TITLE
Isotopes and Atomic Mass

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COURSE
General Chemistry I

TYPE
In-Class Guided-Inquiry Activity

TEACHING MODE
Facilitated Group Inquiry

LEARNING GOALS
Students will be able to:

- Explain the difference between atomic mass and mass number
- Calculate average atomic mass from percent abundance and isotopic mass.

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PhET INTERACTIVE SIMULATIONS

ISOTOPES AND ATOMIC MASS

Commented [YC1]: Learning goals:
- Explain the difference between atomic mass and mass number
- Calculate average atomic mass from percent abundance and isotopic mass.

MODEL 1: Make Isotopes

Open the Isotopes and Atomic Mass simulation
http://phet.colorado.edu/en/simulation/isotopes-and-atomic-mass

Play with the "Make Isotopes" tab of the simulation for a few minutes and then answer the following questions.

1. What particles determine the mass number?
2. Why is mass number always a whole number?
3. One isotope of carbon (C) has exactly the same mass number and atomic mass since it was used as the definition of the atomic mass unit (amu). Which isotope is it and what is its atomic mass?
4. What is the approximate mass of one proton? _________amu
5. What is the approximate mass of one neutron? _________amu
6. Look at 3 or 4 other atoms using the simulation. Do any of them have a whole number for atomic mass?

Commented [TH2]: Facilitation tip: This is a good time to stop and briefly discuss mass defect and possible $E=mc^2$ and to reinforce the reasons why ^{12}C has the only exact mass.

MODEL 2: Mix Isotopes

Play with the "Mix Isotopes" tab for a few minutes, then answer the following questions.

1. What are the factors that affect the average atomic mass of a mixture of isotopes?
2. Beryllium (Be) and Fluorine (F) have only one stable isotope. Use the sim and the periodic table to complete the following table:

Element	Mass of 1 atom	Average mass of 2 atoms (sim)	Average mass of 3 atoms (sim)	Atomic mass (periodic table)
Beryllium (Be)	9.01218 amu			
Fluorine (F)	18.99840 amu			

3. Why are all the values in each row of the table above the same?

4. Lithium has only two stable isotopes. Use the sim to determine the following:
   a. Atomic mass of lithium-6 = _______________amu
   b. Atomic mass of lithium-7 = _______________amu
   c. Average atomic mass of a sample containing three lithium-6 atoms and two lithium-7 atoms. ____________amu
   d. Is the average atomic mass you just determined closer to the mass of lithium-6 or lithium-7? Explain

5. Describe a method to calculate the average atomic mass of the sample in the previous question using only the atomic masses of lithium-6 and lithium-7 without using the simulation.

Commented [YC3]: Facilitation tip:
Questions 5-6 in this section focus on the calculation of average atomic mass using the number of atoms of each isotope, which is typically easier for students than the calculation of average atomic mass from percent abundance.

We extend this calculation to the use of percent abundances in the next section, Nature's Mix of Isotopes

6. Test your method by creating a few sample mixtures of isotopes with the sim and see if your method correctly predicts the average atomic mass of that sample from only the atomic masses of the isotopes and the quantity of each isotope. Use the table below to track your progress.

Element	Atomic mass and quantity of *each* isotope	Average atomic mass of sample (calculate yourself)	Average atomic mass of sample (from simulation)

MODEL 3: Nature's mix of isotopes

1. Using the sim, examine "Nature's mix of isotopes" for several different elements. If you assumed 100 total atoms in a sample, how could you relate the % values shown in the sim into a number you could use for your calculation of average atomic mass?

2. Calculate the atomic mass of each of the following elements using your method from above. Test your answer using the Nature's mix of isotopes and the periodic table. Keep going until you can get two in a row right.

	Isotope 1		**Isotope 2**		**Isotope 3**			**Check answer with sim**	
Element	**Mass (amu)**	**%age**	**Mass (amu)**	**%age**	**Mass (amu)**	**%age**	**Calculated average atomic mass (amu)**	**Yes**	**No**
Hydrogen	1.007	99.98	2.01410	0.011	-	-			
Silicon	27.97	92.22	28.9764	4.685	29.97377	3.092			
Nitrogen	14.00	99.63	15.0001	0.364	-	-			
Argon	35.96	0.336	37.9627	0.063	39.96238	99.60			

Calculations / Rough work:

EXERCISES

Commented [TH4]: These exercises could be left for take-home practice, as they focus primarily on computational skill, not conceptual understanding.

1. Titanium has five common isotopes:
   ^{46}Ti (8.00%), mass= 45.953 amu
   ^{47} Ti (7.80%), mass= 46.952 amu
   ^{48}Ti (73.40%), mass= 47.947 amu
   ^{49}Ti (5.50%), mass= 48.948 amu
   ^{50}Ti (5.30%), mass = 49.945 amu
   Calculate the average atomic mass of titanium.

2. The atomic mass of boron is 10.81 amu. Boron has two isotopes: Boron-10 has a mass of 10.01 amu. Boron-11 has a mass of 11.01 amu. What is the %age of each isotope in boron? (check your answer with the simulation)

3. A certain sample of rubidium has just two isotopes, ^{85}Rb (mass = 84.911amu) and ^{87}Rb (mass = 86.909amu). The atomic mass of this sample is 86.231 amu. What are the percentages of the isotopes in this sample?