Salty Salts

To know if a salt will affect pH, determine: → Will the salt ions will hydrolyze (or split) water?

Conjugates of Strong **Acids/Bases:** do Not hydrolyze water, and thus do NoT affect pH

Conjugates of Weak **Acids/Bases:** do hydrolyze water, and thus do affect pH!

How to Determine the pH of a Salt	Example
1. Dissociate your salt.	$CaSO_3 \rightarrow Ca^{2+} + SO_3^{2-}$
Make the cation into a base : is it strong or weak?	$Ca^{2+} + 2\ OH^- \rightarrow Ca(OH)_2$ **Strong base**
Make the anion into an acid : is it strong or weak?	$H^+ + SO_3^- \rightarrow HSO_3^-$ **Weak acid**
2. **Strong wins!**	SB + WA, so this salt is basic!
3. If either is weak, write the hydrolysis reaction:	$SO_3^- + H_2O \rightleftharpoons OH^- + HSO_3^-$

Conjugate base of WA: $A^- + H_2O \rightleftharpoons OH^- + HA$

Conjugate acid of WB: $BH^+ + H_2O \rightleftharpoons H_3O^+ + B$

4. Use your hydrolysis equation to calculate the pH using the **Weak Acids/Bases** method.

Be careful. Did the problem give you K_a, or K_b instead? Do you need to convert based on your hydrolysis reaction? Remember: $K_w = K_a \times K_b = 1.0 \times 10^{-14}$

Practice: Identify the salt solutions below as acidic, basic, or neutral and justify your answer.

Salt	Parents	Acidic, basic, or neutral?	Justify your answer.
KCl Ions? K^+, Cl^-	Parent acid: HCl = strong Parent base: KOH = strong	neutral	Neither the conjugate base of a strong acid (Cl^-) nor the conjugate acid of a strong base (K^+) will hydrolyze water, so pH is unaffected.
NH_4Cl Ions? NH_4^+, Cl^-	Parent acid: HCl = strong Parent base: NH_3 = weak	acidic	The conjugate base of a strong acid (Cl^-) will not hydrolyze H_2O + will not affect pH, but the conjugate acid of a weak base will hydrolyze H_2O + produce a sol'n w/ pH < 7: $NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$

pH vs pK_a: Which form dominates?

Given the generic weak acid reaction: $HA(aq) + H_2O(l) \rightleftharpoons A^-(aq) + H_3O^+$

- **$pH \le pK_a$** the acid form (HA) predominates (plenty of H^+ present in solution)
- **$pH > pK_a$** the conjugate base form (A^-) predominates (not enough H^+ present in solution)

Let's Practice! (2016 #4, 4 points)

$$C_6H_5OH(aq) + H_2O(l) \rightleftarrows C_6H_5O^-(aq) + H_3O^+(aq) \qquad K_a = 1.12 \times 10^{-10}$$

Phenol is a weak acid that partially dissociates in water according to the equation above.

a. What is the pH of a 0.75 M $C_6H_5OH(aq)$ solution?

b. For a certain reaction involving $C_6H_5OH(aq)$ to proceed at a significant rate, the phenol must be primarily in its deprotonated form, $C_6H_5O^-(aq)$. In order to ensure that the $C_6H_5OH(aq)$ is deprotonated, the reaction must be conducted in a buffered solution. On the number scale below, circle each pH for which more than 50 percent of the phenol molecules are in the deprotonated form ($C_6H_5O^-(aq)$). Justify your answer.

1 2 3 4 5 6 7 8 9 10 11 12 13 14

(a) $K_a = \frac{[C_6H_5O^-][H_3O^+]}{[C_6H_5OH]} = \frac{x^2}{\underbrace{0.75 - x}_{\text{Assume } x \ll 0.75}} = 1.12E{-10}$

$x = \sqrt{(1.12E{-10})(0.75)} = 9.2E{-6} = [H_3O^+]$

$pH = -\log(9.2E{-6}) = \boxed{5.04}$

(b) for deprotonated form to dominate ⇒ $pH > pK_a$

$pK_a = -\log(1.12E{-10}) = 9.951$