

## 1.2: A First Look at the Periodic Table

### Building Blocks

Chemistry involves studying the interaction of the basic building blocks of nature. These building blocks are the atoms of the 118 known elements. People often get confused about atoms and elements. Atoms are the smallest particle of an element that exhibit the properties of that element. An analogy for elements and atoms is Legos™. Each Lego piece is an atom, and each shape represents an element. Thus, all cube-shaped Lego pieces with one "peg" on top, regardless of color, could represent H atoms, and all rectangular box pieces with two pegs on top, regardless of color, could represent He atoms. In nature, the defining feature of each element is the number of protons in the nucleus, which is called the **atomic number** of that element. Chemists created an organized chart of the elements called the Periodic Table of the Elements. In the most common format of the table, the elements are arranged in order of increasing atomic numbers.

The periodic table is not simply a grid of elements arranged numerically. In the periodic table, the elements are arranged in horizontal rows called periods, and into vertical columns called groups. These groups are numbered by two, somewhat conflicting, schemes. In the simplest presentation, favored by the International Union of Pure and Applied Chemistry (IUPAC), the groups are simply numbered 1-18. The convention in much of the world, however, is to number the first two groups IA and IIA, the last six groups IIIA-VIIIA; the middle ten groups are then numbered IB-VIIB (but not in that order!). While the IUPAC numbering appears much simpler, in this class we will use the "old-fashioned" nomenclature (IA-VIIIA). The reason for this choice will become more apparent in later chapters when we discuss "valence" electrons and bonding. The actual layout of the periodic table is based on the grouping of the elements according to chemical properties. For example, elements in each group of the periodic table (each vertical column) will share many of the same chemical properties. As we discuss the properties of elements and the ways they combine with other elements, the reasons for this particular arrangement of the periodic table will become more obvious.

### PERIODIC TABLE OF THE ELEMENTS

1

IA

1

H

Hydrogen

1.008

2

IIA

4

Be

Beryllium

9.012

3

Li

Lithium

6.941

11

Na

Sodium

22.99

19

K

Potassium

39.10

37

Rb

Rubidium

85.47

55

Cs

Cesium

132.91

87

Fr

Francium

223

2

VIIIA

2

He

Helium

4.00

10

Ne

Neon

20.18

18

Ar

Argon

39.95

36

Kr

Krypton

83.80

54

Xe

Xenon

131.29

86

Rn

Radon

222

118

Og

Oganesson

294

13

IIIA

5

B

Boron

10.81

14

IVA

6

C

Carbon

12.01

15

VA

7

N

Nitrogen

14.01

16

VIA

8

O

Oxygen

16.00

17

VIIA

9

F

Fluorine

19.00

26

Fe

Iron

55.85

27

Co

Cobalt

58.93

28

Ni

Nickel

58.69

29

Cu

Copper

63.55

30

Zn

Zinc

65.41

31

Ga

Gallium

69.72

32

Ge

Germanium

72.64

33

As

Arsenic

74.92

34

Se

Selenium

78.96

35

Br

Bromine

79.90

36

Kr

Krypton

83.80

37

Rb

Rubidium

85.47

38

Sr

Strontium

87.62

39

Y

Yttrium

88.91

40

Zr

Zirconium

91.22

41

Nb

Niobium

92.91

42

Mo

Molybdenum

95.94

43

Tc

Technetium

98

44

Ru

Ruthenium

101.07

45

Rh

Rhodium

102.90

46

Pd

Palladium

106.42

47

Ag

Silver

107.87

48

Cd

Cadmium

112.40

49

In

Indium

114.82

50

Sn

Tin

118.71

51

Sb

Antimony

121.76

52

Te

Tellurium

127.60

53

I

Iodine

126.90

54

Xe

Xenon

131.29

55

Cs

Cesium

132.91

56

Ba

Barium

137.34

57

La

Lanthanum

138.91

58

Ce

Cerium

140.12

59

Pr

Praseodymium

140.91

60

Nd

Neodymium

144.24

61

Pm

Promethium

145

62

Sm

Samarium

150.36

63

Eu

Europium

151.96

64

Gd

Gadolinium

157.25

65

Tb

Terbium

158.93

66

Dy

Dysprosium

162.50

67

Ho

Holmium

164.93

68

Er

Erbium

167.26

69

Tm

Thulium

168.93

70

Yb

Ytterbium

173.04

71

Lu

Lutetium

174.97

72

Hf

Hafnium

178.49

73

Ta

Tantalum

180.95

74

W

Tungsten

183.84

75

Re

Rhenium

186.21

76

Os

Osmium

190.23

77

Ir

Iridium

192.22

78

Pt

Platinum

195.08

79

Au

Gold

196.97

80

Hg

Mercury

200.59

81

Tl

Thallium

204.38

82

Pb

Lead

207.2

83

Bi

Bismuth

208.98

84

Po

Polonium

209

85

At

Astatine

210

86

Rn

Radon

222

87

Fr

Francium

223

88

Ra

Radium

226

89

Ac

Actinium

227

90

Th

Thorium

232.04

91

Pa

Protactinium

231.04

92

U

Uranium

238.03

93

Np

Neptunium

237

94

Pu

Plutonium

244

95

Am

Americium

243

96

Cm

Curium

247

97

Bk

Berkelium

247

98

Cf

Californium

251

99

Es

Einsteinium

252

100

Fm

Fermium

257

101

Md

Mendelevium

258

102

No

Nobelium

259

103

Lr

Lawrencium

262

104

Rf

Rutherfordium

261

105

Db

Dubnium

262

106

Sg

Seaborgium

266

107

Bh

Bohrium

264

108

Hs

Hassium

267

109

Mt

Meitnerium

268

110

Ds

Darmstadtium

271

111

Rg

Roentgenium

272

112

Cn

Copernicium

277

113

Nh

Nihonium

284

114

Fl

Flerovium

289

115

Mc

Moscovium

288

116

Lv

Livermorium

292

117

Ts

Tennessine

293

118

Og

Oganesson

294

119

Uut

Ununtrium

289

120

Uuq

Ununquadium

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As you can see, each element in the periodic table is represented by a box containing the chemical symbol, the atomic number (the number of protons in the nucleus) and the atomic mass of the element. As we will discover, the atomic mass is the weighted

average of the masses of all of the natural isotopes of the particular element.

The elements can be classified in many ways. For instance, elements in Groups IA – VIIIA are called the representative, or main group, elements, and the elements in Groups IB - VIIIB are called the transition metals. The broadest classification of elements is into **metals**, **metalloids** (or **semi-metals**) and **nonmetals**. The metallic elements are shown in green on the table here. Metals are solids at room temperature (except for mercury), can conduct electricity, and are usually malleable (can be rolled into sheets) and ductile (can be drawn into wires). Metals are usually separated into the main group metals in Groups IA - VA and the transition metals in Groups IB - VIIIB. Nonmetals (red in the figure) do not conduct electricity well or at all, and have a variety of physical states (some are solids, some liquids and some gases). At the border between metals and nonmetals lie the elements boron, silicon, germanium, arsenic, antimony and tellurium. These elements share physical properties of metals and nonmetals and are called metalloids, or semi-metals. The common semiconductors silicon and germanium are in this group, and it is their unique electrical properties that make transistors and other solid-state devices possible. The elements Po, At, Lv, Ts, and Og are all fairly rare elements, and there is some discussion about how they should be classified. We will not concern ourselves with them.

## Named Families

### Group IA: The Alkali Metals

The alkali metals are lithium, sodium, potassium, rubidium, cesium, and francium. The name "alkali" comes from an Arabic term related to ashes from burned plants. These ashes contain large amounts of potassium and sodium compounds that form basic aqueous solutions. The compounds of the alkali metals are common in nature and daily life. One example is table salt (sodium chloride); lithium compounds are used in greases, in batteries, and as drugs to treat patients who exhibit manic-depressive, or bipolar, behavior. Although lithium, rubidium, and cesium are relatively rare in nature, and francium is so unstable and highly radioactive that it exists in only trace amounts, sodium and potassium are the seventh and eighth most abundant elements in Earth's crust, respectively. **Note:** Hydrogen is generally placed in Group 1, but it is **not** an alkali metal.

### Group IIA: The Alkaline Earth Metals

The **alkaline earth metals** are beryllium, magnesium, calcium, strontium, barium, and radium. The name "alkaline earth" comes from the fact that the oxides of the metals in this family were called "earths", and when these compounds are placed in water, the solution becomes basic. Beryllium, strontium, and barium are rare, and radium is unstable and highly radioactive. In contrast, calcium and magnesium are the fifth and sixth most abundant elements on Earth, respectively; they are found in huge deposits of limestone and other minerals.

### Group VIIA: The Halogens

The **halogens** are fluorine, chlorine, bromine, iodine, astatine, and tennessine. The name halogen is derived from the Greek words for "salt forming," which reflects that all the halogens react readily with metals to form compounds, such as sodium chloride and calcium chloride (used in some areas as road salt).

Compounds that contain the fluoride ion are added to toothpaste and the water supply to prevent dental cavities. Fluorine is also found in Teflon coatings on kitchen utensils. Although chlorofluorocarbon propellants and refrigerants are believed to lead to the depletion of Earth's ozone layer and contain both fluorine and chlorine, the latter is responsible for the adverse effect on the ozone layer. Bromine and iodine are less abundant than chlorine, and astatine is so radioactive that it exists in only negligible amounts in nature.

### Group VIIIA: The Noble Gases

The noble gases are helium, neon, argon, krypton, xenon, radon, and oganesson. Because the noble gases are composed of only single atoms, they are called monatomic elements. At room temperature and pressure, they are unreactive gases. This lack of reactivity led to their name, in that "noble" elements would not interact with the rest of the elements. Because of their lack of reactivity, for many years they were also called inert gases or rare gases. However, the first chemical compounds containing the noble gases were prepared in 1962. Although the noble gases are relatively minor constituents of the atmosphere, natural gas contains substantial amounts of helium. Because of its low reactivity, argon is often used as an unreactive (inert) atmosphere for welding and in light bulbs. The red light emitted by neon in a gas discharge tube is used in neon lights.

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