Chapter 9 Answers

Practice Examples

1a. S

1b. Ca

2a. $V^{3+}(64 \text{ pm}) < Ti^{2+}(86 \text{ pm}) < Ca^{2+}(100 \text{ pm}) < Sr^{2+}(113 \text{ pm}) < Br^{-}(196 \text{ pm})$

2b. As

3a. $K < Mg < S < Cl$

3b. Sb

4a. Cl and Al are paramagnetic; K^{+}, O^{2-}, and Zn are diamagnetic.
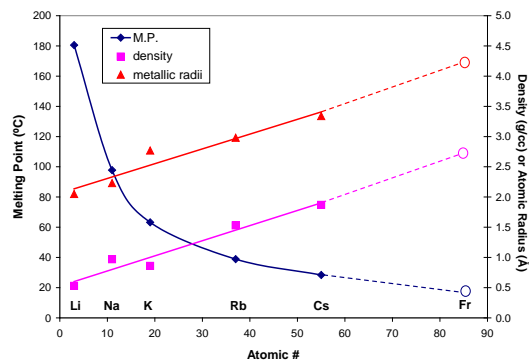
4b. Cr^{2+}

5a. 280 K

5b. 570 K

Integrative Example

A. Based on rough approximations of the trends of data, the properties of francium can be approximated. Melting point: 22 °C, density: 2.75 g/cc, atomic radius: 4.25 Å.

B. Element 168 should be a solid since the trend in boiling point and melting point would put the boiling point temperature above 298 K. The electronic configuration is $[Unk]10s^{2}6h^{8}$.

Exercises

1. $14 \dfrac{g}{cm^{3}}$ to $16 \dfrac{g}{cm^{3}}$

3. A plot of density versus atomic number clearly shows that density is a periodic property for these two periods of main group elements. It rises, falls a bit, rises again, and falls back to the axis, in both cases.

5. Mendeleev arranged elements in the periodic table in order of increasing atomic weight. Atomic masses with non-integral values are permissible. Hence, there always is room for an added element between two elements that already are present in the table. On the other hand, Moseley arranged elements in order of increasing atomic number. Only integral (whole number) values of atomic number are permitted. Thus, when elements with all possible integral values in a certain range have been discovered, no new elements are possible in that range.

7a. 118

7b. 119

7c. $A_{119} \approx 298$ u and $A_{118} \approx 295$ u.

9a. Te

9b. K

9c. Cs

9d. N

9e. P

9f. Au

11. Sizes of atoms do not simply increase with atomic number is because electrons often are added successively to the same subshell. These electrons do not fully screen each other from the nuclear charge (they do not effectively get between each other and the nucleus). Consequently, as each electron is added to a subshell and the nuclear charge increases by one unit, all of the electrons in this subshell are drawn more closely into the nucleus, because of the ineffective shielding.

13a. B

13b. Te

15. $Li^+ < Br < Se < I^-$

17. Fe^{2+} and Co^{3+}, Sc^{3+} and Ca^{2+}, F^- and Al^{3+}, Zn^{2+} and Cu^+.

19. Ions can be isoelectronic without having noble-gas electron configurations.

21. $Cs < Sr < As < S < F$

23. For an ionization potential, negatively charged electron is being separated from a positively charged cation, a process that must always require energy, because unlike charges attract each other.

25. 9951.$\underline{5}$ kJ/mol

27. Exothermic

29. In the case of Na^+, the electron is being removed from a species that is left with a 2+ charge, while in the case of Ne, the electron is being removed from a species with a 1+ charge. The more highly charged the resulting species, the more difficult it is to produce it by removing an electron.

31a. Al < Si < S < Cl

31b. Al < Si < S < Cl

33. Fe^{2+}

35a. Diamagnetic

35b. Paramagnetic

35c. Diamagnetic

35d. Diamagnetic

35e. Paramagnetic

35f. Diamagnetic

35g. Paramagnetic

37. All atoms with an odd number of electrons must be paramagnetic. There is no way to pair all of the electrons up if there is an odd number of electrons. Many atoms with an even number of electrons are diamagnetic, but some are paramagnetic.

39a. Elements that one would expect to exhibit the photoelectric effect with visible light should be ones that have a small value of their first ionization energy. Based on Figure 9-9, the alkali metals have the lowest first ionization potentials of these. Cs, Rb, and K are three suitable metals. Metals that would not exhibit the photoelectric effect with visible light are those that have high values of their first ionization energy. Again from Figure 9-9, Zn, Cd, and Hg seem to be three metals that would not exhibit the photoelectric effect with visible light.

39b. Rn

39c. +600 kJ/mol

39d. 5.7 g/cm^3

41a. 5.4 g/cm^3

41b. Ga_2O_3, 74.5% Ga.

43. ~210 K

45a. Statement 1

45b. Statement 1

45c. Statement 3

45d. Statement 4

45e. Statement 2

45f. Statement 2

47. Ga^{4+} and Ge^{5+}

Integrative and Advanced Exercises

51. Both (b) and (e) are compatible with the sketch.

53. "Gruppe V" or "Gruppe VI."

55.

Element	Atomic Radius, pm	First Ionization Energy, kJ/mol
Ge	123	762
Al	same	same or smaller
In	larger	smaller
Se	smaller	larger

57. BrCl: melting point = 226 K, boiling point = 286 K
ICl: melting point = 280 K, boiling point = 348 K

61a. A

61b. B

61c. A

61d. B

62. Since (0.3734)(382) = 143 u, if we subtract 143 from 382 we get 239 u, which is very close to the correct value of 238 u. First we convert to J/g^oC: 0.0276×(4.184 J/cal) = 0.1155 J/g^oC , so: 0.1155 = 0.011440 + (23.967/atomic mass); solving for atomic mass yields a value of 230 u, which is within about 3% of the correct value.

65. $E_1 = E_1 \times N_A = \dfrac{8.716 \times 10^{-18}}{1 \text{ atom}} \times \dfrac{6.022 \times 10^{23}}{1 \text{ mol}} \times \dfrac{1 \text{ kJ}}{1000 \text{J}} = 5249$ kJ/mol

66. I_1 for F (1681) $\approx I_2$ for Ba (965) $< I_3$ for Sc (2389) $< I_2$ for Na (4562) $< I_3$ for Mg (7733)

Feature Problems

70. A = 2.30×10^{15} Hz and b = 0.969. The value of A (calculated in this question) is close to the Rydberg frequency (3.2881×10^{15} s^{-1}), so it is probably the equivalent term in the Moseley equation. The constant b, which is close to unity, could represent the number of electrons left in the K shell after one K-shell electron has been ejected by a cathode ray. Thus, one can think of b as representing the screening afforded by the remaining electron in the K-shell.

71a. [Ne]$3p^1$ =293 kJ mol^{-1}, [Ne]$4s^1$ = 188 kJ mol^{-1} , [Ne]$3d^1$ = 147 kJ mol^{-1} , [Ne]$4p^1$, = 134 kJ mol^{-1}.

71b. [Ne]$3p^1$: Z_{eff} = 1.42, [Ne]$4s^1$: Z_{eff} = 1.51 , [Ne]$3d^1$: Z_{eff} = 1.00 , [Ne]$4p^1$: Z_{eff} = 1.28.

71c. [Ne]$3p^1$: $\bar{r}_{3p}$ = 466 pm, [Ne]$4s^1$: $\bar{r}_{4s}$ = 823 pm , [Ne]$3d^1$: $\bar{r}_{3d}$ = 555 pm, [Ne]$4p^1$: $\bar{r}_{4p}$ = 950 pm.

71d. The more deeply an orbital penetrates (i.e., the closer the orbital is to the nucleus), the greater is the effective nuclear charge felt by the electrons in that orbital. It follows then that the 4s orbital will experience the greatest effective nuclear charge and that the Z_{eff} values for the 3p and 4p orbitals should be larger than the Z_{eff} for the 3d orbital.

Self-Assessment Exercises

77. The answer is (b).

78. The answer is (a).

79. The answer is (a).

80. The answer is (b).

81. The answer is (a).

82. The answer is (d).

83. Cs$^+$: [Xe], or [Kr] $5s^2 4d^{10} 5p^6$, Cs^{2+}: [Kr] $5s^2 4d^{10} 5p^5$

84. The first ionization energy of Mg is higher than Na because, in the case of Mg, an electron from a filled subshell is being removed, whereas in Na, the removing of one electron leads to the highly stable electron configuration of Ne. The second ionization of Mg is lower than Na, because in the case Mg, the electron configuration of Ar is achieved, whereas in Na, the stable [Ar] configuration is being lost by removing an electron from the filled subshell.

85a. As

85b. F⁻

85c. Cl⁻

85d. Carbon

85e. Carbon

86. The trends would generally follow higher first ionization energy values for a fuller subshell. The exception is the case of S and P, where P has a slightly higher value. This is because there is a slight energy advantage to having a half-filled subshell with an electron in each of p_x, p_y and p_z orbitals as in the case of P, whereas the S has one extra electron.

87. The pairs are Ar/Ca, Co/Ni, Te/I and Th/Pa.

88a. protons = 50

88b. neutrons = 69

88c. *4d* electrons = 10

88d. *3s* electrons = 2

88e. *5p* electrons = 2

88f. valence shell electrons = 4

89a. F

89b. Sc

89c. Si

90a. C

90b. Rb

90c. At

91a. Ba

91b. S

91c. Bi

92. Rb>Ca>Sc>Fe>Te>Br>O>F

93a. False

93b. True

93c. True

93d. True

93e. True

94a. False

94b. False

94c. True

94d. True

95. These ionization energies are the reverse of electron affinities.

96. Ionization energy generally increases with Z for a given period.