

CONCEPTS TO REMEMBER

Subatomic particles. Subatomic particles, the very small building blocks from which atoms are made, are of three major types: electrons, protons, and neutrons. Electrons are negatively charged, protons are positively charged, and neutrons have no charge. All neutrons and protons are found at the center of the atom in the nucleus. The electrons occupy the region about the nucleus. Protons and neutrons have much larger masses than electrons (Section 3.1).

Atomic number and mass number. Each atom has a characteristic atomic number and mass number. The atomic number is equal to the number of protons in the nucleus of the atom. The mass number is equal to the total number of protons and neutrons in the nucleus (Section 3.2).

Isotopes. Isotopes are atoms that have the same number of protons and electrons but have different numbers of neutrons. The isotopes of an element always have the same atomic number and different mass numbers. Isotopes of an element have the same chemical properties (Section 3.3).

Atomic mass. The atomic mass of an element is a calculated average mass. It depends on the percentage abundances and masses of the naturally occurring isotopes of the element (Section 3.3).

Periodic law and periodic table. The periodic law states that when elements are arranged in order of increasing atomic number, elements with similar chemical properties occur at periodic (regularly recurring) intervals. The periodic table is a graphical representation of the behavior described by the periodic law. In a modern periodic table, vertical columns contain elements with similar chemical properties. A group in the periodic table is a vertical column of elements. A period in the periodic table is a horizontal row of elements (Section 3.4).

Metals and nonmetals. Metals exhibit luster, thermal conductivity, electrical conductivity, and malleability. Nonmetals are characterized by the absence of the properties associated with metals. The majority of the elements are metals. The steplike heavy line that runs through the right third of the periodic table separates the metals on the left from the nonmetals on the right (Section 3.5).

Electron shell. An electron shell contains electrons that have approximately the same energy and spend most of their time approximately the same distance from the nucleus (Section 3.6).

Electron subshell. An electron subshell contains electrons that all have the same energy. The number of subshells in a particular shell is equal to the shell number. Each subshell can hold a specific maximum number of electrons. These values are 2, 6, 10, and 14 for *s*, *p*, *d*, and *f* subshells, respectively (Section 3.6).

Electron orbital. An electron orbital is a region of space about a nucleus where an electron with a specific energy is most likely to be found. Each subshell consists of one or more orbitals. For *s*, *p*, *d*, and *f* subshells there are 1, 3, 5, and 7 orbitals, respectively. No more than two electrons may occupy any orbital (Section 3.6).

Electron configuration. An electron configuration is a statement of how many electrons an atom has in each of its subshells. The principle that electrons normally occupy the lowest-energy subshell available is used to write electron configurations (Section 3.7).

Orbital diagram. An orbital diagram is a notation that shows how many electrons an atom has in each of its orbitals. Electrons occupy the orbitals of a subshell such that each orbital within the subshell acquires one electron before any orbital acquires a second electron. All electrons in such singly occupied orbitals must have the same spin (Section 3.7).

Electron configurations and the periodic law. Chemical properties repeat themselves in a regular manner among the elements because electron configurations repeat themselves in a regular manner among the elements (Section 3.8).

Electron configurations and the periodic table. The groups of the periodic table consist of elements with similar electron configurations. Thus the location of an element in the periodic table can be used to obtain information about its electron configuration (Section 3.8).

Classification system for the elements. On the basis of electron configuration, elements can be classified into four categories: noble gases (far right column of the periodic table); representative elements (*s* and *p* areas of the periodic table, with the exception of the noble gases); transition elements (*d* area of the periodic table); and inner transition elements (*f* area of the periodic table) (Section 3.9).

KEY REACTIONS AND EQUATIONS

- Relationships involving atomic number and mass number for a neutral atom (Section 3.2)

Atomic number = number of protons = number of electrons

Mass number = number of protons + number of neutrons

Mass number = total number of subatomic particles in the nucleus

Mass number – atomic number = number of neutrons

Mass number + atomic number = total number of subatomic particles

- Relationships involving electron shells, electron subshells, and electron orbitals (Section 3.6)

Number of subshells in a shell = shell number

Maximum number of electrons in an *s* subshell = 2

Maximum number of electrons in a *p* subshell = 6

Maximum number of electrons in a *d* subshell = 10

Maximum number of electrons in an *f* subshell = 14

Maximum number of electrons in an orbital = 2

- Order of filling of subshells in terms of increasing energy (Section 3.7)

1*s*, 2*s*, 2*p*, 3*s*, 3*p*, 4*s*, 3*d*, 4*p*, 5*s*, 4*d*, 5*p*, 6*s*, 4*f*, 5*d*, 6*p*, 7*s*, 5*f*, 6*d*, 7*p*

EXERCISES and PROBLEMS

The members of each pair of problems in this section test similar material.

Internal Structure of an Atom (Section 3.1)

- 3.1** Indicate which subatomic particle (proton, neutron, or electron) correctly matches each of the following phrases. More than one particle can be used as an answer.
- Possesses a negative charge
 - Has no charge
 - Has a mass slightly less than that of a neutron
 - Has a charge equal to, but opposite in sign from, that of an electron
- 3.2** Indicate which subatomic particle (proton, neutron, or electron) correctly matches each of the following phrases. More than one particle can be used as an answer.
- Is not found in the nucleus
 - Has a positive charge
 - Can be called a nucleon
 - Has a relative mass of 1837 if the relative mass of an electron is 1
- 3.3** Indicate whether each of the following statements about the nucleus of an atom is true or false.
- The nucleus of an atom is neutral.
 - The nucleus of an atom contains only neutrons.
 - The number of nucleons present in the nucleus is equal to the number of electrons present outside the nucleus.
 - The nucleus accounts for almost all the mass of an atom.
- 3.4** Indicate whether each of the following statements about the nucleus of an atom is true or false.
- The nucleus of an atom contains all of the “heavy” subatomic particles.
 - The nucleus of an atom accounts for almost all of the volume of the atom.
 - The nucleus of an atom has an extremely low density compared to that of the atom as a whole.
 - The nucleus of an atom can be positively or negatively charged, depending on the identity of the atom.

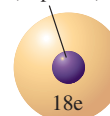
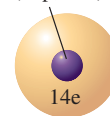
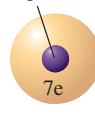
Atomic Number and Mass Number (Section 3.2)

- 3.5** Determine the atomic number and mass number for atoms with the following subatomic makeup.
- 2 protons, 2 neutrons, and 2 electrons
 - 4 protons, 5 neutrons, and 4 electrons
 - 5 protons, 4 neutrons, and 5 electrons
 - 28 protons, 30 neutrons, and 28 electrons
- 3.6** Determine the atomic number and mass number for atoms with the following subatomic makeup.
- 1 proton, 1 neutron, and 1 electron
 - 10 protons, 12 neutrons, and 10 electrons
 - 12 protons, 10 neutrons, and 12 electrons
 - 50 protons, 69 neutrons, and 50 electrons
- 3.7** Determine the number of protons, neutrons, and electrons present in atoms with the following characteristics.
- Atomic number = 8 and mass number = 16
 - Mass number = 18 and $Z = 8$
 - Atomic number = 20 and $A = 44$
 - $A = 257$ and $Z = 100$
- 3.8** Determine the number of protons, neutrons, and electrons present in atoms with the following characteristics.

- Atomic number = 10 and mass number = 20
- Mass number = 110 and $Z = 48$
- $A = 11$ and atomic number = 5
- $Z = 92$ and $A = 238$

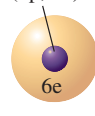
- 3.9** Indicate whether the *atomic number*, the *mass number*, or *both the atomic number and the mass number* are needed to determine the following.
- Number of protons in an atom
 - Number of neutrons in an atom
 - Number of nucleons in an atom
 - Total number of subatomic particles in an atom
- 3.10** What information about the subatomic particles present in an atom is obtained from each of the following?
- Atomic number
 - Mass number
 - Mass number – atomic number
 - Mass number + atomic number
- 3.11** Determine the following information for an atom whose complete chemical symbol is ${}^{39}_{19}\text{K}$.
- Atomic number
 - Mass number
 - Number of protons present
 - Number of electrons present
- 3.12** Determine the following information for an atom whose complete chemical symbol is ${}^{31}_{15}\text{P}$.
- Atomic number
 - Mass number
 - Number of protons present
 - Number of electrons present
- 3.13** Using the information inside the front cover, identify the element X based on the given complete chemical symbol for X.
- ${}^{15}_7\text{X}$
 - ${}^{27}_{13}\text{X}$
 - ${}^{139}_{56}\text{X}$
 - ${}^{197}_{79}\text{X}$
- 3.14** Using the information inside the front cover, identify the element X based on the given complete chemical symbol for X.
- ${}^{16}_8\text{X}$
 - ${}^{19}_9\text{X}$
 - ${}^{45}_{21}\text{X}$
 - ${}^{63}_{29}\text{X}$
- 3.15** Using the information inside the front cover, and the given information, write the complete chemical symbol for the following atoms.

- (7p, 8n)
- (14p, 14n)
- (18p, 22n)
- (22p, 26n)

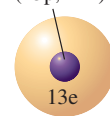


- 3.16** Using the information inside the front cover, and the given information, write the complete chemical symbol for the following atoms.

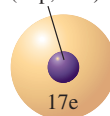
- (6p, 8n)



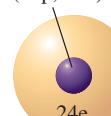
- (13p, 14n)



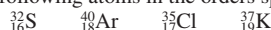
- (17p, 18n)



- (24p, 28n)



3.17 Arrange the following atoms in the orders specified.



- Order of increasing atomic number
- Order of decreasing mass number
- Order of increasing number of electrons
- Order of increasing number of neutrons

3.18 Arrange the following atoms in the orders specified.



- Order of decreasing atomic number
- Order of increasing mass number
- Order of decreasing number of neutrons
- Order of increasing number of nucleons

3.19 Determine the following information for an atom whose complete chemical symbol is ${}^{23}_{11}\text{Na}$.

- The total number of subatomic particles present
- The total number of subatomic particles present in the nucleus of the atom
- The total number of nucleons present
- The total charge (including sign) associated with the nucleus of the atom

3.20 Determine the following information for an atom whose complete chemical symbol is ${}^{37}_{17}\text{Cl}$.

- The total number of subatomic particles present
- The total number of subatomic particles present in the nucleus of the atom
- The total number of nucleons present
- The total charge (including sign) associated with the nucleus of the atom

Isotopes and Atomic Masses (Section 3.3)

3.21 The atomic number of the element carbon (C) is 6. Write the complete chemical symbols for each of the following carbon isotopes: carbon-12, carbon-13, and carbon-14.

3.22 The atomic number of the element sulfur (S) is 16. Write the complete chemical symbols for each of the following sulfur isotopes: sulfur-32, sulfur-33, sulfur-34, and sulfur-36.

3.23 Using the information given in the following table, indicate whether each of the following pairs of atoms are isotopes.

	Atom A	Atom B	Atom C	Atom D
Number of protons	9	10	10	9
Number of neutrons	10	9	10	9
Number of electrons	9	10	10	9

- Atom A and atom B
- Atom A and atom C
- Atom A and atom D

3.24 Using the information given in the table in Problem 3.23, indicate whether each of the following pairs of atoms are isotopes.

- Atom B and atom C
- Atom B and atom D
- Atom C and atom D

3.25 Indicate whether each of the following statements about sodium isotopes is true or false.

- ${}^{23}_{11}\text{Na}$ has one more electron than ${}^{24}_{11}\text{Na}$.
- ${}^{23}_{11}\text{Na}$ and ${}^{24}_{11}\text{Na}$ contain the same number of neutrons.
- ${}^{23}_{11}\text{Na}$ has one less subatomic particle than ${}^{24}_{11}\text{Na}$.
- ${}^{23}_{11}\text{Na}$ and ${}^{24}_{11}\text{Na}$ have the same atomic number.

3.26 Indicate whether each of the following statements about magnesium isotopes is true or false.

- ${}^{24}_{12}\text{Mg}$ has one more proton than ${}^{25}_{12}\text{Mg}$.
- ${}^{24}_{12}\text{Mg}$ and ${}^{25}_{12}\text{Mg}$ contain the same number of subatomic particles.
- ${}^{24}_{12}\text{Mg}$ has one less neutron than ${}^{25}_{12}\text{Mg}$.
- ${}^{24}_{12}\text{Mg}$ and ${}^{25}_{12}\text{Mg}$ have different mass numbers.

3.27 The following are selected properties for the most abundant isotope of a particular element. Which of these properties would also be the same for the second-most-abundant isotope of the element?

- Mass number is 70
- 31 electrons are present
- Isotopic mass is 69.92 amu
- Isotope reacts with chlorine to give a green compound

3.28 The following are selected properties for the most abundant isotope of a particular element. Which of these properties would also be the same for the second-most-abundant isotope of the element?

- Atomic number is 31
- Does not react with the element gold
- 40 neutrons are present
- Density is 1.03 g/mL

3.29 Calculate the atomic mass of each of the following elements using the given data for the percentage abundance and mass of each isotope.

- Lithium: 7.42% ${}^6\text{Li}$ (6.01 amu) and 92.58% ${}^7\text{Li}$ (7.02 amu)
- Magnesium: 78.99% ${}^{24}\text{Mg}$ (23.99 amu), 10.00% ${}^{25}\text{Mg}$ (24.99 amu), and 11.01% ${}^{26}\text{Mg}$ (25.98 amu)

3.30 Calculate the atomic mass of each of the following elements using the given data for the percentage abundance and mass of each isotope.

- Silver: 51.82% ${}^{107}\text{Ag}$ (106.9 amu) and 48.18% ${}^{109}\text{Ag}$ (108.9 amu)
- Silicon: 92.21% ${}^{28}\text{Si}$ (27.98 amu), 4.70% ${}^{29}\text{Si}$ (28.98 amu), and 3.09% ${}^{30}\text{Si}$ (29.97 amu)

3.31 Using information available on the inside front cover, determine the atomic mass associated with the listed elements or the element name associated with the listed atomic masses.

- Iron
- Nitrogen
- 40.08 amu
- 126.90 amu

3.32 Using information available on the inside front cover, determine the atomic mass associated with the listed elements or the element name associated with the listed atomic masses.

- Phosphorus
- Nickel
- 101.07 amu
- 20.18 amu

The Periodic Law and the Periodic Table (Section 3.4)

3.33 Give the symbol of the element that occupies each of the following positions in the periodic table.

- Period 4, Group IIA
- Period 5, Group VIB
- Group IA, Period 2
- Group IVA, Period 5

3.34 Give the symbol of the element that occupies each of the following positions in the periodic table.

- Period 1, Group IA
- Period 6, Group IB
- Group IIIB, Period 4
- Group VIIA, Period 3

3.35 Using the periodic table, determine the following.

- The atomic number of the element carbon
- The atomic mass of the element silicon
- The atomic number of the element with an atomic mass of 88.91 amu
- The atomic mass of the element located in Period 2 and Group IIA

3.36 Using the periodic table, determine the following.

- The atomic number of the element magnesium
- The atomic mass of the element nitrogen

- c. The atomic mass of the element with an atomic number of 10
 d. The atomic number of the element located in Group IIIA and Period 3
- 3.37** Based on periodic table position, select the two elements in each set of elements that would be expected to have similar chemical properties.
- a. ${}_{19}\text{K}$, ${}_{29}\text{Cu}$, ${}_{37}\text{Rb}$, ${}_{41}\text{Nb}$ b. ${}_{13}\text{Al}$, ${}_{14}\text{Si}$, ${}_{15}\text{P}$, ${}_{33}\text{As}$
 c. ${}_{9}\text{F}$, ${}_{40}\text{Zr}$, ${}_{50}\text{Sn}$, ${}_{53}\text{I}$ d. ${}_{11}\text{Na}$, ${}_{12}\text{Mg}$, ${}_{54}\text{Xe}$, ${}_{55}\text{Cs}$
- 3.38** Based on periodic table position, select the two elements in each set of elements that would be expected to have similar chemical properties.
- a. ${}_{11}\text{Na}$, ${}_{14}\text{Si}$, ${}_{23}\text{V}$, ${}_{55}\text{Cs}$ b. ${}_{13}\text{Al}$, ${}_{19}\text{K}$, ${}_{32}\text{Ge}$, ${}_{50}\text{Sn}$
 c. ${}_{37}\text{Rb}$, ${}_{38}\text{Sr}$, ${}_{54}\text{Xe}$, ${}_{56}\text{Ba}$ d. ${}_{2}\text{He}$, ${}_{6}\text{C}$, ${}_{8}\text{O}$, ${}_{10}\text{Ne}$
- 3.39** The following statements either define or are closely related to the terms *periodic law*, *period*, and *group*. Match each statement with the appropriate term.
- a. This is a vertical arrangement of elements in the periodic table.
 b. The properties of the elements repeat in a regular way as atomic numbers increase.
 c. The chemical properties of elements 12, 20, and 38 demonstrate this principle.
 d. Carbon is the first member of this arrangement.
- 3.40** The following statements either define or are closely related to the terms *periodic law*, *period*, and *group*. Match each statement with the appropriate term.
- a. This is a horizontal arrangement of elements in the periodic table.
 b. Element 19 begins this arrangement in the periodic table.
 c. Elements 24 and 33 belong to this arrangement.
 d. Elements 10, 18, and 36 belong to this arrangement.
- 3.41** Identify each of the following elements by name.
- a. Period 2 halogen b. Period 3 alkali metal
 c. Period 4 noble gas d. Period 5 alkaline earth metal
- 3.42** Identify each of the following elements by name.
- a. Period 2 alkali metal b. Period 3 noble gas
 c. Period 4 alkaline earth metal d. Period 5 halogen
- 3.43** How many elements exist with an atomic number less than 40 that are
- a. Halogens b. Noble gases
 c. Alkali metals d. Alkaline earth metals
- 3.44** How many elements exist with an atomic number greater than 20 that are
- a. Halogens b. Noble gases
 c. Alkali metals d. Alkaline earth metals
- 3.45** Determine the following for the “highlighted” elements in the given periodic table. (Specify your answer by giving the “color” of the element.)

- a. Which of the highlighted elements is a halogen?
 b. Which of the highlighted elements is an alkaline earth metal?
 c. Which of the highlighted elements is in Group IIA?
 d. Which of the highlighted elements is in Period 3?

- 3.46** Determine the following for the “highlighted” elements in the periodic table given in Problem 3.45. (Specify your answer by giving the “color” of the element.)
- a. Which of the highlighted elements is an alkali metal?
 b. Which of the highlighted elements is a noble gas?
 c. Which of the highlighted elements is in Group VIIA?
 d. Which of the highlighted elements is in Period 2?

Metals and Nonmetals (Section 3.5)

- 3.47** In which of the following pairs of elements are both members of the pair metals?
- a. ${}_{17}\text{Cl}$ and ${}_{35}\text{Br}$ b. ${}_{13}\text{Al}$ and ${}_{14}\text{Si}$
 c. ${}_{29}\text{Cu}$ and ${}_{42}\text{Mo}$ d. ${}_{30}\text{Zn}$ and ${}_{83}\text{Bi}$
- 3.48** In which of the following pairs of elements are both members of the pair metals?
- a. ${}_{7}\text{N}$ and ${}_{34}\text{Se}$ b. ${}_{16}\text{S}$ and ${}_{48}\text{Cd}$
 c. ${}_{3}\text{Li}$ and ${}_{26}\text{Fe}$ d. ${}_{50}\text{Sn}$ and ${}_{53}\text{I}$
- 3.49** Identify the nonmetal in each of the following sets of elements.
- a. S, Na, K b. Cu, Li, P
 c. Be, I, Ca d. Fe, Cl, Ga
- 3.50** Identify the nonmetal in each of the following sets of elements.
- a. Al, H, Mg b. C, Sn, Sb
 c. Ti, V, F d. Sr, Se, Sm
- 3.51** Classify each of the following general physical properties as a property of metallic elements or of nonmetallic elements.
- a. Ductile b. Low electrical conductivity
 c. High thermal conductivity d. Good heat insulator
- 3.52** Classify each of the following general physical properties as a property of metallic elements or of nonmetallic elements.
- a. Nonmalleable b. High luster
 c. Low thermal conductivity d. Brittle
- 3.53** Determine the following for the “highlighted” elements in the given periodic table.

- a. Is the element highlighted in red a metal or nonmetal?
 b. Is the element highlighted in green a metal or nonmetal?
 c. Is the element highlighted in yellow a good or poor conductor of electricity?
 d. Is the element highlighted in blue a good or poor conductor of heat?
- 3.54** Determine the following, using the periodic table given in Problem 3.53.
- a. Is the element highlighted in yellow a metal or nonmetal?
 b. Is the element highlighted in blue a metal or nonmetal?
 c. Is the element highlighted in red a good or poor conductor of electricity?
 d. Is the element highlighted in green a good or poor conductor of heat?

Electron Arrangements Within Atoms (Section 3.6)

- 3.55** The following statements define or are closely related to the terms *electron shell*, *electron subshell*, and *electron orbital*. Match each statement with the appropriate term.
- a. In terms of electron capacity, this unit is the smallest of the three.

- b. This unit can contain a maximum of two electrons.
 c. This unit is designated just by a number.
 d. The term *energy level* is closely associated with this unit.
- 3.56** The following statements define or are closely related to the terms *electron shell*, *electron subshell*, and *electron orbital*. Match each statement with the appropriate term.
- This unit can contain as many electrons as, or more electrons than, either of the other two.
 - The term *energy sublevel* is closely associated with this unit.
 - Electrons that occupy this unit do not need to have identical energies.
 - The unit is designated in the same way as the orbitals contained within it.
- 3.57** Indicate whether each of the following statements is true or false.
- An orbital has a definite size and shape, which are related to the energy of the electrons it could contain.
 - All the orbitals in a subshell have the same energy.
 - All subshells accommodate the same number of electrons.
 - A $2p$ subshell and a $3p$ subshell contain the same number of orbitals.
- 3.58** Indicate whether each of the following statements is true or false.
- All the subshells in a shell have the same energy.
 - An s orbital has a shape that resembles a four-leaf clover.
 - The third shell can accommodate a maximum number of 18 electrons.
 - All orbitals accommodate the same number of electrons.
- 3.59** Give the maximum number of electrons that can occupy each of the following electron-accommodating units.
- One of the orbitals in the $2p$ subshell
 - One of the orbitals in the $3d$ subshell
 - The $4p$ subshell
 - The third shell
- 3.60** Give the maximum number of electrons that can occupy each of the following electron-accommodating units.
- One of the orbitals in the $4d$ subshell
 - One of the orbitals in the $5f$ subshell
 - The $3d$ subshell
 - The second shell

Electron Configurations and Orbital Diagrams (Section 3.7)

- 3.61** Write complete electron configurations for atoms of each of the following elements.
- ${}_6\text{C}$
 - ${}_{11}\text{Na}$
 - ${}_{16}\text{S}$
 - ${}_{18}\text{Ar}$
- 3.62** Write complete electron configurations for atoms of each of the following elements.
- ${}_{10}\text{Ne}$
 - ${}_{13}\text{Al}$
 - ${}_{19}\text{K}$
 - ${}_{22}\text{Ti}$
- 3.63** On the basis of the total number of electrons present, identify the elements whose electron configurations are
- $1s^2 2s^2 2p^4$
 - $1s^2 2s^2 2p^6$
 - $1s^2 2s^2 2p^6 3s^2 3p^1$
 - $1s^2 2s^2 2p^6 3s^2 3p^4 4s^2$
- 3.64** On the basis of the total number of electrons present, identify the elements whose electron configurations are
- $1s^2 2s^2 2p^2$
 - $1s^2 2s^2 2p^6 3s^1$
 - $1s^2 2s^2 2p^6 3s^2 3p^5$
 - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3$
- 3.65** Write *complete* electron configurations for atoms whose electron configurations *end* as follows.
- $3p^5$
 - $4d^7$
 - $4s^2$
 - $3d^1$
- 3.66** Write *complete* electron configurations for atoms whose electron configurations *end* as follows.
- $4p^2$
 - $3d^{10}$
 - $5s^1$
 - $4p^6$
- 3.67** Draw the orbital diagram associated with each of the following electron configurations.
- $1s^2 2s^2 2p^2$
 - $1s^2 2s^2 2p^6 3s^2$
 - $1s^2 2s^2 2p^6 3s^2 3p^3$
 - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$
- 3.68** Draw the orbital diagram associated with each of the following electron configurations.
- $1s^2 2s^2 2p^5$
 - $1s^2 2s^2 2p^6 3s^1$
 - $1s^2 2s^2 2p^6 3s^2 3p^1$
 - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
- 3.69** How many unpaired electrons are present in the orbital diagram for each of the following elements?
- ${}_7\text{N}$
 - ${}_{12}\text{Mg}$
 - ${}_{17}\text{Cl}$
 - ${}_{25}\text{Mn}$
- 3.70** How many unpaired electrons are present in the orbital diagram for each of the following elements?
- ${}_9\text{F}$
 - ${}_{16}\text{S}$
 - ${}_{20}\text{Ca}$
 - ${}_{30}\text{Zn}$

Electron Configurations and the Periodic Law (Section 3.8)

- 3.71** Indicate whether the elements represented by the given pairs of electron configurations have similar chemical properties.
- $1s^2 2s^1$ and $1s^2 2s^2$
 - $1s^2 2s^2 2p^6$ and $1s^2 2s^2 2p^6 3s^2 3p^6$
 - $1s^2 2s^2 2p^3$ and $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
 - $1s^2 2s^2 2p^6 3s^2 3p^4$ and $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$
- 3.72** Indicate whether the elements represented by the given pairs of electron configurations have similar chemical properties.
- $1s^2 2s^2 2p^4$ and $1s^2 2s^2 2p^5$
 - $1s^2 2s^2$ and $1s^2 2s^2 2p^2$
 - $1s^2 2s^1$ and $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
 - $1s^2 2s^2 2p^6$ and $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
- 3.73** Specify the location of each of the following elements in the periodic table in terms of s area, p area, d area, or f area.
- Magnesium
 - Copper
 - Bromine
 - Iron
- 3.74** Specify the location of each of the following elements in the periodic table in terms of s area, p area, d area, or f area.
- Aluminum
 - Potassium
 - Sulfur
 - Gold
- 3.75** For each of the following elements, specify the extent to which the subshell containing the distinguishing electron is filled (s^2 , p^3 , p^5 , d^4 , etc.).
- ${}_{13}\text{Al}$
 - ${}_{23}\text{V}$
 - ${}_{20}\text{Ca}$
 - ${}_{36}\text{Kr}$
- 3.76** For each of the following elements, specify the extent to which the subshell containing the distinguishing electron is filled (s^2 , p^3 , p^5 , d^4 , etc.).
- ${}_{10}\text{Ne}$
 - ${}_{19}\text{K}$
 - ${}_{33}\text{As}$
 - ${}_{30}\text{Zn}$
- 3.77** Determine the following for the “highlighted” elements in the given periodic table.

- Is the element highlighted in red in the s area or p area of the periodic table?
- Is the element highlighted in green in the d area or p area of the periodic table?

- c. Is the element highlighted in yellow a p^2 element or a p^4 element?
- d. Is the element highlighted in blue a d^2 or an s^2 element?
- 3.78** Determine the following, using the periodic table given in Problem 3.77.
- a. Is the element highlighted in yellow in the p area or d area of the periodic table?
- b. Is the element highlighted in blue in the s area or d area of the periodic table?
- c. Is the element highlighted in red an s^2 or a d^2 element?
- d. Is the element highlighted in green a d^6 or a d^8 element?

Classification of the Elements (Section 3.9)

- 3.79** Classify each of the following elements as a noble gas, representative element, transition element, or inner transition element.
- a. ${}_{15}\text{P}$ b. ${}_{18}\text{Ar}$ c. ${}_{79}\text{Au}$ d. ${}_{92}\text{U}$
- 3.80** Classify each of the following elements as a noble gas, representative element, transition element, or inner transition element.
- a. ${}_{1}\text{H}$ b. ${}_{44}\text{Ru}$ c. ${}_{51}\text{Sb}$ d. ${}_{86}\text{Rn}$
- 3.81** Classify the element with each of the following electron configurations as a representative element, transition element, noble gas, or inner transition element.
- a. $1s^2 2s^2 2p^6$ b. $1s^2 2s^2 2p^6 3s^2 3p^4$
- c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$ d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
- 3.82** Classify the element with each of the following electron configurations as a representative element, transition element, noble gas, or inner transition element.

- a. $1s^2 2s^2 2p^6 3s^1$ b. $1s^2 2s^2 2p^6 3s^2 3p^6$
- c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$ d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

- 3.83** Determine the following for the “highlighted” elements in the given periodic table.

- a. How many of the highlighted elements are representative elements?
- b. How many of the highlighted elements are noble gases?
- c. How many of the highlighted elements are nonmetallic representative elements?
- d. How many of the highlighted elements are metals?
- 3.84** Determine the following for the “highlighted” elements in the periodic table given in Problem 3.83.
- a. How many of the highlighted elements are inner transition elements?
- b. How many of the highlighted elements are transition elements?
- c. How many of the highlighted elements are metallic representative elements?
- d. How many of the highlighted elements are nonmetals?

ADDITIONAL PROBLEMS

- 3.85** With the help of the periodic table, complete the following table.

Element	Complete Chemical Symbol	Atomic Number	Mass Number	Number of Protons	Number of Neutrons
(a)	${}^3_2\text{He}$				
(b) nickel			60		
(c)		18	37		
(d)			90		52
(e)	${}^{235}_{92}\text{U}$				
(f)				17	20
(g)			232	94	
(h)	${}^{32}_{16}\text{S}$				
(i) iron			56		
(j) calcium					20

- 3.86** With the help of the periodic table, write complete chemical symbols for atoms with the following characteristics.
- a. Contains 20 electrons and 24 neutrons
- b. Radon atom with a mass number of 211
- c. Silver atom that contains 157 subatomic particles
- d. Beryllium atom that contains 9 nucleons
- 3.87** Characterize each of the following pairs of atoms as containing (1) the same number of neutrons, (2) the same number of electrons, or (3) the same total number of subatomic particles.
- a. ${}^{13}_6\text{C}$ and ${}^{14}_7\text{N}$ b. ${}^{18}_8\text{O}$ and ${}^{19}_9\text{F}$
- c. ${}^{37}_{17}\text{Cl}$ and ${}^{36}_{18}\text{Ar}$ d. ${}^{35}_{17}\text{Cl}$ and ${}^{37}_{17}\text{Cl}$
- 3.88** Indicate whether each of the following numbers are the same or different for two isotopes of an element.
- a. Atomic number b. Mass number
- c. Number of neutrons d. Number of electrons
- 3.89** Write the complete chemical symbol (${}^A_Z\text{E}$) for the isotope of chromium with each of the following characteristics.
- a. Two more neutrons than ${}^{55}_{24}\text{Cr}$
- b. Two fewer subatomic particles than ${}^{52}_{24}\text{Cr}$
- c. The same number of neutrons as ${}^{60}_{29}\text{Cu}$
- d. The same number of subatomic particles as ${}^{60}_{29}\text{Cu}$

- 3.90** How many electrons are present in nine molecules of the compound $C_{12}H_{22}O_{11}$ (table sugar)?
- 3.91** Which of the six elements nitrogen, beryllium, argon, aluminum, silver, and gold belong(s) in each of the following classifications?
- Period and Roman numeral group numbers are numerically equal
 - Readily conducts electricity and heat
 - Has an atomic mass greater than its atomic number
 - All atoms have a nuclear charge greater than +20
- 3.92** The electron configuration of the isotope ^{16}O is $1s^2 2s^2 2p^4$. What is the electron configuration for the isotope ^{18}O ?
- 3.93** Write electron configurations for the following elements.
- The Group IIIA element in the same period as ${}_4Be$
 - The Period 3 element in the same group as ${}_5B$
 - The lowest-atomic-numbered metal in Group IA
 - The Period 3 element that has three unpaired electrons
- 3.94** Referring only to the periodic table, determine the element of lowest atomic number whose electron configuration contains each of the following.
- Three completely filled orbitals
 - Three completely filled subshells
 - Three completely filled shells
 - Three completely filled s subshells

Multiple-Choice Practice Test

- 3.95** Which of the following listings correctly orders subatomic particles in terms of increasing mass?
- Electron, proton, neutron
 - Electron, neutron, proton
 - Proton, neutron, electron
 - Neutron, proton, electron
- 3.96** Which of the following statements concerning the *nucleus* of an atom is *correct*?
- Contains only neutrons
 - Contains all protons and all electrons
 - Is always positively charged
 - Accounts for most of the total volume of an atom
- 3.97** The number of protons, neutrons, and electrons, respectively, in an atom of $^{60}_{27}Co$ is
- 27, 27, 33
 - 27, 33, 27
 - 33, 27, 33
 - 27, 60, 27
- 3.98** All atoms of a given element have the same
- mass number.
 - number of nucleons.
 - number of neutrons.
 - number of protons.
- 3.99** The atomic number of an oxygen atom containing 10 neutrons is
- 8
 - 10
 - 18
 - 20
- 3.100** The correct electron configuration for the element ${}_{20}Ca$ is
- $1s^2 2s^2 2p^6 3s^2$
 - $1s^2 2s^2 3s^2 4s^2$
 - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
 - $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
- 3.101** Which of the following statements is consistent with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^4$?
- There are 4 electrons present in a $3p$ orbital.
 - There are 4 electrons present in a $3p$ subshell.
 - There are 4 electrons present in a $3p$ shell.
 - There are 4 electrons present in the third shell.
- 3.102** Which of the following elements is located in Period 3 and Group IVA of the periodic table?
- N
 - Si
 - Ge
 - In
- 3.103** In which of the following pairs of elements is one element a metal and the other element a nonmetal?
- ${}_{30}Zn$ and ${}_{31}Ga$
 - ${}_{16}S$ and ${}_{17}Cl$
 - ${}_9F$ and ${}_{53}I$
 - ${}_{15}P$ and ${}_{53}Bi$
- 3.104** Which of the following statements concerning types of elements is *correct*?
- There are more noble gas elements than transition elements.
 - There are more “ s area” elements than “ p area” elements.
 - There are more nonmetals than metals.
 - There are more representative elements than inner transition elements.