

# The Periodic Table of the Elements

## WHY?

Substances that contain only atoms with the same number of protons are called *elements*. The Periodic Table lists all the known elements in order of their atomic number and in columns that depend on similarities in their chemical and physical properties. The Periodic Table is a useful tool for both students and professionals to identify the properties of the elements and understand the properties of molecules.

## LEARNING OBJECTIVES

- Become familiar with the organization of the Periodic Table
- Appreciate both the diversity and commonalities in the chemical and physical properties of the elements

## SUCCESS CRITERIA

- Identify groups and periods in the Periodic Table
- Use the Periodic Table to provide information about the elements

## INFORMATION

Dmitri Mendeleev (1834 – 1907), a Russian scientist, constructed the first Periodic Table by listing the elements in horizontal rows in order of increasing atomic mass. He started new rows whenever necessary to place elements with similar properties in the same vertical column. Mendeleev found that the correlations in properties between some elements in the columns were not perfect. These observations led him to predict the existence of undiscovered elements and to wonder how the table might be better organized. Later H.G.J. Moseley used x-ray spectra to refine the ordering and show that atomic numbers rather than atomic masses should be used to order the elements.

In the Periodic Table, elements with similar properties occur in vertical columns called *groups*. Two numbering conventions are used to label the groups. The older convention numbers the groups using Roman numerals I through VIII followed by a letter A or B; the other convention numbers each column 1 through 18. The A groups are known as the *main group elements*. The B groups are called the *transition elements*. The group numbers IA through VIIIA in the older convention tells you how many valence electrons an element has. The valence electrons are the outer electrons that are most important in determining the chemical bonding and other properties of the element.

The horizontal rows of the table are called *periods*, and are numbered 1 through 7 starting with the row that only contains H and He.

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11A

1

1.008

H

Hydrogen

1

21A

11

22.99

Na

Sodium

11

31A

19

39.10

K

Potassium

19

41A

37

85.47

Rb

Rubidium

37

51A

55

132.91

Cs

Caesium

55

61A

87

(223.02)

Fr

Francium

87

71A

88

(226.03)

Ra

Radium

88

81A

56

137.33

Ba

Barium

56

91A

57

138.91

La

Lanthanum

57

101A

72

178.49

Hf

Hafnium

72

111A

73

180.95

Ta

Tantalum

73

121A

74

186.21

Re

Rhenium

75

131A

76

190.2

Os

Osmium

76

141A

77

192.22

Ir

Iridium

77

151A

78

195.08

Pt

Platinum

78

161A

79

196.97

Au

Gold

79

171A

80

200.59

Hg

Mercury

80

181A

81

204.38

Tl

Thallium

81

191A

82

207.2

Pb

Lead

82

201A

83

208.98

Bi

Bismuth

83

211A

84

(209)

Po

Polonium

84

221A

85

(210)

At

Astatine

85

231A

86

(222)

Rn

Radon

86

241A

54

131.29

Xe

Xenon

54

251A

53

126.90

I

Iodine

53

261A

52

127.60

Te

Tellurium

52

271A

35

79.90

Br

Bromine

35

281A

34

78.96

Se

Selenium

34

291A

33

74.92

As

Arsenic

33

301A

32

72.61

Ge

Germanium

32

311A

31

69.72

Ga

Gallium

31

321A

30

65.39

Zn

Zinc

30

331A

29

63.55

Cu

Copper

29

341A

28

58.69

Ni

Nickel

28

351A

27

58.93

Co

Cobalt

27

361A

26

55.85

Fe

Iron

26

371A

25

54.94

Mn

Manganese

25

381A

24

52.00

Cr

Chromium

24

391A

23

50.94

V

Vanadium

23

401A

22

47.88

Ti

Titanium

22

411A

21

44.96

Sc

Scandium

21

421A

20

40.08

Ca

Calcium

20

431A

12

24.31

Mg

Magnesium

12

441A

4

9.01

Be

Beryllium

4

451A

3

6.94

Li

Lithium

3

461A

2

1.008

H

Hydrogen

1

11B

5

10.81

B

Boron

5

12B

6

12.01

C

Carbon

6

13B

7

14.01

N

Nitrogen

7

14B

8

16.00

O

Oxygen

8

15B

9

19.00

F

Fluorine

9

16B

10

20.18

Ne

Neon

10

17B

13

26.98

Al

Aluminium

13

18B

14

28.09

Si

Silicon

14

19B

15

30.97

P

Phosphorus

15

20B

16

32.07

S

Sulfur

16

21B

17

35.45

Cl

Chlorine

17

22B

18

39.95

Ar

Argon

18

23B

36

83.80

Kr

Krypton

36

24B

54

131.29

Xe

Xenon

54

25B

86

(222)

Rn

Radon

86

26B

102

(262.11)

No

Nobelium

102

27B

101

(257)

Md

Mendelevium

101

28B

100

(257.10)

Fm

Fermium

100

29B

99

(252.08)

Es

Einsteinium

99

30B

98

(251)

Cf

Californium

98

31B

97

(248)

Bk

Berkelium

97

32B

96

(247)

Cm

Curium

96

33B

95

(243.06)

Am

Americium

95

34B

94

(240)

Pu

Plutonium

94

35B

93

(237.05)

Np

Neptunium

93

36B

92

238.03

U

Uranium

92

37B

91

(231.04)

Pa

Protactinium

91

38B

90

232.04

Th

Thorium

90

39B

89

(227.03)

Ac

Actinium

89

40B

104

(261)

Rf

Rutherfordium

104

41B

105

(262)

Db

Dubnium

105

42B

106

(263)

Sg

Seaborgium

106

43B

107

(262)

Bh

Bohrium

107

44B

108

(265)

Hs

Hassium

108

45B

109

(266)

Mt

Mitnerium

109

46B

110

(271)

Ds

Darmstadtium

110

47B

111

(280)

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## INFORMATION

There are three categories of elements in the Periodic Table: metals, nonmetals, and metalloids. The metals are located in the left and center. They are good conductors of heat and electricity. The nonmetals are in the upper right-hand corner. They are poor conductors of heat and electricity. The metals and nonmetals are separated by the metalloids, which are six elements on a diagonal line. These elements are B, Si, Ge, As, Sb, and Te. The metalloids are also called semimetals or semiconductors because their conductivity is between that of metals and nonmetals. Metals readily lose electrons to form positive ions, called cations, and nonmetals readily gain electrons to form negative ions, called anions.

## KEY QUESTIONS

1. What information about an element is provided in each box for that element in the Periodic Table in the model?

*The symbol, the name, the atomic number, and the average atomic mass and molar mass.*

2. What determines the sequence of the elements from the first to the last?

*The elements are arranged in order of increasing atomic number, from 1 through 112 (in the table here).*

3. What determines where one row stops and another begins?

*A row always ends with a noble gas and the next row begins with an alkali metal.*

4. Where are the metals, nonmetals, and metalloids located?

*The metals are to the left (including the center), the non-metals are to the right, and the metalloids lie along the “stair steps” (diagonal line) from boron (B) to tellurium (Te) and separate the metals from the non-metals.*

5. What is the difference between a group and a period?

*A group is a column (vertical) and a period is a row (horizontal) on the periodic table. Elements in the same groups have similar chemical properties.*

6. How can you determine the total number of electrons that an atom has from the Periodic Table?

*Since atoms are electrically neutral, the number of electrons is equal to the number of protons, which is given by the atomic number.*

7. How can you determine the number of valence electrons that atoms in groups 1, 2 and 13 through 18 have?

*The number of valence electrons in Groups 1 and 2 is the group number. The number of valence electrons in Groups 13 – 18 is the group number minus ten (e.g., Group 14 has  $14 - 10 = 4$  valence electrons).*

8. What are the five other elements like helium that are gases and are not very reactive?

*They are the other elements in the same group (column): neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn).*

## EXERCISES

1. Write the name, symbol, atomic number, and average mass for the Group 2 metal in Period 3.

*This element is magnesium (Mg), with atomic number 12 and an average mass 24.31 amu.*

2. Write the name, symbol, average mass, and number of protons for the Group 16 nonmetal in Period 2.

*This element is oxygen (O), with atomic number 8 and an average mass of 16.00 amu.*

3. Write the name, symbol, average mass, and number of electrons for the Group 15 metalloid in Period 4

*This element is arsenic (As), with atomic number 33 and an average mass of 74.92 amu.*

4. Write the name and symbol of the element that has 48 electrons.

*This element is cadmium (Cd).*

5. Name two elements that have properties similar to sodium, Na. How many valence electrons do each of these three elements have?

*These elements could include lithium (Li), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr), but NOT hydrogen (H). All of these elements have one valence electron.*

6. Name two elements that have properties similar to bromine, Br. How many valence electrons do each of these three elements have?

*These elements could include fluorine (F), chlorine (Cl), iodine (I), and astatine (At). All of these elements have seven valence electrons.*

7. Using atomic symbols, list the elements in Period 2 in order of increasing number of electrons.

*Li, Be, B, C, N, O, F, Ne*

8. Using atomic symbols, list the elements in Group 14 in order of increasing number of protons.

*C, Si, Ge, Sn, Pb*

9. Using atomic symbols, list the elements in Group 12 in order of increasing atomic mass.

*Zn, Cd, Hg, (unnamed element 112)*