Proton Transfer

$HCl_{(g)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$

HCl is losing H^+ H_2O is gaining H^+

Proton Transfer

$HCl_{(g)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$

HCl is losing H^+ H_2O is gaining H^+

ACID **BASE**

Proton Transfer

$NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$

NH_3 is gaining H^+ H_2O is losing H^+

Proton Transfer

$NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$

NH_3 is gaining H^+ H_2O is losing H^+

BASE **ACID**

Acid-Base Equilibria

$CH_3COOH + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$

$$K_{eq} = \frac{[H_3O^+]\,[CH_3COO^-]}{[CH_3COOH]}$$

Acid-Base Equilibria

$CH_3COOH + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$

$$1.8 \times 10^{-5} = \frac{[H_3O^+]\,[CH_3COO^-]}{[CH_3COOH]} = K_a$$

Acid Dissociation Constant

Acid Dissociation Constants

- Smaller number (larger exponent) = weaker acid

Name of acid	Formula	Ka
Hydrofluoric acid	HF	3.5×10^{-4}
Formic Acid	HCOOH	1.8×10^{-4}
Carbonic acid	H_2CO_3	4.3×10^{-7}
Phosphoric acid	H_3PO_4	7.5×10^{-3}
Benzoic Acid	C_6H_5COOH	6.4×10^{-5}

Strongest acid? Weakest acid?

Water Auto-Ionization

$2\,H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

$K_{eq} = [H_3O^+]\,[OH^-] = 1 \times 10^{-14} = K_w$

Water Auto-Ionization

$2\ H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

$K_{eq} = [H_3O^+]\ [OH^-] = 1 \times 10^{-14} = K_w$

$[H_3O^+] > 10^{-7}$ ACID

$[H_3O^+] < 10^{-7}$ BASE

pH

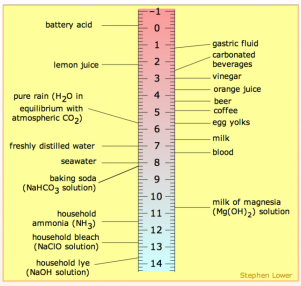
- Pouvoir hydrogène

$pH = -\log_{10}[H_3O^+]$

ACID pH < 7

BASE pH > 7

NEUTRAL pH = 7



pH

What is the pH of coffee if $[H_3O^+] = 1 \times 10^{-5}$?

pH

What is the pH of coffee if $[H_3O^+] = 1 \times 10^{-5}$?

$pH = -\log_{10}[H_3O^+]$

$= -\log_{10}(1 \times 10^{-5})$

$= 5$ **ACIDIC**

pH

What is the pH of coffee if $[H_3O^+] = 1 \times 10^{-5}$ M?

What is $[OH^-]$?

pH

What is the pH of coffee if $[H_3O^+] = 1 \times 10^{-5}$ M?

What is $[OH^-]$?

$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$

$[OH^-] = K_w / [H_3O^+] = 1 \times 10^{-14} / 10^{-5}$

$= 1 \times 10^{-9}$ M

pH and $[H_3O^+]$

- If the pH of drain cleaner is 11.2, what is $[H_3O^+]$?

pH and $[H_3O^+]$

- If the pH of drain cleaner is 11.2, what is $[H_3O^+]$?

$10^{-pH} = [H_3O^+]$

pH and $[H_3O^+]$

- If the pH of drain cleaner is 11.2, what is $[H_3O^+]$?

pH and $[H_3O^+]$

- If the pH of drain cleaner is 11.2, what is $[H_3O^+]$?

$pH = -\log_{10}[H_3O^+]$

$10^{-pH} = [H_3O^+] = 10^{-11.2}$

$= 6.3 \times 10^{-12}$ M

pH and $[H_3O^+]$

- What is the $[H_3O^+]$ for milk (pH = 6.4)?

pH and $[H_3O^+]$

- What is the $[H_3O^+]$ for milk (pH = 6.4)?

$pH = -\log[H_3O^+] = 6.4$

$[H_3O^+] = 10^{-pH} = 10^{-6.4} = 4 \times 10^{-7}$ M

Neutralization

- Acid + Base -----> H_2O + salt

H_2SO_4 + $Ba(OH)_2$ --> 2 H_2O + $BaSO_4$

Antacids

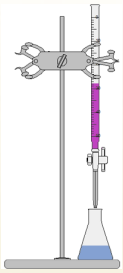
- Neutralizing excess stomach acid

$CaCO_3$ + 2 HCl -> H_2CO_3 + Ca^{2+} + 2 Cl^-

$H_2O + CO_2$

Titration

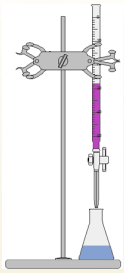
- Using neutralization to determine unknown concentration of acid or base



- Uses an indicator solution to signal when the
  - ENDPOINT is reached

Titration

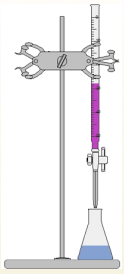
- Using neutralization to determine unknown concentration of acid or base

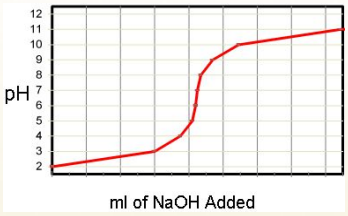


- 36 mL of 0.25 M HCl used to titrate 100 mL ? M KOH
- HCl + KOH ------> H_2O + KCl

Titration

- Adding base raises pH



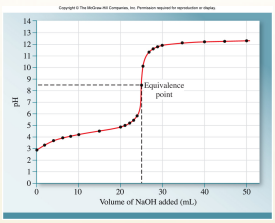


Titration

- At equivalence point:

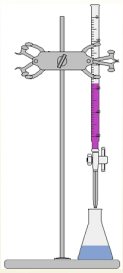
moles acid = moles base

$M_AV_A = M_BV_B$



Titration

- Using neutralization to determine unknown concentration of acid or base



36 mL of 0.25 M HCl used to titrate 100 mL ? M KOH

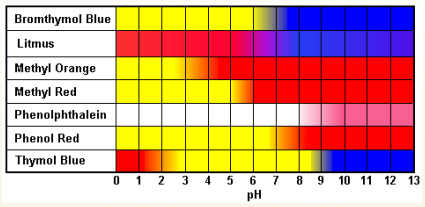
$M_{HCl}V_{HCl} = M_{KOH}V_{KOH}$

(0.036 L)(0.25 M) = 0.009 moles HCl
= 0.009 moles KOH

0.009 moles KOH/0.1 L = **0.09M KOH**

Indicators

- Choose indicator based on expected endpoint



Buffers

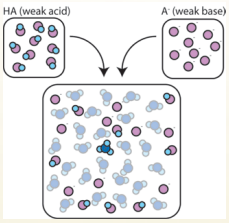
- Solution designed to resist pH change
- Combination of conjugate acid/base pair

Buffers

$HA + H_2O \rightleftharpoons H_3O^+ + A^-$

acid *hydronium* *conjugate base*

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

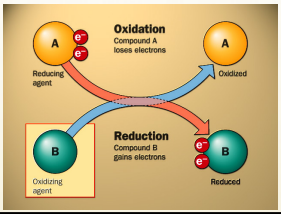


Oxidation-Reduction

Electron Transfer

Oxidation: electron loss X ----> $X^+ + e^-$

Reduction: electron gain $Y + e^-$ -------> Y^-



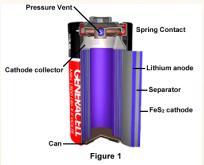
Oxidation-Reduction

Examples of redox reactions:

corrosion

biochemical

batteries



Electron Transfer

Oxidation and Reduction must occur together: Cu ----------> Cu^{2+} + $2e^-$

$2\,Ag^+ + 2e^-$ ----------> Ag

Formation of Silver Crystals

Electron Transfer

Oxidation and Reduction must occur together: Cu ----------> Cu^{2+} + $2e^-$ oxidation

$2\,Ag^+ + 2e^-$ ----------> Ag reduction

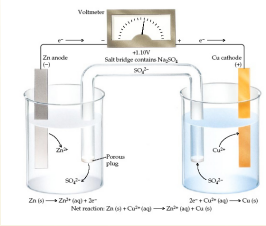
Formation of Silver Crystals

Electron Transfer

Voltaic Cells

Zn ----------> Zn^{2+} + $2e^-$ oxidation

Cu^{2+} + $2e^-$ ----------> Cu reduction

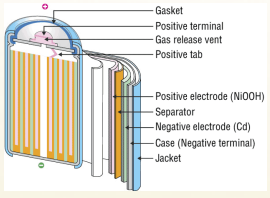


Batteries

Ni-Cad rechargeable batteries

Cd ----------> Cd^{2+} + $2e^-$ anode

Ni^{2+} + $2e^-$ ----------> Ni cathode

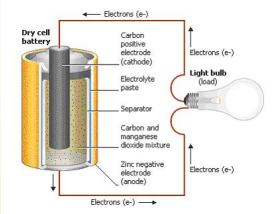


Batteries

Alkaline batteries:

Zn ----------> $Zn^{2+} + 2e^-$

$Mn^{4+} + 2e^-$ ----------> Mn^{2+}



Batteries

Lithium ion batteries:

$LiCoO_2$ ----------> $x\,Li^+ + Li_{1-x}CoO_2 + e^-$

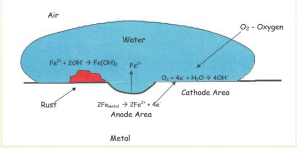
$Li^+ + LiCoO_2 + e^-$ ----------→ $Li_2O + CoO$

Corrosion

Destructive electron transfer

$2\,Fe$ ----------> $2\,Fe^{2+} + 4e^-$

$O_2 + 2\,H_2O + 4e^-$ ----→ $4\,OH^-$



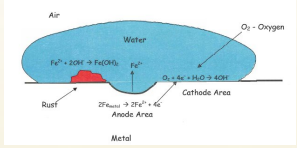
Corrosion

Destructive electron transfer

$2\,Fe$ ----------> $2\,Fe^{2+} + 4e^-$

$O_2 + 2\,H_2O + 4e^-$ ----→ $4\,OH^-$

Adding a zinc liner inhibits corrosion WHY?



Activity Series

Predicts the strength of metals as reducing agents or oxidizing agents

Metal	Oxidation Reaction
Lithium	$Li \rightarrow Li^+ + e^-$
Potassium	$K \rightarrow K^+ + e^-$
Barium	$Ba \rightarrow Ba^{2+} + 2e^-$
Calcium	$Ca \rightarrow Ca^{2+} + 2e^-$
Sodium	$Na \rightarrow Na^+ + e^-$
Magnesium	$Mg \rightarrow Mg^{2+} + 2e^-$
Aluminum	$Al \rightarrow Al^{3+} + 3e^-$
Zinc	$Zn \rightarrow Zn^{2+} + 2e^-$
Chromium	$Cr \rightarrow Cr^{3+} + 3e^-$
Iron	$Fe \rightarrow Fe^{2+} + 2e^-$
Cobalt	$Co \rightarrow Co^{2+} + 2e^-$
Nickel	$Ni \rightarrow Ni^{2+} + 2e^-$
Tin	$Sn \rightarrow Sn^{2+} + 2e^-$
Lead	$Pb \rightarrow Pb^{2+} + 2e^-$
Hydrogen	$H_2 \rightarrow 2H^+ + 2e^-$
Copper	$Cu \rightarrow Cu^{2+} + 2e^-$
Silver	$Ag \rightarrow Ag^+ + e^-$
Mercury	$Hg \rightarrow Hg^{2+} + 2e^-$
Platinum	$Pt \rightarrow Pt^{2+} + 2e^-$
Gold	$Au \rightarrow Au^{3+} + 3e^-$

Activity Series

Which metal will be oxidized? Which one reduced?

Al, Ni

Ag, Mg

Pb, K

Activity Series

Which metal will be oxidized? Which one reduced?

Al is oxidized, Ni is reduced

Mg is oxidized, Ag is reduced

K is oxidized, Pb is reduced

Unit 4 Review

- Types of Chemical Reactions
- Molarity
- Acid/Base $pH = -\log_{10}[H_3O+]$
- Acid/Base strength pKa
- Oxidation/Reduction
- Metal Activity Series

Unit 3 Review

- Electromagnetic Energy $\lambda \nu = c$, $E = h\nu$
- Electron configurations
- Periodic properties, ionization energy, size, electron affinity
- Valence Electrons, Lewis dot structures
- Molecular Shapes
- Polarity
- Gas Laws; Ideal Gas Law, Partial Pressures

Unit 2 Review

- Balancing chemical equations
- Types of chemical reactions
- Mass percent, empirical and molecular formulas
- Molecular mass and the mole
- Mole <–> gram conversions
- Reaction Stoichiometry; Yield; Limiting Reagent
- Energy of Reaction

Unit One Review

- Units of Measurements: SI units, interconversions
- Scientific Notation & Significant Figures
- Density
- Temperature Scales
- Elements, Compounds, Atoms
- Atomic symbols, atomic mass calculations
- Ions and Ionic Formulas, Names
- Molecular compounds and Formulas, names
- Acids and their names