

Q 1 mol = 22.4 L, speed of light =  $3 \times 10^8$  m/s, Planck's constant =  $6.626 \times 10^{-34}$  m<sup>2</sup>kg/s, Avogadro's Constant =  $6.022 \times 10^{23}$  mol<sup>-1</sup>, Faraday = 96,485 C/mol, TGMKhdhdbcmunpfa

Acid/Base equilibrium constants:  $K_a = \frac{[H^+][A^-]}{[HA]}$   $K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$ . pH =  $-\log[H^+]$ , pOH =  $-\log[OH^-]$ . pH + pOH = 14

The larger the  $K_a$ , the equilibrium is further to the right, so more ions are produced.

$K_w = [H^+][OH^-] = 10^{-14}$  at 25 degrees C =  $K_a \cdot K_b$

$\Delta G = -nFE^\circ$ , Nernst equation:  $E^\circ = \frac{0.0592}{n} \log K$ , Spectroscopy/emission:  $E = h\nu = \frac{hc}{\lambda}$  \*E is in Joules\*, relative

abundance:  $M_1 + M_2(1 - x) = ME$ ,  $Q = Sm\Delta T$ ,  $\Delta G = \Delta H - T\Delta S$ ,  $\Delta S > 0$ : more disorder,  $\Delta G > 0$ : not spontaneous

**Enthalpy:** Heat content of a system

**Entropy:** Disorder within a system

The **pKa** is the pH value where a species will accept or donate a proton. The lower the pKa, the stronger the acid. **pKa =**

**$-\log(K_a)$**  Acids low pH (battery acid, cola), Bases high pH (detergents, bleach).

Strong Acids: HCl, HI, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>, HBr, HClO<sub>4</sub> (perchloric acid), HClO<sub>3</sub> (chloric acid)

Important Weak Acids: H<sub>3</sub>PO<sub>4</sub> (phosphoric acid) > CH<sub>3</sub>COOH (acetic acid) > H<sub>2</sub>CO<sub>3</sub> (carbonic acid). Ascorbic acid:

C<sub>6</sub>H<sub>8</sub>O<sub>6</sub> -> used to treat scurvy, vitamin C deficiency, etc.

Carbonic acids have two pKas because there are 2 acidic hydrogens, but they disassociate at different times and pHs

Strong Bases: NaOH, KOH, LiOH

Limited solubility bases: Ca(OH)<sub>2</sub>, Mg(OH)<sub>2</sub>,

Weak Base: Ammonia: NH<sub>3</sub> is reacted with nitric acid for fertilizers and explosives, gas at STP

**Diprotic acids** are acids that yield 2 H<sup>+</sup> ions per acid molecule. I.e. H<sub>2</sub>SO<sub>4</sub>

**Polyprotic Acids** can donate more than one H<sup>+</sup> to the solution. 2nd dissociation is less than the 1st due to the presence of H<sup>+</sup>.  $K_a$  for the overall reaction is  $K_{a1} \cdot K_{a2}$

**Molarity:** mol/L

**Molality:** mol of solute/kg

**Mole Fraction:** Moles of solute/total moles of solution

**Solutes dissolve in solvents to form solutions.**

A Lewis acid: accepts e<sup>-</sup> pair. A Lewis base donates e<sup>-</sup> pair.

A Bronsted Lowry H<sup>+</sup> donator. The conjugate base is formed after the proton is donated. A Bronsted Lowry H<sup>+</sup> acceptor.

The stronger the acid, the weaker the conjugate base. Conjugate bases of strong acids are **spectator ions**.

An Arrhenius acid ↑[H<sup>+</sup>]. An Arrhenius base ↑[OH<sup>-</sup>].

Salts containing Group I elements (Li<sup>+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Cs<sup>+</sup>, Rb<sup>+</sup>) are soluble. There are a few exceptions to this rule. Salts containing the ammonium ion (NH<sub>4</sub><sup>+</sup>) or nitrate ion (NO<sub>3</sub><sup>-</sup>) are also soluble.

Salts containing Cl<sup>-</sup>, Br<sup>-</sup>, or I<sup>-</sup> are generally soluble. Important exceptions to this rule are halide salts of Ag<sup>+</sup>, Pb<sup>2+</sup>, and (Hg<sub>2</sub>)<sup>2+</sup>. Thus, AgCl, PbBr<sub>2</sub>, and Hg<sub>2</sub>Cl<sub>2</sub> are insoluble.

Most silver salts are insoluble. AgNO<sub>3</sub> and Ag(C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>) are common soluble salts of silver; virtually all others are insoluble.

Most sulfate salts are soluble. Important exceptions to this rule include CaSO<sub>4</sub>, BaSO<sub>4</sub>, PbSO<sub>4</sub>, Ag<sub>2</sub>SO<sub>4</sub> and SrSO<sub>4</sub>.

Most hydroxide salts are only slightly soluble. Hydroxide salts of Group I elements are soluble. Calcium and Barium are moderately soluble.

Chromates, phosphates, fluorides, and carbonates are insoluble. Sulfides of transition metals (FeS) are insoluble.

A **neutralization reaction** is when an acid and base react to form water and a salt.

**For strong acids and bases**, the concentration of [H<sup>+</sup>] or [OH<sup>-</sup>] is the same as the original acid or base. With Ca(OH)<sub>2</sub> (and similar ones) the concentration of OH<sup>-</sup> ions will be double the original

**For weak acids**, it is necessary to use  $K_a$  or  $K_b$ . HF:  $1 - x$ .  $H^+ = x$ ,  $F^- = x$ .  $K_a = x^2 / (1 - x)$

**The more electronegative the central atom and/or the more oxygen atoms, the stronger the acid.**

Aluminum forms a dative covalent bond, making it a lewis acid because it accepts an electron pair.

A **buffer** is a solution that contains large concentrations of a weak acid and its conjugate base.

There are two ways to make a buffer: conjugate acid/base pair, titrate a weak base or weak acid to the ½ way point

**Producing acids/bases:**

Cation of a strong base and anion of a strong acid are neutral

Cation of a strong base and anion of a weak acid are basic

Cation of a weak base and anion of a strong acid are acidic

If  $K_a > K_b$ , then acidic

Nonmetal (covalent) oxides produce acids in water

Metal (ionic) oxides produce bases in water

**Titration:** procedure which is used to determine the concentration of an acid or base using volumes or reactants. A measured volume of an acid or base of known concentration is reacted with a sample to the equivalence point.

**Equivalence point:** Moles Acid = moles Base (using the mole ratio)

**End point:** When indicator turns color. Indicators are chosen so that the end point is as close to the equivalence point as possible.

**Case 1:** Strong base titrated with strong acid. Check mole ratio and set moles of known equal to each other.

**Case 2:** Weak acid titrated with strong base. At the equivalence point, the reactants of  $[H^+]$  and  $[OH^-]$  are gone. There is a slightly basic solution. Calculate pH using the  $K_b$  expression.

**Case 3:** Weak base titrated with strong acid. Before equivalence point use  $K_b$ , after equivalence point use  $K_a$ . Graph steep vertically at the equivalence point downwards.

Alkaline solutions often feel slippery because they interact with skin oils, resulting in saponification (conversion to soap and alcohol)

**Colligative properties** are the physical changes that result from adding solute to a solvent. They must accurately describe ideal solutions where enthalpy change is 0 and all intermolecular actions are approximately equal. Colligative properties: boiling-point elevation, freezing-point depression, osmotic pressure (tendency of a solution to take in pure solvent by osmosis), solid-solute solubility, gas-solute solubility.

**Impure substances** tend to have a slightly lower melting point than a pure substance and a broader melting temperature range.

**Suspension** is a heterogeneous mixture of a fluid that contains solid particles large enough for sedimentation.

**Molarity to ppm:** Take molarity and multiply by molar mass to get g/L. Multiply that by 1000 to convert g to mg. PPM is mg/L.

Water is polar.

**Raoult's Law:** Vapor pressure of a solution = mole fraction of the solvent \* vapor pressure of the pure solvent. A positive deviation means that there is a higher than expected vapor pressure and is endothermic. A negative deviation means that there is a lower than expected vapor pressure. Ideal solutions follow Raoult's Law.

**Volatile:** Easily evaporated at normal temperatures

**Acid-Base Indicators:** pH Indicators that change color with changing pH. Usually weak acids or bases.  $K_{in}$  is indicator dissociation constant. Ex: Universal indicator is a mix of indicators that covers a wide pH range. **Thymol Blue - 1st change** - acid color: red, base color: yellow, pH range: 1.2 - 2.8, **Methyl Orange** - acid color: red, base color: yellow, pH range: 3.2 - 4.4, **Bromocresol Green** - acid color: yellow, base color: blue, pH range: 3.8 - 5.4, **Methyl Red** - acid color: yellow, base color: red, pH range: 4.8 - 6.0, **Bromothymol Blue** - acid color: yellow, base color: blue, pH range: 6.0 - 7.6, **Phenol Red** - acid color: yellow, base color: red, pH range: 6.8 - 8.4, **Thymol Blue - 2nd change** - acid color: yellow, base color: blue, pH range: 8.0 - 9.6, **Phenolphthalein** - acid color: colorless, base color: pink, pH range: 8.2 - 10