TOPIC: 1.2 MASS SPECTROSCOPY OF ELEMENTS

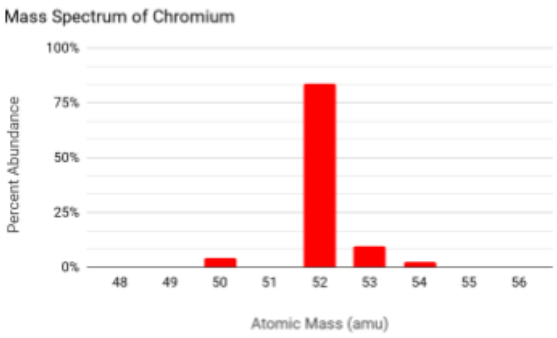
ENDURING UNDERSTANDING:	
SPQ-1	The mole allows different units to be compared.
LEARNING OBJECTIVE:	
SPQ-1.B	Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.
ESSENTIAL KNOWLEDGE:	
SPQ-1.B.1	The mass spectrum of a sample containing a single element can be used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature.
SPQ-1.B.2	The average atomic mass of an element can be estimated from the weighted average of the isotopic masses using the mass of each isotope and its relative abundance
EQUATION(S):	
	N/A

NOTES:

A sample of a pure element contains a variety of *isotopes* (atoms with the same number of protons and electrons, but different numbers of neutrons and therefore different mass numbers). The percentage of each atom with a specific atomic mass in the sample is that isotope's *relative abundance*.

For example, chromium has four naturally occurring isotopes- which are shown in the data table below.
We can see that most of the naturally occurring chromium is chromium-52, so we expect the *average atomic mass* (the weighted average of the masses of all of the naturally occurring isotopes of an element, the mass given on the periodic table) to be close to 52 amu. When we check the periodic table, we see that chromium's average atomic mass is in fact 52.00 amu.

Isotope	Protons	Neutrons	Mass (amu)	Abundance (%)
Chromium-50	24	26	49.95	4.35
Chromium-52	24	28	51.94	83.79
Chromium-53	24	29	52.94	9.50
Chromium-54	24	30	53.94	2.36



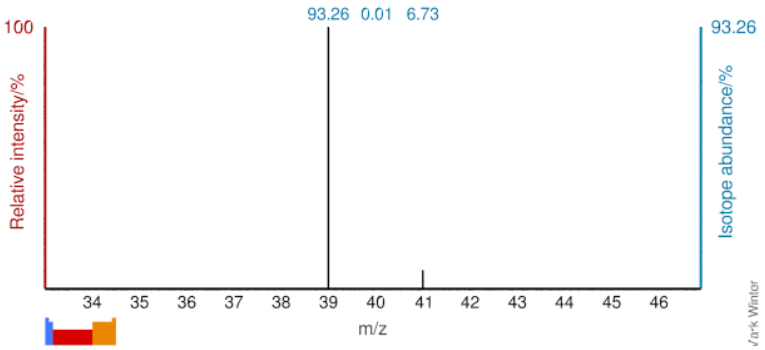
(Data from IUPAC Periodic Table of Isotopes: https://applets.kcvs.ca/IPTEI/IPTEI.html)

Mass Spectroscopy (Mass Spec) is an analytical chemistry lab technique that separates the components of a sample by their mass.
The mass spectrum of a sample containing a single pure element gives information about the naturally occurring isotopes of that element. By reading a mass spectrum, you can determine the isotopic masses (x-axis) as well as the relative abundances of those isotopes (y-axis).

The average atomic mass of an element can be calculated using the relative abundance and mass of each naturally occurring isotope of that element using the following equation.

$$Average\ Atomic\ Mass = \sum_{n} (relative\ abundance\ of\ isotope\ n) \times (mass\ of\ isotope\ n)$$

I DO:



(Mass Spectrum from www.webelements.com)

The mass spectrum of a sample of a pure element is shown above. Calculate the average atomic mass of the element.

From the spectrum, I can see that there are three isotopes representing the following isotopes:
Mass: 39 amu, Abundance: 93.26%
Mass: 40 amu, Abundance: 0.01%
Mass: 41 amu, Abundance: 6.73%

I will find the weighted average of the isotopic masses using the formula below.

$$Average\ Atomic\ Mass = \sum_{n} (relative\ abundance\ of\ isotope\ n) \times (mass\ of\ isotope\ n)$$

$$Average\ Atomic\ Mass = (0.9326 \times 39\ amu) + (0.0001 \times 40\ amu) + (0.0673 \times 41\ amu)$$
$$Average\ Atomic\ Mass = 36.3714\ amu + 0.0040\ amu + 2.7593\ amu$$
$$Average\ Atomic\ Mass = 39.1347\ amu$$

The average atomic mass of the element is 39.1347 amu.

What is the identity of the element?

The identity of the element is potassium, K. The calculated average atomic mass of 39.1347 amu is closest to the average atomic mass given on the periodic table for potassium.

WE DO:

Rhenium, Re, is one of the rarest elements on Earth. Alloys containing rhenium are used for oven filaments and x-ray machines.

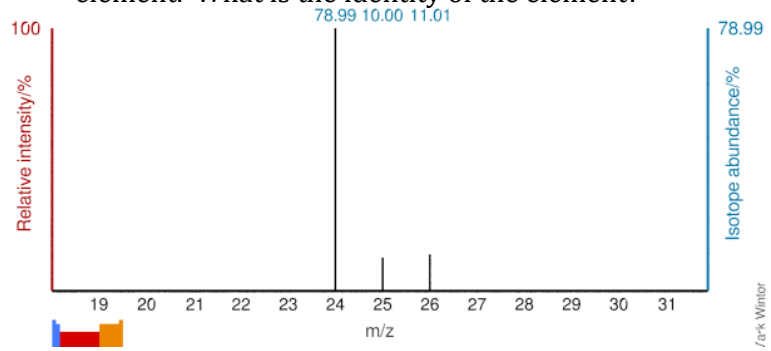
The average atomic mass of naturally occurring rhenium is 186.21 amu. There are two common isotopes of naturally occurring rhenium. Using the information given in the table below, calculate the percent abundance of naturally occurring rhenium.

Isotope	Mass (amu)
Re-185	184.95
Re-187	186.96

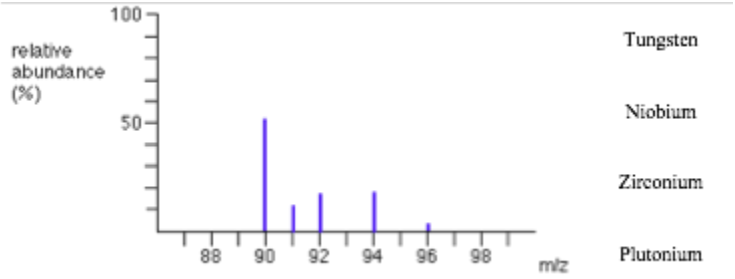
SCAN ME

YOU DO:

1) The mass spectrum of a sample of a pure element is given below. Calculate the average atomic mass of the element. What is the identity of the element?

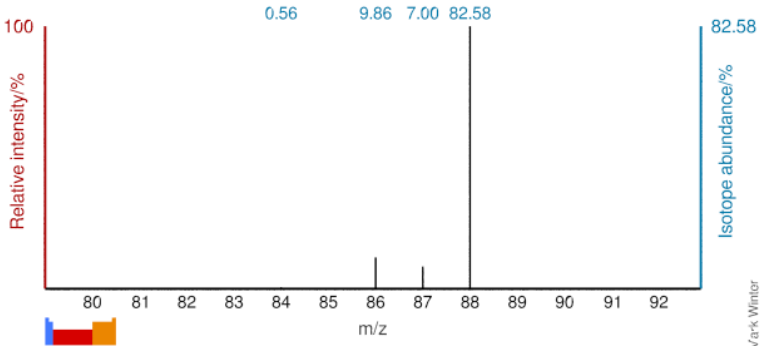


2) Determine the most likely element for the mass spectrum given below. Justify your choice.



3) In the chemical closet, you found an unlabeled vial with a solid piece of an unknown element inside (element Z). You decided to put it in the mass-spec to figure out its atomic mass. The results showed that it has two naturally occurring isotopes, Z-85, and Z-87. Z-85 has a natural abundance of 72.17% and a mass of 84.912 amu. Z-87 has a natural abundance of 27.83% and a mass of 86.909 amu. Calculate the average atomic mass and determine the identity of mystery element Z.

4) Use the mass spectrum below to fill out the information in the table about each isotope.



Isotope	Protons	Neutrons	Mass (amu)	Relative Abundance (%)