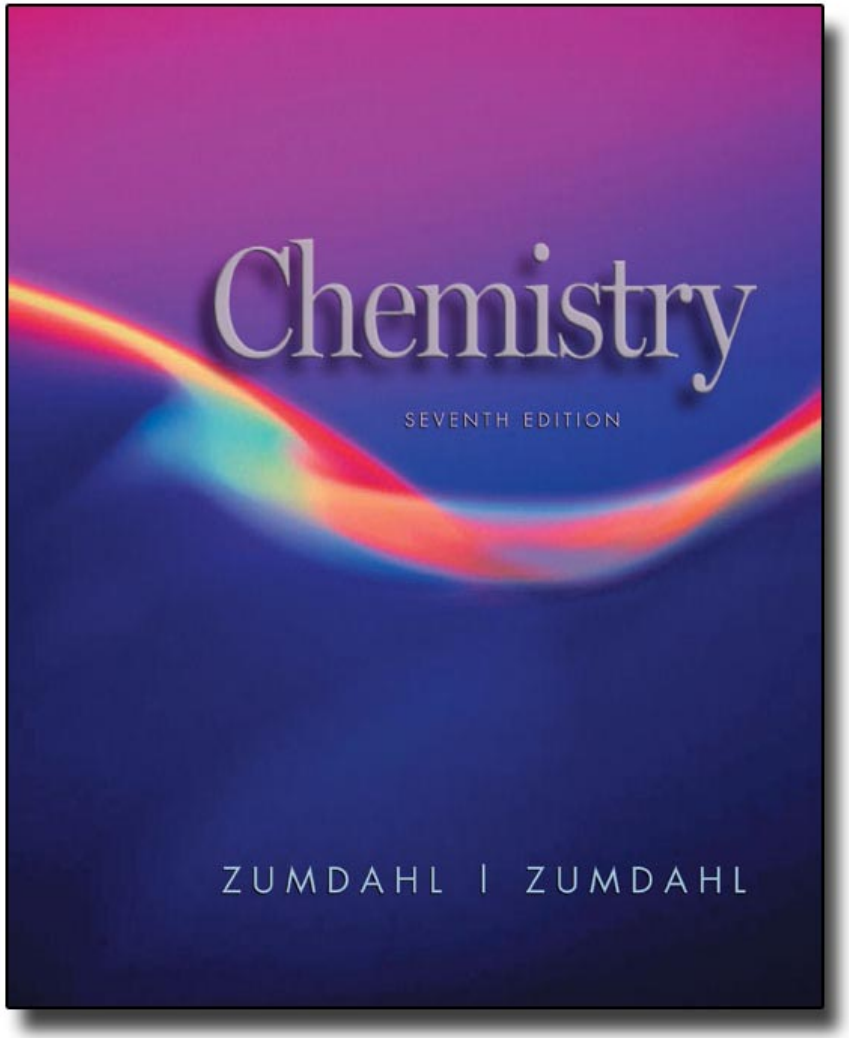
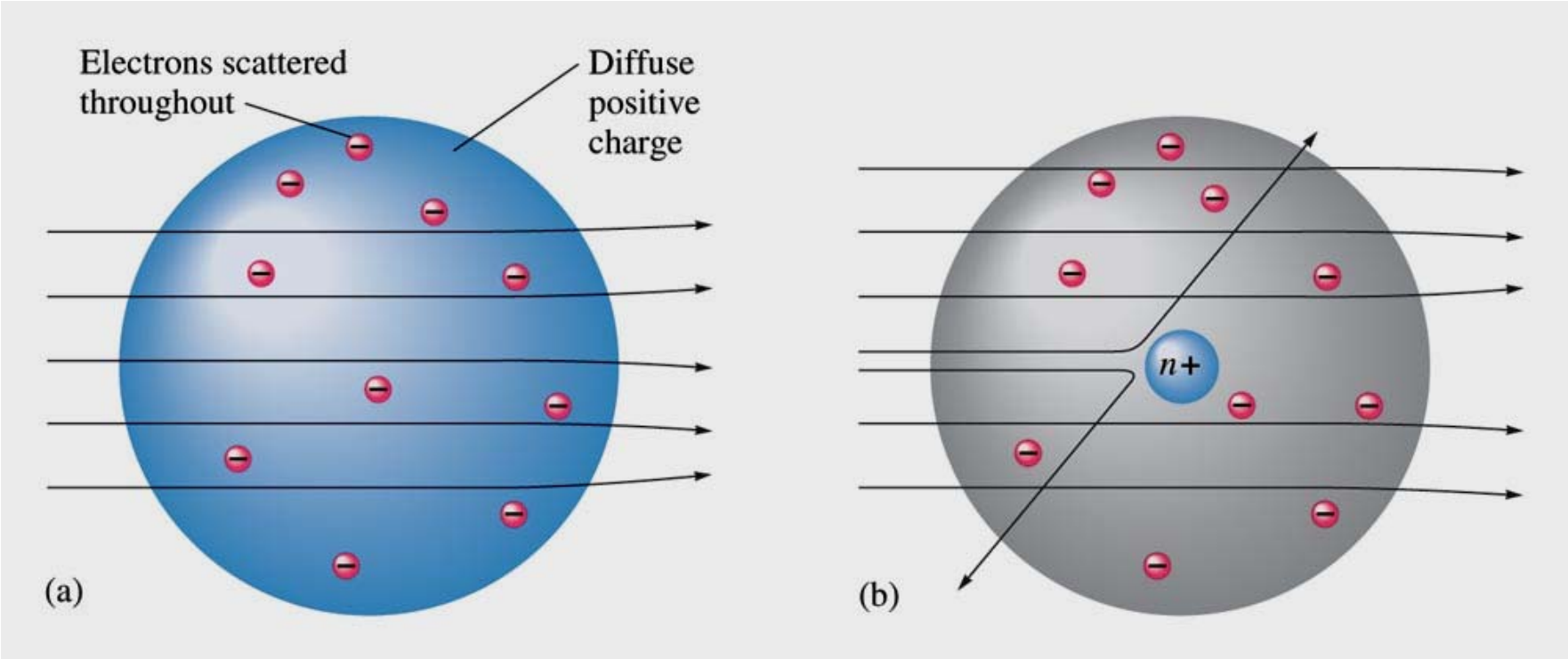


2.5 The Modern View of Atomic Structure: An Introduction

Figure 2.13 a & b
(a) Expected Results of the Metal Foil Experiment if Thomson's Model Were Correct
(b) Actual Results



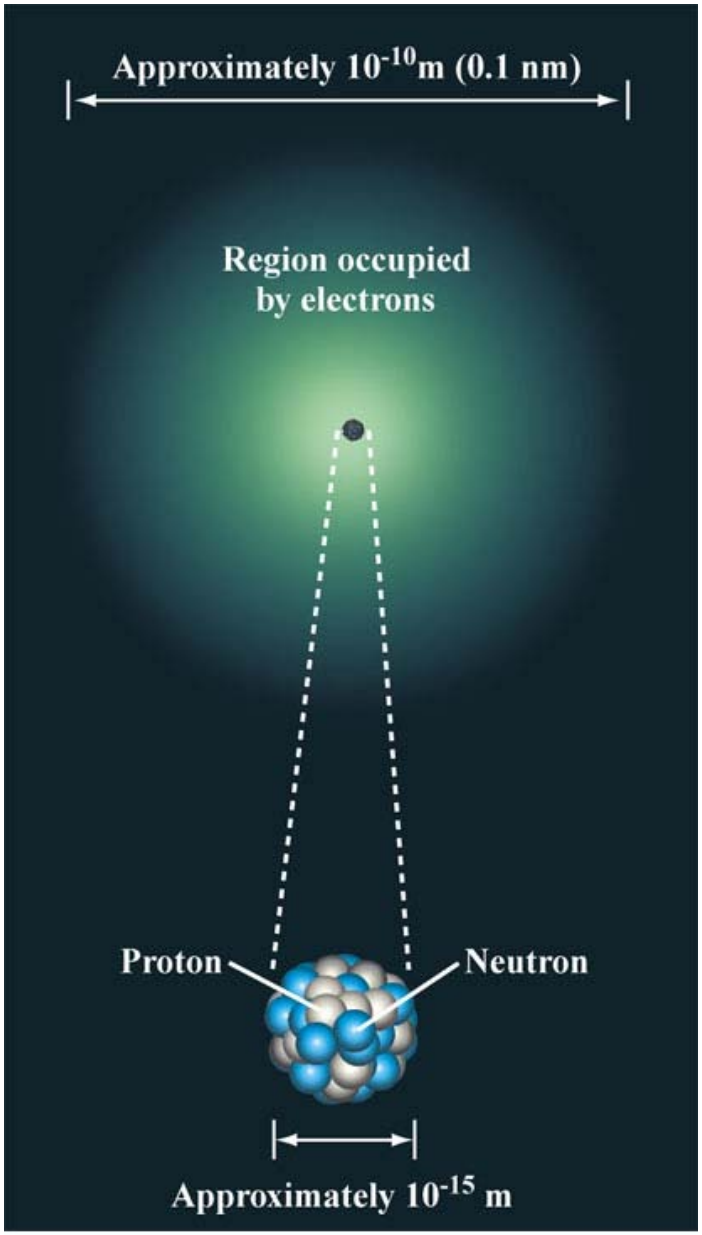
The Modern View of Atomic Structure

- The atom contains:
  - electrons
  - protons: found in the nucleus; positive charge equal in magnitude to the electron's negative charge.
  - neutrons: found in the nucleus; no charge; virtually same mass as a proton.

TABLE 2.1 The Mass and Charge of the Electron, Proton, and Neutron

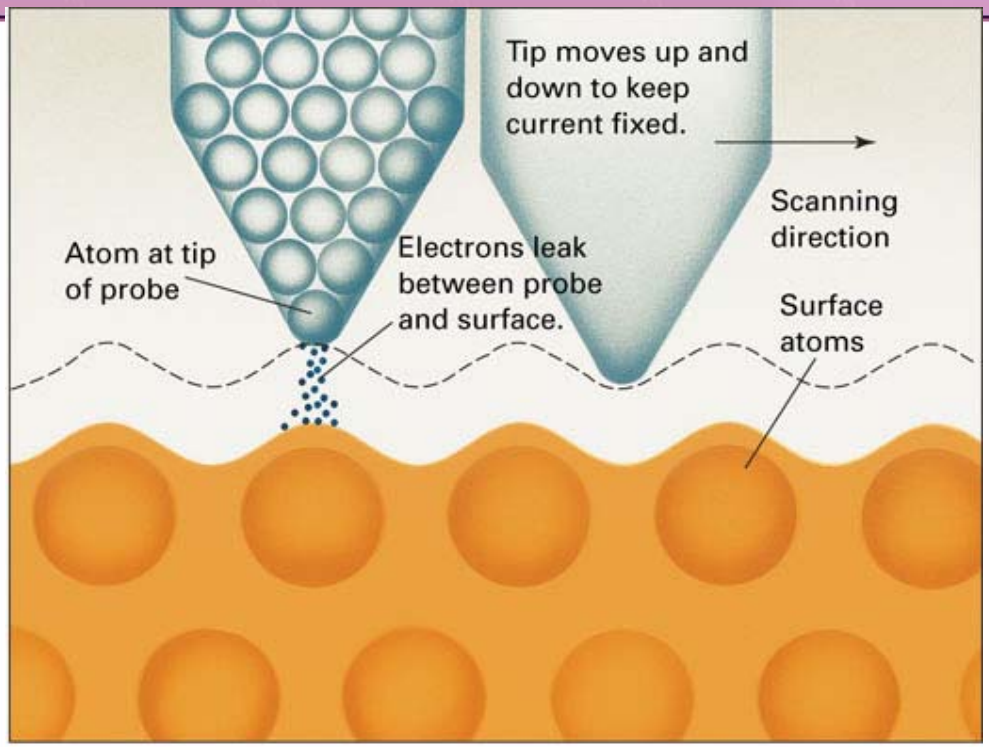
Particle	Mass	Charge*
Electron	9.11×10^{-31} kg	1−
Proton	1.67×10^{-27} kg	1+
Neutron	1.67×10^{-27} kg	None

*The magnitude of the charge of the electron and the proton is 1.60×10^{-19} C.

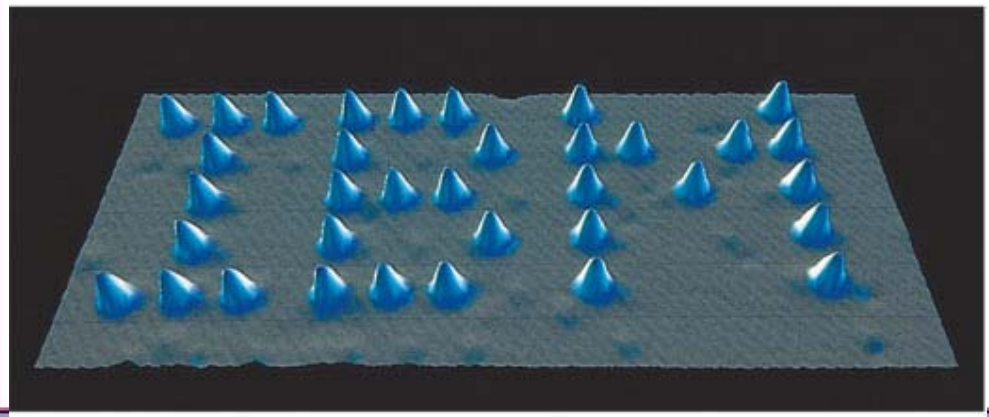


Modern View of the Atom

For an atom, which always has no net electrical charge, the number of negatively charged electrons around the nucleus equals the number of positively charged protons in the nucleus.



(a)



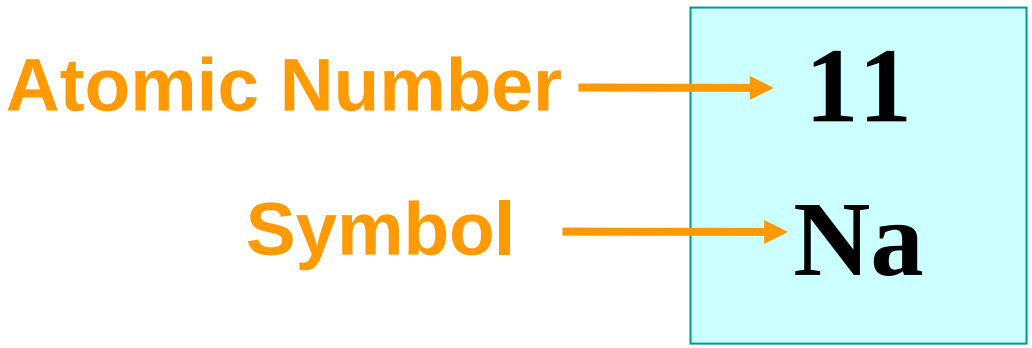
(b)

Scientists have been able to obtain computer-enhanced images of the outer surface of atoms using the scanning tunneling microscope (STM) and the atomic force microscope (AFM).

Atomic Number

The **atomic number**

- is specific for each element.
- is the same for all atoms of an element.
- is equal to the number of protons in an atom.
- appears above the symbol of an element.



Atomic Number and Protons

Examples of atomic number and number of protons:

- Hydrogen has atomic number 1; every H atom has one proton.
- Carbon has atomic number 6; every C atom has six protons.
- Copper has atomic number 29; every Cu atom has 29 protons.
- Gold has atomic number 79; every Au atom has 79 protons.

Learning Check

State the number of protons in each.

A. A nitrogen atom

1) 5 protons 2) 7 protons 3) 14 protons

B. A sulfur atom

1) 32 protons 2) 16 protons 3) 6 protons

C. A barium atom

1) 137 protons 2) 81 protons 3) 56 protons

Solution

State the number of protons in each.

A. A nitrogen atom

2) atomic number 7; 7 protons

B. A sulfur atom

2) atomic number 16; 16 protons

C. A barium atom,

3) atomic number 56; 56 protons

Electrons in An Atom

An atom of

- an element is electrically neutral; the net charge of an atom is zero.
- has an equal number of protons and electrons.

number of protons = number of electrons

Aluminum has 13 protons and 13 electrons. The net charge is zero.

13 protons (13+) + 13 electrons (13 -) = 0

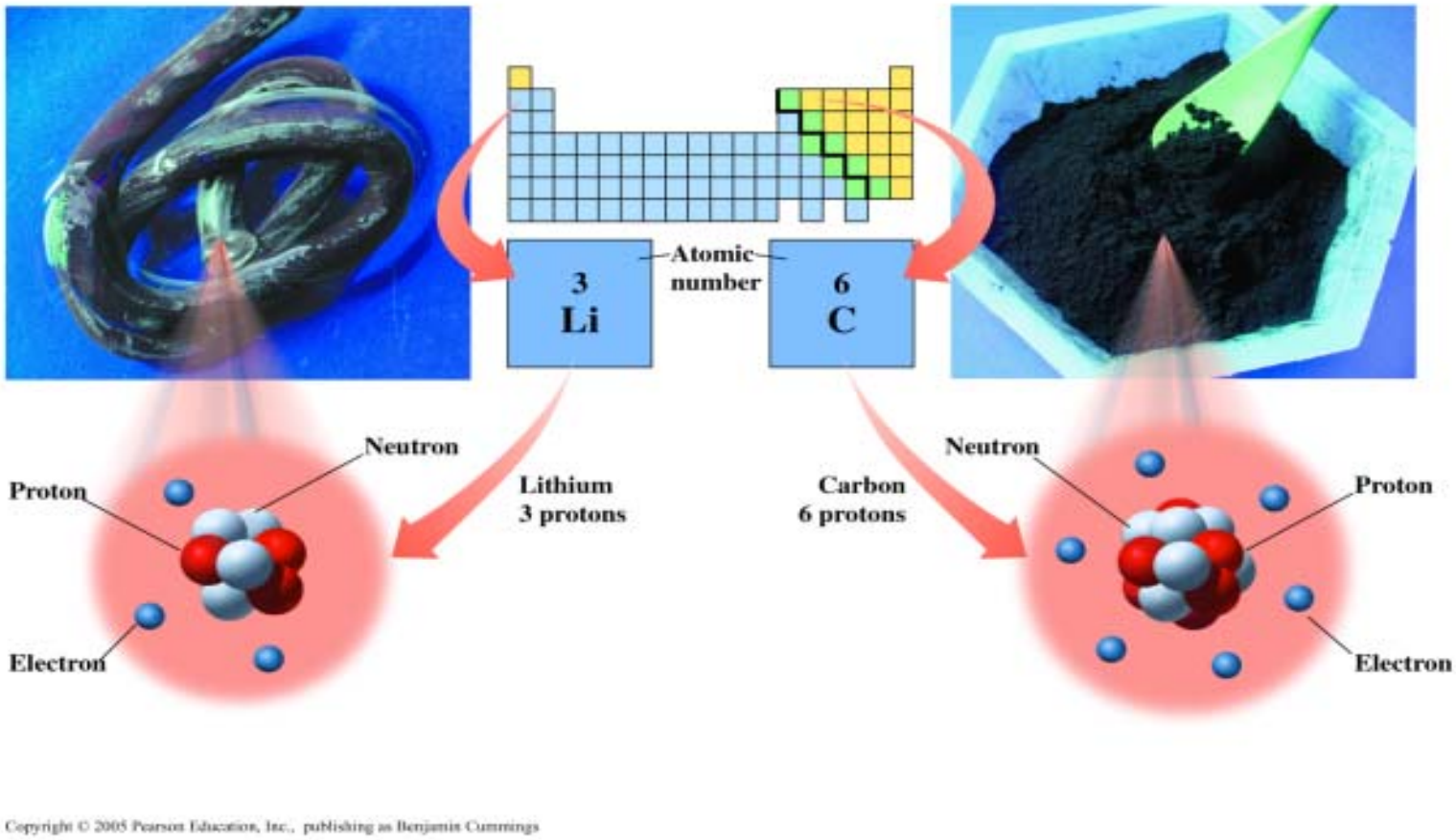
Mass Number

The **mass number**

- represents the number of particles in the nucleus.
- is equal to the **number of protons + the number of neutrons**.

Element	Symbol	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
Hydrogen	H	1	1	1	0	1
Nitrogen	N	7	14	7	7	7
Chlorine	Cl	17	37	17	20	17
Iron	Fe	26	56	26	30	26
Gold	Au	79	197	79	118	79

Atomic Models



Learning Check

An atom of zinc has a mass number of 65.

A. How many protons are in this zinc atom?

1) 30 2) 35 3) 65

B. How many neutrons are in the zinc atom?

1) 30 2) 35 3) 65

C. What is the mass number of a zinc atom that has 37 neutrons?

1) 37 2) 65 3) 67

Solution

An atom of zinc has a mass number of 65.

A. How many protons are in this zinc atom?

1) 30 (atomic number 30)

B. How many neutrons are in the zinc atom?

2) 35 (65 – 30 = 35)

C. What is the mass number of a zinc atom that has 37 neutrons?

3) 67 (30 + 37 = 67)

Learning Check

An atom has 14 protons and 20 neutrons.

A. Its atomic number is

1) 14. 2) 16. 3) 34.

B. Its mass number is

1) 14. 2) 16. 3) 34.

C. The element is

1) Si. 2) Ca. 3) Se.

Solution

An atom has 14 protons and 20 neutrons.

A. It has atomic number
   1) 14

B. It has a mass number of
   3) 34 (14 + 20 = 34)

C. The element is
   1) Si (Atomic number 14)

Isotopes

Isotopes

- are atoms of the same element that have different mass numbers.
- have the same number of protons, but different numbers of neutrons.

Nuclear Symbol

A **nuclear symbol**

- represents a particular atom of an element.
- gives the mass number in the upper left corner and the atomic number in the lower left corner.

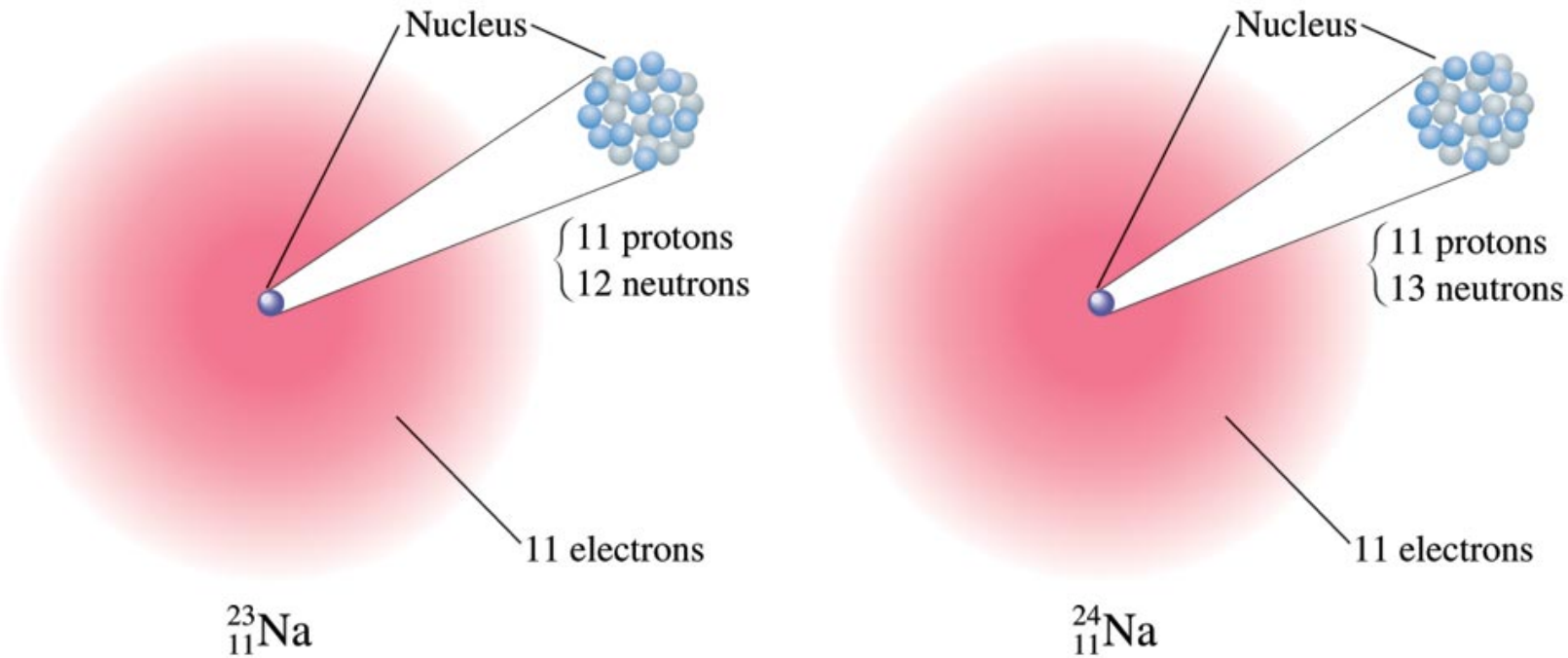
Example: An atom of sodium with atomic number 11 and a mass number 23 has the following atomic symbol:

mass number → **23**

Na

atomic number → **11**

Two Isotopes of Sodium



Information from Nuclear Symbols

From the nuclear symbol, we can determine the number of protons (p^+), neutrons, (n), and electrons (e^-) in a particular atom.

$^{16}_{8}O$ $^{31}_{15}P$ $^{65}_{30}Zn$

$^{16}_{8}O$	$^{31}_{15}P$	$^{65}_{30}Zn$
8 p^+	15 p^+	30 p^+
8 n	16 n	35 n
8 e^-	15 e^-	30 e^-

Learning Check

Naturally occurring carbon consists of three isotopes, $^{12}_{6}C$, $^{13}_{6}C$, and $^{14}_{6}C$. State the number of protons, neutrons, and electrons in each of the following.

	$^{12}_{6}C$	$^{13}_{6}C$	$^{14}_{6}C$
protons	_____	_____	_____
neutrons	_____	_____	_____
electrons	_____	_____	_____

Learning Check

Write the nuclear symbols for atoms with the following subatomic particles.

A. 8 p^+, 8 n, 8 e^- _____

B. 17p^+, 20n, 17e^- _____

C. 47p^+, 60 n, 47 e^- _____

Learning Check

1. Which of the following pairs are isotopes of the same element?
2. In which of the following pairs do both atoms have 8 neutrons?

A. $^{15}_{8}X$ $^{15}_{7}X$

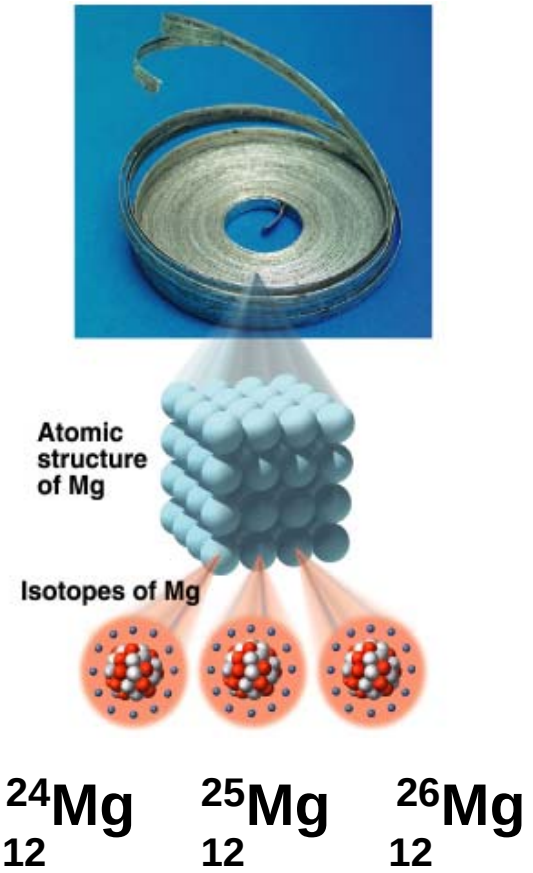
B. $^{12}_{6}X$ $^{14}_{6}X$

C. $^{15}_{7}X$ $^{16}_{8}X$

Isotopes of Magnesium

In naturally occurring magnesium there are three isotopes.

Isotopes of Mg



Isotopes of Sulfur

A sample of naturally occurring sulfur contains several isotopes with the following abundances

Isotope	% abundance
^{32}S	95.02
^{33}S	0.75
^{34}S	4.21
^{36}S	0.02

$^{32}_{16}\mathbf{S}$, $^{33}_{16}\mathbf{S}$, $^{34}_{16}\mathbf{S}$, $^{36}_{16}\mathbf{S}$

Question

By knowing the number of protons a neutral atom has, you should be able to determine

1) the number of neutrons in the neutral atom.
2) the number of electrons in the neutral atom.
3) the name of the atom.
4) two of these.
5) none of these

Question

$^{40}_{20}Ca^{2+}$ has

1) 20 protons, 20 neutrons, and 18 electrons.
2) 22 protons, 20 neutrons, and 20 electrons.
3) 20 protons, 22 neutrons, and 18 electrons.
4) 22 protons, 18 neutrons, and 18 electrons.
5) 20 protons, 20 neutrons, and 22 electrons.