FITCH (KEY) - SEE CHANGE BELOW

# Atoms and Their Isotopes

## *Why?*

Atoms and isotopes are identified by the numbers of protons, neutrons and electrons that they contain. Before you can understand the properties of atoms, how atoms combine to form molecules, and the properties of molecules, you must be familiar with the number of protons, neutrons and electrons associated with atoms.

## *Success Criteria*

- Identify the composition of atoms and their isotopes in terms of the numbers of protons, neutrons, and electrons.
- Use atomic symbols to represent different atoms and their isotopes.
- Efficient use of Periodic Table as a source of data.

## *Resources*

- Periodic Table

## *Information*

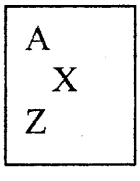
From the perspective of a chemist, the entire world is composed of atoms, and atoms are composed of protons, neutrons and electrons. Protons and neutrons are about 2000 times heavier than an electron. A proton has a charge of +1, a neutron has no charge and an electron has a charge of -1. The nucleus is very dense and very small compared to the entire atom.

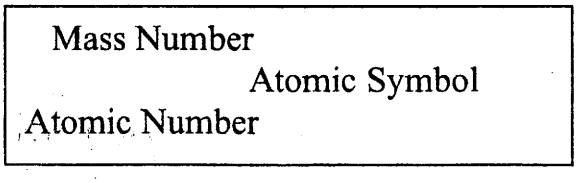
The properties of atoms are determined by the numbers of protons, neutrons and electrons that they contain. Atoms with the same number of protons but different number of neutrons are called isotopes of an element.

The isotopic notation for an atom includes the following information: symbol of the element, the element's atomic number (Z) which specifies the number of protons in the nucleus, and the mass number (A) which indicates the number of protons plus neutrons in the nucleus. [The number of electrons in a neutral atom is equal to the number of protons in the nucleus of the atom. The mass contributed by the electrons in an atom is very small, so it is not included when calculating the mass number.]

OUR PERIODIC TABLE HAS ATOMIC NUMBER ON TOP & ATOMIC MASS ON BOTTOM

***Atomic Symbol Notation***



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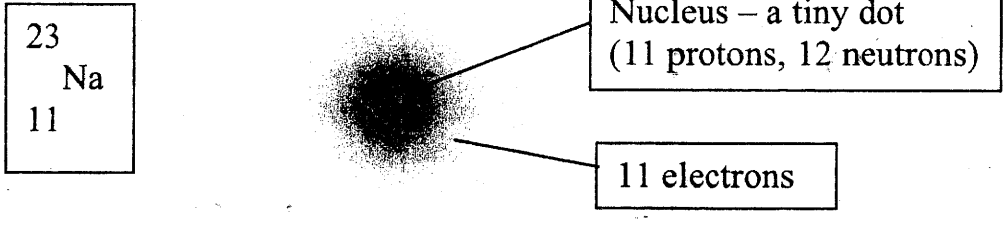
***Subatomic Particles***

| Particle | Symbol | Relative Charge | Absolute Mass | Relative Mass |
|---|---|---|---|---|
| electron | $e^-$ | -1 | $9.109 \times 10^{-31}$ kg | 0 |
| proton | $p^+$ | +1 | $1.673 \times 10^{-27}$ kg | 1 |
| neutron | $n^0$ | 0 | $1.675 \times 10^{-27}$ kg | 1 |

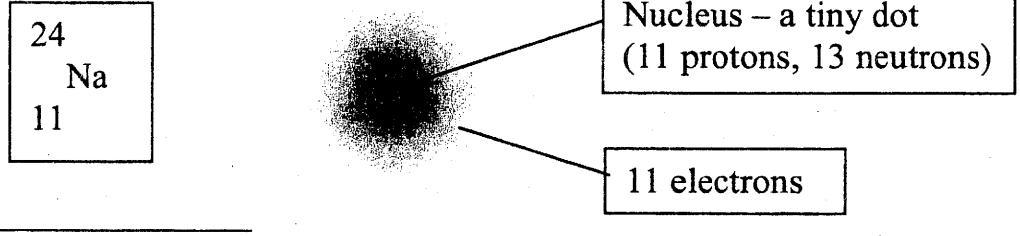
## *Model: Two Isotopes of Sodium*

The diagrams below show representations of sodium isotopes. [Note: the diameter of an atom is about 10,000 times larger than the diameter of the atomic nucleus so the relative sizes of the atom and the nucleus are not accurately depicted in these diagrams.]

**Isotope 1**




**Isotope 2**




## *Key Questions*

1. What information is provided by the atomic number, Z?

– #OF PROTONS

2. What information is provided by the mass number, A?

– #OF PROTONS + #OF NEUTRONS



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3. What is the relationship between the number of protons and the number of electrons in an atom?
   - IN AN UNCHARGED ATOM, # OF PROTONS = # OF ELECTRONS
4. Because of the relationship between the number of protons and number of electrons in an atom, what is the electrical charge of an atom?
   - IT HAS NO CHARGE
5. Where are the protons and neutrons located in an atom?
   - IN THE NUCLEUS
6. What do the two sodium isotopes shown in the model have in common with each other? # OF PROTONS & # OF ELECTRONS
7. How do the two sodium isotopes shown in the model differ from each other?
   - # OF NEUTRONS, THUS ATOMIC MASS
8. What distinguishes an atom of one element from an atom of another element?
   # OF PROTONS

## Exercises

1. Describe the similarities between $^{35}_{17}Cl$, and $^{37}_{17}Cl$.
   BOTH HAVE THE SAME # OF PROTONS AND ELECTRONS
2. Describe the differences between $^{35}_{17}Cl$, and $^{37}_{17}Cl$.
   THEY HAVE DIFFERENT #S OF NEUTRONS AND DIFFERENT ATOMIC MASSES
3. Write the atomic symbols for two isotopes of carbon, C, one with 6 neutrons and the other with 7 neutrons.

   $^{12}_{6}C$ $^{13}_{6}C$



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4. Use a periodic table to fill in the missing information in the following table.

| Name | Symbol | Atomic Number Z | Mass Number A | Number of Neutrons | Number of Electrons |
|---|---|---|---|---|---|
| oxygen | $^{16}_{8}O$ | 8 | 16 | 8 | 8 |
| NITROGEN | $^{14}_{7}N$ | 7 | 14 | 7 | 7 |
| SULFUR | $^{34}_{16}S$ | 16 | 34 | 18 | 16 |
| (DEUTERIUM) HYDROGEN-2 | $^{2}_{1}H$ | 1 | 2 | 1 | 1 |
| (TRITIUM) HYDROGEN-3 | $^{3}_{1}H$ | 1 | 3 | 2 | 1 |
| MAGNESIUM | $^{24}_{12}Mg$ | 12 | 24 | 12 | 12 |
| MAGNESIUM-25 | $^{25}_{12}Mg$ | 12 | 25 | 13 | 12 |
| URANIUM-238 | $^{238}_{92}U$ | 92 | 238 | 146 | 92 |
| KRYPTON | $^{84}_{36}Kr$ | 36 | 84 | 48 | 36 |

BOTH ARE DIFFERENT ISOTOPES

## Problems

1. The radius of a Cl nucleus is 4.0 fm, and the radius of a Cl atom is 100 pm. (1 fm = 1 x $10^{-15}$ m; 1 pm = 1 x $10^{-12}$ m).How many times larger is the diameter of the Chlorine atom than the diameter of the Chlorine nucleus?

NUCLEUS Cl = $4 \times 10^{-15}$ m = $(.00004 \times 10^{-10}$ m$)$ .00004 = 1/25000 OF 1
ATOM Cl = $100 \times 10^{-12}$ m = $1 \times 10^{-10}$ fm ∴ ATOM IS 25000 X BIGGER THAN NUCLEUS

2. Identify two objects that have this same ratio of lengths.

(GOOD) HUGE BUT THINK OF SOMETHING SMALL RELATED TO SOMETHING VERY LARGE

3. How many times larger is the volume of the atom than the volume of the nucleus?

$\frac{4}{3}\pi r^3 = Vol.$

NUC = $\frac{4}{3}\pi (4 \times 10^{-15}\text{ m})^3 = 2.68 \times 10^{-43}\text{ m}^3$

ATOM = $\frac{4}{3}\pi (1 \times 10^{-10}\text{ m})^3 = 4.19 \times 10^{-30}\text{ m}^3$

∴ ATOM IS $10^{13}$ X LARGER THAN NUCLEUS



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