# Average Atomic Mass

How are the masses on the periodic table determined?

Why?

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
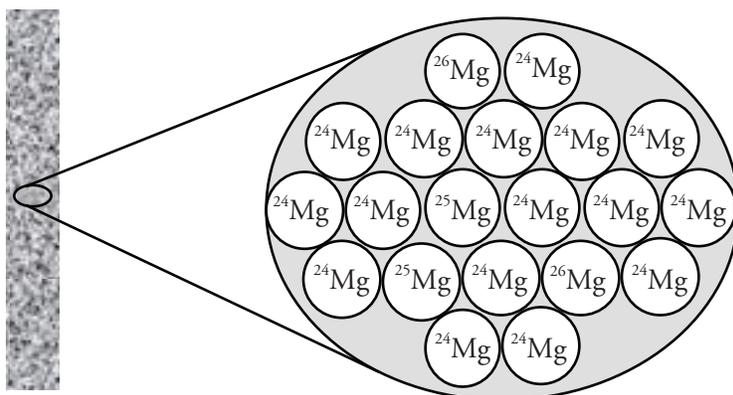
1. Write in the atomic number for each Mg atom in Model 1.

2. What are the mass numbers of the naturally occurring isotopes of magnesium shown in Model 1?

3. Do all of the atoms of magnesium in Model 1 have the same atomic mass? Explain.

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

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

6. Based on Model 1 and the table you created in Question 4, for every 10 atoms of magnesium, approximately how many atoms of each isotope will be found?

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

7. Consider the natural abundance information given in Model 2.

    a. Calculate the expected number of atoms of each isotope that will be found in a sample of 20 atoms of Mg. *Hint:* The number of atoms must be a whole number!

    b. Is Model 1 accurate in its representation of magnesium at the atomic level? Explain.

8. 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. Explain your reasoning.

9. Refer to a periodic table and find the box for magnesium.

    a. Write down the 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?

10. The periodic table does not show the atomic mass of every isotope for an element.

    a. Explain why this would be an impractical goal for the periodic table.

    b. Is it important to the average scientist to have information about a particular isotope of an element? Explain.

11. What would be a practical way of showing the mass of magnesium atoms on the periodic table given that most elements occur as a mixture of isotopes?

12. Propose a possible way to calculate the average atomic mass of 100 magnesium atoms. Your answer may include a mathematical equation, but it is not required.

Model 3 – Proposed Average Atomic Mass Calculations

Mary's Method

$$\frac{(78.99)(23.9850 \text{ amu}) + (10.00)(24.9858 \text{ amu}) + (11.01)(25.9826 \text{ amu})}{100} = \underline{\hspace{2cm}}$$

Jack's Method

$$(0.7899)(23.9850 \text{ amu}) + (0.1000)(24.9858 \text{ amu}) + (0.1101)(25.9826 \text{ amu}) = \underline{\hspace{2cm}}$$

Alan's Method

$$\frac{23.9850 \text{ amu} + 24.9858 \text{ amu} + 25.9826 \text{ amu}}{3} = \underline{\hspace{2cm}}$$

13. Complete the three proposed calculations for the average atomic mass of magnesium in Model 3.

14. Consider the calculations in Model 3.

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

    b. Explain why the mathematical reasoning was incorrect for any method(s) in Model 3 that did not give the correct answer for average atomic mass (the one on the periodic table).

    c. For the methods in Model 3 that gave the correct answer for average atomic mass, show that they are mathematically equivalent methods.

15. 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.

16. Consider the individual atomic masses for magnesium isotopes given in Model 2.

    a. Which isotope has an atomic mass closest to the average atomic mass listed on the periodic table?

    b. Give a mathematical reason for your answer to part *a*.

17. Boron has two naturally occurring isotopes: boron-10 and boron-11. Which isotope is more abundant on Earth? Use grammatically correct sentences to explain how your group determined the answer.

Extension Questions

Model 4 – Allotropes of Carbon

Natural Sample	Properties	Structure	Composition
 Graphite	Black Soft Conductive		98.89% Carbon-12 1.11% Carbon-13
 Diamond	Colorless Very hard Insulator		98.89% Carbon-12 1.11% Carbon-13
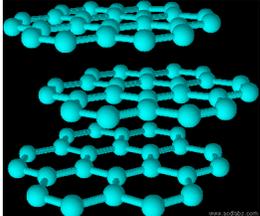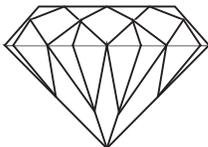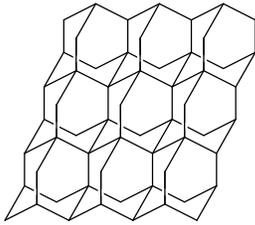
18. Consider the information about carbon provided in Model 4.

    a. Are diamonds and graphite made from the same element?

    b. Can the existence of isotopes explain the difference in properties between diamond and graphite? Explain.

    c. Propose an explanation for the difference in properties between diamond and graphite.

19. O_2 and O_3 (ozone) are allotropes of oxygen. Buckminsterfullerene (C_{60}) is another allotrope of carbon. Based on these statements and the information in Model 4, propose a definition for **allotrope**.

20. Two common forms of phosphorus are red and white. Red phosphorus is fairly stable at room temperature in air, but white phosphorus can ignite easily when exposed to air. Is this difference in properties due to the existence of different isotopes of phosphorus or different allotropes? Explain.