Name _____ pd. _____

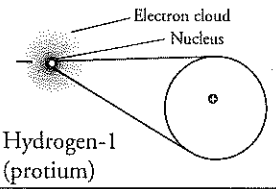
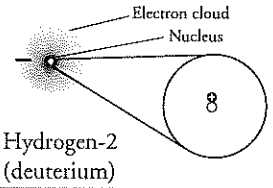
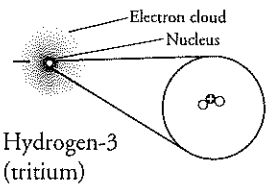
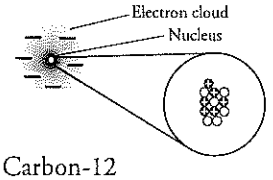
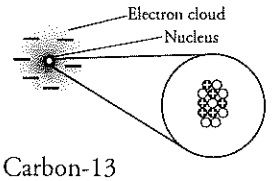
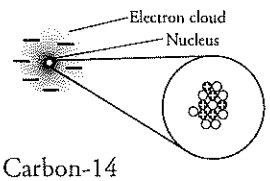
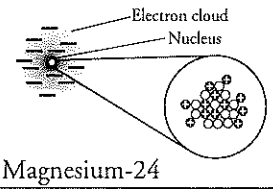
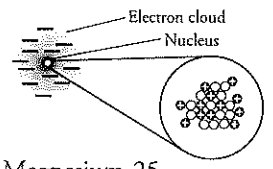
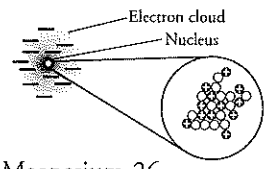
# Isotopes

Are all atoms of an element alike?

## Why?

The following activity will help you learn the important structural characteristics of an atom. How do we classify atoms? How does the combination of subatomic particles affect the mass and charge of an atom? What are isotopes? This is just a sampling of what we will address. Throughout this activity you will want to keep both Model 1 and a periodic table handy.

## Model 1

| Isotopes of Hydrogen | | | |
|---|---|---|---|
| Symbol | $^{1}_{1}H$ | $^{2}_{1}H$ | $^{3}_{1}H$ |
| Atomic Diagram with Name |  Hydrogen-1 (protium) |  Hydrogen-2 (deuterium) |  Hydrogen-3 (tritium) |
| Number of Protons ⊕ | | | |
| Number of Neutrons ○ | | | |
| **Isotopes of Carbon** | | | |
| Symbol | $^{12}_{6}C$ | $^{13}_{6}C$ | $^{14}_{6}C$ |
| Atomic Diagram with Name |  Carbon-12 |  Carbon-13 |  Carbon-14 |
| Number of Protons ⊕ | | | |
| Number of Neutrons ○ | | | |
| **Isotopes of Magnesium** | | | |
| Symbol | $^{24}_{12}Mg$ | $^{25}_{12}Mg$ | $^{26}_{12}Mg$ |
| Atomic Diagram with Name |  Magnesium-24 |  Magnesium-25 |  Magnesium-26 |
| Number of Protons ⊕ | | | |
| Number of Neutrons ○ | | | |

Key

3 ← mass number = $p^+ + n^0$

$^{3}_{1}H$

1 ↖ $p^+$ = atomic number

1. Refer to Model 1. What subatomic particles do the following symbols represent in the Atomic Diagrams?

2. Complete the table in Model 1 by counting the protons and neutrons in each atomic diagram. Divide the work evenly among group members.
3. Find the three elements shown in Model 1 on your periodic table.
   *a.* What whole number shown in Model 1 for each element is also found in the periodic table for that element?

   Hydrogen — Carbon — Magnesium —

   *b.* The whole number in each box of the periodic table is the atomic number of the element. What does the **atomic number** of an element represent?

   *c.* Refer to the isotope symbols in Model 1. Relative to the atomic symbol (H, C, or Mg), where is the atomic number located in the isotope symbol?

4. Refer to your periodic table.
   *a.* How many protons are in all chlorine (Cl) atoms?

   *b.* A student says "I think that some chlorine atoms have 16 protons." Explain why this student is not correct.

5. Refer again to Model 1. In the isotope symbol of each atom, there is a superscripted (raised) number. This number is also used in the name of the atom (*i.e.*, carbon-12). It is called the **mass number**.
   *a.* How is the mass number determined?

   *b.* Why is this number called a "mass" number?

*b.* Do all isotopes of an element have the same mass number? Give at least one example or counter-example from Model 1 that supports your answer.

12. Considering your answers to Question 11, write a definition of **isotope** using a grammatically correct sentence. Your group must come to consensus on this definition.


13. Consult the following list of isotope symbols: $^{204}_{82}Pb$, $^{82}_{35}Br$, $^{78}_{35}Br$, $^{208}_{82}Pb$, $^{204}_{78}Pt$, $^{205}_{82}Pb$.

*a.* Which of the atoms represented by these symbols are isotopes of each other?

*b.* Which part(s) of the isotope symbol was the most helpful in answering part *a* of this question?

14. Fill in the following table.

| **Isotope Symbol** | $^{40}_{19}K$ | $^{18}_{9}F$ | |
|---|---|---|---|
| **Atomic Number** | | | 16 |
| **Mass Number** | | | |
| **Number of Protons** | | | |
| **Number of Neutrons** | | | 15 |

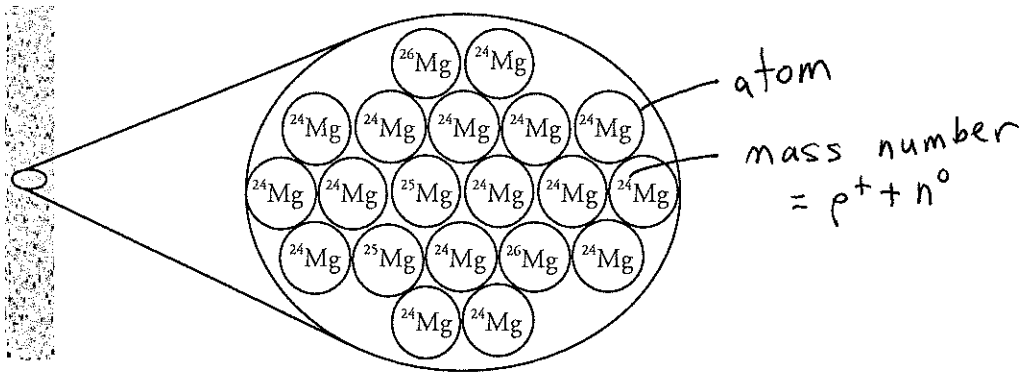
# Average Atomic Mass

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, fill in a table indicating the mass numbers of the three isotopes and the number of atoms of each isotope present.

| mass | # atoms |
|---|---|
| | |
| | |
| | |

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 3 – Proposed Average Atomic Mass Calculations

round to tenths

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

8. 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.

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. round to hundredths

| 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 |