Appendix D ANSWERS TO END-OF-CHAPTER PROBLEMS

Chapter 1

1. F T F T F F T
2. a. 104.6 b. 2,490 c. 0.204
3. 98.6 °F, 310.2 K
4. 1,079 mph

Chapter 2

1. T T T T T F
2. T T F T F T T T T
3. F T T T F
4. a. 116 b. 20 c. 31 d. 16 e. 6 f. 19
5. a. Br b. Ar c. Li d. 5 e. 2 f. Rb g. He i. F (F_2)
6. 107.869 u
7. 60.04% or 60.0% (There are two ways of doing this problem.)

Chapter 3

1. T T F T
2. a. V^{3+} b. P^{3-}
3. a. 24 b. 39
4. a. Te b. Pd

Chapter 4

1. T T T F F F
2. T T F F F F
3. T T T F T T
4. KNO_3, NH_4F
5. SiO_2, ClF_3, B_2H_6
6. K_2O, $CaCO_3$
7. a. 2+ b. 1− c. 2−
8. a. 2 b. 25 c. 1−
9. a. 18 b. 78 c. 1−
10. a. AuI b. C_4H_{10} c. K_2CrO_4 d. NI_3
11. a. Se_2S_6 b. $Ni(NO_3)_3$ c. H_2O_2 d. $NaHCO_3$
12. a. SO_3 b. $Co_2(SO_4)_3$ c. $NaNO_2$ d. Al_2O_3
13. a. PCl_5 b. LiH c. $Ba(CH_3CO_2)_2$ d. $Fe(CN)_3$
14. a. lithium nitride b. chromium(III) perchlorate c. silicon dioxide d. methane
15. a. chlorine trifluoride b. ammonium bisulfate or ammonium hydrogen sulfate
    c. copper(I) sulfite d. mercury(I) nitrate
16. a. iron(II) oxalate b. potassium phosphate c. lead(IV) oxide d. disulfur dichloride

17. a. hydrogen sulfide b. calcium thiosulfate c. nitrogen dioxide d. manganese(III) chlorate

Chapter 5

1. F T T T
2. a. 260.0 b. 96.09 c. 209.98
3. a. 301.43 u b. 166.90 u
4. a. 48.11 g b. 319.1 g c. 239.6 g
5. a. 154.96 g b. 257.83 g
6. 9.689 g
7. a. 0.04444 mol b. 1.606×10^{23} C atoms
8. a. 33.37% b. 43.71%
9. a. BCl b. B_4Cl_4
10. a. H_2SiF b. $H_4Si_2F_2$

Chapter 6

1. a. $B_2H_6 + 6\ HF \rightarrow 2\ BF_3 + 6\ H_2$
   b. $PCl_5 + 4\ H_2O \rightarrow H_3PO_4 + 5\ HCl$
   c. $Cl_2SO + H_2O \rightarrow SO_2 + 2\ HCl$
   d. $2\ K_3AsO_4 + 3\ CaCO_3 \rightarrow Ca_3(AsO_4)_2 + 3\ K_2CO_3$
2. a. $5\ F_2CO + 2\ SbCl_5 \rightarrow 5\ Cl_2CO + 2\ SbF_5$
   b. $Fe_2O_3 + 6\ HBr \rightarrow 2\ FeBr_3 + 3\ H_2O$
   c. $2\ H_2S + 3\ O_2 \rightarrow 2\ H_2O + 2\ SO_2$
   d. $2\ AgNO_3 + H_2C_2O_4 \rightarrow Ag_2C_2O_4 + 2\ HNO_3$
3. a. $Mg_2SiO_4 + 8\ HF \rightarrow 2\ MgF_2 + 4\ H_2O + SiF_4$
   b. $2\ C_2H_3Cl + 5\ O_2 \rightarrow 4\ CO_2 + 2\ HCl + 2\ H_2O$
   c. $PbI_2 + 2\ KHSO_4 \rightarrow PbSO_4 + 2\ KI + H_2SO_4$
   d. $COCl_2 + 4\ KOH \rightarrow 2\ KCl + K_2CO_3 + 2\ H_2O$
4. a. $AlCl_3 + Na_3PO_4 \rightarrow AlPO_4 + 3\ NaCl$
   b. $Co(CH_3CO_2)_2 + (NH_4)_2S \rightarrow CoS + 2\ NH_4CH_3CO_2$
   c. $ClF_3 + 4\ NaOH \rightarrow NaClO_2 + 3\ NaF + 2\ H_2O$
5. $2\ C_3H_9Al + 12\ O_2 \rightarrow 6\ CO_2 + 9\ H_2O + Al_2O_3$
6. $C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12\ CO_2 + 11\ H_2O$
7. First step: $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + H_2CO_3$
   Second step: $H_2CO_3 \rightarrow CO_2 + H_2O$
   Overall: $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + CO_2 + H_2O$
   H_2CO_3 is the intermediate.

Chapter 7

1. 8.765 g
2. 35.34 g
3. 2.53 g

4. 10.2 g
5. 66.10 g
6. 38.40 g
7. 7.08 g
8. 194 g

Chapter 8

1. T T T
2. 8.963 g
3. a. 19.0 g b. 23.6 g c. 10.5 g
4. 95.6%
5. 88.3%

Chapter 9

1. 0.486 M
2. 0.754 M
3. 21.8 g
4. 41 g
5. 11.6 g
6. 573 mL
7. 5.780 g
8. 8.235 g
9. 49.1 g

Chapter 10

1. T F F T F
2. H_3O^+, $H_5O_2^+$

Chapter 11

1. T T F F T T F
2. F F T F T F T
3. a, b, e
4. $Al(OH)_3$, CuCl, CaC_2O_4
5. NH_4HS, $Fe(NO_3)_3$, $MgSO_4$, $CuClO_4$, $K_2S_2O_3$
6. a. $CaSO_4$ b. $CoCO_3$ c. CuC_2O_4 d. $NiCrO_4$
7. $2\ AgNO_3(aq) + ZnBr_2(aq) \rightarrow 2\ AgBr(s) + Zn(NO_3)_2(aq)$
   $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$
8. $(NH_4)_2CO_3(aq) + Mg(CH_3CO_2)_2(aq) \rightarrow 2\ NH_4CH_3CO_2(aq) + MgCO_3(s)$
   $CO_3^{2-}(aq) + Mg^{2+}(aq) \rightarrow MgCO_3(s)$
9. $Hg(ClO_4)_2(aq) + K_2S(aq) \rightarrow 2\ KClO_4(aq) + HgS(s)$
   $Hg^{2+}(aq) + S^{2-}(aq) \rightarrow HgS(s)$
10. Precipitates: AgCl, $PbCl_2$
    Spectator ions: K^+, ClO_4^-, NO_3^-

11. Strong acids: HI, H_2SO_4, HBr
    Weak acids: HClO, HNO_2, H_3PO_4, CH_3CO_2H
12. $H^+(aq)$ (or specifically, $H_3O^+(aq)$ and $H_5O_2^+(aq)$), and $NO_3^-(aq)$
13. Ions: $H^+(aq)$ (or specifically, $H_3O^+(aq)$ and $H_5O_2^+(aq)$), and $ClO_2^-(aq)$
    Neutral molecules: $HClO_2(aq)$

Chapter 12

1. F F T T T F
2. T T T T T T
3. a. HF b. $H_2C_2O_4$ c. HClO d. H_2CO_3
4. a. hydrobromic acid b. nitrous acid c. arsenic acid d. hydrocyanic acid
5. a. $LiNO_3$ b. NH_4Cl c. $NaCH_3CO_2$ d. $CaCl_2$
6. $KOH(aq) + HBr(aq) \rightarrow KBr(aq) + H_2O(l)$
   $OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$
7. $NaOH(aq) + HClO_2(aq) \rightarrow NaClO_2(aq) + H_2O(l)$
   $OH^-(aq) + HClO_2(aq) \rightarrow ClO_2^-(aq) + H_2O(l)$
8. $NH_3(aq) + HF(aq) \rightarrow NH_4F(aq)$
   $NH_3(aq) + HF(aq) \rightarrow NH_4^+(aq) + F^-(aq)$
9. $H_3PO_4(aq) + KOH(aq) \rightarrow KH_2PO_4(aq) + H_2O(l)$
   $H_3PO_4(aq) + 3\ KOH(aq) \rightarrow K_3PO_4(aq) + 3\ H_2O(l)$
10. $Na_2SO_3(aq) + 2\ HClO_4(aq) \rightarrow 2\ NaClO_4(aq) + H_2O(l) + SO_2(g)$
    $SO_3^{2-}(aq) + 2\ H^+(aq) \rightarrow H_2O(l) + SO_2(g)$
11. $BaCO_3(s) + 2\ HBr(aq) \rightarrow BaBr_2(aq) + H_2O(l) + CO_2(g)$
    $BaCO_3(s) + 2\ H^+(aq) \rightarrow Ba^{2+}(aq) + H_2O(l) + CO_2(g)$

Chapter 13

1. T F F T F F F
2. a. H: +1 As: +3 O: −2 b. Na: +1 O: −1/2
   c. Sn: +2 Cl: −1 d. S: +1 O: −2
3. a. Ca: +2 Se: +4 O: −2 b. C: −1/3 H: +1 Cl: −1
   c. H: +1 S: −2/3 d. Te: +4 O: −2 F: −1
4. a. Cr^{2+} b. MnO_4^- c. MnO_4^- d. Cr^{2+}
5. a. Br_2 b. SO_4^{2-} c. SO_4^{2-} d. Br_2
6. a. V^{2+} b. IO_6^{5-} c. IO_6^{5-} d. V^{2+}

Chapter 14

1. a. $H_3PO_2 + 2\ Cu^{2+} + 2\ H_2O \rightarrow H_3PO_4 + 2\ Cu + 4\ H^+$
   b. $2\ HNO_2 + 2\ H^+ + 2\ Cl^- \rightarrow N_2O + H_2O + 2\ HClO$
   c. $2\ BrO_3^- + 8\ OH^- + 5\ Zn \rightarrow Br_2 + 4\ H_2O + 5\ ZnO_2^{2-}$
2. a. $2\ Co^{3+} + NO_2^- + H_2O \rightarrow 2\ Co^{2+} + NO_3^- + 2\ H^+$
   b. $2\ S_2O_6^{2-} + 2\ H_2O + IO^- \rightarrow 4\ SO_2 + IO_3^- + 4\ OH^-$
   c. $2\ ClO_2 + 8\ H^+ + 5\ Co \rightarrow 2\ Cl^- + 4\ H_2O + 5\ Co^{2+}$

3. a. 2 b. 6 c. 6

Chapter 15

1. 7.14 g CaC_2O_4
2. 22.7 g KNO_3
3. 0.1669 g
4. 0.5378 g, 6.72% by mass
5. 2.09 g $PbCl_2$
6. 7.91 g $Ba(ClO_3)_2$
7. 73%
8. 64%

Chapter 16

1. T F T T F F
2. 0.042 mol
3. 0.585 atm
4. 3.06 L
5. 1.52 atm
6. Cl_2, BF_3, SF_4
7. 0.760 g/L
8. C_2F_4
9. 0.790 atm
10. 46.6%
11. 0.702 g/L

Chapter 17

1. T T F T T
2. T T F T F
3. 6.08 L
4. 158 Torr
5. 0.296 atm
6. 1.99 atm
7. a < d < c < b < e
8. 642 m/s
9. 1,920 m/s
10. 87.8 g/mol

Chapter 18

1. T F T F F
2. T T F F F
3. –140 kJ
4. 41 cal

Chapter 19

1. T F T T T T
2. For example: $He(g)$, $Ne(g)$, $Ar(g)$, $Kr(g)$, $Xe(g)$, $H_2(g)$, $N_2(g)$, $O_2(g)$, $F_2(g)$, $Cl_2(g)$, $Br_2(l)$, $I_2(s)$, $C(graph)$
3. a. $Zn(s) + N_2(g) + 3\ O_2(g) \rightarrow Zn(NO_3)_2(s)$
   b. $2\ C(graph) + 5/2\ H_2(g) + 1/2\ I_2(s) \rightarrow C_2H_5I(l)$
   c. $1/2\ H_2(g) + 1/2\ Cl_2(g) + 3/2\ O_2(g) \rightarrow HClO_3(l)$
   d. $1/2\ Br_2(l) + 1/2\ N_2(g) + 1/2\ O_2(g) \rightarrow BrNO(l)$
   e. $2\ Hg(l) + 1/2\ O_2(g) \rightarrow Hg_2O(s)$
4. –617.2 kJ
5. –2,844.94 kJ
6. –103.0 kJ
7. –88.32 kJ
8. 646.24 kJ
9. –269 kJ
10. –1,786 Cal
11. –86.3 kJ
12. –153 kJ
13. 103 g

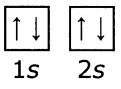
Chapter 20

1. F F T F T
2. F F T F T
3. 5.45×10^{-16} J
4. 587 kJ
5. 120. kJ
6. -2.42×10^{-19} J
7. -3.49×10^{-17} J
8. 2.91×10^{-19} J
9. 5.01×10^{-19} J, 397 nm
10. -1.55×10^{-19} J, 1,280 nm

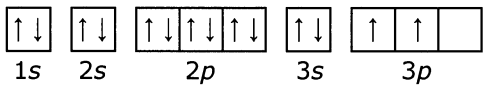
Chapter 21

1. T T T T T T
2. T T T T F F
3. Different colors arise from different transition energies. This will cause absorption of photons which have different energies and different wavelengths.
4. a. l b. m_l
5. a. 4 b. 9 c. 5
6. a. 25 b. 6 c. *s*
7. 2*d*, 4*g*

Chapter 22

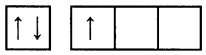
1. T F F T T
2. F T T T F
3. a. $1s^2 2s^2$
   b. $1s^2 2s^2 2p^6 3s^2 3p^2$
4. a. 

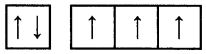
   Be has zero unpaired electrons.

   b. 

   Si has two unpaired electrons.

Chapter 23

1. T T F F F
2. S: $1s^2 2s^2 2p^6 3s^2 3p^4$ S^{2-}: $1s^2 2s^2 2p^6 3s^2 3p^6$
3. Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ Ca^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6$
4. a. $[He]2s^2 2p^3$ b. $[Kr]5s^2 4d^2$ c. $[Xe]6s^2 4f^{14} 5d^6$ d. $[Ar]4s^2 3d^5$
5. a. $[He]2s^2 2p^1$ b. $[Ar]4s^2 3d^1$ c. $[Xe]6s^2 4f^{14} 5d^{10} 6p^3$ d. $[Rn]7s^2 5f^5$
6. a. [Ar] b. [Kr] c. $[Ar]3d^5$ d. [Ne]
7. a. [Xe] b. $[Kr]4d^{10}$ c. $[Xe]4f^{14} 5d^5$ d. [Ar]
8. 

9. 

10. a. 2 valence, 18 core b. 5 valence, 46 core c. 4 valence, 78 core d. 7 valence, 2 core
11. a. Al b. 4 c. Rh
12. a. Sn b. Te c. P
13. a. 6 b. I c. Pd
14. a. He b. K c. Cl
15. a. N b. Be c. O
16. Cl
17. Na^+

Chapter 24

1. T T F T F
2. T T T F F
3. In^{3+}, Hg^{2+}, Sn^{4+}
4. Ca, Ca^{2+}, Mg^{2+}, Cd^{2+}
5. Al^{3+}, Zn^{2+}
6. a. 4 b. 2 c. 5 d. 1
7. a. 4 b. 2 c. 0 d. 4
8. a. Mo, Ru b. Ba c. Mg
9. Br

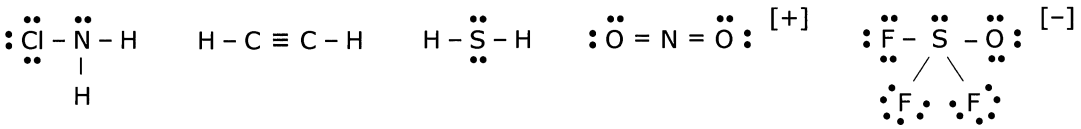
10. Te^{2-}

Chapter 25

1. F F T T T F T
2. MgO
3. Si–P
4. P
5. As–F

Chapter 26

1. T T F F
2. a. b. c. d. e.



   a. One NCl single bond, two NH single bonds. Three lone pairs on Cl, one lone pair on N.

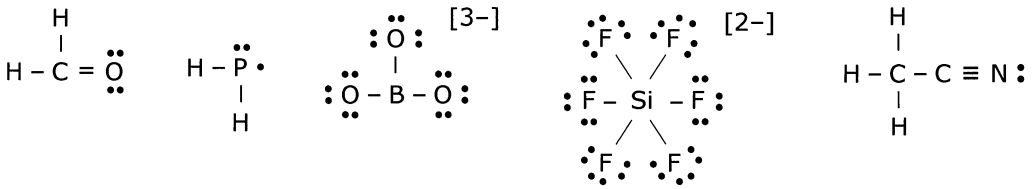
   b. Two CH single bonds, one CC triple bond. No lone pairs.

   c. Two HS single bonds. Two lone pairs on S.

   d. Two NO double bonds. Two lone pairs on each O.

   e. Three SF single bonds, one SO single bond. Three lone pairs on each F, three lone pairs on O, one lone pair on S.

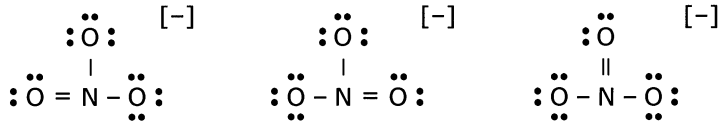
3. a. b. c. d. e.



   PH_2 has an odd number of electrons. BO_3^{3-} is electron deficient. SiF_6^{2-} has expanded valence.

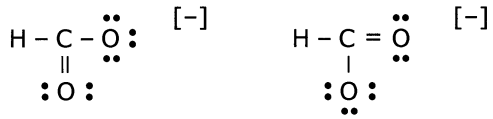
Chapter 27

1. a.



   The average NO bond order is 4/3 (1.33).

   b.



   The average CO bond order is 3/2 (1.5).

2. The estimate using bond energies is –106 kJ. The actual $\Delta H°$ is –90.13 kJ. Although the estimate is high, bond energies still make up the major portion of the actual $\Delta H°$.

3. a. ON: +2 on C, –2 on O. FC: –1 on C, +1 on O.

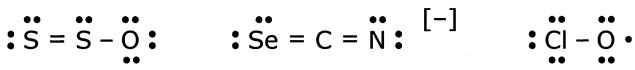
   b. ON: –2 on O, +1 on each H. FC: +1 on O, zero on each H.

c. ON: +3 on B, −1 on each H. FC: −1 on B, zero on each H.

d. ON: +3 on Br, −1 on each F. FC: −1 on Br, zero on each F.

e. ON: +5 on N, −2 on each O. FC: +1 on N, −1 on each O.

4. a. b. c.



Chapter 28

1. a. trigonal planar OLR, bent shape
   b. tetrahedral OLR, trigonal pyramidal shape
   c. trigonal planar OLR and shape
   d. tetrahedral OLR, bent shape
   e. tetrahedral OLR and shape
   f. linear OLR and shape
2. a. trigonal pyramidal b. linear c. trigonal planar d. bent e. tetrahedral f. bent

Chapter 29

1. a. octahedral OLR, square planar shape
   b. tbp OLR, seesaw shape
   c. tbp OLR and shape
   d. tbp OLR, linear shape
   e. octahedral OLR and shape
   f. tbp OLR, T-shape
   g. octahedral OLR, square pyramidal shape
2. a. square planar b. linear c. tbp d. octahedral e. T-shaped
3. N is trigonal pyramidal. C (next to N) is tetrahedral. C (with O's) is trigonal planar. O is bent.
4. a. 180° b. 120° c. 109.5° d. 90°, 120°, 180° e. 90°, 180°
5. PF_3, O_3, BrF_3
6. PF_3, $SeCl_2$, BrF_3
7. Cl_2SO, XeO_2, H_2CO, ClF_3O

Chapter 30

1. T T F F F
2. a. sp^2 b. sp^3 c. sp^2 d. sp^3 e. sp^3 f. sp
3. a. O, sp^3 b. N, sp^3 c. Ge, sp^2 d. Al, sp^2
4. a. Each SiH bond orbital derives from (Si)sp^3 + (H)1s. There are no lone pairs.
   b. The II bond orbital derives from (I)5p + (I)5p. Each I holds three lone pairs in the remaining 5s and 5p atomic orbitals.
   c. Each GaBr bond derives from (Ga)sp^2 + (Br)4p. Each Br holds three lone pairs in its remaining 4s and 4p orbitals.

Chapter 31

1. F T T F
2. a. Three σ bonds.
   b. One σ bond.
   c. Two σ bonds and two π bonds.
   d. Three σ bonds and two π bonds.
3. a. The NO triple bond results from one σ and two π interactions. The σ bond is due to (N)sp + (O)sp while the π bonds arise from (N)2p + (O)2p.
   b. The ClC single bonds are σ type and each arises from (Cl)3p + (C)sp^2. The CS double bond is composed of one σ bond from (C)sp^2 + (S)sp^2 and one π bond from (C)2p + (S)3p.

4. a. The C's are trigonal planar, trigonal planar and linear.

   b. The hybridizations are C sp^2; C sp^2; C *sp* and N *sp*.

   c. The first CC bond is composed of one σ bond (from (C)sp^2 + (C)sp^2) and one π bond (from (C)2*p* + (C)2*p*). The second CC bond is σ type and it arises from (C)sp^2 + (C)*sp*. All CH bonds are σ type and arise from (C)sp^2 + (H)1*s*. The CN bond is composed of one σ bond (from (C)*sp* + (N)*sp*) and two π bonds (from (C)2*p* + (N)2*p*).

   d. The lone pair on N is in an *sp* hybrid orbital.

Chapter 32

1. $(\sigma_{1s})^2(\sigma^*_{1s})^1$, bond order = 0.5, one unpaired electron

2. The configuration is $(\sigma_{2s})^1$ and the bond order is one-half, so it can exist.

Chapter 33

1. F T F T F F T

2. a. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^4$ Bond order = 2; diamagnetic; zero unpaired electrons

   b. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^2$ Bond order = 2; paramagnetic; two unpaired electrons

   c. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^4(\sigma_{2p})^2(\pi^*_{2p})^1$ Bond order = 2.5; paramagnetic; one unpaired electron

   d. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^3$ Bond order = 1.5; paramagnetic; one unpaired electron

3. a. Bond order = 1.5; one unpaired electron b. Bond order = 0.5; one unpaired electron

   c. Bond order = 3; zero unpaired electrons d. Bond order = 2.5; one unpaired electron