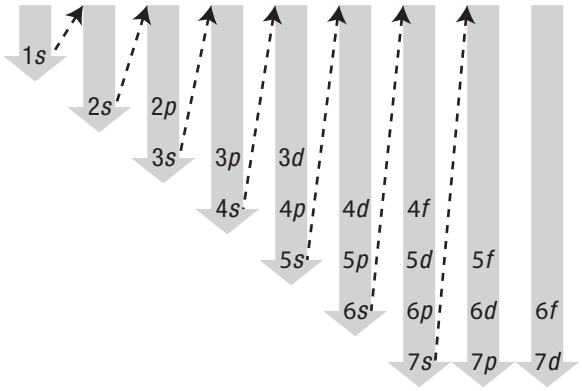
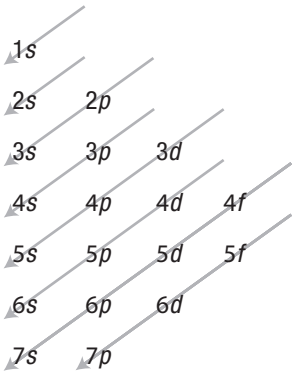
Math Tutor | Writing Electron Configurations

The arrangement of elements in the periodic table reflects the arrangement of electrons in an atom. Each period begins with an atom that has an electron in a new energy level, and with the exception of the first period, each period ends with an atom that has a filled set of *p* orbitals.

To write the electron configuration of an element, you must fill the sublevels in order of increasing energy. If you follow the arrows in either of the two types of mnemonics shown below, you will get correct configurations for most elements.





You also need to know how many orbitals are in each sublevel and that each orbital can contain two electrons of opposite spins. As shown in the following table, the sublevels *s, p, d,* and *f* have 1, 3, 5, and 7 available orbitals, respectively.

SUBLEVEL	*s*	*p*	*d*	*f*
No. of orbitals	1	3	5	7
No. of electrons	2	6	10	14

Sample Problem

Write the full electron configuration for phosphorus.

The atomic number of phosphorus is 15, so a phosphorus atom has 15 protons and 15 electrons. Assign each of the 15 electrons to the appropriate sublevels. The final sublevel can be unfilled and will contain the number of valence electrons.

$$\underbrace{1s^2}_{2e^-} \quad \underbrace{2s^2}_{2e^-} \quad \underbrace{2p^6}_{6e^-} \quad \underbrace{3s^2}_{2e^-} \quad \underbrace{3p^3}_{3e^-}$$

$$2e^- + 2e^- + 6e^- + 2e^- + 3e^- = 15e^-$$

So, the full electron configuration of phosphorus is $1s^2 2s^2 2p^6 3s^2 3p^3$.

Practice

Answers in Appendix E

1. Write full electron configurations for the following elements.
   a. aluminum **c.** tin
   b. neon **d.** potassium

2. Use noble gas symbols to write shorthand electron configurations for the following elements.
   a. silicon **c.** antimony
   b. rubidium **d.** arsenic

CHAPTER 5 Summary

BIG IDEA The properties of the chemical elements are a periodic function of their atomic numbers.

SECTION 1 History of the Periodic Table

- The periodic law states that the physical and chemical properties of the elements are periodic functions of their atomic numbers.
- The periodic table is an arrangement of the elements in order of their atomic numbers so that elements with similar properties fall in the same column.
- The columns in the periodic table are referred to as groups.

KEY TERMS

periodic law
periodic table
lanthanide
actinide

SECTION 2 Electron Configuration and the Periodic Table

- The rows in the periodic table are called periods.
- Many chemical properties of the elements can be explained by the configurations of the elements' outermost electrons.
- The noble gases exhibit unique chemical stability because their highest occupied levels have an octet of electrons, ns^2np^6 (with the exception of helium, whose stability arises from its highest occupied level being completely filled with two electrons, $1s^2$).
- Based on the electron configurations of the elements, the periodic table can be divided into four blocks: the *s*-block, the *p*-block, the *d*-block, and the *f*-block.

KEY TERMS

alkali metals
alkaline-earth metals
transition elements
main-group elements
halogens

SECTION 3 Electron Configuration and Periodic Properties

- The groups and periods of the periodic table display general trends in the following properties of the elements: electron affinity, electronegativity, ionization energy, atomic radius, and ionic radius.
- The electrons in an atom that are available to be lost, gained, or shared in the formation of chemical compounds are referred to as valence electrons.
- In determining what the electron configuration of an ion is, assume electrons are removed from the orbitals with the highest value of *n* first.

KEY TERMS

atomic radius
ion
ionization
ionization energy
electron affinity
cation
anion
valence electron
electronegativity

CHAPTER 5 Review

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SECTION 1

History of the Periodic Table

REVIEWING MAIN IDEAS

1. Describe the contributions made by the following scientists to the development of the periodic table:
   a. Stanislao Cannizzaro
   b. Dmitri Mendeleev
   c. Henry Moseley

2. State the periodic law.

3. How is the periodic law demonstrated within the groups of the periodic table?

SECTION 2

Electron Configuration and the Periodic Table

REVIEWING MAIN IDEAS

4. a. How do the electron configurations within the same group of elements compare?
   b. Why are the noble gases relatively unreactive?

5. What determines the length of each period in the periodic table?

6. What is the relationship between the electron configuration of an element and the period in which that element appears in the periodic table?

7. a. What information is provided by the specific block location of an element?
   b. Identify, by number, the groups located within each of the four block areas.

8. a. Which elements are designated as the alkali metals?
   b. List four of their characteristic properties.

9. a. Which elements are designated as the alkaline-earth metals?
   b. How do their characteristic properties compare with those of the alkali metals?

10. a. Write the group configuration notation for each *d*-block group.
    b. How do the group numbers of those groups relate to the number of outer *s* and *d* electrons?

11. What name is sometimes used to refer to the entire set of *d*-block elements?

12. a. What types of elements make up the *p*-block?
    b. How do the properties of the *p*-block metals compare with those of the metals in the *s*- and *d*-blocks?

13. a. Which elements are designated as the halogens?
    b. List three of their characteristic properties.

14. a. Which elements are metalloids?
    b. Describe their characteristic properties.

15. Which elements make up the *f*-block in the periodic table?

16. a. What are the main-group elements?
    b. What trends can be observed across the various periods within the main-group elements?

PRACTICE PROBLEMS

17. Write the noble-gas notation for the electron configuration of each of the following elements, and indicate the period in which each belongs.
    a. Li
    b. O
    c. Cu
    d. Br
    e. Sn

18. Without looking at the periodic table, identify the period, block, and group in which the elements with the following electron configurations are located. (Hint: See Sample Problem A.)
    a. $[Ne]3s^2 3p^4$
    b. $[Kr]4d^{10}5s^2 5p^2$
    c. $[Xe]4f^{14}5d^{10}6s^2 6p^5$

19. Based on the information given below, give the group, period, block, and identity of each element described. (Hint: See Sample Problem B.)
    a. $[He]2s^2$
    b. $[Ne]3s^1$
    c. $[Kr]5s^2$
    d. $[Ar]4s^2$
    e. $[Ar]3d^5 4s^1$

20. Without looking at the periodic table, write the expected outer electron configuration for each of the following elements. (Hint: See Sample Problem C.)
    a. Group 7, fourth period
    b. Group 3, fifth period
    c. Group 12, sixth period

21. Identify the block, period, group, group name (where appropriate), element name, element type, and relative reactivity for the elements with the following electron configurations. (Hint: See Sample Problem D.)
a. [Ne]$3s^2 3p^1$
b. [Ar]$3d^{10}4s^2 4p^6$
c. [Kr]$4d^{10}5s^1$
d. [Xe]$4f^1 5d^1 6s^2$

SECTION 3

Electron Configuration and Periodic Properties

REVIEWING MAIN IDEAS

22. a. What is meant by *atomic radius*?
b. What trend is observed among the atomic radii of main-group elements across a period?
c. Explain this trend.

23. a. What trend is observed among the atomic radii of main-group elements down a group?
b. Explain this trend.

24. Define each of the following terms:
a. ion
b. ionization
c. first ionization energy
d. second ionization energy

25. a. How do the first ionization energies of main-group elements vary across a period and down a group?
b. Explain the basis for each trend.

26. a. What is electron affinity?
b. What signs are associated with electron affinity values, and what is the significance of each sign?

27. a. Distinguish between a cation and an anion.
b. How does the size of each compare with the size of the neutral atom from which it is formed?

28. a. What are valence electrons?
b. Where are such electrons located?

29. For each of the following groups, indicate whether electrons are more likely to be lost or gained in compound formation and give the number of such electrons typically involved.
a. Group 1
b. Group 2
c. Group 13
d. Group 16
e. Group 17
f. Group 18

30. a. What is electronegativity?
b. Why is fluorine special in terms of electronegativity?

31. Identify the most- and least-electronegative groups of elements in the periodic table.

PRACTICE PROBLEMS

32. Of cesium, Cs, hafnium, Hf, and gold, Au, which element has the smallest atomic radius? Explain your answer in terms of trends in the periodic table. (Hint: See Sample Problem E.)

33. a. Distinguish between the first, second, and third ionization energies of an atom.
b. How do the values of successive ionization energies compare?
c. Why does this occur?

34. Without looking at the electron affinity table, arrange the following elements in order of *decreasing* electron affinities: C, O, Li, Na, Rb, and F.

35. a. Without looking at the ionization energy table, arrange the following elements in order of decreasing first ionization energies: Li, O, C, K, Ne, and F.
b. Which of the elements listed in (a) would you expect to have the highest second ionization energy? Why?

36. a. Which of the following cations is least likely to form: Sr^{2+}, Al^{3+}, K^{2+}?
b. Which of the following anions is least likely to form: I^-, Cl^-, O^{2-}?

37. Which element is the most electronegative among C, N, O, Br, and S? Which group does it belong to? (Hint: See Sample Problem G.)

38. The two ions K^+ and Ca^{2+} each have 18 electrons surrounding the nucleus. Which would you expect to have the smaller radius? Why?

Mixed Review

REVIEWING MAIN IDEAS

39. Without looking at the periodic table, identify the period, block, and group in which each of the following elements is located.

a. [Rn]$7s^1$
b. [Ar]$3d^2 4s^2$
c. [Kr]$4d^{10}5s^1$
d. [Xe]$4f^{14}5d^9 6s^1$

40. **a.** Which elements are designated as the noble gases?
b. What is the most significant property of these elements?

41. Which of the following does not have a noble-gas configuration: Na^+, Rb^+, O^{2-}, Br^- Ca^+, Al^{3+}, S^{2-}?

42. **a.** How many groups are in the periodic table?
b. How many periods are in the periodic table?
c. Which two blocks of the periodic table make up the main-group elements?

43. Write the noble-gas notation for the electron configuration of each of the following elements, and indicate the period and group in which each belongs.

a. Mg
b. P
c. Sc
d. Y

44. Use the periodic table to describe the chemical properties of the following elements:

a. fluorine, F
b. xenon, Xe
c. sodium, Na
d. gold, Au

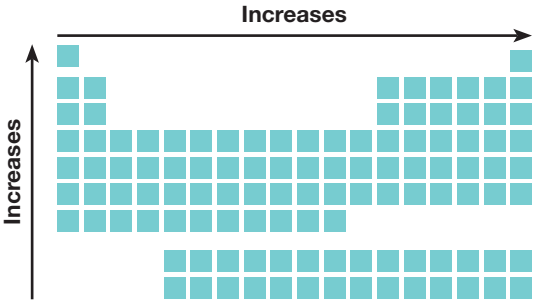
45. For each element listed below, determine the charge of the ion that is most likely to be formed and the identity of the noble gas whose electron configuration is thus achieved.

a. Li
b. Rb
c. O
d. F
e. Mg
f. Al
g. P
h. S
i. Br
j. Ba

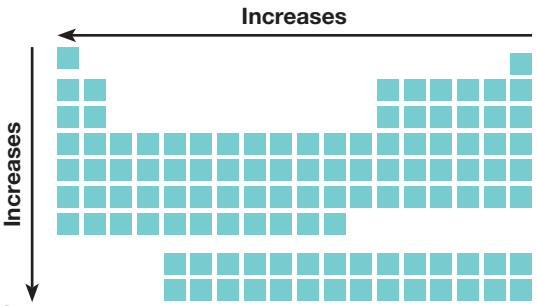
46. Describe some differences between the *s*-block metals and the *d*-block metals.

47. Why do the halogens readily form 1–ions?

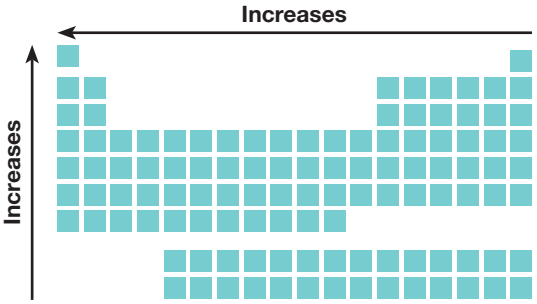
48. Identify which trends in the diagrams below describe atomic radius, ionization energy, electron affinity, and electronegativity.



a.



b.



c.

49. The electron configuration of argon differs from those of chlorine and potassium by one electron each. Compare the reactivity of these three elements.

CRITICAL THINKING

As a member on the newly inhabited space station Alpha, you are given the task of organizing information on newly discovered elements as it comes in from the laboratory. To date, five elements have been discovered and have been assigned names and symbols from the Greek alphabet. An analysis of the new elements has yielded the following data:

Element name	Atomic no.	Atomic mass	Properties
Epsilon ε	23	47.33	nonmetal, very reactive, produces a salt when combined with a metal, gaseous state
Beta β	13	27.01	metal, very reactive, soft solid, low melting point
Gamma γ	12	25.35	nonmetal, gaseous element, extremely unreactive
Delta Δ	4	7.98	nonmetal, very abundant, forms compounds with most other elements
Lambda Λ	9	16.17	metal, solid state, good conductor, high luster, hard and dense

50. Applying Models Create a periodic table based on the properties of the five new elements.

51. Predicting Outcomes Using your newly created periodic table, predict the atomic number of an element with an atomic mass of 11.29 that has nonmetallic properties and is very reactive.

52. Predicting Outcomes Predict the atomic number of an element having an atomic mass of 15.02 that exhibits metallic properties but is softer than lambda and harder than beta.

53. Analyzing Information Analyze your periodic table for trends, and describe those trends.

USING THE HANDBOOK

54. Review the boiling point and melting point data in the tables of the *Elements Handbook* (Appendix A). Make a list of the elements that exist as liquids or gases at the boiling point of water, 100°C.

55. Because transition metals have vacant *d* orbitals, they form a greater variety of colored compounds than do the metals of Groups 1 and 2. Review the section of the *Elements Handbook* (Appendix A) on transition metals, and answer the following:

a. What colors are exhibited by chromium in its common oxidation states?

b. What gems contain chromium impurities?

c. What colors are often associated with the following metal ions: copper, cadmium, cobalt, zinc, and nickel?

d. What transition elements are considered noble metals? What are the characteristics of a noble metal?

RESEARCH AND WRITING

56. Prepare a report tracing the evolution of the current periodic table since 1900. Cite the chemists involved and their major contributions.

57. Write a report describing the contributions of Glenn Seaborg toward the discovery of many of the actinide elements.

ALTERNATIVE ASSESSMENT

58. Construct your own periodic table or obtain a poster that shows related objects, such as fruits or vegetables, in periodic arrangement. Describe the organization of the table and the trends it illustrates. Use this table to make predictions about your subject matter.