Mortimer P. 268

13

(a)

7+ 3+ 4+ 7+

① $H_2O + MnO_4^- + ClO_2^- \longrightarrow MnO_2 + ClO_4^- + OH^-$

Mn : $7^+ \rightarrow 4^+$ 3^- decrease

Cl : $3^+ \rightarrow 7^+$ 4^+ increase

LCM = 12

② $H_2O + 4MnO_4^- + 3ClO_2^- \longrightarrow 4MnO_2 + 3ClO_4^- + OH^-$

③ $2H_2O + 4MnO_4^- + 3ClO_2^- \rightarrow 4MnO_2 + 3ClO_4^- + 4OH^-$

(b)

6+ 2− 3+ Ø

① $H^+ + Cr_2O_7^{2-} + H_2S \longrightarrow Cr^{3+} + S + H_2O$

Cr: $6^+ \rightarrow 3^+$ decrease of $3 \times 2 = 6^-$

S : $2^- \rightarrow Ø$ increase of 2^+

LCM = 6

② $H^+ + Cr_2O_7^{2-} + 3H_2S \rightarrow 2Cr^{3+} + 3S + H_2O$

③ $8H^+ + Cr_2O_7^{2-} + 3H_2S \rightarrow 2Cr^{3+} + 3S + 7H_2O$

(c)

5+ 4+ Ø 6+

① $H^+ + IO_3^- + SO_3^{2-} \longrightarrow I_2 + SO_4^{2-} + H_2O$

I : $5^+ \rightarrow Ø$ decrease of $5 \times 2 = 10^-$

S: $4^+ \rightarrow 6^+$ increase of 2 $= 2^+$

LCM = 10

② $H^+ + 2IO_3^- + 5SO_3^{2-} \longrightarrow I_2 + 5SO_4^{2-} + H_2O$

③ $2H^+ + 2IO_3^- + 5SO_3^{2-} \longrightarrow I_2 + 5SO_4^{2-} + H_2O$

Mortimer P. 768

8.13

(d) ① $\overset{\emptyset}{}$ $\overset{1+}{}$ $\overset{5+}{}$ $\overset{1-}{}$

$H_2O + P_4 + HOCl \rightarrow H_3PO_4 + Cl^- + H^+$

P: $\emptyset \rightarrow 5+$ increase of $5+ \times 4 = 20^+$

Cl: $1^+ \rightarrow 1^-$ decrease of 2^- $= 2^-$

LCM = 20

② $H_2O + P_4 + 10HOCl \rightarrow 4H_3PO_4 + 10Cl^- + H^+$

③ $6H_2O + P_4 + 10HOCl \rightarrow 4H_3PO_4 + 10Cl^- + 10H^+$

(e) ① $\overset{\emptyset}{}$ $\overset{5+}{}$ $\overset{1-}{}$

$OH^- + Cl_2 \longrightarrow ClO_3^- + Cl^- + H_2O$

Cl: $\emptyset \rightarrow 5^+$ increase of 5^+

Cl: $\emptyset \rightarrow 1^-$ decrease of 1^-

LCM=5

② $OH^- + 3Cl_2 \longrightarrow ClO_3^- + 5Cl^- + H_2O$

③ $6OH^- + 3Cl_2 \longrightarrow ClO_3^- + 5Cl^- + 3H_2O$

Mortimer
P. 268

8.14 (a) ① $\overset{\varnothing}{Cu} + H^+ + \overset{5+}{NO_3^-} \longrightarrow \overset{2+}{Cu^{2+}} + \overset{2+}{NO} + H_2O$

Cu: 2^+ LCM = 6

N: 3^-

②+③ $3Cu + 8H^+ + 2NO_3^- \rightarrow 3Cu^{2+} + 2NO + 4H_2O$

(b) ① $H_2O + \overset{4+}{NiO_2} + \overset{\varnothing}{Fe} \longrightarrow \overset{2+}{Ni(OH)_2} + \overset{3+}{Fe(OH)_3}$

Ni: 2^- LCM = 6

Fe: 3^+

②+③ $6H_2O + 3NiO_2 + 2Fe \longrightarrow 3Ni(OH)_2 + 2Fe(OH)_3$

(c) ① $Pb\overset{2-}{S} + H_2\overset{1-}{O_2} \longrightarrow Pb\overset{6+}{S}\overset{2-}{O_4} + H_2\overset{2-}{O}$

O: $1^- \times 2 = 2^-$ LCM = 8

S: $8^+ = 8^+$

②+③ $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$

(d) ① $\overset{4+}{PbO_2} + H\overset{1-}{I} \longrightarrow \overset{2+}{PbI_2} + \overset{\varnothing}{I_2} + H_2O$

Pb: 2^-

I: $1^+ \times 2 = 2^+$ LCM = 2

②+③ $PbO_2 + 4HI \longrightarrow PbI_2 + I_2 + 2H_2O$

(e) ① $H_2O + \overset{3+}{Cr}I_3 + Cl_2 \longrightarrow CrO_4^{2-} + IO_3^- + H^+$

8.15

(a)

$$ReO_2 + Cl_2 \longrightarrow HReO_4 + Cl^-$$

① $ReO_2 \longrightarrow HReO_4$

$Cl_2 \longrightarrow 2Cl^-$

② $2H_2O + ReO_2 \longrightarrow HReO_4 + 3H^+$

$Cl_2 \rightarrow 2Cl^-$

③ $2H_2O + ReO_2 \longrightarrow HReO_4 + 3H^+ + 3e^-$

$2e^- + Cl_2 \rightarrow 2Cl^-$

For e^-
LCM = 6

④ $4H_2O + 2ReO_2 \longrightarrow 2HReO_4 + 6H^+ + 6e^-$

$6e^- + 3Cl_2 \rightarrow 6Cl^-$

⑤ $4H_2O + 2ReO_2 + 3Cl_2 \longrightarrow 2HReO_4 + 6Cl^- + 6H^+$

8.15 (b) $HgI_4^{2-} + N_2H_4 \longrightarrow Hg + I^- + N_2$

(1) $HgI_4^{2-} \longrightarrow Hg + 4I^-$

$N_2H_4 \longrightarrow N_2$

(2) $HgI_4^{2-} \longrightarrow Hg + 4I^-$

$N_2H_4 \longrightarrow N_2 + 4H^+$

(3) $2e^- + HgI_4^{2-} \longrightarrow Hg + 4I^-$

For e^- LCM = 4

$N_2H_4 \longrightarrow N_2 + 4H^+ + 4e^-$

(4) $4e^- + 2HgI_4^{2-} \longrightarrow 2Hg + 8I^-$

$N_2H_4 \longrightarrow N_2 + 4H^+ + 4e^-$

(5) $2HgI_4^{2-} + N_2H_4 \longrightarrow 2Hg + 8I^- + N_2 + 4H^+$

(c) $Te + NO_3^- \longrightarrow TeO_2 + NO$

(1) $Te \longrightarrow TeO_2$

$NO_3^- \longrightarrow NO$

(2) $H_2O + Te \longrightarrow TeO_2 + 2H^+$

$4H^+ + NO_3^- \longrightarrow NO + 2H_2O$

* Check this

(3) $H_2O + Te \longrightarrow TeO_2 + 2H^+ + 2e^-$

$3e^- + 4H^+ + NO_3^- \longrightarrow NO + 2H_2O$

For e^- LCM = 6

(4) $3H_2O + 3Te \longrightarrow 3TeO_2 + 6H^+ + 6e^-$

$6e^- + 8H^+ + 2NO_3^- \longrightarrow 2NO + 4H_2O$

Mistake is here

(5) $3Te + 4NO_3^- + 4H^+ \longrightarrow 3TeO_2 + 4NO + 2H_2O$

Answer is Correct

8.15 (d) $UO^{2+} + Cr_2O_7^{2-} \rightarrow UO_2^{2+} + Cr^{3+}$

(1)
$UO^{2+} \rightarrow UO_2^{2+}$
$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

(2)
$H_2O + UO^{2+} \rightarrow UO_2^{2+} + 2H^+$
$14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

(3)
$H_2O + UO^{2+} \rightarrow UO_2^{2+} + 2H^+ + 2e^-$
$6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

For e^-
LCM = 6

(4)
$3H_2O + 3UO^{2+} \rightarrow 3UO_2^{2+} + 6H^+ + 6e^-$
$6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

(5)
$3UO^{2+} + Cr_2O_7^{2-} + 8H^+ \rightarrow 3UO_2^{2+} + 2Cr^{3+} + 4H_2O$

)
$Zn + H_2MoO_4 \rightarrow Zn^{2+} + Mo^{3+}$

(1)
$Zn \rightarrow Zn^{2+}$
$H_2MoO_4 \rightarrow Mo^{3+}$

(2)
$Zn \rightarrow Zn^{2+}$
$6H^+ + H_2MoO_4 \rightarrow Mo^{3+} + 4H_2O$

(3)
$Zn \rightarrow Zn^{2+} + 2e^-$
$3e^- + 6H^+ + H_2MoO_4 \rightarrow Mo^{3+} + 4H_2O$

For e^-
LCM = 6

(4)
$3Zn \rightarrow 3Zn^{2+} + 6e^-$
$6e^- + 12H^+ + 2H_2MoO_4 \rightarrow 2Mo^{3+} + 8H_2O$

(5)
$3Zn + 2H_2MoO_4 + 12H^+ \rightarrow 3Zn^{2+} + 2Mo^{3+} + 8H_2O$

Mortimer P. 268–269

8.16

(a)

$AsH_3 + Ag^+ \rightarrow As_4O_6 + Ag$

① ② ③ $6H_2O + 4AsH_3 \rightarrow As_4O_6 + 24H^+ + 24e^-$

$1e^- + Ag^+ \rightarrow Ag$

LCM=24

④ $6H_2O + 4AsH_3 \rightarrow As_4O_6 + 24H^+ + 24e^-$

$24e^- + 24Ag^+ \rightarrow 24Ag$

⑤ $6H_2O + 4AsH_3 + 24Ag^+ \rightarrow As_4O_6 + 24Ag + 24H^+$

(b)

$Sb + NO_3^- \rightarrow Sb_4O_6 + NO$

① ② ③ $6H_2O + 4Sb \rightarrow Sb_4O_6 + 12H^+ + 12e^-$

$3e^- + 4H^+ + NO_3^- \rightarrow NO + 2H_2O$

LCM=12

④ $6H_2O + 4Sb \rightarrow Sb_4O_6 + 12H^+ + 12e^-$

$12e^- + 16H^+ + 4NO_3^- \rightarrow 4NO + 8H_2O$

⑤ $4H^+ + 4Sb + 4NO_3^- \rightarrow Sb_4O_6 + 4NO + 2H_2O$

(c)

$Mn^{2+} + BiO_3^- \rightarrow MnO_4^- + Bi^{3+}$

① ② ③ $4H_2O + Mn^{2+} \rightarrow MnO_4^- + 8H^+ + 5e^-$

$2e^- + 6H^+ + BiO_3^- \rightarrow Bi^{3+} + 3H_2O$

(LCM=10)

④ $8H_2O + 2Mn^{2+} \rightarrow 2MnO_4^- + 16H^+ + 10e^-$

$10e^- + 30H^+ + 5BiO_3^- \rightarrow 5Bi^{3+} + 15H_2O$

Continued

18.16

(C) Continued

$$14H^+ + 2Mn^{2+} + 5BiO_3^- \rightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$$

(d)

$$NO + NO_3^- \rightarrow N_2O_4$$

① ② ③

$$2H_2O + 2NO \rightarrow N_2O_4 + 4H^+ + 4e^-$$

$$2e^- + 4H^+ + 2NO_3^- \rightarrow N_2O_4 + 2H_2O$$

(LCM = 2)

④

$$2H_2O + 2NO \rightarrow N_2O_4 + 4H^+ + 4e^-$$

$$4e^- + 8H^+ + 4NO_3^- \rightarrow 2N_2O_4 + 4H_2O$$

⑤

$$4H^+ + 2NO + 4NO_3^- \rightarrow 3N_2O_4 + 2H_2O$$

(e)

$$MnO_4^- + HCN + I^- \rightarrow Mn^{2+} + ICN$$

① ② ③

$$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$$

(LCM = 10)

$$HCN + I^- \rightarrow ICN + H^+ + 2e^-$$ ← (No H_2O needs to be Added To this half reaction)

④

$$10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 8H_2O$$

$$5HCN + 5I^- \rightarrow 5ICN + 5H^+ + 10e^-$$

⑤

$$11H^+ + 2MnO_4^- + 5HCN + 5I^- \rightarrow 2Mn^{2+} + 5ICN + 8H_2O$$

18.17

(a)

$$S_2O_3^{2-} + IO_3^- + Cl^- \rightarrow SO_4^{2-} + ICl_2^-$$

① ② ③

$$5H_2O + S_2O_3^{2-} \rightarrow 2SO_4^{2-} + 10H^+ + 8e^-$$ (LCM = 8)

$$4e^- + 6H^+ + IO_3^- + 2Cl^- \rightarrow ICl_2^- + 3H_2O$$

④

$$5H_2O + S_2O_3^{2-} \rightarrow 2SO_4^{2-} + 10H^+ + 8e^-$$

$$8e^- + 12H^+ + 2IO_3^- + 4Cl^- \rightarrow 2ICl_2^- + 6H_2O$$

⑤

$$2H^+ + S_2O_3^{2-} + 2IO_3^- + 4Cl^- \rightarrow 2SO_4^{2-} + 2ICl_2^- + H_2O$$

(b.)

$$Se + BrO_3^- \rightarrow H_2SeO_3 + Br^-$$

① ② ③

$$3H_2O + Se \rightarrow H_2SeO_3 + 4H^+ + 4e^-$$ (LCM = 12)

$$6e^- + 6H^+ + BrO_3^- \rightarrow Br^- + 3H_2O$$

④

$$9H_2O + 3Se \rightarrow 3H_2SeO_3 + 12H^+ + 12e^-$$

$$12e^- + 12H^+ + 2BrO_3^- \rightarrow 2Br^- + 6H_2O$$

⑤

$$3H_2O + 3Se + 2BrO_3^- \rightarrow 3H_2SeO_3 + 2Br^-$$

Mortimer A 269

8.17 (e)

$$Pb_3O_4 \rightarrow Pb^{2+} + PbO_2$$

$$2e^- + 8H^+ + Pb_3O_4 \rightarrow 3Pb^{2+} + 4H_2O$$ (LCM = 4)

① ② ③

$$2H_2O + Pb_3O_4 \rightarrow 3PbO_2 + 4H^+ + 4e^-$$

④

$$4e^- + 16H^+ + 2Pb_3O_4 \rightarrow 6Pb^{2+} + 8H_2O$$

$$2H_2O + Pb_3O_4 \rightarrow 3PbO_2 + 4H^+ + 4e^-$$

⑤

$$12H^+ + 3Pb_3O_4 \rightarrow 6Pb^{2+} + 3PbO_2 + 6H_2O$$

8.17

(c)

$$H_3AsO_3 + MnO_4^- \rightarrow H_3AsO_4 + Mn^{2+}$$

(1) (2) (3)

$$H_2O + H_3AsO_3 \rightarrow H_3AsO_4 + 2H^+ + 2e^-$$

(LCM=10)

$$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$$

(4)

$$5H_2O + 5H_3AsO_3 \rightarrow 5H_3AsO_4 + 10H^+ + 10e^-$$

$$10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 8H_2O$$

(5)

$$6H^+ + 5H_3AsO_3 + 2MnO_4^- \rightarrow 5H_3AsO_4 + 2Mn^{2+} + 3H_2O$$

(d)

$$H_5IO_6 + I^- \rightarrow I_2$$

(1) (2) (3)

$$14e^- + 14H^+ + 2H_5IO_6 \rightarrow I_2 + 12H_2O$$

(LCM=14)

$$2I^- \rightarrow I_2 + 2e^-$$

(4)

$$14e^- + 14H^+ + 2H_5IO_6 \rightarrow I_2 + 12H_2O$$

$$14I^- \rightarrow 7I_2 + 14e^-$$

(5)

$$14H^+ + 2H_5IO_6 + 14I^- \rightarrow 8I_2 + 12H_2O$$

Reduced To Lowest Terms

$$7H^+ + H_5IO_6 + 7I^- \rightarrow 4I_2 + 6H_2O$$

8.18(a) $Hg_5(IO_6)_2 + I^- \rightarrow HgI_4^{2-} + I_2$

$16e^- + 24H^+ + 18I^- + Hg_5(IO_6)_2 \rightarrow 5HgI_4^{2-} + 12H_2O$

(1)(2)(3) $2I^- \rightarrow I_2 + 2e^-$ (LCM = 16)

(4) $16e^- + 24H^+ + 18I^- + Hg_5(IO_6)_2 \rightarrow 5HgI_4^{2-} + 12H_2O$

$16I^- \rightarrow 8I_2 + 16e^-$

(5) $24H^+ + 34I^- + Hg_5(IO_6)_2 \rightarrow 5HgI_4^{2-} + 8I_2 + 12H_2O$

In Step (1) The half reaction for the Mercury Compound is:

$18I^- + Hg_5(IO_6)_2 \rightarrow 5HgI_4^{2-}$

a coefficient of 5 is needed on the right side to balance the Hg. The only way to get the iodines to balance is to include I^- on the left side. There is no reason why the I^- cannot participate in both half reactions.

And remember that a drawback to this method (ion-electron method) is that the reaction in the beaker may not represent how the Rx mechanism proceeds.

Mortimer P.269

18.18 (b) $MnO_4^- + Mn^{2+} + H_2P_2O_7^{2-} \rightarrow Mn(H_2P_2O_7)_3^{3-}$

(3) (2)

$$4e^- + 8H^+ + MnO_4^- + 3H_2P_2O_7^{2-} \rightarrow Mn(H_2P_2O_7)_3^{3-} + 4H_2O$$

(LCM = 4)

$$Mn^{2+} + 3H_2P_2O_7^{2-} \rightarrow Mn(H_2P_2O_7)_3^{3-} + 1e^-$$

(4)

$$4e + 8H^+ + MnO_4^- + 3H_2P_2O_7^{2-} \rightarrow Mn(H_2P_2O_7)_3^{3-} + 4H_2O$$

$$4Mn^{2+} + 12H_2P_2O_7^{2-} \rightarrow 4Mn(H_2P_2O_7)_3^{3-} + 4e^-$$

(5)

$$8H^+ + MnO_4^- + 4Mn^{2+} + 15H_2P_2O_7^{2-} \rightarrow 5Mn(H_2P_2O_7)_3^{3-} + 4H_2O$$

Here again, as in previous problem, one species ($H_2P_2O_7$), appears on the left side in both half reaction

18.18 (c)

$$CS(NH_2)_2 + BrO_3^- \rightarrow CO(NH_2)_2 + SO_4^{2-} + Br^-$$

(1) (2) (3)

$$5H_2O + CS(NH_2)_2 \rightarrow CO(NH_2)_2 + SO_4^{2-} + 10H^+ + 8e^-$$

$$6e^- + 6H^+ + BrO_3^- \rightarrow Br^- + 3H_2O$$

(LCM = 24)

(4)

$$15H_2O + 3CS(NH_2)_2 \rightarrow 3CO(NH_2)_2 + 3SO_4^{2-} + 30H^+ + 24e^-$$

$$24e^- + 24H^+ + 4BrO_3^- \rightarrow 4Br^- + 12H_2O$$

(5)

$$3H_2O + 3CS(NH_2)_2 + 4BrO_3^- \rightarrow 3CO(NH_2)_2 + 3SO_4^{2-} + 4Br^- + 6H^+$$

(d)

$$Co(NO_2)_6^{3-} + MnO_4^- \rightarrow Co^{2+} + NO_3^- + Mn^{2+}$$

(1) (2) (3)

$$6H_2O + Co(NO_2)_6^{3+} \rightarrow Co^{2+} + 6NO_3^- + 12H^+ + 5e^-$$

$$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$$

(LCM = 5)

(4)

Electrons gained = electrons lost with no Further Manipulation

(5)

$$2H_2O + Co(NO_2)_6^{3+} + MnO_4^- \rightarrow Co^{2+} + 6NO_3^- + Mn^{2+} + 4H^+$$

18.18 (e) $\overset{+3}{HClO_2} \longrightarrow \overset{+4}{ClO_2} + \overset{+5}{ClO_3^-} + \overset{1-}{Cl^-}$

(1) (2)

(3) $H_2O + 2HClO_2 \longrightarrow ClO_2 + ClO_3^- + 4H^+ + 3e^-$

$4e^- + 3H^+ + HClO_2 \longrightarrow Cl^- + 2H_2O$ (LCM = 12)

(4) $4H_2O + 8HClO_2 \longrightarrow 4ClO_2 + 4ClO_3^- + 16H^+ + 12e^-$

$12e^- + 9H^+ + 3HClO_2 \longrightarrow 3Cl^- + 6H_2O$

(5)

$11HClO_2 \longrightarrow 4ClO_2 + 4ClO_3^- + 3Cl^- + 2H_2O + 7H^+$

In writing the half reactions there are two species of Cl on the right side which have lost electrons and their total lost must be equal to the electrons gained to form Cl^-. Therefore the two species ClO_2 and ClO_3 can be written in the same half reaction

(1) $2\overset{3+}{HClO_2} \longrightarrow \overset{4+}{ClO_2} + \overset{5+}{ClO_3}$ 3 electrons lost

(2) $\overset{3+}{HClO_2} \longrightarrow \overset{1-}{Cl}$ 3 electrons gained

Mortimer P269

8.19 (a) $Cr(OH)_4^- + BrO_4^- \longrightarrow CrO_4^{2-} + Br^-$

① $Cr(OH)_4^- \longrightarrow CrO_4^{2-}$

$BrO_4^- \longrightarrow Br^-$

② $Cr(OH)_4^- \rightarrow CrO_4^{2-}$

(For Oxygen)

$4H_2O + BrO_4^- \rightarrow Br^- + 8OH^-$

Then

$4OH^- + Cr(OH)_4^- \rightarrow CrO_4^{2-} + 4H_2O$ (For Hydrogen)

$4H_2O + BrO_4^- \longrightarrow Br^- + 8OH^-$

③ $4OH^- + Cr(OH)_4^- \rightarrow CrO_4^{2-} + 4H_2O + 3e^-$

(LCM = 24)

$8e^- + 4H_2O + BrO_4^- \rightarrow Br^- + 8OH^-$

④ $32OH^- + 8Cr(OH)_4^- \rightarrow 8CrO_4^{2-} + 32H_2O + 24e^-$

$24e^- + 12H_2O + 3BrO_4^- \rightarrow 3Br^- + 24OH^-$

⑤ $8OH^- + 8Cr(OH)_4^- + 3BrO_4^- \longrightarrow 8CrO_4^{2-} + 3Br^- + 20H_2O$

8.19 (b)

$Al + NO_3^- \rightarrow Al(OH)_4^- + NH_3$

① + ②
$8OH^- + Al \rightarrow Al(OH)_4^- + 4H_2O$ (For O)
$3H_2O + NO_3^- \rightarrow NH_3 + 6OH^-$

$4H_2O + 8OH^- + Al \rightarrow Al(OH)_4^- + 4H_2O + 4OH^-$ (For H)
$3H_2O + 3H_2O + NO_3^- \rightarrow NH_3 + 6OH^- + 3OH^-$

③
$4OH^- + Al \rightarrow Al(OH)_4^- + 3e^-$ (LCM= 24)
$8e^- + 6H_2O + NO_3^- \rightarrow NH_3 + 9OH^-$

④
$32OH^- + 8Al \rightarrow 8Al(OH)_4^- + 24e^-$
$24e^- + 18H_2O + 3NO_3^- \rightarrow 3NH_3 + 27OH^-$

⑤
$5OH^- + 18H_2O + 8Al + 3NO_3^- \rightarrow 8Al(OH)_4^- + 3NH_3$

(c)

$P_4 \rightarrow H_2PO_2^- + PH_3$

① + ②
$16OH^- + P_4 \rightarrow 4H_2PO_2^- + 8H_2O$ (For O)
$P_4 \rightarrow 4PH_3$

Then

$8H_2O + 16OH^- + P_4 \rightarrow 4H_2PO_2^- + 8H_2O + 8OH^-$ (For H)
$12H_2O + P_4 \rightarrow 4PH_3 + 12OH^-$

③
$8OH^- + P_4 \rightarrow 4H_2PO_2^- + 4e^-$ (LCM=12)
$12e^- + 12H_2O + P_4 \rightarrow 4PH_3 + 12OH^-$

④
$24OH^- + 3P_4 \rightarrow 12H_2PO_2^- + 12e^-$
$12e^- + 12H_2O + P_4 \rightarrow 4PH_3 + 12OH^-$

⑤
$12OH^- + 12H_2O + 4P_4 \rightarrow 12H_2PO_2^- + 4PH_3$

(Continued) →

8.19 (c) (Continued)

(Reduce to lowest terms)

$$3\,OH^- + 3\,H_2O + P_4 \rightarrow 3\,H_2PO_2^- + PH_3$$

(d)

$$Bi(OH)_3 + Sn(OH)_4^{2-} \rightarrow Bi + Sn(OH)_6^{2-}$$

①+②

$$3OH^- + 3H_2O + Bi(OH)_3 \rightarrow Bi + 6OH^- + 3H_2O$$

$$2H_2O + 4OH^- + Sn(OH)_4^{2-} \rightarrow Sn(OH)_6^{2-} + 2H_2O + 2OH^-$$

③

$$3e^- + Bi(OH)_3 \rightarrow Bi + 3OH^-$$

(LCM = 6)

$$2OH^- + Sn(OH)_4^{2-} \rightarrow Sn(OH)_6^{2-} + 2e^-$$

④

$$6e^- + 2\,Bi(OH)_3 \rightarrow 2Bi + 6OH^-$$

$$6OH^- + 3Sn(OH)_4^{2-} \rightarrow 3Sn(OH)_6^{2-} + 6e^-$$

⑤

$$2\,Bi(OH)_3 + 3\,Sn(OH)_4^{2-} \rightarrow 2\,Bi + 3\,Sn(OH)_6^{2-}$$

(e)

$$Ni^{2+} + Br_2 \rightarrow NiO(OH) + Br^-$$

①② +③

$$H_2O + 4OH^- + Ni^{2+} \rightarrow NiO(OH) + 2H_2O + OH^- + 1e^-$$

$$2e^- + Br_2 \rightarrow 2Br^-$$

(LCM=2)

④

$$2H_2O + 8OH^- + 2Ni^{2+} \rightarrow 2NiO(OH) + 4H_2O + 2OH^- + 2e^-$$

$$2e^- + Br_2 \rightarrow 2Br^-$$

⑤

$$6OH^- + 2Ni^{2+} + Br_2 \rightarrow 2\,NiO(OH) + 2Br^- + 2H_2O$$

Mortimer P. 269

8.20 (a)

$$MnO_4^- + CN \longrightarrow MnO_2 + CNO^-$$

1)+2)

$$2H_2O + MnO_4^- \longrightarrow MnO_2 + 4OH^-$$

$$2OH^- + CN \longrightarrow CNO^- + H_2O$$

3)

$$3e^- + 2H_2O + MnO_4^- \longrightarrow MnO_2 + 4OH^-$$

$$2OH^- + CN \longrightarrow CNO^- + H_2O + 1e$$

(LCM = 3)

4)

$$3e^- + 2H_2O + MnO_4^- \longrightarrow MnO_2 + 4OH^-$$

$$6OH^- + 3CN \longrightarrow 3CNO^- + 3H_2O + 3e$$

5)

$$2OH^- + MnO_4^- + 3CN \longrightarrow MnO_2 + 3CNO^- + H_2O$$

(b)

$$S \longrightarrow SO_3^{2-} + S^{2-}$$

1) 2) 3)

$$6OH^- + S \longrightarrow SO_3^{2-} + 3H_2O + 4e^-$$

(LCM = 4)

$$2e^- + S \longrightarrow S^{2-}$$

4)

$$6OH^- + S \longrightarrow SO_3^{2-} + 3H_2O + 4e^-$$

$$4e^- + 2S \longrightarrow 2S^{2-}$$

5)

$$6OH^- + 3S \longrightarrow SO_3^{2-} + 2S^{2-} + 3H_2O$$

8.20 (c)

$$Al + OH^- \longrightarrow Al(OH)_4 + H_2$$

①+② $4H_2O + 8OH^- + Al \longrightarrow Al(OH)_4 + 4H_2O + 4OH^-$

$H_2O + H_2O + OH^- \longrightarrow H_2 + 2OH^- + OH^-$

③ $4OH^- + Al \longrightarrow Al(OH)_4 + 4e^-$

(LCM = 4)

$2e^- + 2H_2O \longrightarrow H_2 + 2OH^-$

④ $4OH^- + Al \longrightarrow Al(OH)_4 + 4e^-$

$4e^- + 4H_2O \longrightarrow 2H_2 + 4OH^-$

⑤ $Al + 4H_2O \longrightarrow Al(OH)_4 + 2H_2$

(d)

$$HXeO_4^- + O_3 \longrightarrow XeO_6^{4-} + H_2O$$

①+② $OH + 4OH^- + HXeO_4^- \longrightarrow XeO_6^{4-} + 2H_2O + H_2O$

$2H_2O + 2H_2O + O_3 \longrightarrow H_2O + 4OH^- + 2OH^-$

③ $5OH^- + HXeO_4^- \longrightarrow XeO_6^{4-} + 3H_2O + 2e^-$

$6e^- + 4H_2O + O_3 \longrightarrow H_2O + 6OH^-$

(LCM = 6)

④ $15OH^- + 3HXeO_4^- \longrightarrow 3XeO_6^{4-} + 9H_2O + 6e^-$

$6e^- + 4H_2O + O_3 \longrightarrow H_2O + 6OH^-$

⑤ $9OH^- + 3HXeO_4^- + O_3 \longrightarrow 3XeO_6^{4-} + 6H_2O$

Mortimer A 269

8.20 (e) $I_2 + Cl_2 \rightarrow H_3IO_6^{2-} + Cl^-$

(1),(2),(3) $16OH^- + 12OH^- + I_2 \rightarrow 2H_3IO_6^{2-} + 6H_2O + 14e^-$

$2e + Cl_2 \rightarrow 2Cl^-$ (LCM = 14)

(4) $18OH^- + I_2 \rightarrow 2H_3IO_6^{2-} + 6H_2O + 14e^-$

$14e^- + 7Cl_2 \rightarrow 14Cl^-$

(5) $18OH^- + I_2 + 7Cl_2 \rightarrow 2H_3IO_6^{2-} + 14Cl^- + 6H_2O$