Atoms and Elements | 6

LABORATORY GOALS

- Write the correct symbols or names of some elements.
- Describe some physical properties of the elements you observe.
- Categorize an element as a metal, metalloid, or nonmetal from its physical properties.
- Given the atomic symbol, determine its mass number; atomic number; and the number of protons, neutrons, and electrons.

LAB INFORMATION

Time:	2 h
Comments:	Obtain a periodic table as a reference. Tear out the report sheets and place them beside the procedures. Carefully observe the physical properties of the elements in the display.
Related Topics:	Names and symbols of the elements, periodic table, atoms, subatomic particles, isotopes, atomic mass

CHEMICAL CONCEPTS

Elements and Symbol

Primary substances, called elements, build all the materials about you. *Chemical symbols* are one- or two-letter abbreviations for the names of the elements. Only the first letter of an element's symbol is capitalized. If the symbol has a second letter, it is lowercase so that we know when a different element is indicated. If two letters are capitalized, they represent the symbols of two different elements. For example, the element cobalt has the symbol Co, whereas the two capital letters CO specify two elements, carbon (C) and oxygen (O).

One-Letter Symbols		Two-Letter Symbols	
C	carbon	Co	cobalt
S	sulfur	Si	silicon
N	nitrogen	Ne	neon
I	iodine	Ni	nickel

Most of the elements have symbols that use letters from their current names. However, some symbols are derived from the ancient names of elements. For example, Na, the symbol for sodium, comes from the Latin word *natrium*. The symbol for iron, Fe, is derived from the Latin name *ferrum*. Table 6.1 lists the names and symbols of some common elements. Learning their names and symbols will greatly help your learning of chemistry.

TABLE 6.1 Names and Symbols of Some Common Elements

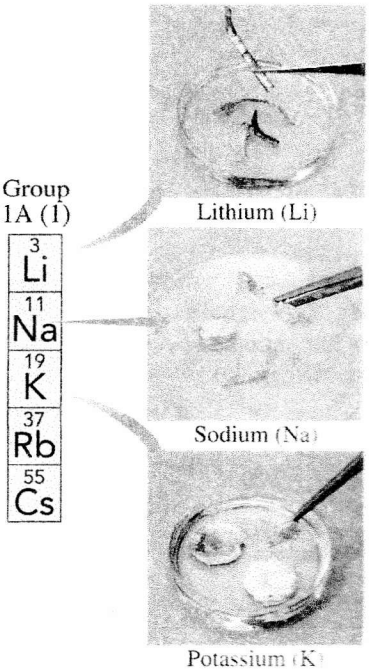
Name*	Symbol	Name*	Symbol	Name*	Symbol
Aluminum	Al	Gold (aurum)	Au	Phosphorus	P
Argon	Ar	Helium	He	Platinum	Pt
Arsenic	As	Hydrogen	H	Potassium (kalium)	K
Barium	Ba	Iodine	I	Radium	Ra
Boron	B	Iron (ferrum)	Fe	Silicon	Si
Bromine	Br	Lead (plumbum)	Pb	Silver (argentum)	Ag
Cadmium	Cd	Lithium	Li	Sodium (natrium)	Na
Calcium	Ca	Magnesium	Mg	Strontium	Sr
Carbon	C	Manganese	Mn	Sulfur	S
Chlorine	Cl	Mercury (hydrargyrum)	Hg	Tin (stannum)	Sn
Chromium	Cr	Neon	Ne	Titanium	Ti
Cobalt	Co	Nickel	Ni	Uranium	U
Copper (cuprum)	Cu	Nitrogen	N	Zinc	Zn
Fluorine	F	Oxygen	O		

*Names given in parentheses are ancient Latin or Greek words from which the symbols are derived.

Metals are elements that are usually shiny or have a metallic luster. They are usually good conductors of heat and electricity, ductile (can be drawn into a wire), and malleable (can be molded into a shape). Some metals such as sodium or calcium may have a white coating formed by reacting with oxygen in the air. If these are cut, you can see the fresh shiny metal underneath. In contrast, nonmetals are not good conductors of heat and electricity; are brittle (not ductile or malleable); and appear dull, not shiny.

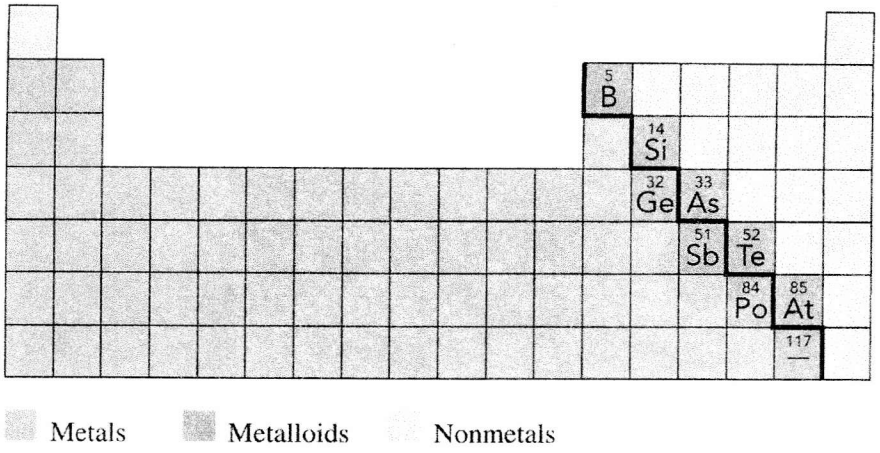
The Periodic Table

The periodic table, shown on the inside front cover of this lab manual and your textbook, contains information about each of the elements. On the table, the horizontal rows are *periods* and the vertical columns are *groups*. Each group contains elements that have similar physical and chemical properties. The groups are numbered across the top of the chart. Elements in Group 1A (1) are the *alkali metals*, elements in Group 2A (2) are the *alkaline earth metals*, and Group 7A (17) are the *halogens* (see Figure 6.1). Group 8A (18) are the *noble gases*, which are elements that are not very reactive compared to other elements. A dark zigzag line that looks like a staircase separates the *metals* on the left side from the *nonmetals* on the right side.



◀ **FIGURE 6.1** Lithium (Li), sodium (Na), and potassium (K) are some alkali metals from Group 1A (1).

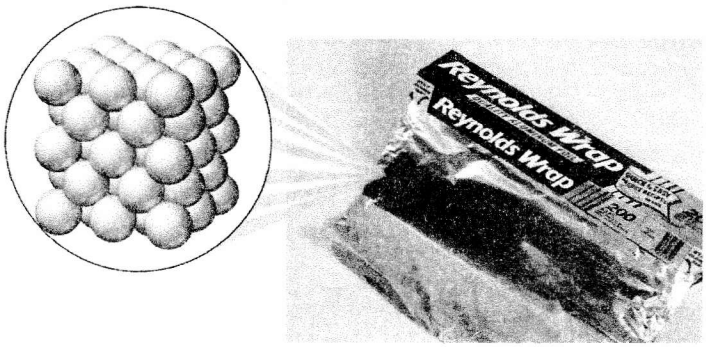
Except for aluminum, the elements located along the heavy zigzag line are *metalloids*: B, Si, Ge, As, Sb, Te, Po, and At (see Figure 6.2). Metalloids exhibit some properties that are typical of the metals and other properties that are characteristic of the nonmetals. For example, metalloids are better conductors of heat and electricity than the nonmetals, but they are not as good conductors as the metals.



▲ **FIGURE 6.2** The metalloids that border the heavy zigzag line have characteristics of both metals and nonmetals.

The Atom

All the elements listed on the periodic table are made up of atoms. An *atom* is the smallest particle of an element. If you could divide a piece of aluminum foil into smaller and smaller pieces, you would eventually have a piece so small that you could not divide it further. Then you would have a single atom of aluminum (see Figure 6.3). There are different kinds of atoms for each of the elements.



▲ **FIGURE 6.3** Aluminum foil consists of atoms of aluminum.

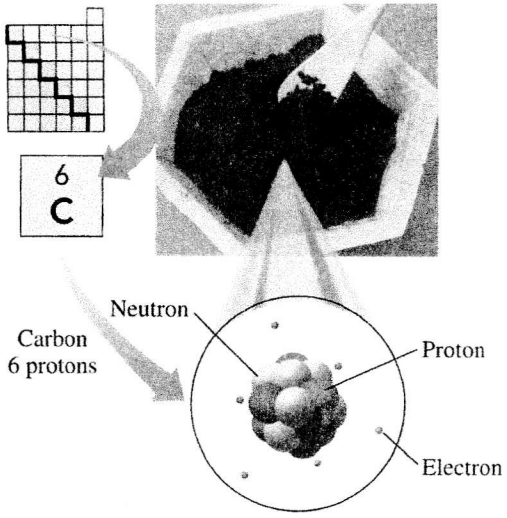
Atomic Number and Mass Number

Atoms are made up of smaller bits of matter called *subatomic particles*. *Protons* are positively charged particles, *electrons* are negatively charged, and *neutrons* are neutral (no charge). In an atom, the protons and neutrons are tightly packed in the tiny center called the *nucleus*. Most of the atom is empty space, which contains fast-moving electrons. Electrons are so small that their mass is considered to be negligible compared to the mass of the proton or neutron. The *atomic number* is equal to the number of protons. The *mass number* of an atom is the number of protons plus the number of neutrons (see Figure 6.4).

atomic number = number of protons (p^+)

mass number = sum of the number of protons and neutrons ($p^+ + n^0$)

number of neutrons = mass number ($p^+ + n^0$) – atomic number (p^+)



◀ **FIGURE 6.4** All atoms of carbon (atomic number 6) contain six protons in the nucleus, some neutrons, and six electrons outside the nucleus.

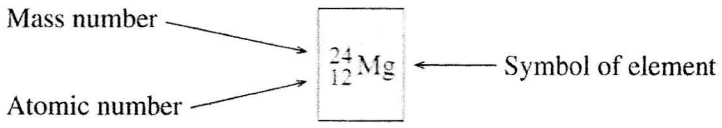
Table 6.2 illustrates these relationships between atomic number; mass number; and the number of protons, neutrons, and electrons in examples of single atoms for different elements.

TABLE 6.2 Composition of Some Atoms of Different Elements

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
Oxygen	O	8	16	8	8	8
Chlorine	Cl	17	37	17	20	17

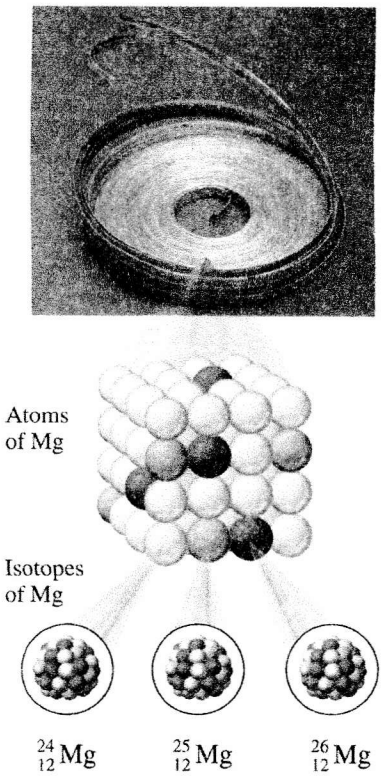
Isotopes and Atomic Mass

Isotopes are atoms of the same element that differ in the number of neutrons. This means that isotopes of an element have the same number of protons, but different mass numbers. To distinguish between the different isotopes of an element, we write an *atomic symbol* for a particular isotope with its mass number in the upper left corner and its atomic number in the lower left corner (see Figure 6.5).



▲ **FIGURE 6.5** The atomic symbol for an isotope of magnesium with 12 neutrons is Mg–24.

All atoms of the element magnesium (Mg) have an atomic number of 12. Thus, every magnesium atom always has 12 protons. However, some of the magnesium atoms have 12 neutrons, others have 13 neutrons, and still others have 14 neutrons (see Figure 6.6). These different numbers of neutrons give the magnesium atoms different mass numbers but do not change their chemical behavior.



◀ **FIGURE 6.6** The nuclei of the three naturally occurring magnesium isotopes have the same number of protons, but different numbers of neutrons.

Calculating the Atomic Mass of an Element

To calculate the atomic mass of an element, we need to know the percent abundance of each isotope and its mass, which are determined experimentally. For example, a sample of naturally occurring chlorine consists of 75.76% of $^{35}_{17}$Cl atoms and 24.24% of $^{37}_{17}$Cl atoms. The atomic mass is a *weighted average* because it is calculated from the percent abundance of each isotope and its mass: the isotope $^{35}_{17}$Cl has a mass of 34.97 amu, and the isotope $^{37}_{17}$Cl has a mass of 36.97 amu.

Isotope	Mass (amu)	×	Abundance (%)	=	Contribution to Average Cl Atom
$^{35}_{17}$Cl	34.97	×	$\frac{75.76}{100}$	=	26.49 amu
$^{37}_{17}$Cl	36.97	×	$\frac{24.24}{100}$	=	8.962 amu
			Atomic mass of Cl	=	35.45 amu (weighted average mass)

EXPERIMENTAL PROCEDURES  *GOGGLES REQUIRED!*

A. Physical Properties of Elements

Materials: A display of elements

1. Write the symbol and atomic number for each element listed.
2. Observe the elements in the laboratory display. Describe their color and luster (shininess).
3. From your observations, identify each element as a metal (M), metalloid (ML), or a nonmetal (NM).

B. The Periodic Table

Materials: Periodic table, colored pencils, display of elements

1. On the partial periodic table in the report sheet, write the symbols and atomic numbers (above the symbols) of the 14 elements you observed in part A.
2. Write the period numbers on the left side of the table.
3. Outline and label the columns that contain the alkali metals, alkaline earths, halogens, and noble gases.
4. Outline and label the sections that contain the transition elements.
5. Draw a dark, heavy line to separate the metals and nonmetals.

C. The Atom

Complete the table for each of the neutral atoms with the symbol, atomic number, mass number, number of protons, neutrons, and electrons.

D. Isotopes and Atomic Mass

1. Complete the information for each of the isotopes of silver: the atomic symbol and the number of protons, neutrons, and electrons.
2. Silver consists of two naturally occurring isotopes. Calculate the atomic mass for silver using the percent abundance of each of the isotopes and their isotopic masses.

Date _____ Name _____

Section _____ Team _____

Instructor _____ _____

Pre-Lab Study Questions | 6

1. Describe the periodic table.

2. Where are the alkali metals and the halogens located on the periodic table?

3. On the following list of elements, circle the symbols of the transition elements and underline the symbols of the halogens:

Mg Cu Br Ag Ni Cl Fe F

4. Complete the list of names of elements and symbols:

Name of Element	**Symbol**		**Name of Element**	Symbol
Potassium				Na
Sulfur				P
Nitrogen				Fe
Magnesium				Cl
Copper				Ag

Date _____ Name _____

Section _____ Team _____

Instructor _____ _____

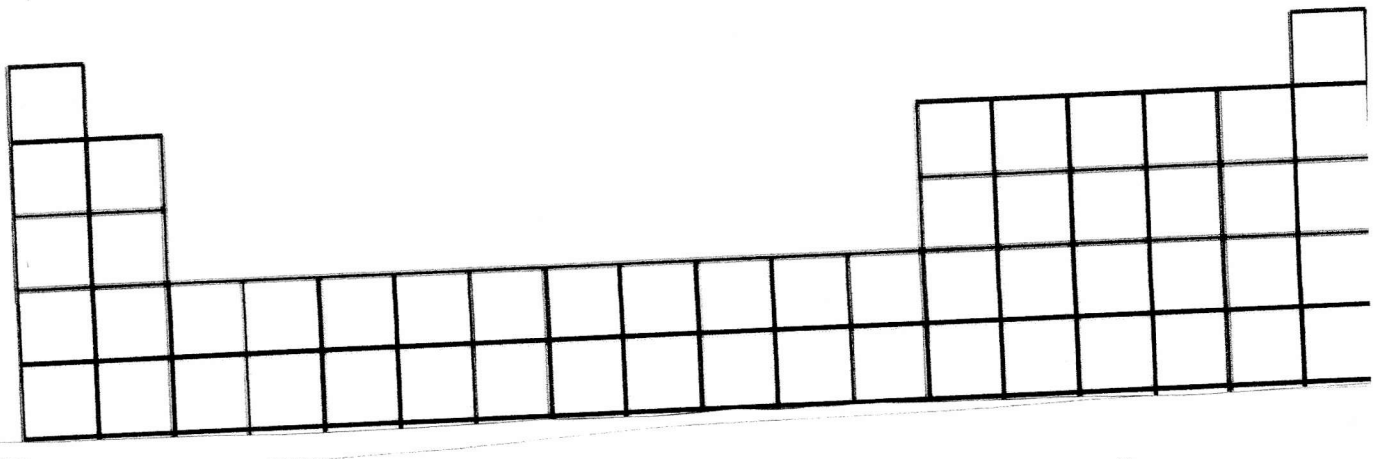
REPORT SHEET | LAB

Atoms and Elements | 6

A. Physical Properties of Elements

Element	1. Symbol	1. Atomic Number	2. Color	2. Luster	3. Metal/Metalloid/ Nonmetal
Aluminum					
Carbon					
Copper					
Iron					
Magnesium					
Nickel					
Nitrogen					
Oxygen					
Phosphorus					
Silicon					
Silver					
Sulfur					
Tin					
Zinc					

B. The Periodic Table



Questions and Problems

Q1 From their positions on the periodic table, categorize each of the following elements as a metal (M), a metalloid (ML), or a nonmetal (NM):

Na _____ S _____ Cu _____ F _____

Fe _____ C _____ As _____ Ca _____

Q2 Give the symbol of each of the following elements:

a. noble gas in Period 2 _____ **b.** halogen in Period 2 _____

c. alkali metal in Period 3 _____ **d.** halogen in Period 3 _____

e. alkali metal in Period 4 _____ **f.** metalloid in Period 2 _____

Q3 Complete the following table for the elements that are listed. If you have a full display of elements, check to see if your predictions are correct.

Element	**Metal/Metalloid/ Nonmetal**	**Prediction: Shiny/Dull**	**Correct? Yes/No**
Chromium			
Gold			
Lead			
Cadmium			
Silicon			

C. The Atom

Name of Element	**Symbol of Element**	**Atomic Number**	**Mass Number**	**Protons**	**Neutrons**	**Electrons**
	Fe				30	
			27			13
				19	20	
Bromine			80			
	Au		197			

D. Isotopes and Atomic Mass

1.

Nuclear Symbol	Protons	Neutrons	Electrons
$^{107}_{47}Ag$			
$^{109}_{47}Ag$			

2.

Nuclear Symbol	Isotopic Mass	Percent Abundance
$^{107}_{47}Ag$	106.9	51.84%
$^{109}_{47}Ag$	108.9	48.15%

(Show calculations here)

Questions and Problems

Q4 A neutral atom has a mass number of 80 and has 45 neutrons. Write its atomic symbol.

Q5 An atom has two more protons and two more electrons than the atom in Question 4. What is its atomic symbol?