Acids and Bases

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**Acid Base Part I (8.1-8)**

**Arrhenius:**

**Acid**-- Substance that, when dissolved in water, increases in the concentration of hydrogen ions. pH<7.

**Base**-- Substance that, when dissolved in water, increases the concentration of hydroxide ions. pH>7.

**Bronsted-Lowry : BAAD**-- Acid: Proton donor \_ Base: Proton acceptor. (Protons refer to H+ ions.)

-If it can be either, it is amphiprotic. (Ex: HCO3-, HSO4-, H20… All have hydrogens to donate and a negative charge.)

-Acid (Remove H+) → Conjugate base \_ Base (Add H+) → Conjugate acid. (Example: HNO2(aq) **\*ACID\*** + H2O(l) **\*BASE\*** ←→ NO2-(aq) **\*CONJUGATE BASE\*** + H3O+(aq) **\*CONJUGATE ACID\***)

-Strong acids are completely dissociated in water. Their conjugate bases are weak. Weak acids only dissociate partially in water. Their conjugate bases are weak bases.

**Neutralization** **:** When substances neutralize, they lose their properties and the pH will equal 7. (Acid + Base → Salt + Water)

-Acids react with most metals. One hydrogen will be replaced by a more active metal. (Unreactive metals include Cu, Ag, and Au.) (Ex: 2HCl + Mg → MgCl2 + H2(g))

-The special equilibrium constant is the **ion-product constant for water**, Kw.

-(In pure water, Kw = [H3O+][OH-] = 1.0 x 10-14)

-The “p” in pH tells us to take the negative log of the quantity (in this case, hydrogen ions).

-pH = -log [H3O+] … pOH = -log [OH-] … pH + pOH = 14 … [H3O+][OH-] = 1.0 x 10x14 …

-Indicators (Ex: Litmus paper) to determine the pH, more accurate measurements with a pH meter

**Strong acids: HCl, HBr, HI, HNO3, H2SO4, H3PO4, and HClO4.**

**Strong bases: LiOH, NaOH, KOH, RbOH, CsOH, Ca(OH)2, and Ba(OH)2.** (pH = 14-(-log[OH-])

-Equilibrium expression = Products/Reactants (No solids/pure liquids) … The greater the Ka, stronger the acid. The strongest acids don’t report Ka values. **USE ICE BOX. Ka = x2/M TO SKIP.**

-Kb can be used to find [OH-] and, through it, pH of weak bases. **ICE BOX FOR pH, THEN SWITCH TO pOH.**

-**Ka x Kb = Kw = 1.0 x 10-14**

-If the difference between Ka for the first dissociation and subsequent Ka values is 10^3 or more, the pH generally depends *only* on the first dissociation.

-Ex: Calculate pH of 0.10M H2SO4 ionizing once … pH = -log(0.10) = 1.0

-Ex 2: Calculate pH of 0.10M H2SO4 ionizing fully … pH = -log(0.20) = 0.70

-Ex 3: Calculate the actual pH … Strong acid fully ionizes, weak acid ice box.

-Ex 4: Calculate the pH ionizing twice, with Ka1 and Ka2 … Ice box both OR add the second Ka value to your x!

-If pH decreases, then H+ increases, vise versa. (pH ↓ then H+ ↑ 10…) -The more polar the bond between H and its neighboring element, the more acidic the compound (it will lost H+ better because the other bond is more attracted).

-Across ( → ) a period and down a group = Increasing acid strength. Opposite = Increasing base strength.

-The more electronegative Y, the more acidic in oxyacids in which an OH is bonded to another atom, Y.

-Acidity increases with number of oxygens.

**Lewis Acid--** Electron pair acceptors … **Lewis Base--** Electron pair donors.

**\*SA + SB → Neutral salt … WA + SB → Basic salt … SA + WB → Acidic salt … WA + WB → Depends on Ka/b**

**Titration--** A known concentration of base/acid is slowly added to a solution of an unknown acid/base to determine its concentration. (Also known as **standardization** if a **primary standard**, a solid where the moles are constant, is used to determine the molarity of a substance.

**Equivalence Point (Neutralization Point)--** When the moles of acid equals that of base.

**Endpoint--** When the indicator actually changed color. **(You want your endpoint close to the equivalence point.)**

-You can use MaVa = MbVb **ONLY** at the equivalence point to determine molarity.

-Equivalence point of a SA and a SB = a pH of 7, the solution containing only a water and a salt.

**-Steps to find pH--** 1) Find moles of each reactant and subtract … 2) If nothing is left over, pH = 7 if SA/SB … If WA/WB, ICE BOX … 3) If acid/base are left over, divide left over by the **TOTAL** volume used. Then calculate pH (-log[H+]).

-If SA/SB was left, **divide by total L** … If WA/WB left, **Hasselbalch**

**Buffers--** Solutions of a **weak** conjugate acid-base pair. Resistant to pH changes. Used to maintain pH balances.

**\*ICE BOX CAN BE USED TO FIND pH\***

**Henderson-Hasselbalch Equation-- pH = pKa + log [salt]/[acid or base] … pOH = pKb + log [salt]/[acid or base]**

-If OH is added, it reacts with the **acidic** part of the buffer … If H+ is added, it reacts with the **basic** part of the buffer.

-WA + SB = Equivalence >7… WB + SA = Equivalence <7(Buffer regions)

**Half-Titration Point--** Amount of original acid equals the amount of conjugate base. **pH = pKa at ½ equivalence.**

-Organic acid: COOH . . . No organic bases.

-**\***Strength dependant on how much ions, concentration dependant on amount dissolved.

**Solubility product constants** are used to describe saturated solutions of ionic compounds of relatively low solubility. A saturated solution is in a state of dynamic equilibrium between the dissolved, dissociated, ionic compound and the undissolved solid. MxAy(s) --> x My+(aq) + y Ax-(aq) **\*Keep coefficients**

The general equilibrium constant for such processes can be written as: Kc = [My+]x[Ax-]y

Ex:PbCl2(s) --> Pb2+(aq) + 2 Cl-(aq) Ksp = [Pb2+][Cl-]2  … Non-metal oxide = Acid … Metal oxide = Base.

**Questions:**

**1)** What is the concentration of H+ ions of a solution with a pH of 4? **Answer:** 1 x 10-4

**2)** What is the pH of a strong acid with a concentration of 0.025M? **Answer:** 1.60

**3)** Calculate the Ka of 2.0M acid with a pH of 5.45. **Answer:** (Ka = 6.3 x 10-12)

**4)** Calculate the pH of 0.10M H2SO assuming it ionizes twice, Ka1= 1.7 x 10-2 and Ka2 = 6.4 x 10-8.

**Answer:** 2.77

**5)** What is a conjugate acid of HSO4-? **Answer:** H2SO4

**6)** Calculate the pH when 25.0mL of 0.10M HCl is titrated with 10.mL of 0.10M NaOH. **Answer:** 1.37

**7)** Calculate the pH of a buffer using 0.20M HF and 0.10M NaF. Ka = 6.8 x 10-4 **Answer:** 2.87

**Acid Base Part II (8.9-11)**

** ACID-BASE PROPERTIES OF SALTS: HYDROLYSIS (Splitting of water)**

Salts are produced when an acid and base react. Some hydrolyze with water to produce aqueous solutions with pHs other than 7.00.

**Neutral Salts**-- formed from the cation of a strong base reacting with the anion of a strong acid are neutral. Beware of solubility issues! If both the acid and base are strong, then the salt is neutral.

**Basic Salts**--formed from the cation of a strong base reacting with the anion of a weak acid are basic. Again, beware of solubility issues! The anion hydrolyzes the water molecule to produce hydroxide ions and thus a basic solution. **USE ICEBOX**

**Acidic Salts**- Salts that are formed from the cation of a weak base reacting with the anion of a strong acid are acidic. The cation hydrolyzes the water molecule to produce hydronium ions and thus an acidic solution. **USE ICEBOX**

**Questions**

1)Calculate the pH of a 0.30 M NaF solution. The Ka value for HF is 7.2 × 10−4 . ***(pH = 8.31)***

2) Calculate the pH of a 0.010 M AlCl3 solution. The Ka value for Al(H2O)6 3+ is 1.4 × 10−5 . ***(pH = 3.43)***

**The equilibrium constant, the Ksp,** is no more than the product of the ions in solution. (Remember, solids do not appear in equilibrium expressions.) For a saturated solution of AgCl, the equation would be: AgCl(s) Ag+ (aq) + Cl− (aq) . The solubility product expression for the AgCl(s) precipitate would be: Ksp = [Ag+ ][Cl− ]

**Questions**

1)Copper(I) bromide has a measured solubility of 2.0 × 10−4 mol/L at 25°C. Calculate its Ksp value.***( = 4.0 × 10−8)***

2)The Ksp value for copper(II) iodate, Cu(IO3)2, is 1.4 × 10−7 at 25°C. Calculate its solubility at 25°C. ***(= 3.3 × 10−3)***

3)Calculate the solubility of solid CaF2 (Ksp = 4.0 × 10−11) in a 0.025 M NaF solution. ***(= 6.4 × 10-8 mol/L)***

**Ksp AND THE REACTION QUOTIENT, Q** with the reaction quotient, we can decide whether a precipitate (ppt) will form AND what concentrations of ions are required to begin the precipitation of an insoluble salt.

1. Q < Ksp, the system is not at equil. (unsaturated)

2. Q = Ksp, the system is at equil. (saturated)

3. Q > Ksp, the system is not at equil. (supersaturated)(precipitates form )

**Questions:**

1) A solution is prepared by mixing 150.0 mL of 1.00 × 10-2 M Mg(NO3)2 and 250.0 mL of 1.00 × 10−1 M NaF. Calculate the concentrations of Mg2+ and F− at equilibrium with solid MgF2 (Ksp = 6.4 × 10−9 ). ***([Mg2+] = 2.1 × 10-6 M [F- ] = 5.50 × 10-2 M)***

**Factors Affecting Solubility** (**The Common-Ion Effect)**◦If one of the ions in a solution equilibrium is already dissolved in the solution, the equilibrium will shift to the left and the solubility of the salt will decrease.

**Complex Ions**◦Metal ions can act as Lewis acids and form complex ions with Lewis bases in the solvent.The formation of these complex ions increases the solubility of these salts. The higher the Kf, the more stable the ion is, and the more soluble the substance is.

**Double the charge on the cation to find how many anions will bond to it.(Co+2 + 4Cl- à CoCl4-2)**

**Questions.**

**1.Zinc (I) ions react with excess ammonia**



**2.Silver ions react with excess cyanide ions**



**3.Cobalt (III) ions are placed in a solution of ammonia.**





 **Polyprotic Acid Weak Base vs. Weak Strong Acid**

 **Weak Acid Vs. Strong Base … pKa=pH at equivalence point**

 **(Look at curves for bump buffer and inital pH.)**

 **Molar mass of acid: g/mol.**

**Multiple Choice Questions**

1. **A buffer with a pH of 10.0 is needed. Which of the following should be used?**
2. Ethanoic acid with a ka of 1.8 x 10-5

(b) Ammonia with a kb of 1.8 x 10 -5

 (c) Nitrous acid with a ka of 7.1 x 10-4

 (d) H2PO43- and PO43- with a ka of 4.5 x 10-13

 **2. pH is equal to pka**

1. When [conjugate acid] = [conjugate base]
2. At the end point of a titration
3. In the buffer region
4. In the Henderson-Hasselbach equation

 **3. The pH of a 1.23 x 10 -3 M solution of Ba(OH)2 aqueous solution is**

1. 2.61
2. 2.43
3. 11.39
4. 13.52

 **4. An indicator has a ka of 6.4 x 10 -6 , the conjugate acid is red, and the conjugate base is yellow. At what pH will the solution be red?**

1. 5.2
2. 5.5
3. 4.0
4. 4.7

 **5. What is the pH of a 0.100 M solution of K2HPO4 ? (For H3PO4, pK1 = 2.15, pK2 = 7.2, pK3 = 12.35.)**

1. 1.00
2. 13.00
3. 9.78
4. 6.67

 **6. If 50.0 g of formic acid (HCHO2** **, Ka = 1.8 x 10-4  ) and 30.0 g of sodium formate (NaCHO2) are dissolved to make 500 mL of solution, the pH of this solution is**

1. 4.76
2. 3.76
3. 3.35
4. 4.12

**7. If 50.0 mL of 0.0134 M HCl solution is mixed with 24.0 mL of a 0.0250 M NaOH solution, what is the pH of the final mixture?**

1. 1.87
2. 12.40
3. 5.29
4. 3.02

**8. A 40.0 amp current flowed through molten iron(III) chloride for 10.0 hours (36,000 s). Determine the mass of iron and the volume of chlorine gas (measured at 25oC and 1 atm) that is produced during this time.**

(Answers: 1 (b), 2 (a), 3 (c) , 4 (c), 5 (c), 6 (c), 7 (d) 8) 278 g Fe, 182 L Cl2)

**\*Electrolysis** involves passing an electric current through either a molten salt or an ionic solution. The ions are "forced" to undergo either oxidation (at the anode) or reduction (at the cathode). The quantities of substances produced or consumed by the electrolysis process is dependent upon the following:

* electric current measured in amperes or amps
* time measured in seconds
* the number of electrons required to produce or consume 1 mole of the substance

Three equations relate these quantities:

* amperes x time = Coulombs
* 96,485 coulombs = 1 Faraday
* 1 Faraday = 1 mole of electrons

To determine the quantity of substance either produced or consumed during electrolysis given the time a known current flowed::

* Write the balanced half-reactions involved.
* Calculate the number of moles of electrons that were transferred.
* Calculate the number of moles of substance that was produced/consumed at the electrode.
* Convert the moles of substance to desired units of measure.

To determine the quantity of time required to produce a known quantity of a substance given the amount of current that flowed:

* Find the quantity of substance produced/consumed in moles.
* Write the balanced half-reaction involved.
* Calculate the number of moles of electrons required.
* Convert the moles of electrons into coulombs.
* Calculate the time required.

To determine the amount of current necessary to produce a known quantity of substance in a given amount of time:

* Find the quantity of substance produced/or consumed in moles.
* Write the equation for the half-reaction taking place.
* Calculate the number of moles of electrons required.
* Convert the moles of electrons into coulombs of charge.
* Calculate the current required