CHEM 2
Problem Set Ch.19 **Oxidation-Reduction Reactions** **Key begins on Page 3.**

1. Balance the following oxidation-reduction reactions.

a) $(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + N_2 + H_2O$

b) $Pb(NO_3)_2 \longrightarrow PbO + NO_2 + O_2$

c) $MnO_2 + HCl \longrightarrow MnCl_2 + H_2O + Cl_2$

d) $KMnO_4 + HCl \longrightarrow KCl + MnCl_2 + H_2O + Cl_2$

e) $Cu + H_2SO_4 \longrightarrow CuSO_4 + SO_2 + H_2O$

f) $Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NH_4NO_3 + H_2O$

g) $Cl_2 + H_2SeO_3 + H_2O \longrightarrow H_2SeO_4 + HCl$

h) $Na_3AsO_3 + I_2 + H_2O \longrightarrow Na_3AsO_4 + HI$

i) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + SO_2 + H_2O$

j) $H_2SO_4 + HBr \longrightarrow SO_2 + Br_2 + H_2O$

k) $HClO_3 \longrightarrow HClO_4 + ClO_2 + H_2O$

2. The reactions here are in acidic solution. You *may* need to use H^+ or H^+/H_2O to balance the equation.

a) $PbS + NO_3^{-1} \longrightarrow Pb^{+2} + SO_4^{-2} + NO$

b) $CuS + NO_3^{-1} \longrightarrow Cu^{+2} + S + NO$

c) $S_2O_3^{-2} + MnO_4^{-1} \longrightarrow SO_4^{-2} + Mn^{+2}$

d) $UO^{+2} + Cr_2O_7^{-2} \longrightarrow UO_2^{+2} + Cr^{+3}$

e) $S_2O_4^{-2} + H_2O \longrightarrow S_2O_3^{-2} + HSO_3^{-1}$

f) $Zn + NO_3^{-1} \longrightarrow NH_4^{+1} + Zn^{+2} + H_2O$

3. The reactions here are in basic solution. You *may* need to use OH^- or OH^-/H_2O to balance the equation.

a) $As_2S_3 + H_2O_2 \longrightarrow AsO_4^{-3} + SO_4^{-2}$

b) $Fe(OH)_2 + CrO_4^{-2} \longrightarrow Fe_2O_3 + Cr(OH)_4^{-1}$

c) $PbO_2 + Cl^{-1} \longrightarrow ClO^{-1} + Pb(OH)_3^{-1}$

d) $Br_2 \longrightarrow Br^{-1} + BrO_3^{-1}$

e) $Zn + ClO^{-1} \longrightarrow Zn(OH)_2 + Cl^{-1}$

f) $MnO_4^{-1} + H_2O_2 \longrightarrow MnO_2 + O_2$

#1

a) $(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + N_2 + 4H_2O$

OXID. LOSS OF 6 e^- TOTAL

REDUCTION GAIN OF 6 e^- TOTAL

↑ THIS BALANCED MASS

b) $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$

TWO OXYGENS ARE OXIDIZED FROM −2 TO 0 LOSS OF 4 e^-

(TWO NITROGENS REDUCED FROM +5 TO +4 GAIN OF 2 e^-) X 2

NOTE: I INITIALLY PUT A 2 IN FRONT OF NO_2 TO BALANCE N's THEN HAD TO DOUBLE THAT TO BALANCE e^-'s

c) $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

NOTE: INITIALLY 2 HCl's WERE NEEDED TO BALANCE Cl's AN ADDITIONAL 2 NEEDED TO BALANCE MASS

OXIDATION LOSS OF 2 e^-

REDUCTION GAIN 2 e^-

d) $2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

(OXID. LOSS OF 2 e^- TOTAL) X 5

(RED. GAIN 5 e^-) X 2

NOTE THAT 6 Cl^{-1} IN ADDITION TO THE 10 Cl^{-1}'s THAT OXIDIZED MUST BE ADDED TO BALANCE MASS. THESE ADDITIONAL Cl^{-1}'s DID NOT OXIDIZE.... THEY ENDED UP IN KCl AND $MnCl_2$

e) $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$

OXIDATION LOSS 2 e^-

ONLY 1 GETS REDUCED

REDUCTION GAIN 2 e^-

#1 CONT.

f) $4\,Cu + 10\,HNO_3 \longrightarrow 4\,Cu(NO_3)_2 + NH_4NO_3 + 3\,H_2O$

(OXIDATION, LOSS 2e⁻) × 4

0 → +2 (Cu)

+1 +5 -2 → +5 -2 (N)

ONLY 1 N REDUCES... THE REST JUST BALANCE MASS

REDUCTION, GAIN 8e⁻

-3 +1 +5 -2 (NH₄NO₃)

TO BALANCE THE MASS

+1 -2 (H_2O)

g) $Cl_2 + H_2SeO_3 + H_2O \longrightarrow H_2SeO_4 + 2\,HCl$

OXIDATION, LOSS 2e⁻

0 → +1 -1 (Cl)

+4 → +6 (Se)

REDUCTION, GAIN 2e⁻

h) $Na_3AsO_3 + I_2 + H_2O \longrightarrow Na_3AsO_4 + 2\,HI$

OXID, LOSS OF 2e⁻

+3 → +5 (As)

0 → -1 (I)

REDUCTION, GAIN 2e⁻

i) $Zn + 2\,H_2SO_4 \longrightarrow ZnSO_4 + SO_2 + 2\,H_2O$

OXID, LOSS OF 2e⁻

0 → +2 (Zn)

+6 → +4 (S)

ONLY ½ S IS REDUCED

REDUCTION, +2e⁻

j) $H_2SO_4 + 2\,HBr \longrightarrow SO_2 + Br_2 + 2\,H_2O$

OXID, LOSS 2e⁻

-1 → 0 (Br)

+6 → +4 (S)

RED GAIN 2e⁻

k) $2\,HClO_3 \longrightarrow HClO_4 + 2\,ClO_2 + H_2O$

TOTAL OF 3 $HClO_4$

OXIDATION, LOSS OF 2e⁻

+5 → +7 (Cl)

REDUCTION, GAIN 1e⁻ × 2

+5 → +4 (Cl)

#2

a) $8H^{\oplus} + 3PbS + 8NO_3^{-1} \longrightarrow 3Pb^{+2} + 3SO_4^{-2} + 8NO + 4H_2O$

(OXID. LOSS OF $8e^-$) $\times 3$

(RED. GAIN $3e^-$) $\times 8$

$8H^{\oplus}$ — TO BALANCE CHARGE.

$4H_2O$ — TO BALANCE MASS

b) $8H^{\oplus} + 3CuS + 2NO_3^{-1} \longrightarrow 3Cu^{+2} + 3S + 2NO + 4H_2O$

(OXID LOSS $2e^-$) $\times 3$

(RED. GAIN $3e^-$) $\times 2$

$8H^{\oplus}$ — TO BAL CHG.

$4H_2O$ — TO BALANCE MASS

c) $14H^{+} + 5S_2O_3^{-2} + 8MnO_4^{-1} \longrightarrow 10SO_4^{-2} + 8Mn^{+2} + 7H_2O$

(OXID LOSS $8e^-$) $\times 5$

(RED GAIN $5e^-$) $\times 8$

$14H^{+}$ — TO BALANCE CHARGE.

$7H_2O$ — TO BAL MASS

d) $8H^{+} + 3UO^{+2} + Cr_2O_7^{-2} \longrightarrow 3UO_2^{+2} + 2Cr^{+3} + 4H_2O$

(OXID LOSS OF $2e^-$) $\times 3$

RED GAIN OF $6e^-$

$8H^{+}$ — TO BAL CHG.

$4H_2O$ — TO BALANCE MASS

e) $2S_2O_4^{-2} + H_2O \longrightarrow S_2O_3^{-2} + 2HSO_3^{-1}$

(2 S's THIS WAY) OXIDATION LOSS OF $2e^-$

2 S's THIS WAY — RED. GAIN $2e^-$

f) $10H^{\oplus} + 4Zn + NO_3^{-1} \longrightarrow NH_4^{+1} + 4Zn^{+2} + 3H_2O$

(OXID LOSS OF $2e^-$) $\times 4$

RED GAIN $8e^-$

$10H^{\oplus}$ — TO BAL CHARGE

$3H_2O$ — TO BAL MASS

#3

a) $12OH^- + As_2S_3 + 14H_2O_2 \rightarrow 2AsO_4^{-3} + 3SO_4^{-2} + 20H_2O$

OXID - LOSS $4e^-$

OXID LOSS OF $24e^-$

TO BAL CHG

RED GAIN OF $1e^-$ FOR EACH O REGARDLESS OF WHERE THEY GO

TO BAL MASS

b) $6Fe(OH)_2 + 2CrO_4^{-2} \rightarrow 3Fe_2O_3 + 2Cr(OH)_4^{-1} + 2OH^- + H_2O$

(OXID LOSS $2e^-$) x3

(RED GAIN $3e^-$) x2

TO BAL CHG.

TO BAL MASS.

c) $OH^- + H_2O + PbO_2 + Cl^- \rightarrow ClO^- + Pb(OH)_3^-$

$2e^-$

TO BAL MASS.

TO BAL CHG.

(RED GAIN $2e^-$)

d) $6OH^- + 3Br_2 \rightarrow 5Br^- + BrO_3^- + 3H_2O$

OXID LOSS $5e^-$ EACH Br

TO BAL CHG.

REDUCTION GAIN OF $1e^-$ EACH Br x5

TO BAL. MASS

e) $H_2O + Zn + ClO^- \rightarrow Zn(OH)_2 + Cl^- +$ [redacted]

TO BAL MASS

(OXID LOSS OF $2e^-$)

(RED GAIN OF $2e^-$)

f) $2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2OH^- + 2H_2O$

(OXID LOSS OF $2e^-$) x3

(RED GAIN $3e^-$) x2

TO BAL CHG

TO BAL MASS