EIT CHEMISTRY REVIEW

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Balance in basic solution:

$S_2O_8^{2-} + Mn(OH)_2 \rightarrow MnO_4^- + SO_4^{2-}$

1. Assign oxidation numbers

+7 -2 +2 -2 +1 +7 -2 +6 -2

$S_2O_8^{2-} + Mn(OH)_2 \rightarrow MnO_4^- + SO_4^{2-}$

NOTE

+1 -2 +1 -2 -2 +1

$2\ H_2O \leftrightarrow H_3O^+ + OH^-$

2. Balance oxidation number changes

+7 -2 +2 -2 +1 +7 -2 +6 -2

$5S_2O_8^{2-} + 2Mn(OH)_2 \rightarrow 2MnO_4^- + 10SO_4^{2-}$

(-2) (+5)

3. Balance charge

$5S_2O_8^{2-} + 2Mn(OH)_2 \rightarrow 2MnO_4^- + 10SO_4^{2-}$

net 10- net 22-

$12OH^- + 5S_2O_8^{2-} + 2Mn(OH)_2 \rightarrow 2MnO_4^- + 10SO_4^{2-}$

net 22- net 22-

4. Balance remaining atoms (O and H)

$12OH^- + 5S_2O_8^{2-} + 2Mn(OH)_2 \rightarrow 2MnO_4^- + 10SO_4^{2-}$

total 56 O atoms total 48 O atoms

$12OH^- + 5S_2O_8^{2-} + 2Mn(OH)_2 \rightarrow 2MnO_4^- + 10SO_4^{2-} + 8H_2O$

5. Check last atoms (H)

$12OH^- + 5S_2O_8^{2-} + 2Mn(OH)_2 \rightarrow 2MnO_4^- + 10SO_4^{2-} + 8H_2O$

total 16 H atoms total 16 H atoms

ASSIGNING OXIDATION NUMBERS

RULES IN PRIORITY ORDER

1. Σ(oxidation numbers) = charge
2. Group IA (Li,Na,K,etc) assign +1
3. Group 2A (Be,Mg,Ca,etc) assign +2
4. B, Al assign +3
5. Hydrogen assign +1
6. Oxygen assign -2

Balance in acidic solution:

$Cr_2O_7^{2-} + N_2H_5^+ \rightarrow NO_{2(g)} + Cr^{3+}$

1. Assign oxidation numbers

$\overset{+6\ -2}{Cr_2O_7^{2-}} + \overset{-2\ +1}{N_2H_5^+} \rightarrow \overset{+4\ -2}{NO_{2(g)}} + \overset{+3}{Cr^{3+}}$

2. Balance oxidation number changes

$\underset{(-6)}{\overset{+6\ -2}{2Cr_2O_7^{2-}}} + \underset{(+12)}{\overset{-2\ +1}{N_2H_5^+}} \rightarrow \overset{+4\ -2}{2\ NO_{2(g)}} + \overset{+3}{4Cr^{3+}}$

3. Balance charge

$2Cr_2O_7^{2-} + N_2H_5^+ \rightarrow 2\ NO_{2(g)} + 4Cr^{3+}$

net 3- net 12+

$15H_3O^+ + 2Cr_2O_7^{2-} + N_2H_5^+ \rightarrow 2\ NO_{2(g)} + 4Cr^{3+}$

net 12+ net 12+

4. Balance remaining atoms (O and H)

$15H_3O^+ + 2Cr_2O_7^{2-} + N_2H_5^+ \rightarrow 2\ NO_{2(g)} + 4Cr^{3+}$

total 50 H atoms total 0 H atoms

$15H_3O^+ + 2Cr_2O_7^{2-} + N_2H_5^+ \rightarrow 2\ NO_{2(g)} + 4Cr^{3+} + 25H_2O$

5. Check last atoms (O)

$15H_3O^+ + 2Cr_2O_7^{2-} + N_2H_5^+ \rightarrow 2\ NO_{2(g)} + 4Cr^{3+} + 25H_2O$

total 29 O atoms total 29 O atoms

STOICHIOMETRY

1. A solid sample is 15.0% $Na_2Cr_2O_7$. How many grams of N_2H_5Cl is needed to react with 5.00 g of this sample.

$$15H_3O^+ + 2Cr_2O_7^{2-} + N_2H_5^+ \rightarrow 2\ NO_{2(g)} + 4Cr^{3+} + 25H_2O$$

$$5.00\text{g sample} \times \frac{.150\text{g } Na_2Cr_2O_7}{\text{g sample}} \times \frac{\text{mole } Na_2Cr_2O_7}{262.0\text{g } Na_2Cr_2O_7} \times$$

$$\times \frac{\text{mole } N_2H_5Cl}{2\text{ mole } Na_2Cr_2O_7} \times \frac{68.5\text{g } N_2H_5Cl}{\text{mole } N_2H_5Cl} = \mathbf{0.0980\ g\ N_2H_5Cl}$$

2. How many liters $NO_{2(g)}$ at 30.0°C and 620.0torr are formed when the 5.00 g of sample is reacted?

$$5.00\text{g sample} \times \frac{.150\text{g } Na_2Cr_2O_7}{\text{g sample}} \times \frac{\text{mole } Na_2Cr_2O_7}{262.0\text{g } Na_2Cr_2O_7} \times$$

$$\times \frac{2\text{mole } NO_2}{2\text{mole } Cr_2O_7} \times \frac{.08205\text{Latm}}{\text{mole}NO_2\text{K}} \times \frac{303.15\text{K}}{620.0\text{torr}} \times \frac{760.0\text{torr}}{\text{atm}} = \mathbf{.0873\ L}$$

3. How many mLs of 3.00N N_2H_5Cl solution would be required to react with 5.00g of the sample?

$$5.00\text{g sample} \times \frac{.150\text{g } Na_2Cr_2O_7}{\text{g sample}} \times \frac{\text{mole } Na_2Cr_2O_7}{262.0\text{g } Na_2Cr_2O_7} \times$$

$$\times \frac{\text{mole } N_2H_5Cl}{2\text{mole } Cr_2O_7^{2-}} \times \frac{12\text{ eq } N_2H_5Cl}{\text{mole } N_2H_5Cl} \times \frac{\text{L } N_2H_5Cl}{3.00\text{eq } N_2H_5Cl} \times$$

$$\times \frac{1000\text{mL}}{\text{L}} = \mathbf{5.73\ mL}$$

IDEAL GAS LAW

$PV = nRT$ R = .08205Lat/moleK

$V = nRT/P$

CONCENTRATION UNITS

Molarity = M = moles solute/L solution

Molality = m = moles solute/kg solvent

Normality = N = equivalents solute/L solution

REDOX

equivalents/mole = ox.# change per formula

$$\underset{(-6)}{2Cr_2O_7^{2-}} + \underset{(+12)}{N_2H_5^+} \rightarrow 2\,NO_{2(g)} + 4Cr^{3+}$$

So $Na_2Cr_2O_7$ has 6 eq/mole and N_2H_5Cl has 12eq/mole here

ACID-BASE

eq/mole = # H^+ gained or lost per formula

$$NH_3 + H_3PO_3 \rightarrow NH_4^+ + HPO_3^{2-}$$

NH_3 has 1eq/mole and H_3PO_3 has 2eq/mole in this reaction

4. Titration of 35.00 mL of a $Ba(OH)_2$ solution requires 27.63 mL of 3.00 M N_2H_5Cl. What is the molarity of $Ba(OH)_2$ solution? What is its normality?

$$Ba(OH)_2 + 2\ N_2H_5Cl \rightarrow BaCl_2 + 2\ H_2O + 2\ N_2H_4$$

$$\frac{.02763L\ N_2H_5Cl}{.03500mLBa(OH)_2} \times \frac{3.00\ mole\ N_2H_5Cl}{L\ N_2H_5Cl} \times \frac{mole\ Ba(OH)_2}{2\ mole\ N_2H_5Cl} =$$

$= 1.18$ mole $Ba(OH)_2$/L$Ba(OH)_2$ or **1.18M**

$$\frac{1.18\ mole\ Ba(OH)_2}{L\ Ba(OH)_2} \times \frac{2eq\ Ba(OH)_2}{mole\ Ba(OH)_2} = \mathbf{2.36N}$$

5. When 250 g $CaCO_3$ and 300 mL 3.00M H_3PO_4 are mixed, how many L $CO_{2(g)}$ at 30.0°C and 700torr result?

$$3CaCO_3 + 2H_3PO_4 \rightarrow 3CO_{2(g)} + 3H_2O + Ca_3(PO_4)_2$$

$$250g\ CaCO_3 \times \frac{mole\ CaCO_3}{100\ g\ CaCO_3} \times \frac{3mole\ CO_2}{3mole\ CaCO_3} \times \frac{.08205Latm}{moleCO_2\ K} \times$$

$$\times \frac{303.15K}{700torr} \times \frac{760torr}{atm} = 67.4\ LCO_2$$

$$.300L\ H_3PO_4 \times \frac{3.00mole\ H_3PO_4}{L\ H_3PO_4} \times \frac{3mole\ CO_2}{2mole\ H_3PO_4} \times \frac{RT}{P} = \mathbf{36.5L}$$

HESS' LAW

Heats of combustion of ethanol (C_2H_5OH) and acetic anhydride ($C_4H_6O_3$) are 327.6 and 431.9 kcal/mole, respectively. Calculate the standard enthalpy change for:

$$2\ C_2H_5OH + 2\ O_{2(g)} \rightarrow C_4H_6O_3 + 3\ H_2O_{(l)}$$

$2\ C_2H_5OH + 6\ O_{2(g)} \rightarrow 4\ CO_{2(g)} + 6\ H_2O_{(l)}$ $\Delta H_1^o = 2(-327.6)$

$\underline{4\ CO_{2(g)} + 3\ H_2O \rightarrow C_4H_6O_3 + 4\ O_{2(g)}}$ $\Delta H_2^o = -1(-431.9)$

$\Delta H_{rxn}^o = -655.2-(-431.9) = -223.3$ kcal/mole rxn

ELECTROCHEM

1. For the voltaic cell:
   $Zn/Zn^{2+}(.200M)//Fe^{3+}(.500M),Fe^{2+}(.100M)/Pt$

a. Write anode, cathode, and cell reactions ($E^o = +\ 0.761v$ and $-0.771v$ for $Zn \rightarrow Zn^{2+}$ and $Fe^{2+} \rightarrow Fe^{3+}$, respectively).

   Anode: $Zn \rightarrow Zn^{2+} + 2e^-$
   Cathode: $Fe^{3+} + e^- \rightarrow Fe^{2+}$
   Cell: $Zn + 2\ Fe^{3+} \rightarrow Zn^{2+} + 2\ Fe^{2+}$

b. Calculate E^o and E for the cell.

   $E^o_{cell} = +0.761 - (-0.771) = \mathbf{+1.532v.}$

   $$E_{cell} = 1.532 - \frac{.0591}{n} \log\frac{[Zn^{2+}][Fe^{2+}]^2}{[Fe^{3+}]^2} =$$

   $$= 1.532 - (.0591/2)\log(.100)^2(.200)/(.500)^2 = \mathbf{+1.594v.}$$

c. If each electrode compartment contains 500mL of solution and the Zn electrode weighs 5.00g, how long can the cell operate at an average current of 2.00amp?

$\frac{.500\text{mole } Fe^{3+}}{\text{L solution}} \times \frac{\text{eq } Fe^{3+}}{\text{mole} Fe^{3+}} \times .500\text{L} = 0.250 \text{ eq } Fe^{3+}$

$5.00\text{gZn} \times \frac{\text{mole Zn}}{65.4\text{gZn}} \times \frac{2 \text{ eq Zn}}{\text{moleZn}} = 0.153 \text{ eq Zn}$

$.153 \text{ eq} \times \frac{96487 \text{ coul}}{\text{eq}} \times \frac{\text{second}}{2.00 \text{ coul}} = 7.38 \times 10^3 \text{ seconds}$

ACID-BASE EQUILIBRIA

1. Calculate the pH of 0.50M HF solution. $K_a = 7.1 \times 10^{-4}$.

   $HF + H_2O \leftrightarrow H_3O^+ + F^-$

   .50-x x x

   $K_a = 7.1 \times 10^{-4} = [H_3O^+][F^-]/[HF] = x^2/(.50-x)$

   $x = 1.85 \times 10^{-2}$ $pH = -\log[H_3O^+] = 1.73$

2. If 0.20 mole NaF is dissolved in 300.0mL 0.50M HF, what is the solution pH?

   $HF + H_2O \leftrightarrow H_3O^+ + F^-$

   .50-x x (.20/.300)+x

$7.1 \times 10^{-4} = [H_3O^+][F^-]/[HF] = x(.667+x)/(.50-x)$

$x = [H_3O^+] = 5.3 \text{ X } 10^{-4}$ pH = = 3.28