

Chapter 6. Periodic Relationships Among the Elements

Student:

- The nineteenth century chemists arranged elements in the periodic table according to increasing
 - atomic number.
 - number of electrons.
 - atomic mass.
 - number of neutrons.
 - nuclear binding energy.
- Mendeleev proposed the existence of an unknown element that he called eka-aluminum. This element is now called
 - gallium.
 - silicon.
 - magnesium.
 - boron.
 - germanium.
- The chief contribution of physicist Henry Moseley to atomic theory was
 - the discovery of the periodic law.
 - the determination of the charge of the proton.
 - the measurement of the atomic numbers of the elements.
 - the determination of the electric charge of the electron.
 - the discovery of the law of octaves.
- The elements in Group 7A are known by what name?
 - transition metals
 - halogens
 - alkali metals
 - alkaline earth metals
 - noble gases

5. The elements in Group 2A are known by what name?
- A. transition metals
 - B. halogens
 - C. alkali metals
 - D. alkaline earth metals
 - E. noble gases
6. The alkali metal elements are found in _____ of the periodic table.
- A. Group 1A
 - B. Group 2A
 - C. Group 3A
 - D. Period 7
 - E. Period 1
7. Which one of these elements is a transition element?
- A. Sr
 - B. Pb
 - C. As
 - D. Fe
 - E. H
8. Which one of these elements is a transition element?
- A. Nickel
 - B. Tin
 - C. Sodium
 - D. Sulfur
 - E. Calcium
9. The general electron configuration for atoms of all elements in Group 5A is
- A. ns^2np^6
 - B. ns^2np^5
 - C. ns^2np^4
 - D. ns^2np^3
 - E. ns^2np^1
10. Which of these choices is the general electron configuration for the outermost electrons of elements in the alkaline earth group?
- A. ns^1
 - B. ns^2
 - C. ns^2np^4
 - D. ns^2np^5
 - E. $ns^2np^6(n-1)d^6$

11. The general electron configuration for atoms of the halogen group is
- A. ns^2np^6 .
 - B. ns^2np^5 .
 - C. $ns^2np^6(n-1)d^7$.
 - D. ns^1 .
 - E. ns^2np^7 .
12. The general electron configuration for noble gas atoms is
- A. ns^2np^6 .
 - B. ns^2np^5 .
 - C. ns^2np^4 .
 - D. ns^2np^3 .
 - E. ns^2 .
13. An element with the general electron configuration for its outermost electrons of ns^2np^1 would be in which element group?
- A. 2A
 - B. 3A
 - C. 4A
 - D. 5A
 - E. 8A
14. In what group of the periodic table is the element with the electron configuration $[\text{Ar}]4s^23d^{10}4p^3$?
- A. 1A
 - B. 2A
 - C. 3A
 - D. 4A
 - E. 5A
15. Consider the element with the electron configuration $[\text{Kr}]5s^24d^7$. This element is
- A. a representative element.
 - B. a transition metal.
 - C. a nonmetal.
 - D. an actinide element.
 - E. a noble gas.
16. Consider the element with the electron configuration $[\text{Kr}]5s^24d^{10}5p^5$. This element is
- A. a representative element.
 - B. a transition metal.
 - C. an alkali metal.
 - D. an actinide element.
 - E. a noble gas.

17. Consider the element with the electron configuration $[\text{Xe}]6s^24f^7$. This element is
- a representative element.
 - a lanthanide element.
 - a nonmetal.
 - an actinide element .
 - a noble gas.
18. The representative elements are those with unfilled energy levels in which the "last electron" was added to
- an s orbital.
 - an s or p orbital.
 - a d orbital.
 - a p or d orbital.
 - an f orbital.
19. How many *valence electrons* does a carbon atom have?
- 1
 - 2
 - 3
 - 4
 - 6
20. How many *valence electrons* does a tin (Sn) atom have?
- 2
 - 4
 - 14
 - 36
 - 50
21. How many electrons are in the $4p$ orbitals of selenium?
- 0
 - 2
 - 4
 - 5
 - 6
22. How many electrons are in the $4p$ orbitals of vanadium?
- 0
 - 2
 - 4
 - 5
 - 6

23. How many electrons are in the $4d$ orbitals of Tc?
- A. 1
 - B. 2
 - C. 3
 - D. 4
 - E. 5
24. What is the charge on the monatomic ion that calcium forms in its compounds?
- A. +2
 - B. +1
 - C. -1
 - D. -2
 - E. -3
25. What is the charge on the monatomic ion of nitrogen, the nitride ion?
- A. +2
 - B. +1
 - C. -1
 - D. -2
 - E. -3
26. What is the charge on the stable ion formed by selenium?
- A. +2
 - B. +1
 - C. -1
 - D. -2
 - E. -3
27. Which of these elements forms stable +2 cations?
- A. Kr
 - B. I
 - C. Se
 - D. Al
 - E. Ba

28. Which two electron configurations represent elements that would have similar chemical properties?
- (1) $1s^2 2s^2 2p^4$
 - (2) $1s^2 2s^2 2p^5$
 - (3) $[\text{Ar}]4s^2 3d^{10} 4p^3$
 - (4) $[\text{Ar}]4s^2 3d^{10} 4p^4$
- A. (1) and (2)
 - B. (1) and (3)
 - C. (1) and (4)
 - D. (2) and (4)
 - E. (2) and (3)
29. Which of these species make an *isoelectronic pair*: Cl^- , O^{2-} , F, Ca^{2+} , Fe^{3+} ?
- A. Ca^{2+} and Fe^{3+}
 - B. O^{2-} and F
 - C. F and Cl^-
 - D. Cl^- and Ca^{2+}
 - E. none of these
30. Which of these pairs consists of *isoelectronic* species?
- A. Mn^{2+} and Ar
 - B. Zn^{2+} and Cu^{2+}
 - C. Na^+ and K^+
 - D. Cl^- and S
 - E. K^+ and Cl^-
31. Which ion is *isoelectronic* with Ar?
- A. Fe^{2+}
 - B. F^-
 - C. Br^-
 - D. Ga^{3+}
 - E. Ca^{2+}
32. Which one of these ions is *not* isoelectronic with Kr?
- A. As^{3+}
 - B. Se^{2-}
 - C. Rb^+
 - D. Sr^{2+}
 - E. Br^-

33. Which of these choices is the electron configuration for the aluminum ion?
- A. $1s^2 2s^2 2p^6 3s^2$
 - B. $1s^2 2s^2 2p^6 3s^2 3p^2$
 - C. $1s^2 2s^2 2p^6 3s^2 3p^1$
 - D. $1s^2 2s^2 2p^6$
 - E. $1s^2 2s^2 2p^6 3s^2 3p^4$
34. Which of these choices is the electron configuration for the chloride ion?
- A. $[\text{Ne}]3s^2 3p^4$
 - B. $[\text{Ne}]3s^2 3p^7$
 - C. $[\text{Ar}]$
 - D. $[\text{Ar}]4s^1$
 - E. $[\text{Ne}]3s^2 3p^5$
35. Which of these choices is the electron configuration of a sulfide ion?
- A. $[\text{Ne}]3s^2 3p^4$
 - B. $[\text{Ne}]$
 - C. $[\text{Ne}]3s^2 3p^1$
 - D. $[\text{Ar}]$
 - E. $[\text{Ne}]3s^2 3p^2$
36. Which of these choices is the electron configuration of the iron(III) ion?
- A. $[\text{Ar}]3d^5$
 - B. $[\text{Ar}]4s^1 3d^5$
 - C. $[\text{Ar}]4s^2 3d^3$
 - D. $[\text{Ar}]3d^6$
 - E. $[\text{Ar}]4s^2 3d^9$
37. The electron configuration of a cobalt(III) ion is
- A. $[\text{Ar}]3d^5$.
 - B. $[\text{Ar}]4s^1 3d^5$.
 - C. $[\text{Ar}]4s^2 3d^4$.
 - D. $[\text{Ar}]3d^6$.
 - E. $[\text{Ar}]4s^2 3d^9$.
38. The sulfide ion, S^{2-} , is isoelectronic with which one of the following?
- A. O^{2-}
 - B. F^-
 - C. Na^+
 - D. Al^{3+}
 - E. K^+

39. Which one of these ions does *not* have [Kr] as its electronic configuration?
- A. Se^{2-}
 - B. Br^-
 - C. Rb^+
 - D. Y^{3+}
 - E. Zn^{2+}
40. Which one of these ions does *not* have [Xe] as its electronic configuration?
- A. Te^{2-}
 - B. I^-
 - C. Cs^+
 - D. Ba^{2+}
 - E. Sn^{4+}
41. The cobalt(III) ion, Co^{3+} , has how many *3d* electrons?
- A. 0
 - B. 7
 - C. 6
 - D. 5
 - E. 4
42. How many *3d* electrons does the copper(I) ion, Cu^+ , have?
- A. 10
 - B. 9
 - C. 8
 - D. 7
 - E. 6
43. How many *3d* electrons does an Fe^{3+} ion have?
- A. 9
 - B. 6
 - C. 5
 - D. 4
 - E. 3
44. Which of these ground-state ions has the largest number of unpaired electrons?
- A. Cr^{2+}
 - B. Mn^{2+}
 - C. Ni^{2+}
 - D. Cu^+
 - E. Co^{2+}

45. Which of these ground-state ions has unpaired electrons?
- A. P^{3-}
 - B. V^{5+}
 - C. Mg^{2+}
 - D. Sc^{2+}
 - E. S^{2-}
46. Which of these atoms has the smallest radius?
- A. Al
 - B. P
 - C. As
 - D. Te
 - E. Na
47. Which of these atoms has the largest radius?
- A. B
 - B. Ga
 - C. Br
 - D. Si
 - E. Cl
48. Which of the elements listed below has the greatest atomic radius?
- A. B
 - B. Al
 - C. S
 - D. P
 - E. Si
49. Which one of these ions has the largest radius?
- A. Cl^-
 - B. K^+
 - C. S^{2-}
 - D. Na^+
 - E. O^{2-}

50. Arrange these ions in order of increasing ionic radius: K^+ , P^{3-} , S^{2-} , Cl^- .

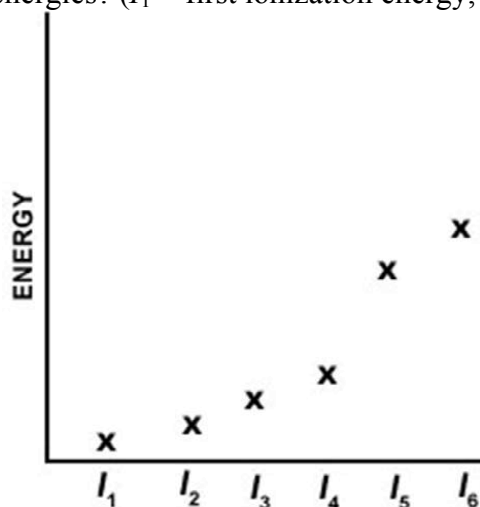
Increasing radius \rightarrow

- Row 1 $K^+ < Cl^- < S^{2-} < P^{3-}$
Row 2 $K^+ < P^{3-} < S^{2-} < Cl^-$
Row 3 $P^{3-} < S^{2-} < Cl^- < K^+$
Row 4 $Cl^- < S^{2-} < P^{3-} < K^+$
Row 5 $Cl^- < S^{2-} < K^+ < P^{3-}$

- A. Row 1
B. Row 2
C. Row 3
D. Row 4
E. Row 5
51. For which of these reactions is the enthalpy change equal to the second ionization energy of nitrogen?
- A. $N^{2+}(g) \rightarrow N^{3+}(g) + e^-$
B. $N^{2+}(g) + e^- \rightarrow N^+(g)$
C. $N(g) \rightarrow N^{2+}(g) + 2e^-$
D. $N^-(g) + e^- \rightarrow N^{2-}(g)$
E. $N^+(g) \rightarrow N^{2+}(g) + e^-$
52. For which of these reactions is the enthalpy change equal to the third ionization energy of vanadium?
- A. $V^{2+}(g) \rightarrow V^{3+}(g) + e^-$
B. $V^{3+}(g) + e^- \rightarrow V^{2+}(g)$
C. $V(g) \rightarrow V^{3+}(g) + 3e^-$
D. $V^{2-}(g) + e^- \rightarrow V^{3-}(g)$
E. $V^{3+}(g) \rightarrow V^{4+}(g) + e^-$
53. Which of these elements has the highest first ionization energy?
- A. Cs
B. Ga
C. K
D. Bi
E. As
54. Which of these elements has the highest first ionization energy?
- A. C
B. Si
C. Ge
D. Sn
E. Pb

55. Which of these elements has the smallest first ionization energy?
- A. Cl
 - B. Na
 - C. Be
 - D. K
 - E. As
56. Which of these elements has the smallest ionization energy?
- A. Li
 - B. Na
 - C. Be
 - D. K
 - E. Rb
57. Which of these elements will display an unusually large jump in ionization energy values between I_3 and I_4 , its third and fourth ionization energies?
- A. Na
 - B. Mg
 - C. Al
 - D. Si
 - E. P
58. For silicon atoms, which ionization energy will show an exceptionally large increase over the preceding ionization energy?
- A. 2nd
 - B. 3rd
 - C. 4th
 - D. 5th
 - E. 6th
59. For phosphorus atoms, which ionization energy will show an exceptionally large increase over the previous ionization energy?
- A. 2nd
 - B. 3rd
 - C. 4th
 - D. 5th
 - E. 6th

60. Which of these elements has the following pattern for its first six ionization energies? (I_1 = first ionization energy, I_2 = second ionization energy, etc.)



- A. Ca
 B. Si
 C. Al
 D. Se
 E. P
61. The successive ionization energies of a certain element are $I_1 = 589.5$ kJ/mol, $I_2 = 1145$ kJ/mol, $I_3 = 4900$ kJ/mol, $I_4 = 6500$ kJ/mol, and $I_5 = 8100$ kJ/mol. This pattern of ionization energies suggests that the unknown element is
- A. K.
 B. Si.
 C. As.
 D. Ca.
 E. S.
62. The successive ionization energies of a certain element are $I_1 = 577.9$ kJ/mol, $I_2 = 1820$ kJ/mol, $I_3 = 2750$ kJ/mol, $I_4 = 11,600$ kJ/mol, and $I_5 = 14,800$ kJ/mol. This pattern of ionization energies suggests that the unknown element is
- A. K.
 B. Al.
 C. Cl.
 D. Se.
 E. Kr.

63. Which of these elements has the greatest electron affinity (largest positive value)?
- A. Mg
 - B. Al
 - C. Si
 - D. P
 - E. S
64. Which of these elements has the greatest electron affinity (largest positive value)?
- A. K
 - B. Br
 - C. As
 - D. Ar
 - E. I
65. Which of these atoms has the greatest electron affinity (largest positive value)?
- A. S
 - B. P
 - C. Ga
 - D. Li
 - E. Br
66. The first ionization energy of sodium is 495.9 kJ/mol. The energy change for the reaction $\text{Na(s)} \rightarrow \text{Na}^+(\text{g}) + \text{e}^-$ is therefore
- A. 495.9 kJ/mol.
 - B. less than 495.9 kJ/mol.
 - C. greater than 495.9 kJ/mol.
 - D. equal to the electron affinity of sodium.
 - E. equal to the second ionization energy of sodium.
67. The first ionization energy of mercury is 1006 kJ/mol. The energy change for the reaction $\text{Hg(l)} \rightarrow \text{Hg}^+(\text{g}) + \text{e}^-$ is therefore
- A. 1006 kJ/mol.
 - B. greater than 1006 kJ/mol.
 - C. less than 1006 kJ/mol.
 - D. equal to the electron affinity of mercury.
 - E. equal to the second ionization energy of mercury.

68. The electron affinity of oxygen is equal to
- the ionization energy of O^- .
 - the ionization energy of O^{2-} .
 - the second ionization energy of O.
 - twice the electron affinity of O^+ .
 - none of these.
69. Which pair of elements from different groups resemble each other the most in their chemical properties?
- Be and B
 - Al and Si
 - Li and Be
 - Al and Be
 - Be and C
70. Which of these elements has the greatest metallic character?
- Br
 - F
 - Ge
 - Mn
 - Sc
71. Which of these elements has the greatest metallic character?
- Br
 - Se
 - Ni
 - As
 - Si
72. Which of these elements has the greatest metallic character?
- Ca
 - Mg
 - Ba
 - As
 - Se
73. If the radius of atom X is greater than the radius of atom Y, then it is also likely that
- X has a larger electron affinity than Y does.
 - X has a larger effective nuclear charge than Y does.
 - X has greater metallic character than Y does.
 - X has a larger first ionization energy than Y does.
 - X is a poorer conductor of electricity than Y when in the solid state.

74. Which of these compounds is an *amphoteric* oxide?
- A. Na_2O
 - B. MgO
 - C. Al_2O_3
 - D. SO_2
 - E. Cl_2O_7
75. Which of these compounds is a *basic* oxide?
- A. CO_2
 - B. CaO
 - C. SO_2
 - D. H_2O
 - E. NO_2
76. Which of these compounds is an *acidic* oxide?
- A. P_4O_{10}
 - B. MgO
 - C. Fe_2O_3
 - D. K_2O
 - E. Cr_2O_3
77. Which of these compounds is a *basic* oxide?
- A. CO_2
 - B. MgO
 - C. As_2O_3
 - D. SO_2
 - E. Cl_2O_7
78. Which of these compounds is a *basic* oxide?
- A. NO_2
 - B. H_2O
 - C. Na_2O
 - D. SnO
 - E. SO_2
79. Since arsenic is a nonmetal, As_2O_3 is expected to be a/an _____ oxide.
- A. acidic
 - B. ionic
 - C. amphoteric
 - D. neutral
 - E. basic

80. Since zirconium is a metal, ZrO_2 is expected to be a/an _____ oxide.
- A. acidic
 - B. ionic
 - C. amphoteric
 - D. neutral
 - E. basic
81. Which of these elements exhibits chemical behavior similar to that of calcium?
- A. magnesium
 - B. sodium
 - C. sulfur
 - D. chlorine
 - E. iron
82. Which of these elements exhibits chemical behavior similar to that of potassium?
- A. magnesium
 - B. sodium
 - C. beryllium
 - D. chlorine
 - E. iron
83. Which of these elements exhibits chemical behavior similar to that of oxygen?
- A. magnesium
 - B. sodium
 - C. sulfur
 - D. chlorine
 - E. iron
 - F. beryllium
84. Which of these elements exhibits chemical behavior similar to that of silver?
- A. nickel
 - B. gold
 - C. sulfur
 - D. chlorine
 - E. iron
 - F. beryllium
85. The second ionization energy of Mg is _____ than its first ionization energy, and is _____ than the second ionization energy of Na.
- A. higher, higher
 - B. lower, higher
 - C. higher, lower
 - D. lower, lower

86. Consider the following reaction: $3\text{Li} + \text{Z} \rightarrow \text{Li}_3\text{Z}$.
What is the formula for the compound if we substitute sodium for lithium?
- A. NaZ
 - B. Na_2Z
 - C. NaZ_2
 - D. Na_3Z
 - E. NaZ_3
87. Consider the following reaction: $3\text{Li} + \text{Z} \rightarrow \text{Li}_3\text{Z}$.
What is the formula for the compound if we substitute magnesium for lithium?
- A. MgZ
 - B. Mg_2Z
 - C. MgZ_2
 - D. Mg_3Z
 - E. Mg_3Z_2
88. Consider the following reaction $2\text{A} + 3\text{F}_2 \rightarrow 2\text{AF}_3$.
What is the formula for the reaction product if we substitute iodine for fluorine?
- A. A_2I_3
 - B. A_3I_2
 - C. AI_3
 - D. A_3I
 - E. AI
89. Consider the following reaction $2\text{A} + 3\text{F}_2 \rightarrow 2\text{AF}_3$.
What is the formula for the reaction product if we substitute sulfur for fluorine?
- A. A_2S_3
 - B. A_3S_2
 - C. AS_3
 - D. A_3S
 - E. AS
90. Write the ground-state electron configuration for S^{2-} .
91. Write the ground-state electron configuration for Ca^{2+} .

92. Write the ground-state electron configuration for Cr^{3+} .
93. Write the ground-state electron configuration for Ni^{2+} .
94. Write the ground-state electron configuration for Br^- .
95. Write the ground-state electron configuration for K^+ .
96. Write the ground-state electron configuration for Al^{3+} .
97. Write the ground-state electron configuration for O^{2-} .
98. Write the ground-state electron configuration for I^- .

99. Write the ground-state electron configuration for Mg^{2+} .
100. Why is the Mg^{2+} ion smaller than F^- even though they are isoelectronic?
101. Which species has the greater radius, an I^- ion or an I atom? Briefly explain your choice of answer.
102. Briefly explain why the atomic radius decreases within a period when moving from left to right.
103. The radius of an atom of sodium is 190 picometers. How many nanometers is this?
104. Given the following density data, what is a reasonable estimate of the *density* of the element gallium?
- | | |
|----------|------------|
| Boron | 2.34 g/mL |
| Aluminum | 2.70 g/mL |
| Indium | 7.31 g/mL |
| Thallium | 11.85 g/mL |

105. Given the following melting point data, what is a reasonable estimate of the melting point of potassium.

Lithium	180°C
Sodium	98°C
Rubidium	39°C
Cesium	29°C

106. What is the difference between a calcium atom and a calcium ion?

107. How do sodium metal and sodium ions differ in their chemical properties?

108. Consider the following reaction: $3\text{Li} + \text{Z} \rightarrow \text{Li}_3\text{Z}$.
What is a reasonable guess for the identity of element Z?

109. Consider the following reaction $2\text{A} + 3\text{F}_2 \rightarrow 2\text{AF}_3$.
What is a reasonable guess for the identity element A?

110. The radii of ions are always smaller than the radii of the corresponding atoms of the same element.

True False

111. *Electron affinity* is always a positive quantity.

True False

112. The electron configuration of the outermost electrons of atoms of the halogen group is ns^2np^7 .

True False

113. *Amphoteric* oxides exhibit both acidic and basic properties.

True False

114. For Mg atoms a very large jump in the magnitudes of the ionization energies will occur between the second and the third ionization energies.

True False

Chemistry 110-KAU - Prof. A. M. Asiri

Chapter 6 Periodic Relationships Among the Elements **Key**

1.C	22.A	43.C	64.B	85.C	106.A calcium
2.A	23.E	44.B	65.E	86.D	107.Sodium
3.C	24.A	45.D	66.C	87.E	108.Nitrogen
4.B	25.E	46.B	67.B	88.C	109.Aluminum
5.D	26.D	47.B	68.A	89.A	110.FALSE
6.A	27.E	48.B	69.D	90.[Ar]	111.FALSE
7.D	28.C	49.C	70.E	91.[Ar]	112.FALSE
8.A	29.D	50.A	71.C	92.[Ar]3d ³	113.TRUE
9.D	30.E	51.E	72.C	93.[Ar]3d ⁸	114.TRUE
10.B	31.E	52.A	73.C	94.[Kr]	
11.B	32.A	53.E	74.C	95.[Ar]	
12.A	33.D	54.A	75.B	96.[Ne]	
13.B	34.C	55.D	76.A	97.[Ne]	
14.E	35.D	56.E	77.B	98.[Xe]	
15.B	36.A	57.C	78.C	99.[Ne]	
16.A	37.D	58.D	79.A	100.Mg ²⁺ has a	
17.B	38.E	59.E	80.E	101.I ⁻ ; I and I ⁻	
18.B	39.E	60.B	81.A	102.Effective	
19.D	40.E	61.D	82.B	103.0.190 nm	
20.B	41.C	62.B	83.C	104.5-6 g/mL	
21.C	42.A	63.E	84.B	105.Around	