APPENDIX I

Answers to Selected Even-Numbered Problems

Chapter 1

1-6. (a) 299 800 000 (b) 0.000 548 580 (c) 0.000 000 000 05292 (d) 155 000 000 000 0000

1-8. 556.0×10^3

1-10. (a) 10^{-12} (b) 10^9 (c) 10^{-9} (d) 10^3 (e) 10^{-18} (f) 10^{-15}

1-12. f < d < b < e < a < c

1-14. 8.000×10^{-30} m^3

1-16. 1.61 cm^3

1-18. *Celsius* 233 or *Kelvin* 506

1-20. 86 m·s^{-1}

1-22. 31 m

1-24. 550 kW·h; $55

1-26. 2%

1-28. 0.6%

1-30. (a) three (b) three (c) exact (d) nine (e) two

1-32. (a) 33209 (b) 254 (c) 0.0143 877 (d) -1.26×10^{-13}

1-34. 2.35×10^6 pm^3

1-36. (a) 1.259 kJ (b) 2.18 aJ (c) 5.5×10^3 kJ (d) 7.5×10^3 fs (e) 2.0×10^6 mL

1-38. (a) 99.1 m (b) 154 pm and 0.154 nm (c) 79.4 kg

1-40. 7.44×10^3 cm^3 or 7.44 L

1-42. 2.8 min

1-44. (a) 10^6 mL (b) 10^3 L

1-46. 0.650 g·mL^{-1}

1-48. Use Time/s and Distance/ft as table headings

1-50. The table is

Height/cm	Time/s
27	6.09
42.7	11.65
60.7	18.11
129	30.41

1-60. class average = 11.31 g·cm^{-3}; class percentage error = 0%

1-62. 88.2°C

1-64. 63 mL

1-66. 430 kJ

1-68. area = 56m^2; pay for themselves in 10 years

1-70. 9.0×10^{10} kJ

1-72. 1.4 g

1-74. 1500 K and 2200°F

1-76. 1.60 g·mL^{-1}

1-78. 2.472 acre

1-80. 0.0200 mm

1-84. 0.12 mm

1-86. 2.0%

Chapter 2

2-14. 85.4% La and 14.6% O

2-16. 75.74% Sn and 24.26% F

2-18. 52.2% C; 13% H; 34.6% O

2-28. (a) 287.92 (b) 231.53 (c) 209.94 (d) 537.50 (e) 222.84

2-30. (a) 286.45 (b) 300.81 (c) 376.36 (d) 793.30 (e) 176.12

2-32. (a) 153.18 (b) 162.23

2-34. 63.6483% N and 36.3517% O

2-36. 32.85171% Na; 12.85194% Al; 54.2963% F

2-38. 40.050% S and 2.237 grams S

2-40. 68.420% Cr in Cr_2O_3; 29.2 g Cr in Cr_2O_3; 29.2% Cr in the ore

2-42. (a) 15 protons, 15 electrons, 15 neutrons
(b) 43 protons, 43 electrons, 54 neutrons
(c) 26 protons, 26 electrons, 29 neutrons
(d) 95 protons, 95 electrons, 145 neutrons

2-44. The completed table is

Symbol	Atomic number	Number of neutrons	Mass number
$^{48}_{20}Ca$	20	28	48
$^{90}_{40}Zr$	40	50	90
$^{131}_{53}I$	53	78	131
$^{99}_{42}Mo$	42	57	99

2-46. The completed table is

Symbol	Atomic number	Number of neutrons	Mass number
$^{39}_{19}K$	19	20	39
$^{56}_{26}Fe$	26	30	56
$^{84}_{36}Kr$	36	48	84
$^{120}_{50}Sn$	50	70	120

2-48. 24.31

2-50. 28.0854

2-52. 68.925

2-54. 19.9% boron-10 and 80.1% boron-11

2-56. 47.8% europium-151 and 52.2% europium-153

2-58. (a) 36 (b) 18 (c) 46 (d) 18

2-60. (a) 54 (b) 54 (c) 2 (d) 28

2-66. (a) 18.038 (b) 33.007 (c) 178.77 (d) 243.69

2-72. 0.023% D in DHO and 0.00013% D in D_2O

2-74. 35 100 if there is one Co atom per protein molecule

2-76. 183.84

2-78. ratio = 2.28/1.14 = 2/1

2-80. 1.333

Chapter 3

3-2. (a) $2\,KHF_2(s) \rightarrow 2\,KF(s) + H_2(g) + F_2(g)$
(b) $C_3H_8(g) + 5\,O_2(g) \rightarrow 3\,CO_2(g) + 4\,H_2O(l)$
(c) $P_4O_{10}(s) + 6\,H_2O(l) \rightarrow 4\,H_3PO_4(l)$
(d) $3\,N_2H_4(g) \rightarrow 4\,NH_3(g) + N_2(g)$

3-4. (a) $H_2SO_4(aq) + 2\,KOH(aq) \rightarrow K_2SO_4(aq) + 2\,H_2O(l)$
(b) $Li_3N(s) + 3\,H_2O(l) \rightarrow 3\,LiOH(aq) + NH_3(g)$
(c) $Al_4C_3(s) + 12\,HCl(aq) \rightarrow 4\,AlCl_3(aq) + 3\,CH_4(g)$
(d) $ZnS(s) + 2\,HBr(aq) \rightarrow ZnBr_2(aq) + H_2S(g)$

3-6. (a) $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(s)$
phosphorus trichloride; chlorine; phosphorus pentachloride

(b) $2\,Sb(s) + 3\,Cl_2(g) \rightarrow 2\,SbCl_3(s)$
antimony; chlorine; antimony trichloride

(c) $2\,GaBr_3(s) + 3\,Cl_2(g) \rightarrow 2\,GaCl_3(s) + 3\,Br_2(l)$
gallium bromide; chlorine; gallium chloride; bromine

(d) $Mg_3N_2(s) + 6\,HCl(g) \rightarrow 3\,MgCl_2(s) + 2\,NH_3(g)$
magnesium nitride; hydrogen chloride; magnesium chloride; ammonia

3-8. (a) $Sr(s) + S(s) \rightarrow SrS(s)$
strontium sulfide

(b) $2\,K(s) + 2\,H_2O(l) \rightarrow 2\,KOH(aq) + H_2(g)$
potassium hydroxide; hydrogen

(c) $Ca(s) + 2\,H_2O(l) \rightarrow Ca(OH)_2(aq)$
calcium hydroxide

(d) $2\,Al(s) + 3\,Cl_2(g) \rightarrow 2\,AlCl_3(s)$
aluminum chloride

3-10. (a) colorless; (b) odorless; (c) Ra(*g*); (d) no reaction

3-12. Se, a main-group (16) nonmetal; As, a main-group (15) semimetal; Mo, a transition (6) metal; Rn, a main-group (18) nonmetal; Ta, a transition (5) metal; Bi, a main-group (15) metal; In, a main-group (13) metal

3-22. (a) semimetal; (b) metal; (c) metal; (d) metal; (e) semimetal

3-28. (a) $2\,K(s) + 2\,H_2O(l) \rightarrow 2\,KOH(s) + H_2(g)$
(b) $KH(s) + H_2O(l) \rightarrow KOH(s) + H_2(g)$
(c) $SiO_2(s) + 3\,C(s) \rightarrow SiC(s) + 2\,CO(g)$
(d) $SiO_2(s) + 4\,HF(g) \rightarrow SiF_4(g) + 2\,H_2O(l)$
(e) $2\,P(s) + 3\,Cl_2(g) \rightarrow 2\,PCl_3(l)$

3-30. $Na_3P(s) + 3\,H_2O(l) \rightarrow PH_3(g) + 3\,NaOH(aq)$

3-32. (b)

3-34. (a) $6\,F_2(g) + 2\,Al_2O_3(s) \rightarrow 4\,AlF_3(s) + 3\,O_2(g)$
(b) $4\,NH_3(g) + 5\,O_2(g) \rightarrow 4\,NO(g) + 6\,H_2O(l)$
(c) $2\,C_6H_6(l) + 15\,O_2(g) \rightarrow 12\,CO_2(g) + 6\,H_2O(l)$
(d) $3\,H_2SO_4(aq) + Al_2(CO_3)_3(s) \rightarrow Al_2(SO_4)_3(aq) + 3\,CO_2(g) + 3\,H_2O(l)$

3-36. (a) $2\,Na(s) + S(l) \rightarrow Na_2S(l)$
(b) $Ca(s) + Br_2(l) \rightarrow CaBr_2(s)$
(c) $2\,Ba(s) + O_2(g) \rightarrow 2\,BaO(s)$
(d) $2\,SO_2(g) + O_2(g) \rightarrow 2\,SO_3(g)$
(e) $4\,Mg(s) + 3\,N_2(g) \rightarrow 2\,Mg_2N_3(s)$

3-40. The chemical equations are
$2\,CuO(s) + C(s) \rightarrow 2\,Cu(s) + CO_2(g)$
$SnO_2(s) + C(s) \rightarrow Sn(s) + CO_2(g)$
$2\,Fe_2O_3(s) + 3\,C(s) \rightarrow 4\,Fe(s) + 3\,CO_2(g)$

3-42. $2\,HCl(aq) + 2\,NaI(aq) + NaClO(aq) \rightarrow I_2(s) + 3\,NaCl(aq) + H_2O(l)$

3-44. $16\,HCl(aq) + 2\,K_2Cr_2O_7(aq) + C_2H_5OH(aq) \rightarrow 4\,CrCl_3(aq) + 2\,CO_2(g) + 4\,KCl(aq) + 11\,H_2O(l)$

3-46. $As_2S_5(s) + 40\,NaNO_3(aq) + 35\,HCl(aq) \rightarrow 2\,H_3AsO_4(aq) + 5\,NaHSO_4(aq) + 40\,NO_2(g) + 12\,H_2O(l) + 35\,NaCl(aq)$

Chapter 4

4-2. Ba < Sr < Ca < Mg

4-4. 11.45 aJ

4-6. 7.624 MJ

4-10. $\cdot\ddot{\underset{\cdot\cdot}{\text{O}}}\cdot$ $\cdot\ddot{\underset{\cdot\cdot}{\text{S}}}\cdot$ $\cdot\ddot{\underset{\cdot\cdot}{\text{Se}}}\cdot$ $\cdot\ddot{\underset{\cdot\cdot}{\text{Te}}}\cdot$

4-12. B^{3+} $:\ddot{\underset{\cdot\cdot}{\text{N}}}:^{3-}$ $:\ddot{\underset{\cdot\cdot}{\text{F}}}:^{-}$ Na^{+}

4-16. $5.088 \times 10^{14}\ s^{-1}$

4-18. 8.52 mm to 8.77 mm

4-20. No, $E = 2.5$ aJ

4-22. 5.70×10^{8} J

4-24. 26 mJ

4-26. 7.77×10^{8} J

4-28. Will not eject an electron; $\nu = 3.57 \times 10^{14}\ s^{-1}$

4-30. $5.96 \times 10^{14}\ s^{-1}$

4-32. 2.37×10^{-34} m

4-34. $7.58 \times 10^{6}\ m\cdot s^{-1}$

4-36. 6.6×10^{-20} kg

4-40. $2.9244 \times 10^{15}\ s^{-1}$, Lyman series in the ultraviolet region

4-42. Infrared region.

n_f	4	5	6	7	8
λ/µm	1.875	1.282	1.094	1.005	0.9544

4-44. $n = 6$

4-46. $n = 2$

4-50.

n_f	5	6	7	8	9
E/aJ	0.1962	0.3028	0.3670	0.4087	0.4373
λ/µm	1.012	0.65560	0.5413	0.4860	0.4542

The infrared-visible region corresponding to visible emission lines in stars.

4-62. $h = 6.63 \times 10^{-34}\ J\cdot s$; $\nu_0 = 1.1 \times 10^{15}\ s^{-1}$

4-64. $n = 6$

4-66. slope $= -3.29 \times 10^{15}\ s^{-1}$

4-68. 2.6×10^{17} photons$\cdot s^{-1}\cdot cm^{-2}$

Chapter 5

5-2. $4\ m\cdot s^{-1}$

5-4. $2.8 \times 10^{-38}\ m\cdot s^{-1}$; No

5-8. (a) $3p$ orbital (b) $5s$ orbital (c) $2p$ orbital (d) $4f$ orbital

5-12. The possible sets of quantum numbers are

n	l	m_l	m_s
4	3	−3	+1/2 or −1/2
4	3	−2	+1/2 or −1/2
4	3	−1	+1/2 or −1/2
4	3	0	+1/2 or −1/2
4	3	1	+1/2 or −1/2
4	3	2	+1/2 or −1/2
4	3	3	+1/2 or −1/2

5-14. 2 electrons; 8 electrons; 18 electrons; 32 electrons

5-20. We have the following:

(a) $1s^22s^22p^63s^23p^1$	13 electrons, aluminum
(b) $1s^22s^22p^63s^23p^64s^23d^3$	23 electrons, vanadium
(c) $1s^22s^22p^5$	9 electrons, fluorine
(d) $1s^22s^22p^63s^23p^64s^23d^{10}4p^1$	31 electrons, gallium
(e) $1s^22s^22p^4$	8 electrons, oxygen

5-22.
(a) Si: [Ne]$3s^23p^2$ (b) Ni: [Ar]$4s^23d^8$
(c) Se: [Ar]$4s^23d^{10}4p^4$ (d) Cd: [Kr]$5s^24d^{10}$
(e) Mg: [Ne]$3s^2$

5-24.
(a) Ba: [Xe]$6s^2$ (b) Ag: [Kr]$5s^14d^{10}$
(c) Gd: [Xe]$4f^75d^16s^2$ (d) Pd: [Kr]$4d^{10}$
(e) Sn: [Kr]$5s^24d^{10}5p^2$

5-26. The electron configuration for sulfur is

$1s$	$2s$	$2p$	$3s$	$3p$
$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$ $\uparrow$ $\uparrow$

The electron configuration for chromium is

$1s$	$2s$	$2p$	$3s$	$3p$	$4s$	$3d$
$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$	$\uparrow$	$\uparrow$ $\uparrow$ $\uparrow$ $\uparrow$ $\uparrow$

5-28. The ground state electron configurations are as follows:
(a) Y: [Kr]$5s^2\,4d^1$ (b) Po: [Xe]$6s^2\,4f^{14}\,5d^{10}\,6p^4$
(c) Co: [Ar]$4s^2\,3d^7$ (d) Es: [Rn]$7s^2\,5f^{11}$
(e) Pb: [Xe]$6s^2\,4f^{14}\,5d^{10}\,6p^2$

5-30. (a) cerium, Ce (b) vanadium, V
(c) copper, Cu (d) sulfur, S

5-32. (a) one (b) six (c) two (d) none

5-34. (a) 2 electrons; Ca^{2+}, argon
(b) 1 electron, Li^+, helium
(c) 1 electron, Na^+, neon
(d) 2 electrons, Mg^{2+}, neon

5-36. (a) $1s^22s^22p^3$; isoelectronic with nitrogen
(b) $1s^22s^22p^3$; isoelectronic with nitrogen
(c) $1s^22s^22p^4$; isoelectronic with oxygen
(d) $1s^22s^22p^2$; isoelectronic with carbon

5-38. (a) none (b) one (c) one (d) none (e) none

5-40. (a) Ne; (b) K; (c) H; (d) Hg; (e) Ne

5-42. (a) $I(g) + e^- \rightarrow I^-(g)$
$[Kr]5s^24d^{10}5p^5 + e^- \rightarrow [Kr]5s^24d^{10}5p^6$ or [Xe]
(b) $K(g) + F(g) \rightarrow K^+(g) + F^-(g)$
$[Ar]4s^1 + [He]2s^22p^5 \rightarrow [Ar] + [He]2s^22p^6$ or [Ne]

5-44. (a) Ne; (b) Na; (c) He

5-46. (a) 0 valence electrons He
(b) 8 valence electrons $:\ddot{\underset{\cdot\cdot}{\mathrm{N}}}:^{3-}$
(c) 7 valence electrons $\cdot\ddot{\underset{\cdot\cdot}{\mathrm{F}}}\cdot^{+}$
(d) 1 valence electron $\mathrm{Na}\cdot$
(e) 0 valence electrons K^+

5-48. (a) O > F (b) Xe > Kr (c) Cl > F (d) Ca > Mg

5-50. (a) Li < Na < Rb < Cs (b) P < Al < Mg < Na
(c) Mg < Ca < Sr < Ba

5-52. $Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$

5-56. (a) B < O < F < Ne (b) Sn < Te < I < Xe
(c) Cs < Rb < K < Ca (d) Na < Al < S < Ar

5-60. (a) nickel (b) silver (c) sulfur (d) lead

5-62. (a) aluminum (b) oxygen (c) zinc
(d) krypton

5-64. (b) He; (c) Ca; (e) La

5-66. (a) 2; O (b) 0; Cd (c) 0; Hg (d) 1; Cl

5-68. $2s^1$, $2s^12p_x^1$, $2s^12p_x^12p_y^1$, $2s^12p_x^12p_y^12p_z^1$, $2s^22p_x^12p_y^12p_z^1$, $2s^22p_x^22p_y^12p_z^1$, $2s^22p_x^22p_y^22p_z^1$, $2s^22p_x^22p_y^22p_z^2$

Chapter 6

6-2. (a) Xe; (c) Kr; (d) Ne; (e) Kr

6-4. (a) Li^+ and O^{2-}; lithium oxide
(b) Ca^{2+} and S^{2-}; calcium sulfide

(c) Mg^{2+} and N^{3-}; magnesium nitride
(d) Al^{3+} and S^{2-}; aluminum sulfide

6-6. (a) Ga_2S_3 gallium sulfide
(b) Fe_2Se_3 iron(III) selenide
(c) PbO_2 lead(IV) oxide
(d) $BaAt_2$ barium astatide
(e) Zn_3N_2 zinc nitride

6-8. (a) Al_2S_3 (b) Na_2O (c) BaF_2 (d) LiH

6-10. (a) Cs_2O (b) Na_2Se (c) Li_2S (d) CaI_2

6-12. (a) tin(IV) oxide (b) iron(III) fluoride
(c) lead(IV) oxide (d) cobalt(III) nitride
(e) mercury(II) selenide

6-14. (a) sodium hydride (b) tin(II) iodide
(c) gold(I) sulfide (d) cadmium sulfide
(e) potassium oxide

6-16. (a) Ru_2S_3 (b) ScF_3 (c) OsO_4 (d) MnS (e) $PtCl_4$

6-18. (a) $TlCl_3$ (b) CdI_2 (c) Zn_3As_2 (d) $AlBr_3$

6-20. (a) stannic oxide (b) ferric fluoride
(c) plumbic oxide (d) cobaltic nitride
(e) mercuric selenide

6-22. (a) PbF_4 lead(IV) fluoride
(b) Hg_2Cl_2 mercury(I) chloride
(c) PbS lead(II) sulfide
(d) HgO mercury(II) oxide

6-24. (a) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
(b) $2Cs(s) + Br_2(l) \rightarrow 2CsBr(s)$
(c) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
(d) $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

6-26. (a) $Ga([Ar]4s^23d^{10}4p^1) + 3F([He]2s^22p^5) \rightarrow Ga^{3+}([Ar]3d^{10}) + 3F^-([Ne]) \rightarrow GaF_3(g)$
(b) $Ag([Kr]5s^14d^{10}) + Cl([Ne]3s^23p^5) \rightarrow Ag^+([Kr]4d^{10}) + Cl^-([Ar]) \rightarrow AgCl(g)$
(c) $3Li([He]2s^1) + N([He]2s^22p^3) \rightarrow 3Li^+([He]) + N^{3-}([Ne]) \rightarrow Li_3N(g)$

6-28. (a) $3\cdot Ca\cdot + 2\cdot\dot{N}\cdot \rightarrow 3Ca^{2+} + 2:\ddot{N}:^{3-}$ or Ca_3N_2
(b) $\cdot\dot{Al}\cdot + 3:\ddot{Cl}\cdot \rightarrow Al^{3+} + 3:\ddot{Cl}:^-$ or $AlCl_3$
(c) $2Li\cdot + \cdot\ddot{O}\cdot \rightarrow 2Li^+ + :\ddot{O}:^{2-}$ or Li_2O

6-30. (a) $Ru^{2+}([Kr]4d^6)$ (b) $W^{3+}([Xe]4f^{14}5d^3)$
(c) $Pd^{2+}([Kr]4d^8)$ (d) $Ti^+([Ar]3d^3)$

6-32. (a) six (b) ten (c) three (d) eight

6-36. (b), (d), and (e)

6-38. (a) H (b) Fe^{2+} (c) S^{2-} (d) O^{2-}

6-40. (a) Cl^- (b) Au^+ (c) Cr^+ (d) P^{3-}

6-42. $Mo^{+6} < Y^{3+} < Rb^+ < Br^- < Se^{2-}$

6-44. K > Na > B > H > He

6-48. (a) 0.71 aJ; (b) 4.71 aJ; (c) 2.56 aJ

6-50. –0.983 aJ

6-52. 0.35 aJ

6-54. 1.45 aJ

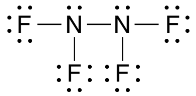
6-66. (a) Zn^{2+}, Cd^{2+}, and Hg^{2+} (b) Ti^{4+}, Zr^{4+}, Hf^{4+}

6-70. chloride ion

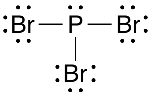
6-76. –2.55 aJ

Chapter 7

7-2.



7-4. (a)



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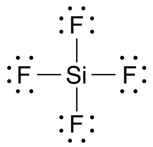

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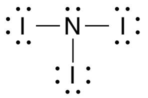

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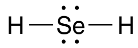
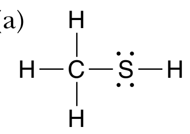


7-6. (a)



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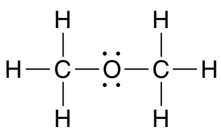

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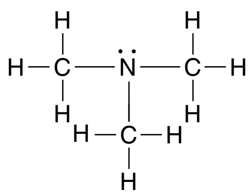
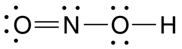
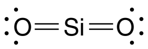


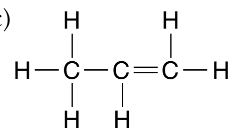
7-8. (a)



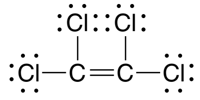
(b)

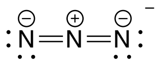


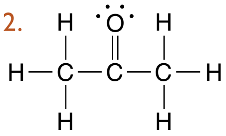
(c)

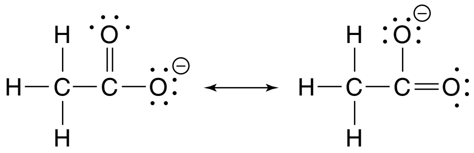


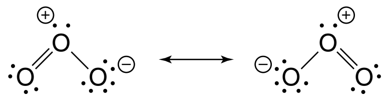
(d)

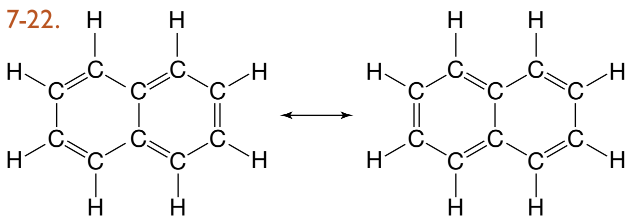


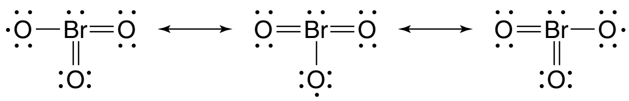
7-10. 

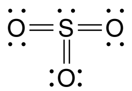
7-12. 

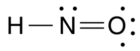
7-18. 

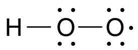
7-20. 

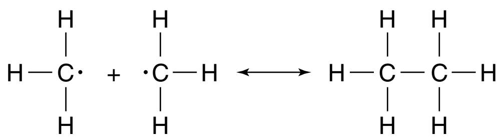
7-22. 

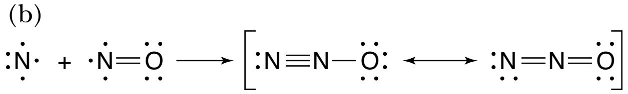
7-24. (a) 

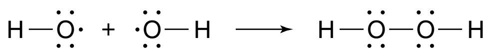
(b) 

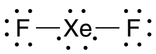
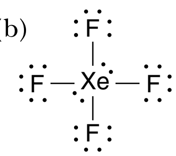
(c) 

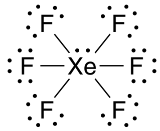
(d) 

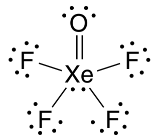
7-26. (a) 

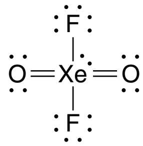
(b) 

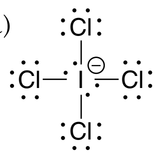
(c) 

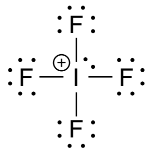
7-28. (a)  (b) 

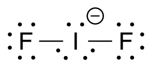
(c) 

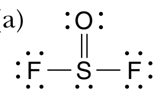
(d) 

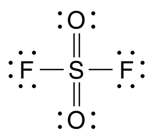
(e) 

7-30. (a) 

(b) 

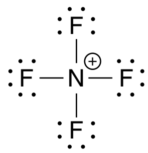
(c) 

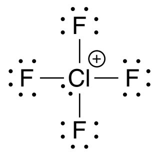
7-32. (a) 

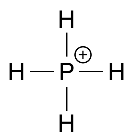
(b) 

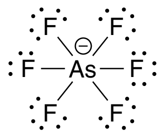
7-34. Cl > S > Se > Sb > In

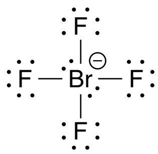
7-36. (a) $IF_3 < BrF_3 < ClF_3$; (b) $H_2Te < H_2Se < H_2S < H_2O$; (c) $H_2S < SO_2 < O_3$

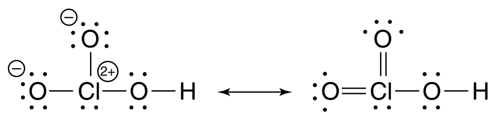
7-46. (a) 

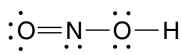
(b) 

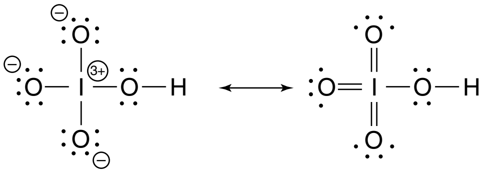
(c) 

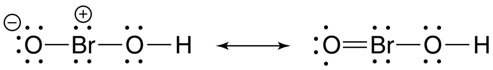
(d) 

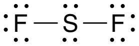
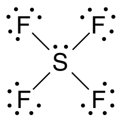
(e) 

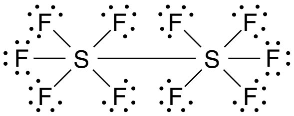
7-48. (a) 

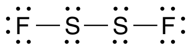
(b) 

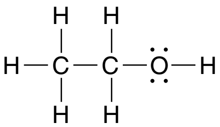
(c) 

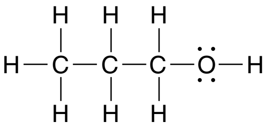
(d) 

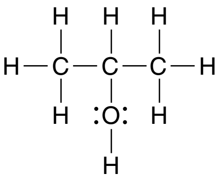
7-50. (a)  (b) 

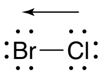
(c) 

(d) 

7-56. (a) 

(b) 

(c) 

7-58. 

Chapter 8

8-2. PF_5 and AlF_6^{3-}

8-4. SeF_6 and BrF_2^-

8-6. (a) bent (b) bent (c) bent (d) linear

8-8. NH_2Cl, PF_3

8-10. (a) AX_4E_2, 6, square planar; (b) AX_4, 4, tetrahedral; (c) AX_4, 4, tetrahedral; (d) AX_4E, 5, seesaw-shaped

8-12. We have for the given fluorides

(a) AX_6	octahedral	90°
(b) AX_4	tetrahedral	109.5°
(c) AX_3E_2	T-shaped	90°
(d) AX_5E	square pyramidal	< 90°

8-14. We have for the given ions

(a) AX_4	tetrahedral	109.5°
(b) AX_6	octahedral	90°
(c) AX_3	trigonal planar	120°
(d) AX_6	octahedral	90°

8-16. We have for the given molecules

(a) AX_4	tetrahedral	109.5°
(b) AX_3E	trigonal pyramidal	< 109.5°
(c) AX_6	octahedral	90°
(d) AX_4E	seesaw-shaped	< 120° and < 180°

8-18. We have for the given molecules

(a) AX_2E_2	bent	< 109.5°
(b) AX_6	octahedral	90°
(c) AX_4E	seesaw-shaped	< 120°, < 180°
(d) AX_4E_2	square planar	90°

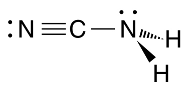
8-20. (a) square pyramidal < 90° (b) octahedral 90° (c) tetrahedral ~ 109.5° (d) tetrahedral ~ 109.5°

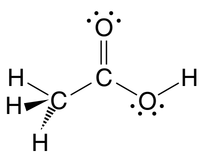
8-22. (a) seesaw-shaped < 90°, < 120° (b) bent < 109.5° (c) bent < 120° (d) trigonal planar < 120°

8-24. (a) tetrahedral ~ 109.5° (b) linear 180° (c) tetrahedral < 109.5° (d) bent < 109.5°

8-26. (a) tetrahedral 109.5° (b) bent < 109.5° (c) trigonal planar 120° (d) trigonal pyramidal < 109.5°

8-28. (a) a bent ion, < 120° (b) a trigonal planar ion, 120° (c) a linear ion, 180° (d) a tetrahedral ion, 109.5°

8-30. 

8-32. 

8-36. (a) tetrahedral (no dipole moment) (b) bent (dipole moment) (c) octahedral (no dipole moment) (d) T-shaped (dipole moment)

8-38. (a) AX_6, octahedral (no dipole moment); (b) AX_5E, square pyramidal (dipole moment); (c) AX_4, tetrahedral (no dipole moment); (d) AX_2E_2, bent (dipole moment)

8-40. (a) seesaw-shaped, polar (b) trigonal planar, nonpolar (c) octahedral, polar (d) trigonal bipyramidal, polar

8-48. (a) and (d)

8-56. (a) trigonal pyramidal (b) tetrahedral (c) seesaw shaped (d) octahedral

8-58. (a) bent (b) trigonal pyramidal (c) tetrahedral

8-60. The PCl_4^+ ions are tetrahedral and the PI_6^- ions are octahedral.

8-62. SOF_2

8-64. $BeCl_2$

8-66. (a) linear (b) square planar (c) bent (d) seesaw shaped

8-68. (a) 1 and 8 (b) 3 (c) 2 and 9 (d) 1 and 2

8-70. (a) 90° (b) 90°, 120° (c) 90° (d) 120°

8-76. (a) no isomers; (b) two geometric isomers; (c) two optical isomers; (d) no isomers

Chapter 9

9-2. One

9-4. B_2 is paramagnetic

9-8. C_2^{2-} has a larger bond energy and shorter bond length than C_2

9-10. We have

	Ground-state electron configuration	Bond order
NO	$(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2(\pi_{2p}^*)^1$	$2\frac{1}{2}$
NO^+	$(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2$	3
NO^-	$(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2(\pi_{2p}^*)^2$	2

9-12. (a) 13 electrons; $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^1$; bond order = $2\frac{1}{2}$
(b) 9 electrons; $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s})^2(\pi_{2p})^1$; bond order = $\frac{1}{2}$
(c) 3 electrons; $(\sigma_{1s})^2(\sigma_{1s}^{*1})$; bond order = $\frac{1}{2}$
(d) 20 electrons; $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p}^*)^4(\sigma_{2p}^*)^2$; bond order = 0

9-14. (a) $\frac{1}{2}$; stable (b) 0, unstable (c) $1\frac{1}{2}$; stable (d) $-\frac{1}{2}$, unstable

9-18. $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2(\pi_{2p}^*)^4(\sigma_{2p}^*)^2(\sigma_{3s})^2(\sigma_{3s}^*)^2(\pi_{3p})^4(\sigma_{3p})^2$; bond order is 3; :P≡P:

9-20. 16 valence electrons; Use *sp* hybrid orbitals on the Hg atom.

9-22. 20 valence electrons; Use sp^3 hybrid orbitals on the S atom.

9-26. Use sp^2 hybrid orbitals on the C atom.

9-28. 26 valence electrons; Use sp^3 hybrid orbitals on the C atom.

9-30. 22 valence electrons; Use sp^3d hybrid orbitals on the Xe atom.

9-32. 42 valence electrons; Use sp^3d^2 hybrid orbitals on the Te atom.

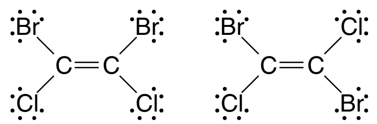
9-34. Use sp^3 hybrid orbitals on the two C atoms and the O atom. ~105°

9-36. Use sp^3 hybrid orbitals on the two C atoms and the N atom. 9 σ-bonds, 1 lone pair on the N atom; tetrahedral around the C atom; trigonal pyramidal around the N atom

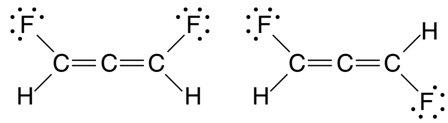
9-38. Use sp^3 hybrid orbitals on the three C atoms and the O atom. 11 localized bond orbitals

9-40. (a) five σ bonds and one π bond (b) seven σ bonds and two π bonds (c) six σ bonds and two π bonds (d) eight σ bonds and two π bonds

9-42. five σ bonds and two π bonds; Bond order of the C–C bond is 1; the bond order of the C≡N bond is 3

9-46.


cis-isomer *trans*-isomer

9-48.


cis-isomer *trans*-isomer

9-50. 26 σ bonds and seven delocalized π bonds

9-60. $2\frac{1}{2}$

9-62. $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2$; 3;$N_2$ and CO

9-64. The excited state bond length is greater than that of the ground state.

9-66. It can emit light or photodissociate.

9-68. Use sp^2 hybrid orbitals on the central C atom and O atom. Trigonal planar around central C atom

9-70. Use sp^3 hybrid orbitals on the C atom bonded to H atoms and and sp hybrid orbitals on cyanide C atom and N atom. Eight σ bonds and two π bonds

9-72. (a) eight σ bonds and one π bond (b) six σ bonds and one π bond (c) five σ bonds and two π bonds (d) eight σ bonds

9-78. $1\frac{1}{3}$

Chapter 10

10-2. (a) sodium acetate (b) calcium chlorate (c) ammonium carbonate (d) barium nitrate

10-4. (a) ammonium thiosulfate (b) sodium sulfite (c) potassium carbonate (d) sodium thiosulfate

10-6. (a) chromium(II) sulfate (b) cobalt(II) cyanide (c) tin(II) nitrate (d) copper(I) carbonate

10-8. (a) $HC_2H_3O_2$ (b) $HClO_3$ (c) H_2CO_3 (d) $HClO_4$

10-10. (a) $NaClO_4$ (b) $KMnO_4$ (c) $CaSO_3$ (d) LiCN

10-12. (a) $Hg_2(C_2H_3O_2)_2$ (b) $Hg(CN)_2$ (c) $Fe(ClO_4)_2$ (d) $CrSO_3$

10-14. (a) NaClO(s) (b) $H_2O_2(l)$ (c) KOH(s) (d) $CH_3COOH(aq)$

10-16. (a) basic (b) acidic (c) acidic (d) basic (e) basic

10-18. (a) and (b)

10-20. (a) organic acid (b) oxyacid (c) organic acid (d) oxyacid

10-22. (a) nitrous acid (b) hyposulfurous acid (c) chlorous acid (d) iodic acid

10-24. (a) copper(II) hypochlorite (b) scandium(III) iodate (c) iron(III) bromate (d) ruthenium(III) periodate

10-30. (a) barium hydroxide octahydrate (b) lead(II) chloride dihydrate (c) lithium hydroxide monohydrate (d) lithium chromate dihydrate

10-32. (a) $H_2C_2O_4 \cdot 2H_2O$ (b) $Al_2(SO_4)_3 \cdot 8H_2O$ (c) $NdI_3 \cdot 9H_2O$ (d) $Na_2HPO_4 \cdot 7H_2O$

10-34. (a) decomposition (b) single replacement (c) double-replacement (d) single replacement

10-36. (a) decomposition
$2NaClO_3(s) \rightarrow 2NaCl(s) + 3O_2(g)$
(b) combination; already balanced
(c) single replacement
$H_2(g) + 2AgCl(s) \xrightarrow[H_2O(l)]{} 2Ag(s) + 2HCl(aq)$
(d) double replacement
$Hg_2(NO_3)_2(aq) + 2CH_3COOH(aq) \rightarrow Hg_2(CH_3COO)_2(s) + 2HNO_3(aq)$

10-38. (a) $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$
(b) $MgO(s) + CO_2(g) \rightarrow MgCO_3(s)$
(c) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
(d) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

10-40. (a) $Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$
(b) $Fe(s) + H_2SO_4(aq) \rightarrow 2FeSO_4(aq) + H_2(g)$
(c) $Ca(s) + 2HBr(aq) \rightarrow CaBr_2(aq) + H_2(g)$
(d) $Pb(s) + 2HCl(aq) \rightarrow PbCl_2(aq) + H_2(g)$

10-42. (a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
(b) $Pb^{2+}(aq) + CO_3^{2-}(aq) \rightarrow PbCO_3(s)$
(c) $2Ag^+(aq) + SO_4^{2-}(aq) \rightarrow Ag_2SO_4(s)$
(d) $S^{2-}(aq) + Zn^{2+}(aq) \rightarrow ZnS(s)$

10-44. We have
(a) $2AgNO_3(aq) + Na_2S(aq) \rightarrow Ag_2S(s) + 2NaNO_3(aq)$
$2Ag^+(aq) + S^{2-}(aq) \rightarrow Ag_2S(s)$
(b) $H_2SO_4(aq) + Pb(NO_3)_2(aq) \rightarrow PbSO_4(s) + 2HNO_3(aq)$
$SO_4^{2-}(aq) + Pb^{2+}(aq) \rightarrow PbSO_4(s)$
(c) $Hg(NO_3)_2(aq) + 2NaI(aq) \rightarrow HgI_2(s) + 2NaNO_3(aq)$
$Hg^{2+}(aq) + 2I^-(aq) \rightarrow HgI_2(s)$
(d) $CdCl_2(aq) + 2AgClO_4(aq) \rightarrow 2AgCl(s) + Cd(ClO_4)_2(aq)$
$Cl^-(aq) + Ag^+(aq) \rightarrow AgCl(s)$

10-46. (a) insoluble, Rule 5 (b) soluble, Rule 4 (c) soluble, Rule 1 (d) insoluble, Rule 3 (e) insoluble, Rule 3

10-48. (a) insoluble, Rule 3 (b) soluble, Rule 2 (c) insoluble, Rule 3 (d) soluble, Rule 2 (e) insoluble, Rule 3

10-50. (a) soluble; $FeBr_3(s) \xrightarrow[H_2O(l)]{} Fe^{3+}(aq) + 3Br^-(aq)$
(b) insoluble (c) soluble;
$(NH_4)_2CO_3(s) \xrightarrow[H_2O(l)]{} 2NH_4^+(aq) + CO_3^{2-}(aq)$
(d) soluble; $K_2S(s) \xrightarrow[H_2O(l)]{} 2K^+(aq) + S^{2-}(aq)$

10-52. (a) $CaSO_4$ is insoluble by Rule 6.
$H_2SO_4(aq) + Ca(ClO_4)_2(aq) \rightarrow CaSO_4(s) + 2HClO_4(aq)$
$SO_4^{2-}(aq) + Ca^{2+}(aq) \rightarrow CaSO_4(s)$
(b) All compounds are soluble; thus there is no reaction. (c) $Hg_2(C_7H_5O_2)_2$ is insoluble by Rule 3.
$Hg_2(NO_3)_2(aq) + 2NaC_7H_5O_2(aq) \rightarrow Hg_2(C_7H_5O_2)_2(s) + 2NaNO_3(aq)$
$Hg^{2+}(aq) + 2C_7H_5O_2^-(aq) \rightarrow Hg_2(C_7H_5O_2)_2(s)$
(d) $PbBr_2$ is insoluble by Rule 3.
$Pb(CH_3COO)_2(aq) + 2KBr(aq) \rightarrow PbBr_2(s) + 2KCH_3COO(aq)$
$Pb^{2+}(aq) + 2Br^-(aq) \rightarrow PbBr_2(s)$

10-54. (a) $NH_4NO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(l) + NH_3(aq)$
$NH_4^+(aq) + OH^-(aq) \rightarrow H_2O(l) + NH_3(aq)$
(b) $2HNO_3(aq) + BaCO_3(s) \rightarrow Ba(NO_3)_2(aq) + H_2O(l) + CO_2(g)$
$2H^+(aq) + BaCO_3(s) \rightarrow Ba^{2+}(aq) + H_2O(l) + CO_2(g)$
(c) $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

10-56. (a) $2HClO_4(aq) + Ca(OH)_2(aq) \rightarrow \underbrace{Ca(ClO_4)_2(aq)}_{\text{calcium perchlorate}} + 2H_2O(l)$
$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
(b) $2HCl(aq) + CaCO_3(s) \rightarrow \underbrace{CaCl_2(aq)}_{\text{calcium chloride}} + \underbrace{CO_2(g)}_{\text{carbon dioxide}} + H_2O(l)$
$2H^+(aq) + CaCO_3(s) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$
(c) $6HNO_3(aq) + Al_2O_3(s) \rightarrow \underbrace{2Al(NO_3)_3(aq)}_{\text{aluminum nitrate}} + 3H_2O(l)$
$6H^+(aq) + Al_2O_3(s) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$
(d) $H_2SO_4(aq) + Cu(OH)_2(s) \rightarrow \underbrace{CuSO_4(aq)}_{\text{copper(II) sulfate}} + 2H_2O(l)$
$2H^+(aq) + Cu(OH)_2(s) \rightarrow Cu^{2+}(aq) + 2H_2O(l)$

10-58. (a) $K_2CrO_4(aq) + Pb(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + PbCrO_4(s)$
(b) $2HCl(aq) + Na_2S(aq) \rightarrow 2NaCl(aq) + H_2S(g)$
(c) $Ba(OH)_2(aq) + ZnSO_4(aq) \rightarrow Zn(OH)_2(s) + BaSO_4(s)$
(d) $2HNO_3(aq) + CaO(s) \rightarrow Ca(NO_3)_2(aq) + H_2O(l)$

10-60. (a) precipitation reaction (b) gas forming reaction (c) precipitation reaction (d) acid-base reaction

10-62. (a) $Li(s)$ is the reducing agent and $Se(s)$ is the oxidizing agent.
(b) $Sc(s)$ is the reducing agent and $I_2(g)$is the oxidizing agent.
(c) $Ga(s)$ is the reducing agent and $P_4(s)$ is the oxidizing agent.
(d) $K(s)$ is the reducing agent and $F_2(g)$ is the oxidizing agent.

10-64. (a) 2 (b) 12 (c) 12 (d) 2

10-66. (a) $CH_4(g)$ is the reducing agent and $O_2(g)$ is the oxidizing agent. 8

10-70. Carbon dioxide and water.

10-72. (a) $2Na(s) + H_2(g) \rightarrow 2NaH(s)$
(b) $2Al(s) + 3S(s) \rightarrow Al_2S_3(s)$
(c) $H_2O(g) + C(s) \rightarrow CO(g) + H_2(g)$
(e) $PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s)$

10-74. $HCHO_2(aq) + NH_3(aq) \rightarrow NH_4CHO_2(aq)$

10-76. (a) $Cl_2(g) + 2NaI(aq) \rightarrow 2NaCl(aq) + I_2(s)$
(b) $Br_2(l) + 2NaI(aq) \rightarrow 2NaBr(aq) + I_2(s)$
(c) no reaction (d) no reaction

10-78. (a) $ZnS(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2S(g)$
(b) $2PbO_2(s) \rightarrow 2PbO(s) + O_2(g)$
(c) $3CaCl_2(aq) + 2H_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6HCl(aq)$

10-80. (a) $C_{12}H_{22}O_{11}(s) \rightarrow 12C(s) + 11H_2O(l)$
(b) $Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(l)$
(c) $Li_2O(s) + H_2O(l) \rightarrow 2LiOH(aq)$

10-82. (a) $Na_2CO_3{\cdot}10H_2O(s) \rightarrow Na_2CO_3(s) + 10H_2O(g)$
(b) $Pb(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow PbSO_4(s) + 2NaNO_3(aq)$

(c) $2\,Fe(s) + 3\,Pb(NO_3)_2(aq) \rightarrow 2\,Fe(NO_3)_3(aq) + 3\,Pb(s)$

10-86. $2\,Pb(l) + O_2(g) \rightarrow 2\,PbO(s)$
$Ag(l) + O_2(g) \rightarrow$ no reaction

10-88. $2\,HgS(s) + 2\,O_2(g) \xrightarrow{\text{heat}} HgO(s) + SO_2(g)$
$HgO(s) + HgS(s) \xrightarrow{\text{heat}} Hg(g) + SO_2(g)$
$Hg(g) \xrightarrow{\text{cold}} Hg(l)$

10-92. $3\,CH_3CH_2OH(aq) + 2\,K_2Cr_2O_7(aq) + 8\,H_2SO_4(aq) \rightarrow 3\,CH_3COOH(aq) + 2\,Cr_2(SO_4)_3(aq) + 2\,K_2SO_4(aq) + 11\,H_2O(l)$

Chapter 11

11-2. (a) 602 g (b) 332.2 g (c) 18 g (d) 56 g

11-4. 75.35% C; 8.959% H; 7.323% N; 8.365% O

11-6. (a) 37.48% C; 49.93% O; 12.58% H (b) 88.81% O; 11.19% H (c) 94.07% O; 5.926% H (d) 9.861% Mg; 13.01% S; 71.40% O; 5.725% H

11-8. (a) 5.26 g (b) 0.081 g (c) 3.69 g (d) 1.67 g

11-10. Fe_2O_3

11-12. FeS

11-14. Al_2O_3

11-16. (a) TlBr, thallium(I) bromide (b) $PbCl_2$, lead(II) chloride (c) NH_3, ammonia (d) Mg_3N_2, magnesium nitride

11-18. 47.7; titanium, Ti

11-20. 35.4; chlorine, Cl

11-22. $C_6H_{12}O_6$

11-24. 59 700

11-26. $C_{10}H_{10}Fe$

11-28. $C_{15}H_{24}O$

11-30. $C_8H_{20}Pb$

11-32. 59.1 g

11-34. 3.92 g

11-36. 58.5 metric tons

11-38. 2.46×10^3 kg

11-40. 9.41 metric tons

11-42. 17.0 g

11-44. 78.0%

11-46. 43.3% K_2SO_4 and 56.7% $MnSO_4$

11-48. 62.3% Al and 37.7% Mg

11-50. 5.49 g

11-52. 19.4 g

11-54. (a) $CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$ (b) 22.8 g (c) 4.50 g $CaCO_3$ remaining

11-56. (a) $CdCl_2(aq) + 2\,AgClO_4(aq) \rightarrow Cd(ClO_4)_2(aq) + 2\,AgCl(s)$ (b) 24.5 g (c) excess of 1.8 g $CdCl_2$

11-58. $Hg(NO_3)_2(aq) + 2\,NaBr(aq) \rightarrow HgBr_2(s) + 2\,NaNO_3(aq)$; 26.3g $HgBr_2(s)$; excess of 1.3 g $Hg(NO_3)_2$

11-60. 97.8%

11-62. 82.3%

11-64. (a) $Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$ (b) 29.2 kg

11-70. 6.95×10^{25}

11-72. 1280 g Na_2CS_3; 442 g Na_2CO_3; 225 g H_2O

11-74. (a) 1.02 g (b) 1.09 g (c) 0.825 g (d) 0.744 g

11-76. 29.8 g O_2; 40.9 g CO_2

11-78. 23% NaCl and 77% $CaCl_2$

11-80. 6 water molecules

11-82. B_5H_9

11-84. 48.2% Na_2SO_4 and 51.8% $NaHSO_4$

11-86. 1.58×10^5 kg

11-88. $C_{17}H_{21}NO_4$, it may be cocaine

11-90. 4.5 ton as the ad claims

11-92. $C_6H_{12}SO_2$

Chapter 12

12-2. 14.3 M

12-4. 0.00653 M

12-6. (a) 1.00×10^{-5} mol (b) 4.00×10^{-6} mol

12-8. 21 mL

12-10. Put 2.50 grams in a 50 mL volumetric flask and add water to the 50 mL mark

12-12. $1.7\ g \cdot mL^{-1}$

12-14. $C_{12}H_{22}O_{11}(aq)$, nonelectrolyte; $NaCl(aq)$, strong electrolyte; $NaHCO_3(aq)$, strong electrolyte; $NH_3(aq)$, weak electrolyte; $CH_3COCH_3(aq)$, nonelectrolyte

12-16. 0.050 M in $Ni^{3+}(aq)$ and 0.150 M in $Cl^-(aq)$

12-18. 27.7 mL

12-20. 4.33 g

12-22. 0.456 g

12-24. 320 g Br_2 and 142 g Cl_2

12-26. 32.2 mL

12-28. 34.9 g AgI; 0.319 M Ca^{2+}, 0.496 M NO_3^-, and 0.141 M I^-

12-30. 0.738 M

12-32. 170 mL by $Mg(OH)_2$ and 190 mL by $Al(OH)_3$

12-34. 0.11 M NaOH and 0.0286 M NaBr

12-36. 92.8%; we assumed that any impurities do not react with $HCl(aq)$.

12-38. 60.1

12-44. 30.0 M

12-46. 13.2 M

12-48. 70.8 g

12-50. 4.2 mL

12-52. Add 3.75 mL of 8.0 M $H_2SO_4(aq)$ to a 250-mL volumetric flask and add water to the 250-mL mark

12-54. 9.5×10^{-5} M

12-56. 23 g

12-58. 1.00 kg

12-60. 184 g

12-62. 177.8 mL

12-64. Two acidic protons

12-66. 2.57%

12-68. 2.10 g

12-70. 5.15 g

12-72. 0.2300 M

12-74. 6.89%

12-76. 0.0310 M

12-78. 63.6%

12-80. $190\ g \cdot L^{-1}$

12-82. 2.77 g

12-84. 14.1 mL

Chapter 13

13-2. 739 Torr and 0.972 atm

13-4. 12.6 mL

13-6. two cylinders

13-8. 1.0 L

13-10. –78°C

13-14. 0.28 L O_2; 0.55 L H_2O

13-16. 676 g

13-18. 1.93×10^5 Pa

13-20. 56.2 μg

13-22. 3.3×10^{13} molecules

13-24. $5.40\ g \cdot L^{-1}$

13-26. C_4H_6

13-28. C_2H_4

13-30. C_3H_8O

13-32. 0.4818 H_2; 0.4277 N_2; 0.0906 Ar

13-34. 24.8% O_2; 75.2% N_2. The discrepancy suggests that air consists of more than just nitrogen and oxygen.

13-36. 103 kPa

13-38. 466 Torr N_2; 318 Torr O_2; 784 Torr total

13-40. 52.3 L of each

13-42. 34.9 L; 50.9 L

13-44. 7.43 metric tons

13-46. 986 L; 56 atm

13-48. zero

13-50. 408 $m\cdot s^{-1}$; 518 $m\cdot s^{-1}$; 1140 $m\cdot s^{-1}$

13-52. 11.22

13-54. 7.01 mL

13-56. 46.4%

13-58. 0.123 atm; 1.23×10^{-4} atm; 1.23×10^{-7} atm

13-60. 1.0×10^{-4} collisions$\cdot s^{-1}$

13-64. 20.9 bar; 22.1 bar from the ideal gas equation

13-68. 29.5 in

13-70. 3.0 m

13-74. 8300 gallons. Information is approximately correct.

13-76. 21.2 mL

13-78. 0.58 bar

13-82. 287 L CO_2; 144 L O_2

13-84. 238 mL

13-86. 3.0 L

13-88. 43% NaH and 57% CaH_2

13-90. NO(*g*)

13-92. 62.8%

Chapter 14

14-2. 3.2 kJ

14-4. +87.50 J

14-6. 200 J

14-8. –860 $kJ\cdot mol^{-1}$

14-10. –601 $kJ\cdot mol^{-1}$

14-12. –73.8 kJ

14-14. –1154 $kJ\cdot mol^{-1}$

14-16. 333 J; –73.5 kJ

14-18. 0.879 $kJ\cdot g^{-1}$

14-20. 82.9 $kJ\cdot mol^{-1}$

14-22. –521 $kJ\cdot mol^{-1}$

14-24. 1.0 $kJ\cdot mol^{-1}$

14-26. –139 $kJ\cdot mol^{-1}$

14-28. –11.3 $kJ\cdot mol^{-1}$

14-30. (a) –196.0 $kJ\cdot mol^{-1}$; exothermic
(b) –100.7 $kJ\cdot mol^{-1}$; exothermic
(c) –902.0 $kJ\cdot mol^{-1}$; exothermic

14-32. (a) –725.9 $kJ\cdot mol^{-1}$ (b) –622.2 $kJ\cdot mol^{-1}$

14-34. –2226.1 $kJ\cdot mol^{-1}$

14-36. (a) 44.0 $kJ\cdot mol^{-1}$ (b) 32.5 $kJ\cdot mol^{-1}$

14-38. –2808.7 $kJ\cdot mol^{-1}$; -7.015×10^6 kJ

14-40. 192 $kJ\cdot mol^{-1}$

14-42. –435 $kJ\cdot mol^{-1}$

14-44. 943 $kJ\cdot mol^{-1}$

14-46. 324.40 $kJ\cdot mol^{-1}$

14-48. 195 $J\cdot K^{-1}\cdot mol^{-1}$

14-50. 7.46×10^4 g

14-52. 3.3°C

14-54. 2.6 $J\cdot K^{-1}\cdot g^{-1}$

14-56. –26.0 $kJ\cdot mol^{-1}$

14-58. –66.3 $kJ\cdot mol^{-1}$

14-60. –33.3 $kJ\cdot K^{-1}$

14-62. –2820 $kJ\cdot mol^{-1}$

14-64. –236 kJ; –56.4 Calories

14-66. –1343 $kJ\cdot mol^{-1}$; –695 $kJ\cdot mol^{-1}$

14-74. 1210 Cal; 5060 kJ

14-76. 48 g

14-78. –110 J

14-80. TlCl

14-82. (a) –49.94 $kJ \cdot g^{-1}$ (b) –50.30 $kJ \cdot g^{-1}$ (c) –51.89 $kJ \cdot g^{-1}$

14-84. –352.7 $kJ \cdot mol^{-1}$

14-86. –0.557 kJ; 0.666°C

14-88. 5.35 $Cal \cdot g^{-1}$

14-90. 1.62×10^5 $kJ \cdot day^{-1}$; 7 $barrel \cdot yr^{-1}$

14-92. 92 molecules

14-94. –748.6 $kJ \cdot mol^{-1}$

Chapter 15

15-2. 30.7 $kJ \cdot mol^{-1}$

15-4. 1180 g; 848 g

15-6. 5.08×10^{-2} J

15-8. 4.19 mol

15-10. Takes longer to vaporize the water.

15-12. 19.1 $kJ \cdot mol^{-1}$

15-14. He, Cl_2

15-16. CH_3CH_2OH

15-18. $T_b[PH_3] < T_b[NH_3] < T_b[KCl] < T_b[MgO]$

15-20. $\Delta H_{vap}[CH_4] < \Delta H_{vap}[CCl_4] < \Delta H_{vap}[SiCl_4] < \Delta H_{vap}[SiBr_4]$

15-22. 580 Torr

15-24. 95°C; 80°C; 95°C; 85°C

15-26. 51 Torr

15-28. 8.1 mJ

15-32. (a) gas (b) solid (c) gas (d) solid

15-36. Four

15-38. 330.51 pm

15-40. 6.02×10^{23} $atom \cdot mol^{-1}$

15-42. 4.31×10^{-8} cm; 373 pm

15-44. Four; NaCl type

15-54. 117 Cal

15-56. 0.36 $kJ \cdot mol^{-1}$; 2.3 $kJ \cdot mol^{-1}$; 7.4 $kJ \cdot mol^{-1}$; 10 $kJ \cdot mol^{-1}$; 14 $kJ \cdot mol^{-1}$

15-58. 21 $kJ \cdot mol^{-1}$, 2%; 32 $kJ \cdot mol^{-1}$, 20%; 18 $kJ \cdot mol^{-1}$, 4%

15-64. 0.313 cm is the depth removed per m^2.

15-68. 23°C

15-70. 3.994 $g \cdot cm^{-3}$

15-72. 1.28×10^{-3} $mol \cdot L^{-1}$

15-78. 1100 Torr

15-80. 65.3 $g \cdot mol^{-1}$

15-82. 5.92 Torr; 21.2 Torr; 83.9 Torr; 622 Torr

Chapter 16

16-2. 0.30 H_2CO; 0.071 CH_3OH; 0.63 H_2O

16-4. 365 grams of sucrose in 135 grams of water

16-6. 0.21

16-8. 457 grams of $Ba(NO_3)_2(s)$ in 1000 grams of water

16-10. 4.0 kg

16-12. (a) 1.0 m_c (b) 4.0 m_c (c) 3.0 m_c (d) 3.0 m_c

16-14. (a) 3 (b) 3 (c) 3

16-16. HCl

16-18. 5.71 kPa; 0.56 kPa

16-20. 0.873 atm; 0.13 atm

16-22. 6.8 Torr

16-24. 62.5 mbar

16-26. (a) 0.834 mbar (b) 1.10 mbar (c) 0.423 mbar

16-28. 7.37 m

16-30. (a) 3.58 m (b) 2.38 m (c) 2.38 m

16-32. 57 g

16-34. 100.6°C; 12.5 Torr

16-36. 66.83°C

16-38. -1.36°C

16-40. 324

16-42. 10 m

16-44. $C_3H_8O_3$

16-46. $K_2HgI_4 \xrightarrow[H_2O(l)]{} 2K^+(aq) + HgI_4^{2-}(aq)$

16-48. 28.0 atm

16-50. 34 400

16-52. 23 L

16-54. P_{prop} = 5.2 Torr; 10 Torr; 16 Torr and P_{iso} = 34 Torr; 23 Torr; 11 Torr; in the vapor, x_{prop} = 0.13; 0.30; 0.59 and x_{iso} = 0.87; 0.70; 0.41

16-56. $CO_2(g)$

16-58. 8.6 mg O_2 and 14 mg N_2

16-68. $MgCl_2$ solution

16-70. –4.4°C wine and –21°C vodka

16-74. (a) no net flow (b) no net flow (c) 0.10 M → 0.50 M

16-76. (a) 0.115 m; 0.345 m_c; –0.64°C; 100.18°C (b) 0.434 m; 0.434 m_c; –0.81°C; 100.22°C

16-78. P_4

16-80. 2.26 M

16-82. 108.26°C

16-88. 2.01

16-90. ammonium nitrate, NH_4NO_3

16-92. 125 mL and 375 mL; 0.16 M each

Chapter 17

17-2. $-\frac{1}{2}\frac{\Delta[SO_2]}{\Delta t}; -\frac{\Delta[O_2]}{\Delta t}; \frac{1}{2}\frac{\Delta[SO_3]}{\Delta t}$

17-6. 3.5×10^{-14} M·min^{-1}; third order

17-8. (a) 2.36×10^{-4} M·min^{-1} (b) 1.7×10^{-4} M·min^{-1} (c) 6.4×10^{-4} M·min^{-1}

17-12. $(20\ mol^{-1}\cdot L\cdot s^{-1})[NOBr]^2$

17-14. $(1.44 \times 10^{-4}\ Torr^{-1}\cdot s^{-1})P^2_{C_5H_6}$

17-16. $(6.1\ s^{-1})P_{N_2O_3}$

17-18. $(1.5\ M^{-1}\cdot s^{-1})[CoBr(NH_3)_5^{2+}][OH^-]$

17-20. $(4.0 \times 10^{-3}\ M^{-1}\cdot s^{-1})[CH_3COCH_3][H^+][Br_2]$

17-22. 1.9×10^{-5} M

17-24. 0.99

17-26. 0.0864 min^{-1}

17-28. $(2.8 \times 10^{-5}\ s^{-1})P_{H_2C_2O_4}$

17-30. 0.624

17-32. 300 years

17-34. 0.17

17-36. 1230 years old

17-38. 3600 years old

17-40. 2.44×10^9 years

17-42. 0.12 M

17-44. 5.11 M^{-1}·s^{-1}

17-46. 0.015 M

17-52. $(1.01 \times 10^{-6}\ Torr^{-1}\cdot s^{-1})P^2_{CO}$

17-54. 3.6×10^{-4} M·s^{-1}; 1.3 mol·L^{-1}

17-58. 3.7×10^8 years; 1.6×10^{10} years

17-60. 0.464 disintegrations·min^{-1}

17-62. 5.00 L

17-64. $(0.030\ M^{-1}\cdot s^{-1})[BrO_3^-][I^-]$

17-66. 1.4×10^6 per milliliter

17-70. 8.3 s

17-72. 0.0102 min^{-1}; first order

17-74. 3.40×10^{-6} Torr^{-2}·s^{-1}

17-76. 170 million years old

Chapter 18

18-2. 1.50×10^2 kJ·mol^{-1}

18-4. 4.9×10^{-3} s^{-1}

18-6. 41 beats·min^{-1}

18-8. (a) rate of reaction = k[K][HCl] (b) rate of reaction = $k[H_2O_2]$ (c) rate of reaction = $k[O_2]^2$[Cl] (d) rate of reaction = $k[NO_3]$[CO]

18-10. (a) Second order; first order in [K], first order in [HCl]; bimolecular reaction
(b) First order; first order in $[H_2O_2]$; unimolecular reaction
(c) Third order; second order in $[O_2]$, first order in [Cl]; termolecular reaction
(d) Second order; first order in $[NO_3]$, first order in [CO]; bimolecular reaction

18-12. Yes

18-14. Step 1 is a bimolecular reaction and step 2 is a unimolecular reaction. The reaction intermediate is $NO_3(g)$.

18-16. Yes

18-18. (a) First two mechanisms; (b) Mechanism b

18-20. Yes; $k = \frac{k_2 k_1}{k_{-1}}$

18-24. $k[H_2O_2][I^-]^2[H^+]$; $H^+(aq)$ and $I^-(aq)$

18-28. 45 μmol·L^{-1}·min^{-1}; 10 μmol·L^{-1}

18-30. 16 mmol·L^{-1}·min^{-1}; 44 mmol·L^{-1}

18-32. 38 mmol·L^{-1}·s^{-1}; 26 mmol·L^{-1}·s^{-1}

18-34. 1.4×10^4 min^{-1}

18-36. 1.0×10^7 s^{-1}

18-50. (a) increase (b) increase (c) decrease (d) decrease

18-52. 3.1 min

18-54. 5.0×10^{-3} M^{-1}·s^{-1}; 120 kJ·mol^{-1}

18-56. second order; 46.06 kJ·mol^{-1}; 27 mbar

18-58. (a) $k[H_2][Br_2]^{1/2}$ in agreement with rate law
(b) L$^{1/2}$·mol$^{-1/2}$·s^{-1} (c) no

18-60. 51 kJ·mol^{-1}

18-62. 102 kJ·mol^{-1}

18-66. 16.2 μmol·L^{-1}

18-68. 8.23 mmol·L^{-1}

18-70. 110 μmol·s^{-1}; R_{max} = 0.64 M·s^{-1}

Chapter 19

19-2. 0.527 M SO_2 and 0.274 M SO_3

19-4. (a) $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$ M^{-1}

(b) $K_c = [CO_2][H_2O]$ M^2 (c) $K_c = \frac{[CH_4]}{[H_2]^2}$ M^{-1}

19-6. (a) $K_c = [CO_2][NH_3]^2$ M^3 (b) $K_c = [O_2]$ M

(c) $K_c = \frac{[N_2O_4]}{[N_2][O_2]^2}$ M^{-2}

19-8. (a) $K_p = P^2_{NH_3}P_{CO_2}$ bar^3 (b) $K_p = P_{O_2}$ bar

(c) $K_p = \frac{P_{N_2O_4}}{P_{N_2}P^2_{O_2}}$ bar^{-2}

19-10. 27 bar^2

19-12. 1.8 M

19-14. 39 bar

19-16. 0.83 bar

19-18. 1.18 bar

19-20. 688 g

19-22. 4.54 bar

19-24. both are 0.51 bar

19-26. $[COCl_2]$ = 0.146 M; $[Cl_2]$ = 0.104 M; [CO] = 0.354 M

19-28. P_{H_2} = 1.3 bar and P_{HI} = 3.2 bar

19-30. P_{H_2} = 1.51 bar and P_{CH_4} = 0.60 bar

19-32. 1.9 bar

19-34. 0.076 bar^2

19-38. (a) to the right (b) to the right (c) to the left (d) to the left

19-40. (a) no change (b) to the left (c) to the right (d) to the right

19-42. Low temperature and high pressure

19-44. P_{PCl_3} = 6.7 Torr; P_{PCl_5} = 224 Torr; P_{Cl_3} = 26.7 Torr

19-46. $P_{N_2O_4}$ = 0.390 bar; P_{NO_2} = 0.464 bar; P_{tot} = 0.854 bar

19-48. 26.4 Torr

19-50. No; from left to right

19-52. From right to left

19-60. (a) more intense (b) less intense (c) no change

19-66. 170 M^{-2}

19-68. (a) 0.088 bar (b) P_{CH_3OH} = 8.95 bar and P_{CO} = 1.03 bar

19-70. 6.2 bar

19-72. 1.60 moles

19-74. (a) No (b) $[H_2] = [I_2] = 1.7 \times 10^{-3}$ M; [HI] = 0.016 M

19-76. P_{Cl_2} = 2.24 atm; P_{O_2} = 1.64 atm

19-78. Brown crystalline form

19-80. 25.1 moles

19-82. 78.5%

19-84. $P_{CO} = P_{H_2O}$ = 12.0 Torr $P_{CO_2} = P_{H_2}$ = 14.1 Torr

19-86. $P_{NH_3} = P_{HCl}$ = 0.24 bar; 9.41 g

19-88. 3.3 moles

19-92. 0.982 bar

19-96. $[H_2O]$ = 0.0559 M; $[CH_4]$ = 0.443 M; [CO]= 0.557 M; $[H_2]$ = 0.219 M

Chapter 20

20-2. $[OH^-]$ = 0.25 M; $[K^+]$ = 0.25 M; $[H_3O^+] = 4.0 \times 10^{-14}$ M; basic

20-4. $[OH^-]$ = 0.0162 M; $[Ca^{2+}] = 8.10 \times 10^{-3}$ M; $[H_3O^+] = 6.17 \times 10^{-13}$ M

20-6. 13.30; basic

20-8. pOH = 1.40 and pH = 12.60

20-10. pOH = −0.20 and pH = 14.20

20-12. 1×10^{-3} M

20-14. 300

20-16. $[H_3O^+] = 7.1 \times 10^{-9}$ M and $[OH^-] = 1.4 \times 10^{-6}$ M

20-18. 1.4×10^{-5} M

20-20. 1.8×10^{-4} M

20-22. pH = 4.11; $[ClO^-] = [H_3O^+] = 7.7 \times 10^{-5}$ M; [HClO] ≈ 0.15 M; $[OH^-] = 1.3 \times 10^{-10}$ M

20-24. pH = 1.96; $[ClCH_2COO^-] = [H_3O^+]$ = 0.011 M; $[ClCH_2COOH]$ = 0.09 M; $[OH^-] = 9.1 \times 10^{-13}$ M

20-26. 4.6×10^{-4} M

20-28. 9.52

20-30. 11.28

20-32. (a) left to right (b) right to left (c) left to right (d) right to left

20-34. (a) right to left (b) right to left (c) left to right (d) left to right

20-36. (a) NO_3^- (*aq*) (b) $HCOO^-$ (*aq*) (c) $C_6H_5COO^-$ (*aq*) (d) CH_3NH_2 (*aq*)

20-38. (a) Acid; the conjugate base is $ClCH_2COO^-$ (*aq*)
(b) Base; the conjugate acid is NH_4^+ (*aq*)
(c) Base; the conjugate acid is HClO(*aq*)
(d) Base; the conjugate acid is HCOOH(*aq*)
(e) Acid; the conjugate base is N_3^- (*aq*)
(f) Base; the conjugate acid is HNO_2(*aq*)

20-40. (a) $K_a = 6.7 \times 10^{-6}$ M for $C_6H_5NH^+$
(b) $K_a = 4.8 \times 10^{-10}$ M for HCN
(c) $K_a = 1.1 \times 10^{-6}$ M for NH_3OH^+
(d) $K_a = 1.9 \times 10^{-11}$ M for $(CH_3)_2NH_2^+$

20-42. (a) acidic (b) neutral (c) acidic (d) basic

20-44. (a) basic (b) acidic (c) acidic (d) neutral

20-48. 9.08

20-50. $[OH^-] = 2.1 \times 10^{-6}$ M; $[HNO_2] = 2.1 \times 10^{-6}$ M; $[NO_2^-]$ ≈ 0.25 M; $[H_3O^+] = 4.8 \times 10^{-9}$ M; pH = 8.32

20-52. 9.00

20-54. 1.25

20-56. 1.11

20-58. $[H_3O^+] = 5.7 \times 10^{-3}$ M; $f_1 = 1.0$; $f_2 = 3.0 \times 10^{-3}$; $f_3 = 7.0 \times 10^{-5}$

20-70. 180

20-72. 6.81

20-74. 9.62×10^{-4} g per 100 mL of solution

20-76. 2.39

20-78. 16

20-80. 3.34

20-82. (a) 9.5 (b) 17.1

20-84. 7.46; acidic

20-86. 1.74

20-88. $[(CH_3)_2NH_2^+] = [OH^-] = 8.7 \times 10^{-3}$ M; $[(CH_3)_2NH] = 0.141$ M; $[H_3O^+] = 1.1 \times 10^{-12}$ M; pH = 11.94

20-90. 5.7%

20-94. 6.943

Chapter 21

21-2. 5.04

21-4. 3.13

21-6. 8.95

21-8. (a) −0.04 (b) 0.04

21-10. 5.51

21-12. 330 mL

21-14. almost equal concentrations of pyridinium chloride and pyridine

21-16. (b) 9.03 (d) 9.43

21-18. Mix 28.7 mL of 0.100 M $K_2SO_3(aq)$ with 21.3 mL of 0.200 M $KHSO_3(aq)$.

21-20. React 139 mL of the lactic acid solution with 61.0 mL of the $Ba(OH)_2(aq)$ solution.

21-22. 4.5 to 5.0

21-24. 11.0 to 12.0

21-28. 3×10^{-11} M

21-30. (a) 7.00 (b) 1.60

21-32. (a) 210 mL (b) 250 mL

21-36. 0.289 M

21-38. 8.01; phenolphthalein or thymol blue

21-40. (a) 2.72 (b) 4.14 (c) 4.74 (d) 8.88 (e) 11.59

21-42. (a) 11.97 (b) 10.66 (c) 8.11 (d) 5.82 (e) 3.55

21-46. 122

21-48. No

21-62. 340 mL

21-64. 7.21

21-66. $[CH_3COOH] \approx [CH_3COOH]_0$ and $[CH_3COO^-] \approx [CH_3COO^-]_0$

21-68. $$3\,HCO_3^-(aq) + H_3C_6H_5O_7(aq) \rightleftharpoons 3\,CO_2(g) + C_6H_5O_7^{3-}(aq) + 3\,H_2O(l)$$

21-70. 190 mL

21-72. 88.1

21-74. 50.0 mL

21-76. three acidic protons

21-78. 4.15%

21-80. (a) 7.21 (b) 7.51 (c) 6.91

21-82. 4.85

21-84. 3.25

21-86. 0.900 grams

21-88. 11.7 grams

21-90. 3.55

21-92. (a) 0.4 (b) 1.3 (c) 4.0 (d) 6.70 (e) 10.34

Chapter 22

22-2. (a) insoluble (b) soluble (c) soluble (d) insoluble

22-4. (a) insoluble (b) soluble (c) insoluble (d) soluble

22-6. (a) $H_2SO_4(aq) + Ca(ClO_4)_2(aq) \rightarrow CaSO_4(s) + 2\,HClO_4(aq)$

$Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

(b) no reaction

(c) $Hg_2(NO_3)_2(aq) + 2\,NaC_6H_5COO(aq) \rightarrow Hg_2(C_6H_5COO)_2(s) + 2\,NaNO_3(aq)$

$Hg_2^{2+}(aq) + 2\,C_6H_5COO^-(aq) \rightarrow Hg_2(C_6H_5COO)_2(s)$

(d) $Na_2SO_4(aq) + 2\,AgF(aq) \rightarrow Ag_2SO_4(s) + 2\,NaF(aq)$

$2\,Ag^+(aq) + SO_4^{2-}(aq) \rightarrow Ag_2SO_4(s)$

22-8. 3.3 $g \cdot L^{-1}$

22-10. 4.3×10^{-3} g·L^{-1}

22-12. 2.5×10^{-3} M^2

22-14. 1.1×10^{-8} M^2

22-16. 5.5×10^{-7} g·L^{-1}

22-18. 0.027 g·L^{-1}

22-20. 1.4 g·L^{-1}

22-22. $Cu(NO_3)_2(aq) + 2NH_3(aq) + 2H_2O(l) \rightarrow Cu(OH)_2(s) + 2NH_4NO_3(aq)$
$Cu(OH)_2(s) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq) + 2OH^-(aq)$

22-24. 5.8×10^{-3} g·L^{-1}

22-26. 4.1×10^{-4} g·L^{-1}

22-28. (a) increased (b) slightly decreased (c) decreased

22-30. (a) $PbCrO_4$ (b) $Ag_2C_2O_4$ (d) Ag_2O

22-32. 0.14 g·L^{-1}

22-34. Yes

22-36. Yes; 5.4×10^{-6} mol; $[Ag^+] = [NO_3^-] = 0.25$ M; $[Br^-] = 2.2 \times 10^{-12}$ M; $[Na^+] = 5.0 \times 10^{-5}$ M

22-38. (a) 0.19 mg (b) 1.1×10^{-23} M

22-40. Yes

22-42. No

22-44. 9.1×10^{-9} M

22-46. 2.2 M $Cu(OH)_2$ and 1.0×10^5 M $Zn(OH)_2$; No

22-48. Separation can be achieved at about pH = –1

22-50. For $Cd(OH)_2$, $s = (7.2 \times 10^{13}\ M^{-1})[H_3O^+]^2$; for $Fe(OH)_3$, $s = (2.8 \times 10^3\ M^{-2})[H_3O^+]^3$; pH from 2 to 8

22-52. 0.008 M

22-62. Ag_2CrO_4

22-66. For FeS, $s = 0.57$M at pH 2.00 and 5.7×10^{-5} M at pH 4.00; For CdS, $s = 7.3 \times 10^{-10}$ M at pH 2.00 and 7.3×10^{-14} M at pH 4.00; we can separate the two at pH = 2.00 but not at pH = 4.00

22-68. 3.9

22-72. 0.29 M

22-74. (a) $K_3 = 3.8 \times 10^{12}\ M^{-1}$ (b) $K_3 = 2.2 \times 10^{-5}$

22-76. 0.0061 M

22-78. $K_3 = \dfrac{[Ag^+]^2}{[Ca^{2+}]} = 0.24$; $[Ca^{2+}] = 0.018$ M and $[Ag^+] = 0.064$ M

22-80. 3.0 M

22-80. 5.0×10^{-4} M

22-84. 1.4×10^{-2} M; 1.0 g·L^{-1}

22-88. 2.4×10^{-9} M

22-90. 3.5×10^{-15} M; 4.4×10^{-14}

22-92. 5.8×10^{-4} M; not soluble

22-94. For chromium,

$$s = (6.3 \times 10^{11}\ M^{-1})[H_3O^+]^3 + \frac{4.0 \times 10^{-16}\ M^2}{[H_3O^+]};$$

For tin, $s = (55\ M^{-1})[H_3O^+]^2 + \dfrac{1 \times 10^{-30}\ M^3}{[H_3O^+]^2}$;

between pH 4 and 7

22-98. (1) $K_1 = 0.013$ M (2) $K_2 = \dfrac{I_3^-}{[I^-]} = 0.61$ (3) $K_3 = 47\ M^{-1}$

Chapter 23

23-2. For HF, $\Delta S_{fus} = 24.08$ J·K^{-1}·mol^{-1}; $\Delta S_{vap} = 86.03$ J·K^{-1}·mol^{-1}
For HCl, $\Delta S_{fus} = 12.53$ J·K^{-1}·mol^{-1}; $\Delta S_{vap} = 93.10$ J·K^{-1}·mol^{-1}
For HBr, $\Delta S_{fus} = 12.92$ J·K^{-1}·mol^{-1}; $\Delta S_{vap} = 93.45$ J·K^{-1}·mol^{-1}
For HI, $\Delta S_{fus} = 12.92$ J·K^{-1}·mol^{-1}; $\Delta S_{vap} = 88.99$ J·K^{-1}·mol^{-1}

23-4. $CH_4(l) < NH_3(l) < H_2O(l)$

23-6. (a) $S°(CO) < S°(CO_2)$ (b) $S°$(cyclopropane) < $S°$(propane) (c) $S°$(neopentane) < $S°$(pentane)

23-8. $S°(H_2O) < S°(NH_3) < S°(CH_4) < S°(CH_3OH) < S°(CH_3OD)$

23-10. The entropy of $H_2O(g)$ is greater than $H_2O(l)$

23-12. (a) decrease (b) increase (c) increase (d) decrease

23-14. $S°(a) < S°(b) \approx S°(d) < S°(c)$

23-16. (a) 606.4 J·K^{-1}·mol^{-1}; (b) 24.8 J·K^{-1}·mol^{-1} (c) –324.2 J·K^{-1}·mol^{-1} (d) –120.8 J·K^{-1}·mol^{-1}

23-18. Spontaneous; $\Delta G^\circ_{rxn} < 0$, $\Delta H^\circ_{rxn} > 0$, $\Delta S^\circ_{rxn} > 0$; entropy driven

23-20. $\Delta S^\circ_{rxn} = -128.6\ J\cdot K^{-1}\cdot mol^{-1}$; $\Delta G^\circ_{rxn} = -5.9\ kJ\cdot mol^{-1}$; left to right

23-22. $\Delta S^\circ_{rxn} = 175.9\ J\cdot K^{-1}\cdot mol^{-1}$; $\Delta G^\circ_{rxn} = 120.0\ kJ\cdot mol^{-1}$; $\Delta G_{rxn} = 75.0\ kJ\cdot mol^{-1}$; right to left

23-24. $-42.2\ kJ\cdot mol^{-1}$; left to right

23-26. $\Delta G^\circ_{rxn} = 35.8\ kJ\cdot mol^{-1}$; right to left; $\Delta G_{rxn} = -25.5\ kJ\cdot mol^{-1}$; left to right

23-28. $\Delta G^\circ_{rxn} = 42.2\ kJ\cdot mol^{-1}$; No; $\Delta G_{rxn} = -20.6\ kJ\cdot mol^{-1}$; Yes

23-30. $\Delta G^\circ_{rxn} = 27.1\ kJ\cdot mol^{-1}$ right to left; $\Delta G_{rxn} = -34.0\ kJ\cdot mol^{-1}$; Yes

23-32. $48.3\ kJ\cdot mol^{-1}$; Insoluble $CaCO_3(s)$ will precipitate.

23-34. $\Delta G^\circ_{rxn} = -41.7\ kJ\cdot mol^{-1}$ left to right; $\Delta G_{rxn} = 5.71\ kJ\cdot mol^{-1}$; right to left

23-36. (a) $-822.9\ kJ\cdot mol^{-1}$; 1×10^{144} (b) $175\ kJ\cdot mol^{-1}$; 2×10^{-31} (c) $-232.2\ kJ\cdot mol^{-1}$; 4.7×10^{40}

23-38. $\Delta G^\circ_{rxn} = 226.6\ kJ\cdot mol^{-1}$; $\Delta H^\circ_{rxn} = 331.4\ kJ\cdot mol^{-1}$; 2.0×10^{-40}

23-40. $\Delta G^\circ_f[CCl_4] = -65.3\ kJ\cdot mol^{-1}$; $\Delta H^\circ_f[CCl_4] = -128.2\ kJ\cdot mol^{-1}$

23-42. 818.1 kJ

23-44. $193\ kJ\cdot mol^{-1}$

23-46. $\Delta H^\circ_{rxn} = -9.4\ kJ\cdot mol^{-1}$; 46

23-48. 243 Torr

23-50. 0.323 Torr

23-52. $33.87\ kJ\cdot mol^{-1}$

23-54. 62.0°C

23-56. 15

23-64. (a) $144.6\ J\cdot K^{-1}\cdot mol^{-1}$ (b) $173.8\ J\cdot K^{-1}\cdot mol^{-1}$ (c) $12.1\ J\cdot K^{-1}\cdot mol^{-1}$ (d) $-100.3\ J\cdot K^{-1}\cdot mol^{-1}$

23-70. $39.5\ kJ\cdot mol^{-1}$; The discrepancy is due to the large temperature difference between 25°C and the data.

23-72. (a) 2×10^{-10} (b) 6×10^{-13}

23-74. 1.35

23-76. 2873 kJ

23-78. $55.9\ kJ\cdot mol^{-1}$

23-80. $61.4\ kJ\cdot mol^{-1}$

23-82. 0.282 bar

23-84. 15 kPa

23-86. (a) $-100\ kJ\cdot mol^{-1}$

23-88. 21%

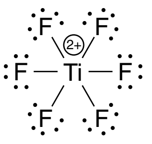
Chapter 24

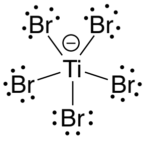
24-2. (a) $-1/2$ (b) 2 central O atoms = -1, 6 terminal O atoms = -2 (c) $-1/3$ (d) -1

24-4. Each O atom is -2; the Cl atoms are (a) $+1$ (b) $+4$ (c) $+7$ (d) $+5$

24-6. (a) H = +1, O = −2, Fe = +3 (b) O = −2, Fe = +8/3 (or equivalently two Fe = +3 and one Fe = +2 atoms) (c) K = +1, C = +2, N = −3 (d) C = +2, N = −1, O = −2

24-8. S is −2, C is +4 (b) H is +1, S is −1, C is −2 (c) H is +1, C is +2, O is −2, N is −3 (d) H is +1, C is +4, N is −3, S is −2

24-10. (a) 

(b) 

24-12. (a) linear (b) tetrahedral (c) trigonal planar

24-14. $Na_2SO_4(s)$ is the oxidizing agent; $C(s)$ is the reducing agent

24-16. $ClO_2(g)$ is the oxidizing agent; $C(s)$ is the reducing agent

24-18. (a) $In^+(aq)$ is the reducing agent and $Fe^{3+}(aq)$ is the oxidizing agent.
$In^+(aq) \rightarrow In^{3+}(aq) + 2e^-$ (oxidation half reaction)
$2Fe^{3+}(aq) + 2e^- \rightarrow 2Fe^{2+}(aq)$ (reduction half reaction)
(b) $H_2S(g)$ is the reducing agent and $ClO^-(aq)$ is the oxidizing agent. $H_2S(aq) \rightarrow S(s) + 2H^+(aq) + 2e^-$ (oxidation half reaction)
$ClO^-(aq) + 2H^+(aq) + 2e^- \rightarrow Cl^-(aq) + H_2O(l)$ (reduction half reaction)

24-20. (a), (c), (e)

24-22. (a) Fe is oxidized (+2 → +3), Cr is reduced (+6 → +3), $Cr_2O_7^{2-}$ (*aq*) is the oxidizing agent, Fe^{2+}(*aq*) is the reducing agent
(b) not an oxidation-reduction reaction
(c) C is oxidized (−4 → +4), O is reduced (0 → −2), $O_2(g)$ is the oxidizing agent, $CH_4(g)$ is the reducing agent
(d) not an oxidation-reduction reaction
(e) Br is oxidized (−1 → 0), Cl is reduced (0 → −1), $Cl_2(g)$ is the oxidizing agent, NaBr(*aq*) is the reducing agent

24-26. (a) $H_2BO_3^-(aq) + 8H^+(aq) + 8e^- \rightarrow BH_4^-(aq) + 3H_2O(l)$
(b) $2ClO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow Cl_2(g) + 6H_2O(l)$
(c) $Cl_2(g) + 2H_2O(l) \rightarrow 2HClO(aq) + 2H^+(aq) + 2e^-$

24-28. (a) $OsO_4(s) + 8H^+(aq) + 8e^- \rightarrow Os(s) + 4H_2O(l)$
(b) $S(s) + 6OH^-(aq) \rightarrow SO_3^{2-}(aq) + 3H_2O(l) + 4e^-$
(c) $Sn(s) + 2H_2O(l) \rightarrow HSnO_2^-(aq) + 3H^+(aq) + 2e^-$

24-30. (a) $[Au(CN)_2]^-(aq) + e^- \rightarrow Au(s) + 2CN^-(aq)$
(b) $MnO_4^-(aq) + 4H^+(aq) + 3e^- \rightarrow MnO_2(s) + 2H_2O(l)$
(c) $Cr(OH)_3(s) + 5OH^-(aq) \rightarrow CrO_4^{2-}(aq) + 4H_2O(l) + 3e^-$

24-32. (a) $3ZnS(s) + 2NO_3^-(aq) + 8H^+(aq) \rightarrow 3S(s) + 3Zn^{2+}(aq) + 2NO(g) + 4H_2O(l)$
oxidizing agent, $NO_3^-(aq)$; reducing agent, ZnS(s); species oxidized, S; species reduced, N
(b) $2MnO_4^-(aq) + 5HNO_2(aq) + H^+(aq) \rightarrow 5NO_3^-(aq) + 2Mn^{2+}(aq) + 3H_2O(l)$
oxidizing agent, $MnO_4^-(aq)$; reducing agent, $HNO_2(aq)$; species oxidized, N; species reduced, Mn

24-34. (a) $2CoCl_2(s) + Na_2O_2(aq) + 2H_2O(l) + 2OH^-(aq) \rightarrow 2Co(OH)_3(s) + 4Cl^-(aq) + 2Na^+(aq)$
(b) $C_2O_4^{2-}(aq) + MnO_2(s) + 4H^+(aq) \rightarrow Mn^{2+}(aq) + 2CO_2(g) + 2H_2O(l)$

24-36. (a) $Cr_2O_7^{2-}(aq) + 6I^-(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(s) + 7H_2O(l)$
(b) $3CuS(s) + 2NO_3^-(aq) + 8H^+(aq) \rightarrow 3S(s) + 3Cu^{2+}(aq) + 2NO(g) + 4H_2O(l)$

24-38. (a) $N_2H_4(aq) + 2Cu(OH)_2(s) \rightarrow N_2(g) + 2Cu(s) + 4H_2O(l)$
(b) $H_3AsO_3(aq) + I_2(aq) + H_2O(l) \rightarrow H_3AsO_4(aq) + 2I^-(aq) + 2H^+(aq)$

24-40. (a) $Co(OH)_2(s) + SO_3^{2-}(aq) \rightarrow SO_4^{2-}(aq) + Co(s) + H_2O(l)$
(b) $3IO_3^-(aq) + 24I^-(aq) + 18H^+(aq) \rightarrow 9I_3^-(aq) + 9H_2O(l)$

24-42. 0.103 M; 202 mg

24-44. 0.452 g; 10.7%

24-46. $4NaOH(aq) + Ca(OH)_2(aq) + C(s) + 4ClO_2(g) \rightarrow 4NaClO_2(aq) + CaCO_3(aq) + 3H_2O(l)$; 0.746 metric tons

24-48. 0.02824 M

24-54. (a) H is +1, N is −3 (b) N is 0
(c) H is +1, N is −2 (d) N is +1, O is −2
(e) N is +2, O is −2

24-56. (a) Se is −2, Mo is +4 (b) S is −2, Si is +4
(c) Ga is +3, As is −3 (d) K is +1, O is −2, S is +2

24-58. $2Tl^+(aq) + IO_3^-(aq) + 2Cl^-(aq) + 6H^+(aq) \rightarrow 2Tl^{3+}(aq) + ICl_2^-(aq) + 3H_2O(l)$

24-60. $2S_2O_8^{2-}(aq) + 2H_2O(l) \rightarrow 4SO_4^{2-}(aq) + O_2(g) + 4H^+(aq)$

24-62. $2KMnO_4(aq) + 16H^+(aq) + 5Na_2C_2O_4(aq) \rightarrow 2Mn^{2+}(aq) + 2K^+(aq) + 8H_2O(l) + 10CO_2(g) + 10Na^+(aq)$

24-64. $3MnO_4^-(aq) + 4H^+(aq) + 5Mo^{3+}(aq) \rightarrow 3Mn^{2+}(aq) + 5MoO_2^{2+}(aq) + 2H_2O(l)$; 0.103 M

24-66. 11.07%

24-68. 1.825×10^{-4}%

24-70. 0.018%

Chapter 25

25-2. At negative electrode: $Mn(s) \rightarrow Mn^{2+}(aq) + 2e^-$, at positive electrode: $Cr^{2+}(aq) + 2e^- \rightarrow 2Cr(s)$; $Mn(s)|MnSO_4(aq)||CrSO_4(aq)|Cr(s)$

25-4. At negative electrode: $Co(s) \rightarrow Co^{2+}(aq) + 2e^-$, at positive electrode: $Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$; $Co(s)|Co(NO_3)_2(aq)||Pb(NO_3)_2(aq)|Pb(s)$

25-6. At negative electrode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$, at positive electrode:
$Hg_2Cl_2(s) + 2e^- \rightarrow 2Hg(l) + 2Cl^-(aq)$;
$Zn(s)|ZnCl_2(aq)|Hg_2Cl_2(aq)|Hg(l)|Pt(s)$

25-8. At left electrode: $Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$
At right electrode: $Ag^+(aq) + e^- \rightarrow Ag(s)$
$Sn(s) + 2Ag^+(aq) \rightarrow Sn^{2+}(aq) + 2Ag(s)$

25-10. At left electrode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
At right electrode: $Ag^+(aq) + e^- \rightarrow Ag(s)$
$Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

25-12. $Pb(s) + Hg_2SO_4(s) \rightarrow 2Hg(l) + PbSO_4(s)$

25-14. (a) voltage increases (b) no change (c) voltage increases (d) no change

25-22. 2.7×10^7

25-24. 0.140 V; 5.4×10^4

25-26. 1.560 V; 5.0×10^{52}

25-28. $H_2(g) + Cd^{2+}(aq) \rightarrow 2H^+(aq) + Cd(s)$; −0.450 V

25-30. 0.0272 V

25-32. 0.47 M

25-34. 0.99 M

25-36. (a) 1.88 V (b) −0.951 V (c) 0.96 V

25-38. +0.80 V

25-40. +0.234 V; No

25-42. +0.458 V; 3.0×10^{15}; spontaneous

25-44. 0.307 V

25-46. $BH_4^-(aq) + 8OH^-(aq) \rightarrow H_2BO_3^-(aq) + 5H_2O(l) + 8e^-$ oxidation; $8O_2(g) + 8e^- \rightarrow 8O_2^-(aq)$; $E^\circ_{red}[O_2|O_2^-] = -0.56$ V; $E^\circ_{red}[H_2BO_3^-|BH_4^-] = -1.24$ V

25-48. $E_{cell} = 0.329$ V; spontaneous

25-50. $E_{cell} = 1.36$ V; spontaneous

25-52. −392 kJ·mol^{-1}

25-54. −267 kJ·mol^{-1}

25-56. (a) −213.0 kJ·mol^{-1} (b) 2.8 kJ·mol^{-1}

25-58. $E^\circ_{cell} = 1.08$ V; $\Delta G^\circ_{rxn} = -208$ kJ·mol^{-1}; $\Delta G^\circ_{rxn} = -220$ kJ·mol^{-1}; $E_{cell} = 1.14$ V

25-60. 0.84 g

25-62. 54 min

25-64. 13.9 L

25-70. Between Mg and Al

25-72. 0.402 g

25-74. (a) 6.9×10^6 metric tons (b) 1.1×10^{14} kJ (c) 0.85%

25-78. 5.0×10^{-13} M^2

25-80. 1.1447 V

25-86. +3

25-88. (a) $Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightleftharpoons 2PbSO_4(s) + 2H_2O(l)$
(b) 2.050 V (c) −396.6 kJ·mol^{-1}
(d) 2.05 V (e) six cells

25-90. −0.744 V

Chapter 26

26-2. $TiO_2(s) + C(s) + 2Cl_2(g) \xrightarrow{\text{high T}} TiCl_4(l) + CO_2(g)$
$TiCl_4(l) + 2Mg(l) \rightarrow Ti(s) + 2MgCl_2(l)$

26-6. $2Cr^{3+}(aq) + Zn(s) \rightarrow 2Cr^{2+}(aq) + Zn^{2+}(aq)$
$4Cr^{2+}(aq) + 4H^+(aq) + O_2(g) \rightarrow 4Cr^{3+}(aq) + 2H_2O(l)$

26-8. $TiCl_4(l) + 2H_2O(l) \rightarrow \underset{\text{(a smoke)}}{TiO_2(s)} + 4HCl(g)$

26-12. Selenium and tellurium

26-14. 58%

26-16. 30.2 g

26-18. 3500 metric tons of iron and 9670 metric tons of slag

26-20. 36 400 metric tons

26-22. (a) $[Ar]3d^6$ (b) [Ar] (c) $[Xe]4f^{14}5d^8$ (d) $[Ar]3d^{10}$

26-24. (a) 4 (b) none (c) 4 (d) 10

26-26. (a) V(II), Nb(II), Ta(II) (b) Co(I), Rh(I), Ir(I) (c) Ti(IV), Zr(IV), Hf(IV)

26-28. (a) +3 (b) +3 (c) +2 (d) +2

26-30. (a) +3 (b) +3 (c) +3 (d) 0

26-32. (a) hexaamminochromium(III)
(b) triamminetrichloroplatinum(IV)
(c) hexaaquamolybdenum(III)
(d) hexacyanochromate(II)

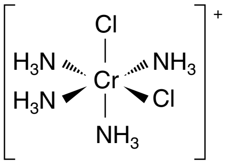
26-36. (a) potassium hexacyanoferrate(III)
(b) tetracarbonylnickel(0)
(c) hexaaquaruthenium(III) chloride
(d) sodium tetrahydroxoaluminate(III)

26-38. (a) sodium tetracyanoaurate(III)
(b) hexaaquachromium(III) chloride
(c) tris(ethylenediamine) vanadium(III) chloride
(d) hexaamminecopper(II) chloride

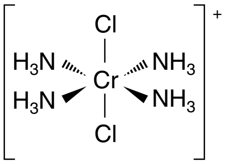
26-40. (a) $Na_2[Ni(CN)_2BrCl]$ (b) $Rb_2[Co(NO_2)_4]$
(c) $K_3[VCl_6]$ (d) $[Cr(NH_3)_5Cl](CH_3COO)_2$

26-42. (a) $Ba_2[Fe(CN)_6]$ (b) $[CoCl(OH)(en)_2]NO_3$
(c) $Li_2[Pt(NO_2)_2(ox)_2]$ (d) $[V(en)_2ox]CH_3COO$

26-44. (a)

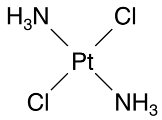


cis

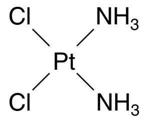


trans

(b) no geometric isomers
(c) no geometric isomers
(d)



trans



cis

26-48. (a) $t_{2g}^6e_g^2$ (b) $t_{2g}^3e_g^2$ (c) $t_{2g}^5e_g^0$ (d) $t_{2g}^0e_g^0$ (e) $t_{2g}^6e_g^2$

26-50. $[Mn(NH_3)_6]^{3+}$ is low spin; $[Rh(CN)_6]^{3-}$ is low spin; $[Co(C_2O_4)_3]^{4-}$ is high spin; $[IrBr_6]^{4-}$ is high spin; and $[Ru(NH_3)_6]^{3+}$ is low spin.

26-52. (a) none (b) 5 (c) none

26-56. (a) $[Co(NO_2)_6]^{3-}$ (b) *trans*-$[PtCl_2(en)_2]^{2+}$
(c) $[Fe(CN)_5CO]^{3-}$ (d) *trans*-$[AuCl_2I_2]^-$

26-60. (a) tetrahedral (b) trigonal bipyramidal
(c) tetrahedral (d) tetrahedral

26-66. tetraamminediiodoplatinum(IV); tetraiodoplatinate(II)

26-68. two optical isomers and no geometric isomers

26-70. 1.0×10^{-16} M^3