M&Ms as Isotopes Activity – Student Document

Group Member Names:____

Isotopes are atoms of the same element that have different numbers of neutrons. Isotopes differ in their mass number but never in their atomic number because all isotopes of a given element have the same number of protons. We cannot see atoms, but (luckily) M&Ms come in different sizes, so we can use them to model isotopes for us. The purpose of this activity is to calculate the weighted average atomic mass using M&M's, and to observe the difference between isotopes.

Experimental Procedure

1. There are 6 stations set up. Each group will rotate to 3 of the 6 stations to complete a data table and M&M isotope analysis. Fill in the station number and color of the M&Ms at that station.
2. At each station are baggies of M&M's that contain 3 different "isotopes" of the same element.
    - The color of the M&M's represent that they are the same element and, therefore, have the same number of protons.
    - The size represents, in a relative sense, the different numbers of neutrons – small, medium and large M&M's represent fewest neutrons (lightest) to greatest number of neutrons (heaviest), respectively.

2. Count the number of small, medium, and large M&M's in your baggie and record this number in the data table below.

3. Using a weigh boat, measure the masses of each "isotope" sample and the total mass of your M&M's and record these numbers in the data table. ****REMEMBER to ZERO out the weigh boat before you put your M&Ms on the scale!*

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Data Table 1. Station number________________ M&M color__________________________

	Number of M&M's	**Total Mass of this size M&M's (include units)**	**Calculate the average mass of each isotope using the formula** $Average\ Mass = \frac{Total\ Mass\ of\ that\ isotope}{\#\ of\ M\&M's of\ that\ size}$ **Show your work and answer.**	**Calculate the fractional abundance of each isotope. Of all the M&M's you have, what fraction of them are small, medium, and large?** $Fractional\ Abundance = \frac{\#\ of\ each\ size\ M\&M}{TOTAL\ \#\ of all\ M\&M's}$ **Show your work and answer.**
Isotope #1 – small M&M's				
Isotope #2 – medium M&M's				
Isotope #3 - large M&M's				
Totals (add all numbers in the column)				

A. Calculate the average atomic mass using the "totals" row numbers and the following equation:

$$\text{Average Atomic mass} = \frac{Total\ Mass\ of\ all\ M\&M's\ in\ baggie}{Total\ number\ of\ M\&M's\ in\ baggie}$$

Show your work and answer.

B. Calculate the weighted average "atomic mass" of your M&M's using the equation:

Average Atomic mass =Σ(fractional abundance × average isotopic mass)

Show your work and answer.

Repeat the Experimental Procedure for 2 more stations.

Data Table 2. Station number________________ M&M color__________________________

	Number of M&M's	Total Mass of this size M&M's (include units)	Calculate the average mass of each isotope using the formula $Average\ Mass = \frac{Total\ Mass\ of\ that\ isotope}{\#\ of\ M\&M's\ of\ that\ size}$ Show your work and answer.	Calculate the fractional abundance of each isotope. Of all the M&M's you have, what fraction of them are small, medium, and large? $Fractional\ Abundance = \frac{\#\ of\ each\ size\ M\&M}{TOTAL\ \#\ of\ all\ M\&M's}$ Show your work and answer.
Isotope #1 – small M&M's				
Isotope #2 – medium M&M's				
Isotope #3 - large M&M's				
Totals (add all numbers in the column)				

A. Calculate the average atomic mass using the "totals" row numbers and the following equation:

$$\text{Average Atomic mass} = \frac{Total\ Mass\ of\ all\ M\&M's\ in\ baggie}{Total\ number\ of\ M\&M's\ in\ baggie}$$

Show your work and answer.

B. Calculate the weighted average "atomic mass" of your M&M's using the equation:

$$\text{Average Atomic mass} = \Sigma(\text{fractional abundance} \times \text{average isotopic mass})$$

Show your work and answer.

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Data Table 3. Station number________________   M&M color__________________________

	Number of M&M's	**Total Mass of this size M&M's (include units)**	**Calculate the average mass of each isotope using the formula** $Average\ Mass = \frac{Total\ Mass\ of\ that\ isotope}{\#\ of\ M\&M's\ of\ that\ size}$ **Show your work and answer.**	**Calculate the fractional abundance of each isotope. Of all the M&M's you have, what fraction of them are small, medium, and large?** $Fractional\ Abundance = \frac{\#\ of\ each\ size\ M\&M}{TOTAL\ \#\ of\ all\ M\&M's}$ **Show your work and answer.**
Isotope #1 – small M&M's				
Isotope #2 – medium M&M's				
Isotope #3 - large M&M's				
Totals (add all numbers in the column)				

A. Calculate the average atomic mass using the "totals" row numbers and the following equation:

$$\text{Average Atomic mass} = \frac{Total\ Mass\ of\ all\ M\&M's\ in\ baggie}{Total\ number\ of\ M\&M's\ in\ baggie}$$

Show your work and answer.

B. Calculate the weighted average "atomic mass" of your M&M's using the equation:

$$\text{Average Atomic mass} = \Sigma(\text{fractional abundance} \times \text{average isotopic mass})$$

Show your work and answer.

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Write your answers to questions A & B on the board under the appropriate station heading.

Think about it questions:

1. How does your average mass from Data Table 1 (question A) compare to the weighted average mass based upon isotopic abundance (question B)? Is the same true for Data Table 2 and 3? Explain.

2. Which method of calculating atomic mass do you think is more likely to give you a "true" average mass – the simple average method in question A or the weighted average method in question B? Explain why you answered that.

3. Considering the class data on the board, is your weighted average atomic mass (question B) close to or the same as that of other groups for all 3 stations that your group completed? Why do you think that is?

4. Looking at your own data, is your weighted average atomic mass (question B) the same for any of the stations you ran (within experimental error)? Are any different? Using your data tables, explain why this observation is true.

5. If a classmate ate a *random handful* of M&M's from one of the stations before your group got to that station, do you think your weighted average mass (question B) for that station would be the same as it was for a group who finished at that station prior to the classmate eating the handful. Explain your answer.

6. If that same classmate ate a *single* M&M from one of the stations before your group got to that station, do you think your weighted average mass (question B) for that station would be the same as it was for a group who finished at that station prior to the classmate eating the candy. Explain your answer.

7. If you were to weigh any piece of candy from a bag of M&Ms, would it have the weighted average mass you calculated? Explain.

8. All atoms of an element have the same number of protons, but the number of neutrons in an atom can vary. The nuclear symbol of any element is given by $^{A}_{Z}X$. The superscript, A, in a nuclear symbol represents the sum of the number of protons and neutrons. The subscript, Z, indicates the number of protons, or the atomic number. Since an atom is electrically neutral, the number of electrons can also be determined from the nuclear symbol because it is equal to the number of protons. Bromine has 2 isotopes, $^{79}_{35}Br$ and $^{81}_{35}Br$. How many protons, neutrons, and electrons are in each of these isotopes?

9. If the fractional abundance of $^{79}_{35}Br$ and $^{81}_{35}Br$ are 0.5069 and 0.4931 respectively, calculate the weighted average atomic mass of bromine if the masses are 78.9183 amu for $^{79}_{35}Br$ and 80.9163 amu for $^{81}_{35}Br$.

10. Does any single atom actually have the weighted average atomic mass of bromine that you calculated in question 9? If not, explain why it is ok to use the weighted average atomic mass as given on the periodic table in all calculations requiring an atomic mass in this class.