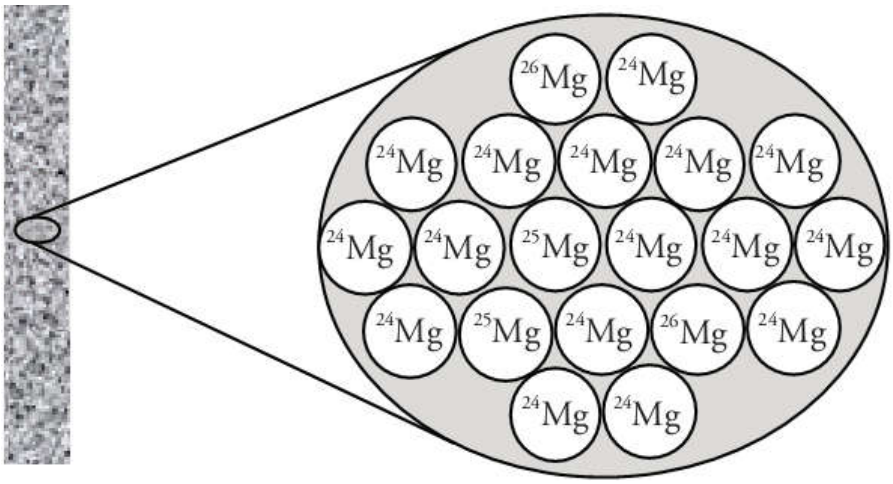
Chemistry
Ms. Ye

Name _____
Date _____Block _____

## ***Average Atomic Mass:*** *How are the masses on the periodic table determined?*

Most elements have more than one naturally occurring isotope. As you learned previously, the atoms of those isotopes have the same atomic number (number of protons), making them belong to the same element, but they have different mass numbers (total number of protons and neutrons) giving them different atomic masses. So which mass is put on the periodic table for each element? Is it the most common isotope's mass? The heaviest mass? This activity will help answer that question.

### ***Model 1 – A Strip of Magnesium Metal***




1. Even though the Mg atoms above have different masses (24, 25, or 26), what is the atomic number for each Mg atom in Model 1? Why?

2. Since the mass number is equal to the total number of protons and neutrons, if each Mg atom has the same atomic number, what causes them to have a different mass (i.e. 24, 25, or 26)?

3. For the sample of 20 atoms of magnesium shown in Model 1, complete the table indicating the mass numbers of the three isotopes and the number of atoms of each isotope present.

| **mass number** | **number of atoms present** |
|---|---|
| 24 | |
| 25 | |
| 26 | |

4. Which isotope of magnesium is the most common in Model 1?

### *Model 2 – Natural Abundance Information for Magnesium*

| Isotope | Natural Abundance on Earth (%) | Atomic Mass (amu) |
|---|---|---|
| $^{24}Mg$ | 78.99 | 23.9850 |
| $^{25}Mg$ | 10.00 | 24.9858 |
| $^{26}Mg$ | 11.01 | 25.9826 |

Note: The **natural (percent) abundance** of an element is a measure of how much of a particular isotope exists. For example, if the natural abundance for Mg-24 is 78.99%, that means 78.99% of all naturally occurring magnesium atoms have a mass of 24 amu.

5. If you could pick up a single atom of magnesium and put it on a balance, the mass of that atom would most likely be _____ amu. Why?

6. Refer to a periodic table and find the box for magnesium.
   a. Write down the atomic mass decimal number shown in that box _____
   b. Does the decimal number shown on the periodic table for magnesium match any of the atomic masses listed in Model 2?

### *Model 3 – Proposed Average Atomic Mass of Magnesium Calculations*

**Mary's Method**

$$\frac{(78.99)(23.9850\text{ amu}) + (10.00)(24.9858\text{ amu}) + (11.01)(25.9826\text{ amu})}{100} = _____$$

**Jack's Method**

$$(0.7899)(23.9850\text{ amu}) + (0.1000)(24.9858\text{ amu}) + (0.1101)(25.9826\text{ amu}) = _____$$

**Alan's Method**

$$\frac{23.9850\text{ amu} + 24.9858\text{ amu} + 25.9826\text{ amu}}{3} = _____$$

7. Complete the 3 proposed calculations for the average atomic mass of Mg in Model 3 and put your answers in the blanks above.

8. Consider the calculations in Model 3.
   a. Which methods shown in Model 3 gives an answer for average atomic mass that matches the mass of magnesium on the periodic table?

   b. Why do you think the other method did not give the correct answer for average atomic mass (the one on the periodic table)?

9. Use one of the methods in Model 3 that gave the correct answer for average atomic mass to calculate the average atomic mass for oxygen. Isotope information is provided below. Show all of your work and check your answer against the mass listed on the periodic table.

| Isotope | Natural Abundance on Earth (%) | Atomic Mass (amu) |
|---|---|---|
| $^{16}O$ | 99.76 | 15.9949 |
| $^{17}O$ | 0.04 | 16.9991 |
| $^{18}O$ | 0.20 | 17.9992 |

## Read This!

Recall that all isotopes of an element have the same physical and chemical properties, with the exception of atomic mass (and for unstable isotopes, radioactivity). Therefore, the periodic table lists a weighted **average atomic mass** for each element. In order to calculate this quantity, the natural abundance and atomic mass of each isotope must be provided.

10. Consider the individual masses for the magnesium isotopes given in Model 2.
    a. Which isotope ($^{24}Mg$, $^{25}Mg$, or $^{26}Mg$) has an atomic mass closest to the average atomic mass listed on the periodic table?

    b. Based on how the average atomic mass of an element is calculated, give a mathematical reason for your answer to part a.

11. Lithium has two naturally occurring isotopes: Lithium-6 and Lithium-7. Based on the average atomic mass for Lithium, determine which isotope is more abundant on earth. Justify your answer.

**Average Mass Practice:** ***Show all work!***

1. Argon has three naturally occurring isotopes: argon-36, argon-38, and argon-40. Based on argon's reported atomic mass, which isotope do you think is the most abundant in nature? Explain.

2. What is the average atomic mass for element X?

| Isotope | Atomic Mass (amu) | Natural Abundance (%) |
|---|---|---|
| X-22 | 22.03256 | 78.33 |
| X-23 | 22.99893 | 2.56 |
| X-24 | 24.04562 | 19.11 |

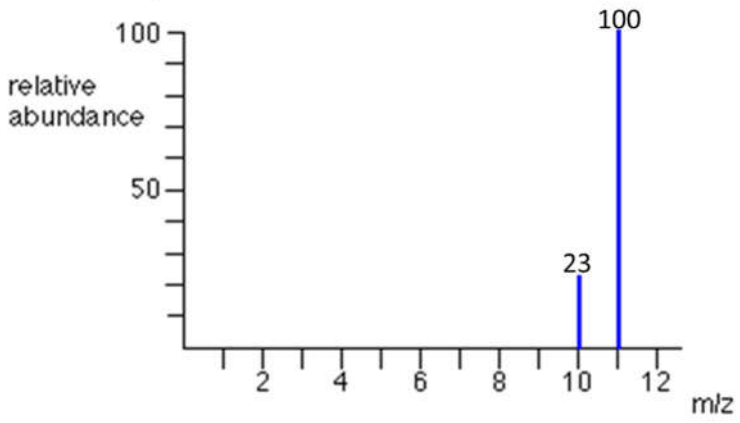
3. An unknown element has the following atomic masses for three isotopes. Determine the average atomic mass and identify the element (write in standard nuclear notation).

| Isotope | Atomic Mass (amu) | Natural Abundance (%) |
|---|---|---|
| 1 | 27.9769271 | 92.2297 |
| 2 | 28.9764949 | 4.6832 |
| 3 | 29.9737707 | 3.0872 |

4. Calculate the atomic mass of lead. The four lead isotopes have atomic masses and relative abundances of 203.973 amu (1.4%), 205.974 amu (24.1%), 206.976 amu (22.1%) and 207.977 amu (52.4%).

5. An unknown element exists in nature as two isotopes: Isotope 1 has a mass of 150.9196 amu in a 47.81% abundance and Isotope 2 has a mass of 152.9209 amu in 52.19%. What is the identity and average atomic mass of the unknown element?

6. The following is the mass spectrum for the stable isotopes of Boron. Determine the average atomic mass of Boron from the information provided. (note: you need to calculate the percent abundance first)




**Challenge Question:**

7. There are 2 isotopes of copper that occur naturally; $^{63}Cu$ and $^{65}Cu$. The $^{63}Cu$ atoms have a mass of 62.929601 amu and the $^{65}Cu$ atoms have a mass of 64.927794 amu. What is the percent natural abundance for each isotope?