

Atoms and Ions

(adapted from Chemistry A Guided Inquiry, Moog, R. S. and Farrell, J. J.)

There are 118 different elements currently on the periodic table. With the exception of technetium, all the elements with atomic numbers below 92, uranium, have been found in nature. These naturally occurring elements, either individually or combined, make up everything you have or will ingest, inject, buy, sell, breathe or see in your lifetime. Some of these elements are required in our body to sustain life but at the same time if we consume too much of the element we will die. As a nurse you will give many elements or compounds to sick patients in order to improve their health. As a fisheries and wildlife professional, you may have water samples analyzed to determine what element or compound is killing the fish population. As an emergency manager or administrator, you would need to know what elements would be released during a nuclear accident and how harmful they would be to the public. Understanding the neutron, proton and electron structure of the atom is essential in understand elements, compounds and ions and ultimately the benefit or harm they offer.

Prerequisites

- Definition of proton, neutron, and electron
- Basic atomic structure; protons and neutrons in nucleus, electrons around the outside
- Atomic symbols from the Periodic Table

Objectives

At the conclusion of this worksheet, the student will be able to:

- Define atomic number and mass number.
- Determine the atomic charge on an atom, given the number of protons and electrons.
- Define the symbols A, X, Z and n used in ${}^A_Z X^n$

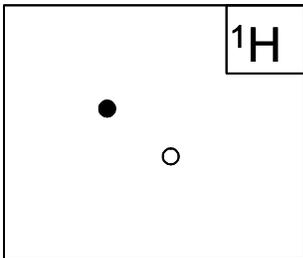
Pre-class Activity

Information

On the following page is a schematic representation of various atoms.

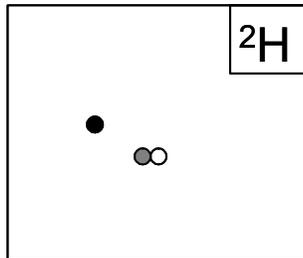
Model

Hydrogen



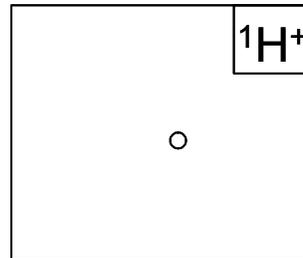
___ e⁻ ___ p⁺ ___ n

Hydrogen



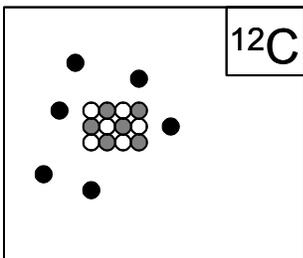
___ e⁻ ___ p⁺ ___ n

Hydrogen ion



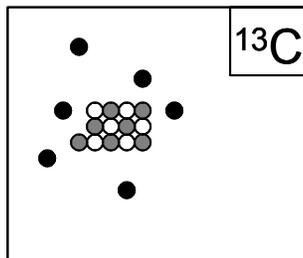
___ e⁻ ___ p⁺ ___ n

Carbon



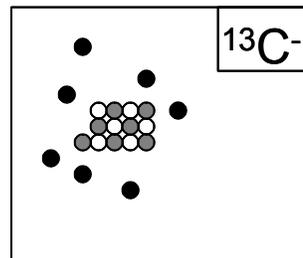
___ e⁻ ___ p⁺ ___ n

Carbon



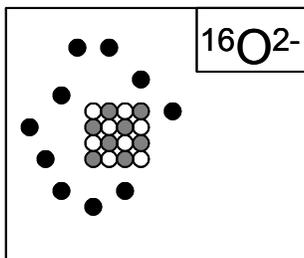
___ e⁻ ___ p⁺ ___ n

Carbon ion



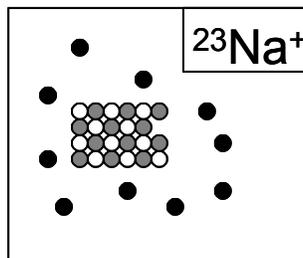
___ e⁻ ___ p⁺ ___ n

Oxygen ion



___ e⁻ ___ p⁺ ___ n

Sodium ion



___ e⁻ ___ p⁺ ___ n

Legend

- electron, e⁻, -1 charge
- proton, p⁺, +1 charge
- neutron, n, no charge

Key Questions

1. Count the number of electrons (e^-), protons (p^+), and neutrons (n) in each of the atoms and put those numbers in the blanks below the atoms.
2. Looking at the diagrams of the atoms what patterns do you see?
3. What questions about the diagrams do you have?
4. How many protons are found in:
 ^{12}C ?
 ^{13}C ?
 $^{13}\text{C}^-$?
5. How many neutrons are found in:
 ^{12}C ?
 ^{13}C ?
 $^{13}\text{C}^-$?
6. How many electrons are found in:
 ^{12}C ?
 ^{13}C ?
 $^{13}\text{C}^-$?

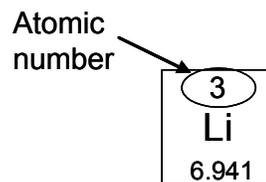
In-class Activity

Assign the roles of manager, presenter, recorder, and reader based on the number of letters in your first name (many \rightarrow few).

Compare your answers to Questions 1-6 with your group. *Spend no more than 5 minutes.*

Information

The **atomic number** is the whole number that appears above the symbol of each element on the periodic table. The periodic table is arranged with the elements in increasing atomic number.



Key Questions

7. Based on the model on the previous page,
 - a. What do all carbon atoms (and ions) have in common?

 - b. What do all hydrogen atoms (and ions) have in common?

8. What is the atomic number:
 - a. for carbon?

 - b. for hydrogen?

9. Comparing your answers to 7 and 8, what do you think the atomic number represents?

10. What is the atomic number for sodium (Na)?

11. How many protons does the sodium ion from the model contain?

12. How many protons does any atom of sodium contain?

13. Give the number of protons for the following atoms:
 - a. Silver, Ag

 - b. Uranium, U

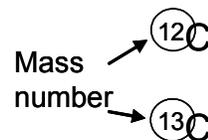
 - c. Phosphorus, P

14. Carbon-12 can be written as $^{12}_6\text{C}$. The number 6 represents the atomic number. Why is it generally left off of the symbol?

Information

All the subatomic particles are extremely small compared with the things you see around you. One proton has a mass of 1.673×10^{-24} g, and the neutron is about the same. The mass of the electron is almost 2000 times smaller than the mass of the proton and neutron, 9.110×10^{-28} g. Because the electron mass is so small, it is usually ignored in atomic mass calculations.

Single atoms are assigned a **mass number**. It can be found as the left-hand superscript next to the atomic symbol or after the name of the element; carbon-12 (^{12}C). However, the mass number does NOT appear on the periodic table because it applies to single atoms only.



Key Questions

15. Hydrogen-1 (^1H) and hydrogen-2 (^2H) are isotopes of hydrogen. Carbon-12 (^{12}C) and carbon-13 (^{13}C) are isotopes of carbon.
 - a. Do isotopes have the same number of protons or different numbers of protons?
 - b. Do isotopes have the same number of neutrons or different numbers of neutrons?
16. Based on the model at the beginning of this activity, what do you think the mass number represents?
17. Give the number of protons and neutrons for the following atoms.
 - c. Thorium-234 (^{234}Th)
 - d. Bromine-81 (^{81}Br)
 - e. Lead-206 (^{206}Pb)

Information

An atom which has an electrical charge because of a loss or gain of electrons is called an **ion**.

Key Questions

18. Look at the sodium ion present in the model at the beginning of this activity.
- How many protons does the sodium ion contain?
 - How many electrons does the sodium ion contain?
 - Since each proton has a +1 charge and each electron has a -1 charge, what is the overall charge of the ion?
 - The symbol for the sodium ion is $^{23}\text{Na}^+$. Where on the symbol is the charge of an ion indicated?
19. Look at the oxygen ion present in the model at the beginning of this activity.
- How many protons does the oxygen ion contain?
 - How many electrons does the oxygen ion contain?
 - What is the overall charge of the ion?
20. Why is there no charge indicated for the ^{12}C atom in the model at the beginning of this activity?
21. How many protons, neutrons, and electrons are there in one ion of $^{19}\text{F}^-$?

22. Complete the following table.

Isotope	Atomic Number	Mass Number	Number of protons	Number of neutrons	Number of electrons	Charge
^{31}P					15	
^{18}O			8	10		
	19	39			18	
$^{58}\text{Ni}^{2+}$		58				

Reflection

1. Define mass number.
2. Define atomic number.
3. The following is the generic symbol of an atom. Define what A, Z, and n stand for.



Exercises

1. Indicate whether the following statement is true or false and explain your reasoning. An ${}^{18}\text{O}$ atom contains the same number of protons, neutrons, and electrons.

2. How many electrons, protons, and neutrons are found in each of the following?



3. Complete the following table.

Isotope	Atomic Number Z	Mass Number A	Number of Electrons
	27	59	25
${}^{14}\text{N}$			
	3	7	3
${}^{58}\text{Zn}^{2+}$			
${}^{19}\text{F}^-$			

4. Describe what the isotopes of an element have in common and how they are different.