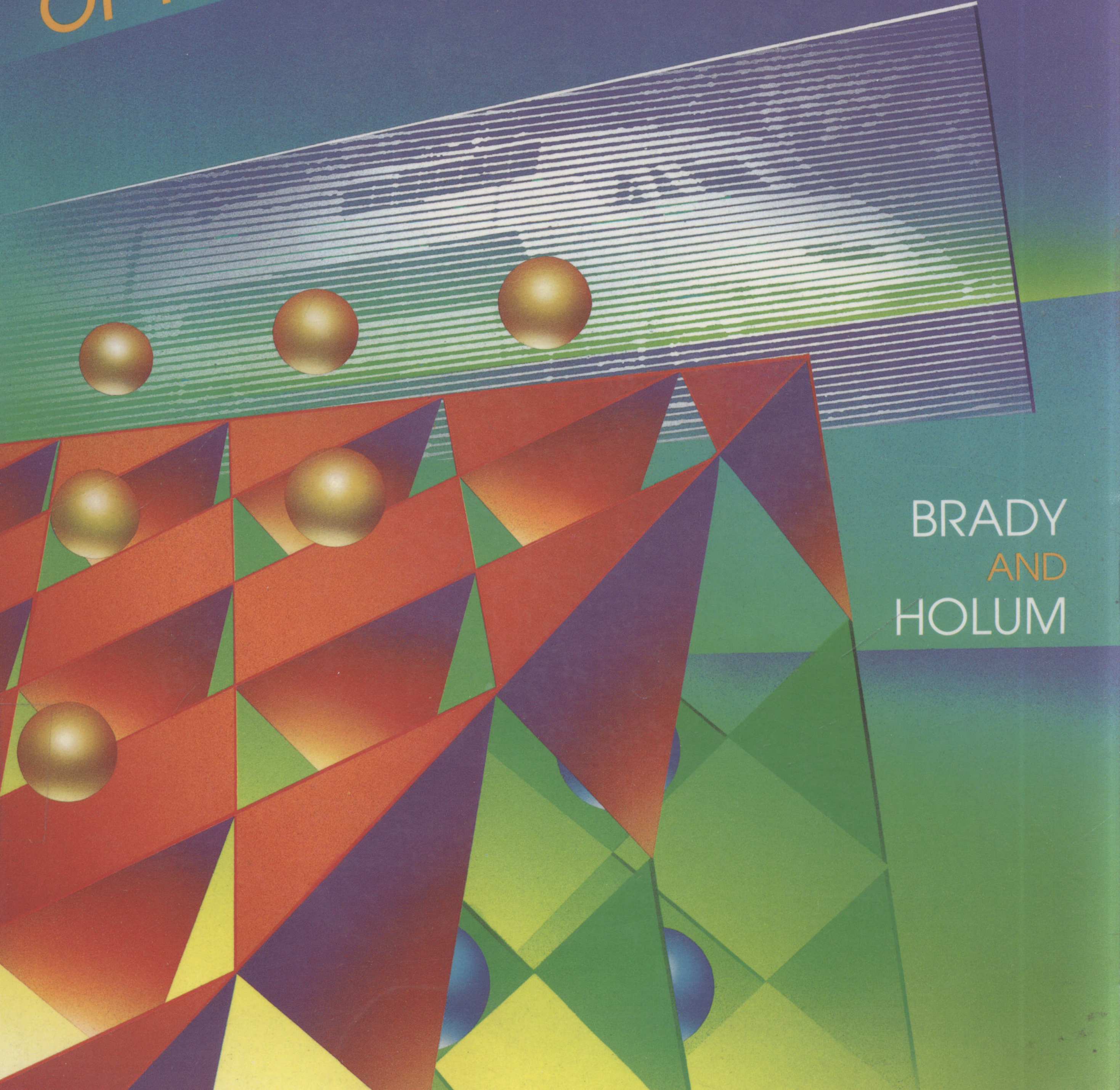
DESCRIPTIVE CHEMISTRY OF THE ELEMENTS



BRADY
AND
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Descriptive Chemistry of the Elements

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Appendix A

Answers to Selected Exercises

CHAPTER 1

Review Exercises

1.9 (a) $NaH(s) + H_2O \rightarrow H_2(g) + NaOH(aq)$
(b) $CaH_2(s) + 2H_2O \rightarrow 2H_2(g) + Ca(OH)_2(aq)$
(c) $HCl(g) + H_2O \rightarrow H_3O^+(aq) + Cl^-(aq)$
(d) $2Na(s) + 2H_2O \rightarrow H_2(g) + 2NaOH(aq)$
(e) $Mg(s) + H_2(g) \rightarrow MgH_2(s)$

1.11 Ionic: MgH_2, KH, CaH_2 Molecular: H_2Se, HI, PH_3

1.20 (a) alkali metals (b) alkali metals (c) Group IIIA (d) Group VIIA

1.23 Covalent. Ionic oxides are basic and react with acids.

1.26 It must have an oxygen–oxygen bond.

1.28 -1

1.31 (a) $H_2O_2 + H_2SO_3 \rightarrow H_2O + SO_4^{2-} + 2H^+$
(b) $E^\circ_{cell} = 1.60$ V (c) 1.42 g H_2O_2

1.34 (a) $2NaH(s) + O_2(g) \rightarrow Na_2O(s) + H_2O$
(b) $H^-(s) + H_2O \rightarrow H_2(g) + OH^-(aq)$
(c) $2HgO(s) \xrightarrow{heat} 2Hg(l) + O_2(g)$
(d) $2KClO_3(s) \xrightarrow{heat} 2KCl(s) + 3O_2(g)$
(e) $Na_2O_2(s) + 2H_2O \rightarrow 2NaOH(aq) + H_2O_2(aq)$
(f) $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$
(g) $2H_2O_2(l) \rightarrow 2H_2O + O_2(g)$

1.40 More difficult, because the NH_3 would vaporize more *rapidly*.

1.41 (a) $NH_3(aq) + H_2O \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
(b) $NH_3(aq) + H_3O^+(aq) \rightarrow NH_4^+(aq) + H_2O$
(c) $4NH_3(aq) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O$

1.42 (a) $NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$
(b) $NH_3(aq) + HBr(aq) \rightarrow NH_4Br(aq)$
(c) $NH_3(aq) + HI(aq) \rightarrow NH_4I(aq)$
(d) $2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$
(e) $NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$

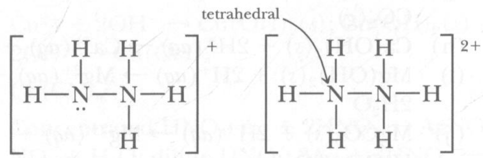
1.47 $KNH_2(s) + H_2O \rightarrow KOH(aq) + NH_3(aq)$
$NH_2^-(s) + H_2O \rightarrow OH^-(aq) + NH_3(aq)$

1.49 $NH_4^+(aq) + H_2O \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

1.52 (a) $Mg_3N_2(s) + 6H_2O \rightarrow 2NH_3(g) + 3Mg(OH)_2(s)$
(b) magnesium oxide; $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

1.55 Poisonous hydrazine can be formed.

1.58



1.60 ammonia

1.63 basic; $N_3^-(aq) + H_2O \rightleftharpoons HN_3(aq) + OH^-(aq)$

1.73 Decomposition into N_2 and O_2 supplies expanding gases.

1.74 NO_2 has an unpaired electron on N; N_2O_4 has no unpaired electrons.

1.76 (a) 4.5×10^{-4} (b) $HNO_2(aq) + H_2O \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

1.77 Raise the pH; $NO_2^-(aq) + H_2O \rightleftharpoons HNO_2(aq) + OH^-(aq)$

1.95 $CN^-(aq) + H_2O \rightleftharpoons HCN(aq) + OH^-(aq)$

1.104 (a) $N_2(g) + 2H_2(g) \rightarrow N_2H_4(l)$,
$\Delta H^\circ_f = +50.6$ kJ mol^{-1}
(b) Thermodynamically unstable, because ΔH°_f is positive and ΔS°_f would be negative.
(c) Its decomposition is so slow that the compound is able to exist.
(d) $\Delta S^\circ_f = -331$ J mol^{-1} K^{-1}. ΔS°_f is negative because molecules are becoming more complex (of lower entropy).

1.106 (a) $NO_3^-(aq) + 2H^+(aq) + e^- \rightarrow NO_2(g) + H_2O$ (reduction)
$NO(g) + H_2O \rightarrow NO_2(g) + 2H^+(aq) + 2e^-$ (oxidation)
(b) $2NO_3^-(aq) + NO(g) + 2H^+(aq) \rightarrow 3NO_2(g) + H_2O$
(c) $E^\circ_{cell} = -0.04$ V, not spontaneous. The negative value of E°_{cell} corresponds to a positive

value of $\Delta G°$ and so to a nonspontaneous event.

(d) $E_{cell} = E°_{cell} - \frac{0.0592}{2} \log \frac{P^2_{NO_2}}{[NO_3^-]^2[H^+]^2 P_{NO}}$; as $[NO_3^-]$ becomes larger, the second term on the right becomes smaller, so E_{cell} becomes, overall, less negative. This makes $\Delta G°$ less positive and so tends to favor the forward reaction.

1.108 Net ionic equations are as follows:

(a) $H^+(aq) + OH^-(aq) \rightarrow H_2O$
(b) $H^+(aq) + HCO_3^-(aq) \rightarrow H_2O + CO_2(g)$
(c) $2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O + CO_2(g)$
(d) same as (a)
(e) same as (c)
(f) same as (b)
(g) $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O + CO_2(g)$
(h) $Ca(OH)_2(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O$
(i) $Mg(OH)_2(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + 2H_2O$
(j) $MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O + CO_2(g)$
(k) $S^{2-}(aq) + 2H^+(aq) \rightarrow H_2S(g)$
(l) $SO_3^{2-}(aq) + 2H^+(aq) \rightarrow SO_2(g) + H_2O$
(m) no reaction
(n) no reaction
(o) $CN^-(aq) + H^+(aq) \rightarrow HCN(g)$
(p) $Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$
(q) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
(r) $Ca(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2(g)$
(s) $NO_2^-(aq) + H^+(aq) \rightarrow HNO_2(aq)$
(t) no reaction
(u) $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$
(v) $C_2H_3O_2^-(aq) + H^+(aq) \rightarrow HC_2H_3O_2(aq)$
(w) $NaNH_2(s) + 2H^+(aq) \rightarrow Na^+(aq) + NH_4^+(aq)$
(x) $N_3^-(s) + H^+(aq) \rightarrow HN_3(aq)$
(y) $NH_3(aq) + H^+(aq) \rightarrow NH_4^+(aq)$
(z) no reaction

CHAPTER 2

Review Exercises

2.10 Sulfurous acid; sulfur dioxide, $SO_2 \cdot nH_2O$, bisulfite ion, $HSO_3^-(aq)$, and sulfite ion, $SO_3^{2-}(aq)$.

2.11 (a) $NaOH(aq) + SO_2(g) \rightarrow NaHSO_3(aq)$
(b) $NaHCO_3(aq) + SO_2(g) \rightarrow NaHSO_3(aq) + CO_2(g)$

2.16 (a) $NaHSO_3(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O + SO_2(g)$
$HSO_3^-(aq) + H^+(aq) \rightarrow H_2O + SO_2(g)$
(b) $Na_2SO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O + SO_2(g)$
$SO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O + SO_2(g)$

2.18 (a) $SO_3(g) + H_2O \rightarrow H_2SO_4(aq)$
(b) $SO_3(g) + NaHCO_3(aq) \rightarrow NaHSO_4(aq) + CO_2(g)$
$SO_3(g) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + H_2O + 2CO_2(g)$
(c) $SO_3(g) + Na_2CO_3(aq) \rightarrow Na_2SO_4(aq) + CO_2(g)$
(d) $SO_3(g) + NaOH(aq) \rightarrow NaHSO_4(aq)$
$SO_3(g) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O$

2.23 CO_2, $NaHSO_4$, $2NaHSO_4(aq) + Na_2CO_3(s) \rightarrow 2Na_2SO_4(aq) + CO_2(g) + H_2O$

2.30 (a) $S_2O_3^{2-}(aq) + 4Cl_2(g) + 5H_2O \rightarrow 2HSO_4^-(aq) + 8H^+(aq) + 8Cl^-(aq)$
(b) $2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

2.34 pH = 6.96

2.40 $H_2SeO_4(aq) + 2NaOH(aq) \rightarrow Na_2SeO_4(aq) + 2H_2O$

2.48 $PBr_3 + 3H_2O \rightarrow H_3PO_3 + 3HBr$
$PBr_5 + 4H_2O \rightarrow H_3PO_4 + 5HBr$

2.57 (a) arsenic acid (b) sodium arsenate (c) arsenous acid (d) sodium dihydrogen arsenate (e) arsenic trichloride (f) antimony pentachloride

2.60 $2F_2 + 2H_2O \rightarrow 4HF + O_2$; $Cl_2 + H_2O \rightarrow HCl + HOCl$; $Br_2 + H_2O \rightarrow HBr + HOBr$; $I_2 + H_2O \rightarrow HI + HOI$

2.68 (a) Y (actually, Y^-) (b) X (actually, X_2) (c) No, Br_2 is a weaker oxidizing agent than Cl_2. (d) Yes, Cl_2 is a stronger oxidizing agent than Br_2. (e) Yes, Br_2 is a stronger oxidizing agent than I_2.

2.79 (a) P_2S_5 (b) P_4S_{10}

2.80 (a) $IO_3^- + 3HSO_3^- \rightarrow I^- + 3SO_4^{2-} + 3H^+$
(b) $5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O$
(c) 3.79 g $NaHSO_3$ (d) 7.98 g brine

2.81 $K_{eq} = \frac{[H^+][Cl^-][HOCl]}{[Cl_2]} = 0.015$

CHAPTER 3

Review Exercises

3.3 (a) Tl (b) Ba (c) K

3.5 MgO

3.9 It is not economically feasible to extract aluminum from aluminosilicates.

3.43 (a) $2Li + 2H_2O \rightarrow 2LiOH + H_2(g)$

(b) $2K + 2H_2O \rightarrow 2KOH + H_2(g)$
(c) $2Rb + 2H_2O \rightarrow 2RbOH + H_2(g)$

3.45 (a) $Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2$
(b) $Na_2O + H_2O \rightarrow 2NaOH$
(c) $2KO_2 + 2H_2O \rightarrow 2KOH + O_2 + H_2O_2$

3.53 $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$, pH = 12.16

3.54 (a) $NaClO_4$ (b) $KC_2H_3O_2$ (c) $KC_2H_3O_2$

3.57 1.41×10^5 lb

3.77 $Mg(OH)_2$. $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

3.80 $2Mg + O_2 \rightarrow 2MgO$; $MgCO_3 \xrightarrow{\text{heat}} MgO + CO_2$; $Mg(OH)_2 \xrightarrow{\text{heat}} MgO + H_2O$

3.116 PbO_2

3.121 $Pb(OH)_4^{2-} + OCl^- \rightarrow PbO_2(s) + Cl^- + 2OH^- + H_2O$

3.122 $PbO_2(s) + 4Cl^-(aq) + 4H^+(aq) \rightarrow PbCl_2(s) + Cl_2(g) + 2H_2O$

3.126 (a) 1.6×10^{-2} *M* (b) 8.1×10^{-3} *M* (c) $1.3 \times 10^{+3}$ *M*

3.128 The halide ion is oxidized by Pb^{IV}. $PbBr_4 \rightarrow PbBr_2 + Br_2$

3.142 16.7 g/cm³

3.147 Magnetic domains within the solid shift to align with Earth's magnetic field.

3.154 $Bi^{3+} + H_2O \rightarrow [Bi{-}OH_2]^{3+} \rightarrow BiO^+ + 2H^+$

3.162 $Cr(H_2O)_6^{3+} + H_2O \rightleftharpoons Cr(H_2O)_5OH^{2+} + H_3O^+$

3.166 $H_2CrO_4 \rightleftharpoons H^+ + HCrO_4^-$; $HCrO_4^- \rightleftharpoons H^+ + CrO_4^{2-}$

3.173 (a) $Mn(s) + 2HCl(aq) \rightarrow MnCl_2(aq) + H_2(g)$
(b) $MnCl_2(aq) + 2NaOH(aq) \rightarrow Mn(OH)_2(s) + 2NaCl(aq)$

3.187 $Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$

3.193 $Cr(H_2O)_3(OH)_3$ is able to dissolve in base, but $Fe(H_2O)_3(OH)_3$ is not.

3.194 The Fe^{3+} ion has more of a polarizing effect on a neighboring water molecule than does the larger and less highly charged Fe^{2+} ion.

3.198 Add Fe^{2+} to the solution suspected to contain CN^-. If CN^- is present it will form $Fe(CN)_6^{4-}$. Then add Fe^{3+} ion. A blue precipitate of Prussian blue confirms the presence of CN^-.

3.203 $4Co^{3+}(aq) + 2H_2O \rightarrow 4Co^{2+}(aq) + O_2(g) + 4H^+(aq)$

3.216 Very thin gold foil; 9.09×10^{-5} mm, 3.58×10^{-6} in.

3.220 (a) N.R.
(b) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$
(c) $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$
(d) $Cu + 4HNO_4 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

3.225 $Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2(s)$; $Cu(OH)_2(s) + 2OH^- \rightarrow Cu(OH)_4^{2-}$

3.226 $Cu(CN)_4^{2-}$

3.228 Concentrated HNO_3: $Ag + 2HNO_3 \rightarrow AgNO_3 + NO_2 + H_2O$; dilute HNO_3: $3Ag + 4HNO_3 \rightarrow 3AgNO_3 + NO + 2H_2O$

3.233 Because gold is so easily reduced.

3.238 $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$
$Zn(OH)_2(s) + 2OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq)$

3.241 $4Zn(s) + NO_3^-(aq) + 10H^+(aq) \rightarrow 4Zn^{2+}(aq) + NH_4^+(aq) + 3H_2O$

3.243 $Hg(l) + 2NO_3^-(aq) + 4H^+(aq) \rightarrow Hg^{2+}(aq) + 2NO_2(g) + 2H_2O$

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Index

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