(49) Ox. Numbers for

(a) nitrogen oxide — $\overset{+2}{N}\overset{-2}{O}$

(c) ammonia — NH_3 (but technically $\overset{+1}{H_3}\overset{-3}{N}$)

(b) potassium peroxide — $\overset{+1}{K_2}\overset{-1}{O_2}$

$0 = (2x) + (1(-2))$

$x = +1$

[peroxide ion is O_2^{2-}]

(d) ClO_3^-

$(-1) = (x) + (-6)$

$x = +5$

$\overset{+5}{Cl}\overset{-2}{O}^-$

(50) (a) methane — H_4C (although commonly written CH_4)

$0 = (4) + (x)$ $\quad x = -4$

$\overset{+1}{H_4}\overset{-4}{C}$

(b) $H_2SO_3 \rightarrow 2H^+ + SO_3^{2-}$

$(-2) = (x) + (3 \cdot -2)$

$-2 = x + -6$

$+4$

$\overset{+1}{H}\overset{+4}{S}\overset{-2}{O_3}^{2-}$

(c) $Na_2O \Rightarrow O^{-2} \Rightarrow$ each Na is +1

$\overset{+1}{Na_2}\overset{-2}{O}$

(50 con't)

(d) $H_2PO_4^-$

$2H^+$ PO_4^{3-} $\longrightarrow$ $(-3) = (x) + (4 \cdot -2)$

$-3 = x - 8$

$+5$

$\overset{+1}{H_2}\overset{+5}{P}\overset{-2}{O_4}{}^-$

(51/52) Assign oxidation numbers to each element

(51) (a) P_2O_5 = $(0) = (2x) + (-10)$

$+10 = 2x$

$+5 = x$

$P = +5$
$O = -2$

$\overset{+5}{P_2}\overset{-2}{O_5}$

(c) CO_3^{2-} = $(-2) = (x) + (-6)$

$+4 = x$

$\overset{+4}{C}\overset{-2}{O_2}$

(52)(d) NOF F = -1 (most electronegative)

2ND most electronegative will also remove electrons from where it can = N

$O = -2$

So

$0 = (N) + (-2) + (-1)$

$+3 = N$

$\overset{+3}{N}\overset{-2}{O}\overset{-1}{F}$

53/54 oxidation or reduction (LEO says GER)

(53) (a) $O_2(g) \rightarrow O^{2-}(aq)$

$O_2 + 2e^- \rightarrow O^{2-}$

(yes, it's not balanced)

gain electrons = reduction

(b) $MnO_4^- \rightarrow MnO_2$

+7 −2 +4 −2

gained $3e^-$

gain electrons = reduction

(c) $Cr_2O_7^{2-} \rightarrow Cr^{3+}$

$(-2) = (2x) + (-14)$

$+12 = 2x \rightarrow x = +6$

$Cr^{+6} \rightarrow Cr^{3+} + 3e^-$

reduction

(d) $Cl^- \rightarrow Cl_2$

$-1 \rightarrow 0 + e^-$

lose

lose electron = oxidation

(54 a) $TiO_2 \rightarrow Ti^{3+}$ GER reduction

+4 $+e^-$

(b) $Zr^{2+} \rightarrow Zr^0$ GER reduction

$+2e^-$

(c) $NH_4^+ \rightarrow N_2$ LEO oxidation

-3 0

lose e^-

(d) $CH_3CH \rightarrow CH_2O$

+1 -2 +1 +1 -2

$\emptyset = (C) + (4 \cdot +1) + 1(-2)$

$+4$ -2

$\emptyset = (C) + (+2)$

$\emptyset = (C) + (+2) + (-2)$

$\emptyset = \emptyset$

$C^{2-} \rightarrow C^0$ LEO oxidation

lose e^-

Balancing Redox Rxns in Acid

① half-reactions
② balance — (a) atoms (using (b) H^+ & (c) H_2O) (d) e^-
③ multiply each half-rxn by integer so e's balance
④ add half reactions

$$Cr_2O_7^{2-}(aq) + I^-(aq) \rightarrow Cr^{3+}(aq) + I_2(s) \quad \text{(acidic)}$$

① $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ $\quad$ $I^- \rightarrow I_2$

② (a) $Cr_2O_7^{2-} \rightarrow \underline{2}\,Cr^{3+}$ $\quad$ $\underline{2}\,I^- \rightarrow I_2$

balance "O" by adding H_2O

$Cr_2O_7^{2-} \rightarrow \underline{2}\,Cr^{3+} + \underline{7}\,H_2O$ —

balance H by adding H^+ (acid environment)

$14H^+ + Cr_2O_7^{2-} \rightarrow \underline{2}\,Cr^{3+} + \underline{7}\,H_2O$

(b) $+14$ $\quad$ -2 $\quad$ $+12$ $\quad$ $+6$ $\quad$ $6+$

"Excess of +6 on left, so add $6e^-$ on left"

for Cr $\underline{6}\,e^- + \underline{14}\,H^+ + Cr_2O_7^{2-} \rightarrow \underline{2}\,Cr^{3+} + \underline{7}\,H_2O$ (reduction b/c e^- on left)

(acidic 2)

(for I) $2\,I^- \rightarrow I_2$

(2) (a) (balanced above)

(b) no O's so no H_2O's needed

(c) no H's so no H^+'s

(d) charge balance:

$2\,I^- \rightarrow I_2 + 2e^-$ (oxidation b/c electrons lost, on right)

(Cr & I +)

(3) Multiply by integers so e's balance)

Cr rxn needs $6e^-$

I rxn (as is) loses $2e^-$, so:

$3(2\,I^- \rightarrow I_2 + 2e^-)$

$\equiv 6\,I^- \rightarrow 3\,I_2 + 6e^-$

(4) Add 1/2 rxns & simplify

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

$+ \quad 6\,I^- \rightarrow 3\,I_2 + 6e^-$

$14H^+ + Cr_2O_7^{2-} + 6\,I^- \rightarrow 2Cr^{3+} + 7H_2O + 3I_2$

(aq) (aq) (aq) (aq) (l) (s)

Check atoms — they balance!

Balancing Redox Reactions (basic solutions)

Repeat steps for acidic solutions (1-4)
Then add OH^- and cancel excess H_2O

Ex $MnO_4^-(aq) + C_2O_4^{2-}(aq) \rightarrow MnO_2(s) + CO_3^{2-}(aq)$

(1) Balance atoms other than O & H

$MnO_4^- \rightarrow MnO_2$ $\quad$ $C_2O_4^{2-} \rightarrow 2CO_3^{2-}$

(O) $2H_2O + MnO_4^- \rightarrow MnO_2 + 2H_2O$ $\quad$ $2H_2O + C_2O_4^{2-} \rightarrow 2CO_3^{2-}$

(H) $4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O$ $\quad$ $2H_2O + C_2O_4^{2-} \rightarrow 2CO_3^{2-} + 4H^+$

(e⁻) $(+4) + (-1) \rightarrow (0) + (0)$ $\quad$ $(0) + (-2) \rightarrow (-4) + (+4)$

$= +3$ needs $3e^-$ $\quad$ $= 0$ $\quad$ $= -2$ loses $2e^-$ $\quad$ $= 0$

(3) $2(3e^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O)$

$+ 3(2H_2O + C_2O_4^{2-} \rightarrow 2CO_3^{2-} + 4H^+)$

(4) $6e^- + 8H^+ + 2MnO_4^- \rightarrow 2MnO_2 + 4H_2O$

$2H_2O + 3C_2O_4^{2-} \rightarrow 6CO_3^{2-} + 4H^+$

$2MnO_4^- + 2H_2O + 3C_2O_4^{2-} \rightarrow 2MnO_2 + 6CO_3^{2-} + 4H^+$

(5) Add OH^- to neutralize H^+ & Cancel excess H^+

Adding $4OH^-$ to both sides forms $4H_2O$ on right

$\Rightarrow$

basic (2)

$$\underline{2}MnO_4^- + \underline{2}H_2O + 3C_2O_4^{2-} + \underline{4}OH^- \rightarrow \underline{2}MnO_2 + \underline{6}CO_3^{2-} + (4H^+ + 4OH^-)$$

$$\underline{2}MnO_4^- + \underline{2}H_2O + 3C_2O_4^{2-} + 4OH^- \rightarrow \underline{2}MnO_2 + 6CO_3^{2-} + \underline{2}H_2O$$

$\Rightarrow$

$$\underset{(aq)}{2MnO_4^-} + \underset{(aq)}{3C_2O_4^{2-}} + \underset{(aq)}{4OH^-} \rightarrow \underline{2}\underset{(s)}{MnO_2} + \underline{6}\underset{(aq)}{CO_3^{2-}} + 2H_2O(l)$$

check

$(\underline{2}Mn; \underline{2}4O, \underline{6}C, \underline{4}H, \underline{12}e^-) \rightarrow (\underline{2}Mn, \underline{2}4O, \underline{6}C, 12e^-)$