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| **The pH of Aqueous Salt Solutions** |
| Image result for pH**Key Concepts**   * A salt is a chemical compound formed from the reaction of an acid with a base.  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **acid** | **+** | **base** | **→** | **salt** | **+** | **water** |  * A salt consists of a positive ion from the base and a negative ion from the acid. * When dissolved in water a soluble salt will undergo a **dissociation reaction**   Example:  A **dissociation reaction** is a chemical **reaction** in which a compound breaks apart into two or more parts. The general formula for a **dissociation reaction** follows the form:  AB → A + B  **Hydrolysis** is a **reaction** involving the breaking of a bond in a molecule using water.  NaCl(s) 🡪 Na+(aq) + Cl-(aq)   * The cations and anions may react with the water to produce H3O+ or OH- ions. This type of reaction is called a **hydrolysis reaction**.   Examples:  CH3COO- (aq) + H2O(l) ⇋ CH3COOH(aq) + OH-(aq)  NH4+(aq) + H2O(l) ⇋ NH3(aq) + H3O+(aq)   * Only ions from weak acids and bases will undergo hydrolysis, any ions derived from strong acids and bases do not react with water and therefore do not affect pH * When an ion undergoes hydrolysis, the resulting solution may become acidic or basic. * The relative strength of the acid and base used to produce the salt can be used to determine if the aqueous salt solution is acidic, basic, or remains neutral.  |  |  |  | | --- | --- | --- | | **aqueous solutions** | **strong acid** | **weak acid** | | **strong base** | neutral salt | basic salt | | **weak base** | acidic salt | " neutral salt" \* |   **\*dependent on the relative strength of the acid and base**  If the acid is stronger than the base, the salt solution will be acidic (pH < 7).  If the base is stronger than the acid, the salt solution will be basic (pH > 7).  If the acid and base are of equal strength, the salt solution will be neutral (pH = 7).    **Sample Questions**   1. Is an aqueous solution of sodium chloride, NaCl (aq), acidic, basic, or neutral? 2. Use the formula of the salt to decide which acid and which base could be used to produce the ions.   NaCl dissociates to Na+ and Cl-  The negative ion (anion), Cl-, comes from the acid HCl, hydrochloric acid.  The positive ion (cation), Na+, comes from the base, NaOH, sodium hydroxide.   1. Determine the relative strengths of the acid and the base used.   Hydrochloric acid, HCl, is a [strong acid](http://www.ausetute.com.au/acidstrength.html) Sodium hydroxide, NaOH, is a [strong base](http://www.ausetute.com.au/basestrength.html)   1. Determine the acidity (alkalinity) of the salt solution.   strong acid + strong base → neutral salt + water  NaCl(aq) is a neutral solution  Explanation:  Both ions are from a strong acid or base, therefore, neither ion will react with water   1. Is the pH of an aqueous solution of potassium ethanoate, KCH3COO (aq), equal to 7, less than 7 or greater than 7?   KCH3COO dissociates to K+ and CH3COO-  The positive ion, K+, comes from the strong base, KOH, potassium hydroxide. The negative ion, CH3COO-, comes from the weak acid, CH3COOH, ethanoic acid.  weak acid + strong base → basic salt + water  KCH3COO (aq) will have a pH greater than 7  Explanation:  The K+ ion is from a strong base and has no effect. The CH3COO- ion is the conjugate base of a weak acid and will react with water to produce OH- ions  CH3COO- (aq) + H2O (l) 🡪 CH3COOH(aq) + OH-(aq)   1. Is an aqueous solution of ammonium nitrate, NH4NO3(aq), acidic, basic, or neutral?   NH4NO3 dissociates to NH4+ and NO3- The negative ion, NO3--, comes from the strong acid, HNO3, nitric acid.  The positive ion, NH4+, comes from the weak base, NH3, ammonia.  Strong acid + weak base → acidic salt + water  NH4NO3aq) will be an acidic solution.  Explanation:  The NO3- ion is from a strong acid (HNO3) and therefore has no effect. The NH4+- ion is the conjugate acid of a weak base (NH3) and will react with water to produce H3O+ ions  NH4+ (aq) + H2O(l) 🡪 NH3(aq) + H3O+(aq)   1. What is the pH of an ammonium ethanoate, NH4CH3COO, solution?   NH4CH3COO dissociates into NH4+ and CH3COO- ions  The positive ion, NH4+, comes from the weak base NH3, ammonia.  The negative ion, CH3COO-, comes from the weak acid, CH3COOH, ethanoic acid.  weak acid + weak base → neutral salt + water  NH4CH3COO(aq) will be a neutral solution.  Explanation:  Both ions will react with water  NH4+ (aq) + H2O(l) ⇋ NH3(aq) + H3O+(aq) K = 5.65 x 10–10  CH3COO- (aq) + H2O (l) ⇋ CH3COOH(aq) + OH-(aq) K = 5.60 x 10-10  Since the equilibrium constants are nearly identical, equal amounts of H3O+ and OH- are produced. These ions will react with each other, resulting in a neutral solution of pH 7.  H3O+(aq) + OH-(aq) ⇋ 2H2O(l)  The accurate pH on salts derived from a weak acid and weak base depends on the “relative strengths” of the weak acid and weak base.  **Amphoteric Ions**  Amphoteric ions are ions that can act as acids and bases.  To determine the pH of a salt containing an amphoteric ion (e.g. HCO3-) you need to compare the equilibrium constants of both reactions to determine which reaction will be dominant.  For example, what is the pH of a sodium hydrogencarbonate, NaHCO3 solution?    The first reaction occurs to a greater extent than the second does. Therefore, there will be more OH- produced than H3O+.  The Na+ ion is from a strong base (NaOH), and does not react with water.  A sodium hydrogencarbonate solution would therefore be basic.  Image result for unsure**Which Acids and Bases are Strong?**  **Strong Acids**  Strong acids completely ionise in water, forming H3O+ and an anion. There are six strong acids. The others are considered weak acids.  Common strong acids   * HCl - hydrochloric acid * HNO3 - nitric acid * H2SO4 - sulfuric acid   Less common strong acids   * HBr - hydrobromic acid * HI - hydroiodic acid * HClO4 - perchloric acid   **Strong Bases**  Strong bases are bases that completely dissociate in water into the cation and OH- (hydroxide ion). The hydroxides of the Group I and Group II metals usually are considered strong bases.  Here is a list of the most common strong bases.   * LiOH - lithium hydroxide * NaOH - sodium hydroxide * KOH - potassium hydroxide * RbOH - rubidium hydroxide * Image result for mad chemist cartoonCsOH - cesium hydroxide * \*Ca(OH)2 - calcium hydroxide * \*Sr(OH)2 - strontium hydroxide * \*Ba(OH)2 - barium hydroxide   \* These bases completely dissociate, however, they are only slightly soluble and can only produce solutions of 0.3 mol L-1 or less. The other strong bases, can form solutions of 1.0 mol L-1 or greater and completely dissociate potentially producing solutions of very high pH.  There are other strong bases than those listed, but they are not often encountered. |