CHAPTER 4 LECTURE NOTES GENERAL CHEMISTRY

A SOLUTION IS A HOMOGENOUS MIXTURE OF TWO OR MORE SUBSTANCES

THE SOLVENT IS THE MAJOR COMPONENT

SOLUTE(S) ARE MINOR COMPONENTS

ELECTROLYTES ARE IONIC COMPOUNDS. SOLUTIONS OF ELECTROLYTES PRODUCE IONS, CONDUCT ELECTRICITY

$$NaCl_{(s)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$$

NONELECTROLYTES ARE MOLECULAR COMPOUNDS

SOLUTIONS OF NON ELECTROLYTES → NO IONS, NO CONDUCTION

$$C_6H_{12}O_{6(s)} \rightarrow C_6H_{12}O_{6(aq)} \quad \text{(SUGAR)}$$

WEAK ELECTROLYTES ARE MOLECULAR SUBSTANCES

THESE SOLUTIONS PRODUCE A FEW IONS

$$CH_3COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-_{(aq)}$$

REVERSIBLE REACTIONS LIKE THESE ARE EQUILIBRIA

PRECIPITATION REACTIONS

- PRODUCE INSOLUBLE IONIC SOLIDS

TO DETERMINE IF A COMPOUND IS SOLUBLE, USE THE SOLUBILITY RULES (TABLE 4.2, PAGE 98)

IONIC EQUATIONS, MOLECULAR EQUATIONS AND NET IONIC EQUATIONS

MOLECULAR → ALL MOLECULES

$$Pb(NO_3)_{2\,(AQ)} + 2KI_{(AQ)} \rightarrow PbI_{2\,(S)} + 2KNO_{3\,(AQ)}$$

IONIC → ALL IONS

$$Pb^{2+}_{(AQ)} + 2NO_3^-{}_{(AQ)} + 2K^+_{(AQ)} + 2I^-_{(AQ)} \rightarrow PbI_{2\,(S)} + 2K^+_{(AQ)} + 2NO_3^-{}_{(AQ)}$$

NET → PARTICIPANTS ONLY

$$Pb^{2+}_{(AQ)} + 2I^-_{(AQ)} \rightarrow PbI_{2\,(S)}$$

WHEN WRITING IONIC EQUATIONS

1) IS THERE AN INSOLUBLE SUBSTANCE?
   - CHECK THE RULES, TABLE 4.2
2) IDENTIFY AND CANCEL SPECTATOR IONS

ACIDS AND BASES

- ACIDS ARE COMPOUNDS THAT PRODUCE HYDROGEN ION $H^+_{(AQ)}$ (BRONSTED ACIDS)
  HYDROGEN ION IS "HYDRATED" $H_3O^+_{(AQ)}$ (HYDRONIUM)
- EITHER $H^+_{(AQ)}$ OR $H_3O^+_{(AQ)}$ MAY BE USED

ACIDS REACT WITH METALS TO PRODUCE $H_{2\,(g)}$

$$2HCl_{(AQ)} + 2Na^0_{(S)} \rightarrow 2NaCl_{(AQ)} + H_{2\,(g)}$$

ACIDS REACT WITH CARBONATES TO PRODUCE $CO_{2\,(g)}$

$$CaCO_{3\,(S)} + 2HCl_{(AQ)} \rightarrow CaCl_{2\,(AQ)} + H_2O_{(l)} + CO_{2\,(g)}$$

ONLY SIX ACIDS ARE STRONG ELECTROLYTES

HCl, HNO_3, H_2SO_4, HBr, HI, $HClO_3$

$$HCl_{(AQ)} \rightarrow H^+_{(AQ)} + Cl^-_{(AQ)}$$

H_2SO_4 IS DIPROTIC

$$H_2SO_{4(AQ)} \rightarrow H^+_{(AQ)} + HSO_4^-{}_{(AQ)}$$

$$HSO_4^-{}_{(AQ)} \rightleftharpoons H^+_{(AQ)} + SO_4^{=}{}_{(AQ)}$$

MOST ACIDS ARE WEAK ELECTROLYTES

$$CH_3COOH \rightleftharpoons H^+_{(AQ)} + CH_3COO^-_{(AQ)}$$

BASES

- PRODUCE HYDROXIDE ION $^-OH_{(AQ)}$

$$NaOH_{(AQ)} \rightarrow Na^+_{(AQ)} + {}^-OH_{(AQ)}$$

$$NH_{3(g)} + H_2O_{(l)} \rightarrow NH_4^+{}_{(AQ)} + {}^-OH_{(AQ)}$$

NEUTRALIZATION

ACID + BASE → WATER + SALT

$$HCl_{(AQ)} + NaOH_{(AQ)} \rightarrow NaCl_{(AQ)} + H_2O_{(l)}$$

NET IONIC EQUATION (Na^+ AND Cl^- ARE SPECTATORS)

$$H^+_{(AQ)} + {}^-OH_{(AQ)} \rightarrow H_2O_{(l)}$$

OXIDATION-REDUCTION REACTIONS (REDOX)

ELECTRONS ARE TRANSFERRED FROM ONE SPECIES TO ANOTHER

OXIDATION IS LOSS OF e^- OIL
REDUCTION IS GAIN OF e^- RIG

$$2\,Mg^0_{(s)} + O_{2(g)} \rightarrow 2\,MgO_{(s)}$$

HALF REACTIONS → 1 OXIDATION, 1 REDUCTION

$$2\,Mg^0 \rightarrow 2\,Mg^{2+} + 4e^- \quad \text{OXIDATION}$$

$$O_2 + 4e^- \rightarrow 2\,O^{2-} \quad \text{REDUCTION}$$

FOR MOLECULAR COMPOUNDS, USE OXIDATION NUMBERS

$$\overset{0}{H_{2(g)}} + \overset{0}{Cl_{2(g)}} \rightarrow \overset{+1\ -1}{2\,HCl_{(g)}}$$

AN INCREASE IN OXIDATION NUMBER = OXIDATION

A DECREASE IN OXIDATION NUMBER = REDUCTION

1) ELEMENTS = 0 $H_2 = 0$
2) MONATOMIC IONS = CHARGE $Cu^{2+} = 2$
3) OXYGEN = −2
4) HYDROGEN = +1 (EXCEPT METAL HYDRIDES)
5) THE SUM OF OXIDATION NUMBERS = 0

L_2O $L_i = +1$ $O = -2$ HNO_3 $H = +1$ $O = -2\,(-6)$ $N = +5$

$Cr_2O_7^{2-}$ $O = -2$ $Cr = 6^+$ $KMnO_4$ $K = +1$ $O = -2$ $Mn = +7$

COMMON REDOX REACTIONS

COMBINATIONS

$$\overset{0}{S}_{(s)} + \overset{0}{O}_{2(g)} \rightarrow \overset{+4\ -2}{SO_2}$$

DECOMPOSITIONS

$$2HgO_{(s)} \rightarrow 2Hg_{(\ell)} + O_{2(g)}$$

COMBUSTIONS

$$\overset{-4}{CH_4}{}_{(g)} + 2O_{2(g)} \rightarrow \overset{+4}{CO_2}{}_{(g)} + 2H_2O_{(\ell)}$$

DISPLACEMENTS

- HYDROGEN DISPLACEMENT

FROM WATER

$$2\overset{0}{Na}_{(s)} + 2H_2O_{(\ell)} \rightarrow 2\overset{+1\ -1}{NaOH}_{(AQ)} + \overset{0}{H_2}{}_{(g)}$$

FROM ACID

$$Zn_{(s)} + 2HCl_{(AQ)} \rightarrow ZnCl_{2(AQ)} + H_{2(g)}$$

- METAL DISPLACEMENT

$$\overset{0}{Zn}_{(s)} + CuSO_{4(AQ)} \rightarrow ZnSO_{4(AQ)} + Cu_{(s)}$$

NET

$$\overset{0}{Zn}_{(s)} + \overset{2+}{Cu}_{(AQ)} \rightarrow \overset{2+}{Zn}_{(AQ)} + Cu_{(s)}$$

THIS LEADS TO THE ACTIVITY SERIES OF THE METALS

CONCENTRATION OF SOLUTION

- EXPRESSED AS MOL/L (M) MOLAR

A SOLUTION PREPARED BY ADDING 0.400 MOL NaOH TO 0.500L H_2O HAS A MOLARITY OF

$$\frac{0.400 \text{ mol NaOH}}{0.500 \text{ L } H_2O} = 0.800 \text{ M NaOH}$$

A SOLUTION PREPARED BY ADDING 60.0g HF (MW = 20.0) TO 0.750L H_2O IS:

$$60.0 \text{ g HF} \times \frac{1 \text{ mol HF}}{20.0 \text{ g HF}} = \frac{3.00 \text{ mol HF}}{0.750 \text{ L}} = 4.00 \text{ M HF}$$

HOW MANY GRAMS OF GLUCOSE (MW = 180.2g) ARE PRESENT IN 0.450L OF 1.20 M GLUCOSE?

$$0.450 \text{ L soln} \times \frac{1.20 \text{ mol glucose}}{1 \text{ L soln}} \times \frac{180.2 \text{ g glucose}}{1 \text{ mol glucose}} = 97.3 \text{ g glucose}$$

NOTE: VOLUME × MOLARITY = MOL

$$L \times \frac{\text{MOL}}{L} = \text{MOL}$$

DILUTION

- SINCE NUMBER OF MOLES DOES NOT CHANGE,

$$V_1 M_1 = V_2 M_2$$

PREPARE: 0.521 L OF 0.150 M H_2SO_4 FROM 0.350 M H_2SO_4

$$V_2 = \frac{V_1 M_1}{M_2} = \frac{0.521 \text{ L} \times 0.150 \text{ mol}}{0.350 \frac{\text{mol}}{\text{L}}} = 0.223 \text{ L}$$

SO, DILUTE 0.223L OF 0.350M H_2SO_4 → 0.521 L

ACID / BASE NEUTRALIZATIONS

AN EXAMPLE OF SOLUTION STOICHIOMETRY

WHAT VOLUME OF 0.22 M NaOH WILL NEUTRALIZE 100.0 mL OF 0.57 M HCl

$$NaOH_{(AQ)} + HCl_{(AQ)} \rightarrow H_2O_{(l)} + NaCl_{(AQ)}$$

NOTE: WHEN THE MOLAR RATIO IS 1:1

$$V_1 M_1 = V_2 M_2$$

SO $100.0\,mL \times \frac{1\,L}{1000\,mL} \times \frac{0.57\,mol\,HCl}{L} = V_2 \times 0.22\,\frac{mol}{L}$

$$V_2 = \frac{.057\,mol}{0.22\,\frac{mol}{L}} = 0.259\,L\ NaOH$$

IF MOLAR RATIOS ARE NOT 1:1 THEN YOU MUST USE MOLE RATIO IN CALC

WHAT VOLUME OF 0.091 M NaOH NEUTRALIZES .025L OF 0.33 M H_2SO_4

$$H_2SO_{4(AQ)} + 2\,NaOH_{(AQ)} \rightarrow 2\,H_2O_{(l)} + Na_2SO_{4(AQ)}$$

$$.025\,L \times \frac{0.33\,mol\,H_2SO_4}{1\,L} \times \frac{2\,mol\,NaOH}{1\,mol\,H_2SO_4} \times \frac{1\,L}{.091\,mol\,NaOH} = 0.181\,L\ NaOH$$

CHECK

$$0.181\,L\ NaOH \times \frac{0.091\,mol\,NaOH}{1\,L\,NaOH} = 0.0165\,mol\,NaOH$$

$$.025\,L\ H_2SO_4 \times \frac{0.33\,mol\,H_2SO_4}{1\,L\,H_2SO_4} = 0.00825\,mol\,NaOH$$

THIS IS THE 2:1 MOL RATIO