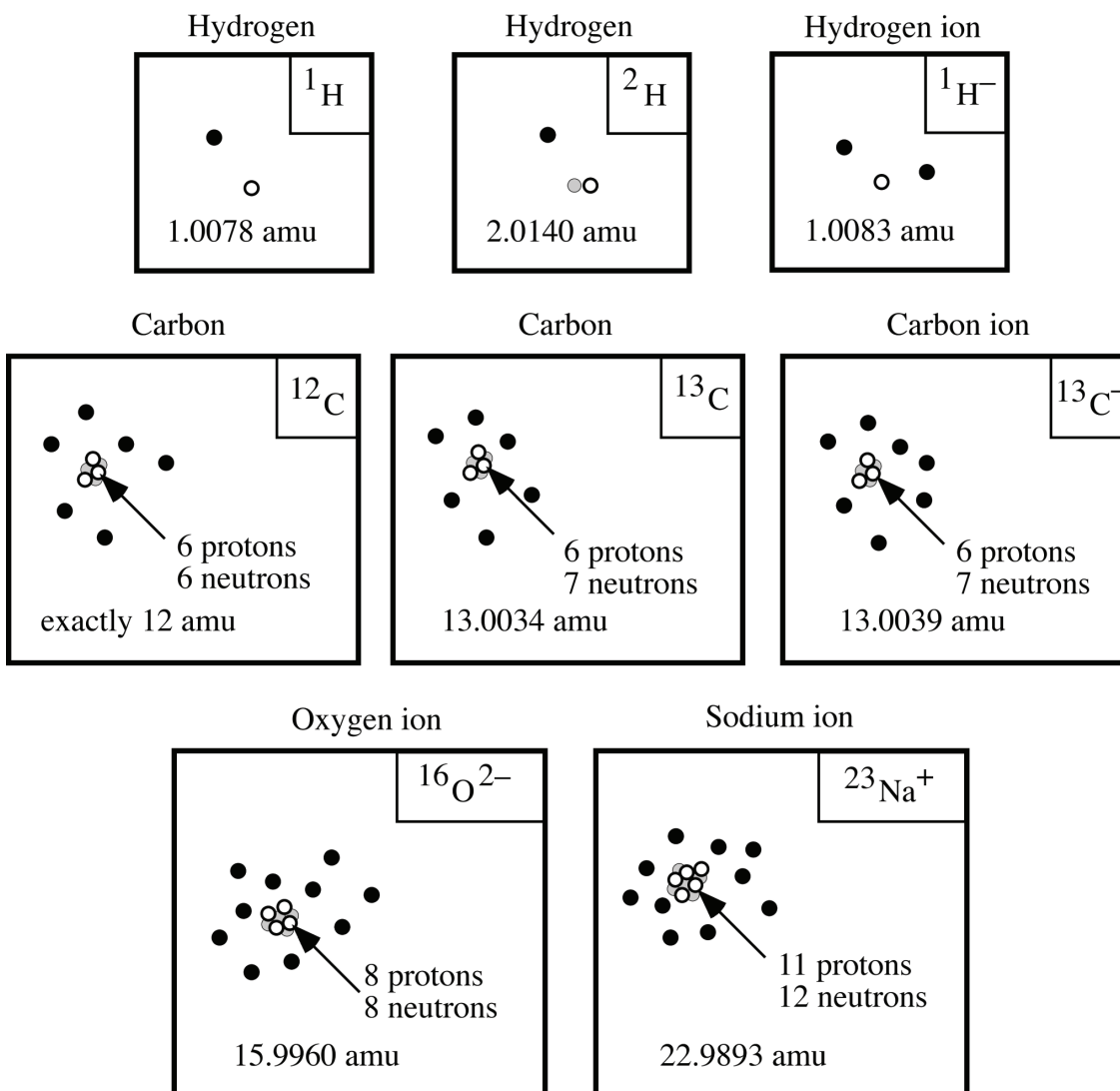## ChemActivity 1

The Nuclear Atom

(What Is an Atom?)

Model: Schematic Diagrams for Various Atoms.

● electron (−)

○ proton (+)

◌ neutron (no charge)

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

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

Hydrogen

^1H

1.0078 amu

Hydrogen

^2H

2.0140 amu

Hydrogen ion

$^1\text{H}^-$

1.0083 amu

Carbon

^{12}C

6 protons
6 neutrons
exactly 12 amu

Carbon

^{13}C

6 protons
7 neutrons
13.0034 amu

Carbon ion

$^{13}\text{C}^-$

6 protons
7 neutrons
13.0039 amu

Oxygen ion

$^{16}\text{O}^{2-}$

8 protons
8 neutrons
15.9960 amu

Sodium ion

$^{23}\text{Na}^+$

11 protons
12 neutrons
22.9893 amu

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

^{12}C and ^{13}C 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. Based on your answers to CTQs 1-3, what do all carbon atoms (and ions) have in common?

5. Based on the model, what do all hydrogen atoms (and ions) have in common?

6. Based on your answers to CTQs 4 and 5, 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?

8. In terms of the numbers of protons, neutrons and electrons:

   a) Why does the notation $^{13}C^-$ have a negative sign in the upper right hand corner?

   b) What feature distinguishes a neutral atom from an ion?

   c) Provide an expression for calculating the charge on an ion.

9. Determine the number of protons, neutrons, and electrons in one $^1\text{H}^+$ ion. Explain how you found your answer.

10. What structural feature is different in isotopes of a particular element?

11. 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)?

12. Show that the mass number and charge given for $^{16}\text{O}^{2-}$ and $^{23}\text{Na}^+$ are correct in Model 1.

13. Based on the information in Model 1, 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 Z	Mass Number A	Number of Electrons
^{31}P	15		
^{18}O			8
	19	39	18
$^{58}Ni^{2+}$		58	

2. What is the mass (in grams) of a) one ^1H 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 ^{12}C atom and four ^1H atoms, $^{12}C^1H_4$?

6. a) Define mass number. b) Define atomic number.

7. Indicate whether the following statement is true or false and explain your reasoning.

   An ^{18}O 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 Number Z	Mass Number A	Number of Electrons
	27	59	25
^{14}N			
	3	7	3
	3	6	3
$^{58}Zn^{2+}$			
$^{19}F^-$			

10. Using grammatically correct English sentences, describe what the isotopes of an element have in common and how they are different.

Problems

1. Estimate the mass of one ^{14}C 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 ^{12}C atom is less than the sum of the masses of the constituent particles.