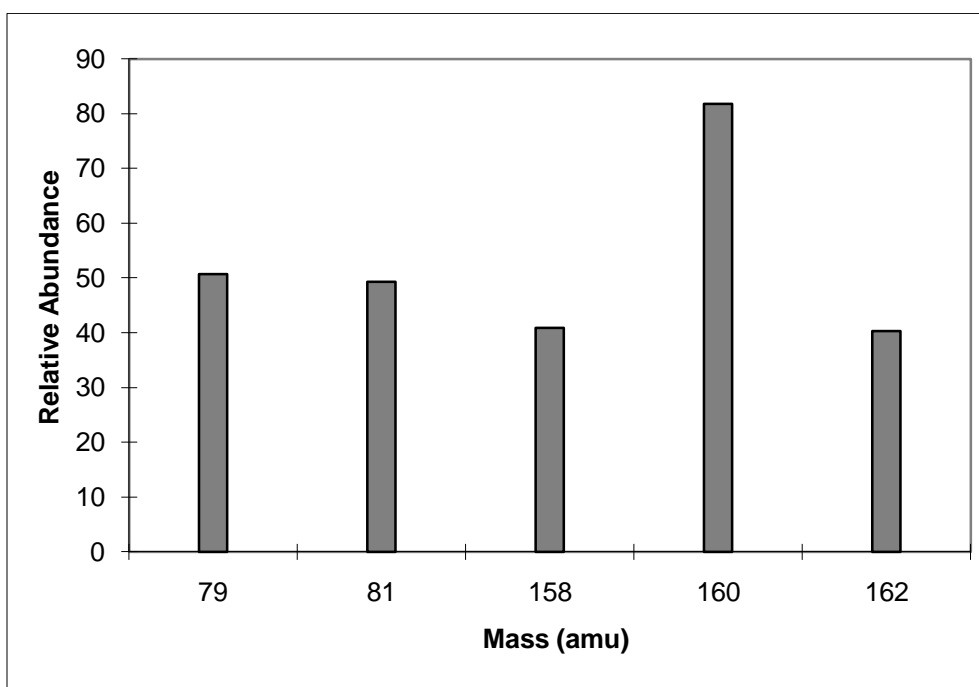


Figure 4. Mass Spectrum of Br<sub>2</sub>.

### Data/Results

Consider the fragmentation of diatomic compounds. For example,  $^{158}\text{Br}_2$  will give a signal at 79 for  $^{79}\text{Br}$  and one at 81 for  $^{81}\text{Br}$ . Br has two naturally occurring isotopes, the 79 isotope and the 81 isotope. Determine the origin (formula) of each of the signals for the mass spectrum of molecular bromine. Example,  $^{158}\text{Br}_2$  is equal to  $^{79}\text{Br}^{79}\text{Br}$ .

1. Mercury peaks

<b>Mass Number</b>	<b>Measurement (cm)</b>	<b>Abundance</b>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Molybdenum peaks

<b>Mass Number</b>	<b>Measurement (cm)</b>	<b>Abundance</b>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

3. Bromine, Br<sub>2</sub>, peaks

<b>Mass Number</b>	<b>Measurement (cm)</b>	<b>Abundance</b>	<b>Formula</b>
_____	_____	_____	_____
_____	_____	_____	_____
_____	XXXX	XXXX	_____
_____	XXXX	XXXX	_____
_____	XXXX	XXXX	_____

## Calculations

1. Calculate the fractional abundances of the atomic isotopes of mercury, molybdenum, and bromine.
2. Calculate the atomic masses of mercury, molybdenum, and bromine from your data.

## Discussion Questions

1. Compare your results to the actual atomic weights of these elements found on the periodic table. Calculate the percent difference for each.

$$\% \text{ difference} = \frac{|\text{experimental} - \text{theoretical}|}{\text{theoretical}} \times 100$$

2. Why does the mass spectrum of Br<sub>2</sub> contain three signals whose heights are approximately in the ratio 1:2:1? What are the origins of these signals?