ChemActivity 1

The Nuclear Atom

(What Is an Atom?)

Model: Schematic Diagrams for Various Atoms.

• electron (–)

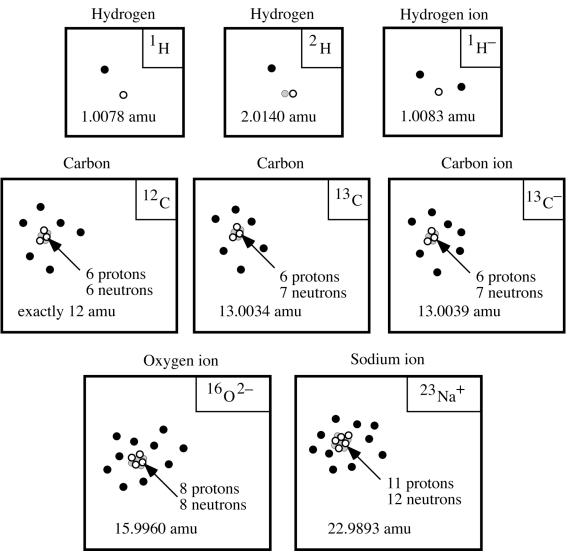
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proton (+)

$$1 \text{ amu} = 1.6606 \times 10^{-24} \text{ g}$$

• neutron (no charge)

The **nucleus** of an atom contains the protons and the neutrons.



¹H and ²H are **isotopes** of hydrogen.

¹²C and ¹³C are **isotopes** of carbon.

Critical Thinking Questions

- 1. How many protons are found in ${}^{12}C$? ${}^{13}C$? ${}^{13}C$??
- 2. How many neutrons are found in ${}^{12}C$? ${}^{13}C$? ${}^{13}C$?
- 3. How many electrons are found in ${}^{12}C$? ${}^{13}C$? ${}^{13}C$?
- 4. a) What feature distinguishes a neutral atom from an ion?
 - b) Provide an expression for calculating the charge on an ion.
- 5. Based on the model,
 - a) what do all carbon atoms (and ions) have in common?
 - b) what do all hydrogen atoms (and ions) have in common?
 - c) how many protons, neutrons, and electrons are there in one atom of ${}^{1}\text{H}^{+}$?
- 6. What is the significance of the atomic number, Z, above each atomic symbol in the periodic table?
- 7. Based on your answer to CTQ 6, what do all nickel (Ni) atoms have in common?

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- 8. What structural feature is different in isotopes of a particular element?
- 9. How is the mass number, A, (left-hand superscript next to the atomic symbol as shown in the Model) determined (from the structure of the atom)?
- 10. Where is most of the mass of an atom, within the nucleus or outside of the nucleus? Explain your reasoning using grammatically correct English sentences.

Exercises

1.	. Complete the following table.			
	Isotope	Atomic Number	Mass Number	Number of Electrons
		Z	А	
	31p	15		
	¹⁸ O			8
		19	39	18
	58 _{Ni} 2+		58	

- 2. What is the mass (in grams) of a) one ${}^{1}H$ atom? b) one ${}^{12}C$ atom?
- 3. What is the mass (in grams) of 4.35×10^6 atoms of ${}^{12}C$?
- 4. What is the mass (in grams) of 6.022×10^{23} atoms of ^{12}C ?
- 5. What is the mass (in grams) of one molecule of methane which has one ¹²C atom and four ¹H atoms, ¹²C¹H₄?
- 6. a) Define mass number. b) Define atomic number.

- Indicate whether the following statement is true or false and explain your reasoning.
 An ¹⁸O atom contains the same number of protons, neutrons, and electrons.
- 8. How many electrons, protons, and neutrons are found in each of the following?

 ^{24}Mg $^{23}Na^+$ ^{35}Cl $^{35}Cl^ ^{56}Fe^{3+}$ ^{15}N $^{16}O^{2-}$ $^{27}Al^{3+}$

- 9. Complete the following table. Isotope Atomic Mass Number of Number Number Electrons Ζ А 27 59 25 14N3 7 3 3 6 3 $58Zn^{2+}$ 19F-
- 10. Using grammatically correct English sentences, describe what the isotopes of an element have in common and how they are different.
- J. N. Spencer, G. M. Bodner, and L. H. Rickard, *Chemistry: Structure & Dynamics*, Fourth Edition, John Wiley & Sons, 2008. Chapter 1: Problems: 21, 24, 25, 29-31, 33, 49abd, 52.

Problems

- 1. Estimate the mass of one ¹⁴C atom (in amu) as precisely as you can (from the data in the model). Explain your reasoning.
- 2. Use the data in Model 1 to estimate the values (in amu) of a) the mass of an electron, b) the mass of a proton, and c) the mass of a neutron.
- 3. The mass values calculated in Problem 2 are only approximate because when atoms (up through iron) are made (mainly in stars) from protons, neutrons, and electrons, energy is released. Einstein's equation $E = mc^2$ enables us to relate the energy released to the mass loss in the formation of atoms. Use the known values for the mass of a proton, 1.0073 amu, the mass of a neutron, 1.0087, and the mass of an electron, 5.486×10^{-4} amu, to show that the mass of a ¹²C atom is less than the sum of the masses of the constituent particles.