Average Atomic Masses

Strand Atomic Structure and Periodic Relationships

Topic Investigating isotopes and the periodic table

Primary SOL CH.2 The student will investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of
a) average atomic mass, mass number, and atomic number.

Related SOL CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include
a) designated laboratory techniques;
b) safe use of chemicals and equipment;
d) manipulation of multiple variables, using repeated trials;
e) accurate recording, organization, and analysis of data through repeated trials;
f) mathematical and procedural error analysis;
g) mathematical manipulations including SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, and dimensional analysis;
h) use of appropriate technology including computers, graphing calculators, and probeware for gathering data, communicating results, and using simulations to model concepts.

Background Information
The atomic mass of each element on the periodic table is a weighted average of the masses of all naturally occurring isotopes of the element.

Materials
- Electronic balances (analytical balance, if available)
- Small weighing boats
- Calculators
- Large dried beans (e.g., lima beans)
- Small cups

Vocabulary
average atomic mass, average mass, isotope

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)
The following activity is one way for students to grasp the idea of differences in masses of individual atoms and how they are averaged to yield the atomic mass of an element. By using objects such as large dried beans whose masses vary slightly, students will be able to determine the average mass for a model "element," named Bean. Beans that have relatively large masses, such as lima beans, work best. A comparison of the results of different teams will demonstrate

analysis through repeated trials and the analysis of errors. This activity requires an electronic balance with 0.001 g precision.

1. Put students into small groups, and provide each group with an electronic balance, several small weighing boats, a calculator, and 10 large dried beans.
2. Have each team place a weighing boat on the scale and weigh and record the mass of each of the 10 beans.
3. Instruct students to calculate the average mass of one bean in their group of 10.
4. Have teams compare their average masses. Then, have the class calculate the average of all the averages.
5. Mass a full cup of beans. Then, have students calculate and estimate of the number of beans in the cup, based on the class average mass of one bean.
6. Tell students that the cup of beans can be compared to a mole. Explain how we use a quantity of atoms in a mole for calculations because it is impractical for us to measure the mass of one atom. (Nevertheless, use of a mass spectrometer is the way we identify different isotopes.)

Assessment

- **Questions**
  - Complete the table with the appropriate information.

Element	Elemental Symbol	Atomic Number	Most Abundant Isotope	Family Name	Average Atomic Mass
astatine					
xenon					
radium					
strontium					
lead					
sodium					
argon					
cesium					
bromine					
hydrogen					
chlorine					
uranium					

  - What are the isotope symbols for the following?
    - Chlorine-35
    - Manganese-53
    - Barium-135
    - Cobalt-60
    - Titanium-48
    - Curium-243
    - Calcium-46
    - Potassium-41
    - Krypton-80

    - Tin-114
    - Gold-197
  - There are two principal stable isotopes for chlorine: ^{35}Cl, which comprises about 75.76% of all chlorine atoms, and ^{37}Cl, which makes up the other 24.24%. What is the average atomic mass of chlorine, calculated to four significant figures?
  - Naturally occurring iron (Fe) consists of four primary isotopes: 5.845% of ^{54}Fe , 91.754% of ^{56}Fe, 2.119% of ^{57}Fe, and 0.282% of ^{58}Fe. What is the average atomic mass of iron?
- **Journal/Writing Prompts**
  - Since opposite charges attract and like charges repel, explain why the protons, all of which are positively charged, remain in the nucleus together and do not fly apart. Also, since opposites attract, explain why the electrons, which are negative, do not fly into the nucleus, which is positive.
- **Other**
  - Have students select an element on which to prepare a presentation that reveals its atomic number, average mass, specific properties, uses of its compounds, and anything else discovered. Have the class vote on the best presentation.
  - Have students use toothpicks, gumdrops, and/or other small candies to build an atom. Have them use one type of item to represent protons, another type for neutrons, and a much smaller type for electrons. The protons and neutrons should be close together in the nucleus, while the electrons should be widely separated from the nucleus.

Extensions and Connections (for all students)

- Assign each member of a team a different component of the atom (i.e., protons, neutrons, electrons, isotope information) about which to present information to the remainder of the team. Have team members work together to communicate the information to each other, recording all information in a graphic organizer of their choice.
- Inform students that particle physics is the discipline that examines the quarks, leptons, and baryons that are believed to compose the protons and neutrons in an atom's nucleus. Have students research articles on these fundamental subatomic particles.

Strategies for Differentiation

- Allow students to specify the sample for each mass trial, making sure they carry out at least three trials.
- Have students construct a bar graph with the number of beans of similar mass to demonstrate variation of atomic mass.

Ed. Note: Does this make any sense?