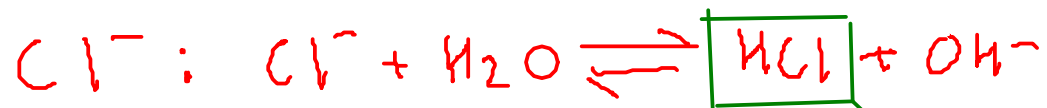


0.100 M NH_4Cl ... Find the pH of the solution

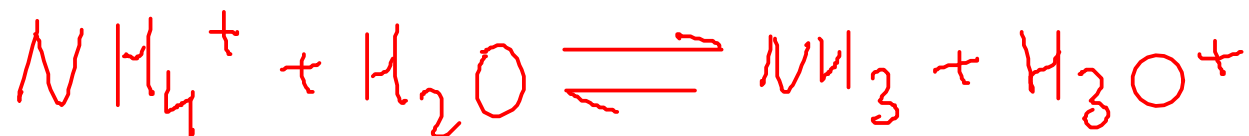


This is the WEAK BASE ammonia. Stable in water



This is a STRONG ACID (hydrochloric acid), which means that it doesn't exist in the molecular form in water. In other words, this product isn't stable - it will lose the hydrogen again. Therefore, chloride ion is NOT a base.

We have two possible equilibria here, but only one is important. The ammonium ion will act as an acid in water, and the chloride ion will be neutral (won't affect pH). We need to solve:





$$K_a, \text{NH}_4^+ = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]}$$

We can get K_a for ammonium from K_b for its conjugate, ammonia:

$$K_b, \text{NH}_3 = 1.8 \times 10^{-5}$$

$$K_a + K_b = 1.0 \times 10^{-14}$$

$$\text{So, } K_a = 5.56 \times 10^{-10}$$

Species	[Initial]	Δ	[Equil.]
NH_3	0	+x	x
H_3O^+	0	+x	x
NH_4^+	0.100	-x	0.100 - x

$$\frac{x^2}{0.100 - x} = 5.56 \times 10^{-10}$$

$$\begin{array}{l} x \ll 0.100 \\ \downarrow \\ 0.100 - x \approx 0.100 \end{array}$$

$$\frac{x^2}{0.100} = 5.56 \times 10^{-10}$$

$$x = 7.45 \times 10^{-6}$$

$$\text{So, } [\text{H}_3\text{O}^+] = 7.46 \times 10^{-6}$$

$$\text{pH} = 5.13$$

Compare:

pH = 1.00 for 0.100 M strong acid

pH = 2.16 for 0.100 M weak acid (nitrous acid)

pH = 7.00 for distilled water

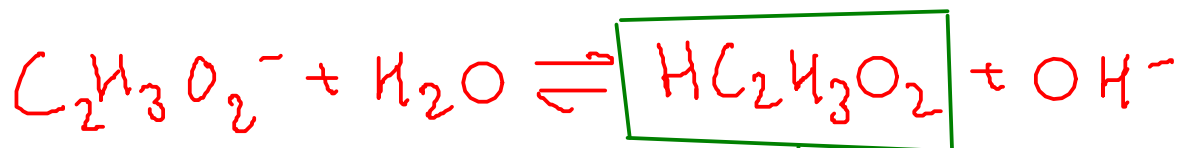
0.100 M $\text{NaC}_2\text{H}_3\text{O}_2$, Find pH



Check the ions formed by the salt to see if there's an acid or a base.

Na^+ : Not a B-L acid, since it has no protons to donate. Unlikely to be as base, since it has a positive charge. We expect sodium ion to be neutral.

$\text{C}_2\text{H}_3\text{O}_2^-$: Has hydrogens, but also a negative charge. It's PROBABLY a proton acceptor rather than a donor due to the negative charge.

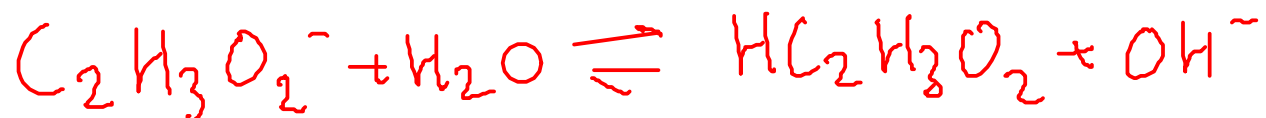


Acetic acid. Acetic acid is a WEAK ACID and stable in water. We expect the ACETATE ION to function as a base.

$$K_{b, \text{C}_2\text{H}_3\text{O}_2^-} = \frac{[\text{HC}_2\text{H}_3\text{O}_2][\text{OH}^-]}{[\text{C}_2\text{H}_3\text{O}_2^-]}$$

As expected, K_b for acetate ion is not available on the chart on page A-14. . But we can find K_a for acetic acid (the conjugate of acetate ion) on the previous page.

$$K_{a, \text{HC}_2\text{H}_3\text{O}_2} = 1.7 \times 10^{-5}; \quad K_a \times K_b = 1.0 \times 10^{-14}; \quad K_b = 5.88 \times 10^{-10}$$



$$K_b, \text{C}_2\text{H}_3\text{O}_2^- = 5.88 \times 10^{-10} = \frac{[\text{HC}_2\text{H}_3\text{O}_2][\text{OH}^-]}{[\text{C}_2\text{H}_3\text{O}_2^-]}$$

Species	[Initial]	Δ	[Equil.]
$\text{HC}_2\text{H}_3\text{O}_2$	0	+x	x
OH^-	0	+x	x
$\text{C}_2\text{H}_3\text{O}_2^-$	0.100	-x	0.100

$$\frac{x^2}{0.100 - x} = 5.88 \times 10^{-10}$$

$x \ll 0.100$
 $0.100 - x \approx 0.100$

$$\frac{x^2}{0.100} = 5.88 \times 10^{-10}$$

$$x = 7.67 \times 10^{-6} = [\text{OH}^-]$$

We need pH, but remember that we have calculated the HYDROXIDE concentration!

$$\text{pOH} = -\log_{10}(7.67 \times 10^{-6})$$

$$\text{pOH} = 5.12$$

$$pOH = 5.12$$

$$pH + pOH = 14.00$$

$$pH = 8.88$$

Compare:

pH = 7.00 for pure distilled water

pH = 11.13 for 0.100 M ammonia

pH = 13.00 for 0.100 M NaOH (strong base)

0.100 M NaCl, Find pH



As before, let's check the ions to see whether either of them have acidic or basic properties

Na^+ : Not B-L acid, and unlikely to be B-L base due to the positive charge. It's a simple - neutral - alkali metal ion.

Cl^- : Not a B-L acid, since it has no protons to donate. It MIGHT be a proton acceptor, but as we see below that's not very likely.



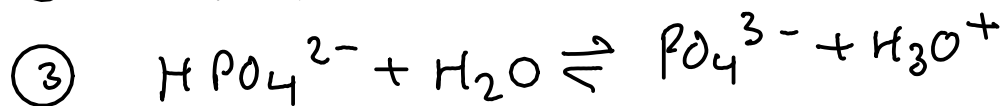
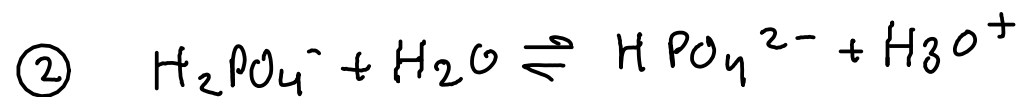
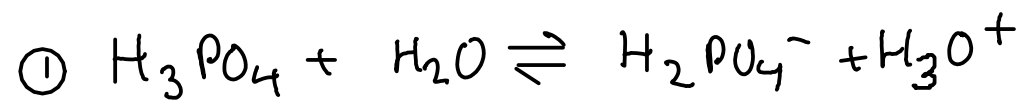
This is hydrochloric acid, a strong acid. If completely ionizes in water, meaning that the chloride ion can't be a very good proton acceptor!

... so chloride ion is NEUTRAL

Since neither sodium ion nor chloride ion affect the water equilibrium, the pH of the solution will be the same as that of pure water: 7.00

Find pH of 0.10 M H_3PO_4

... what's special about phosphoric acid?



Phosphoric acid has THREE acidic protons!

$$K_{a1} = 6.9 \times 10^{-3}$$

$$K_{a2} = 6.2 \times 10^{-8}$$

$$K_{a3} = 4.8 \times 10^{-13}$$

The first dissociation is dominant here, and for simple calculations of phosphoric acid in water, we will simply use the first ionization and ignore the other two.

Remember: This is a weak acid. It exists in water mostly as undissociated phosphoric acid molecules.