Acid Base Equilibria Problem Set

I. Acids, Bases, Salts, pH (you may need to look up Ka and/or Kb value in your book

Hydrolysis reactions:

- Write the general hydrolysis rxn for HA:

$$HA_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$$

- Write the general hydrolysis rxn for A-:

$$A^-_{(aq)} + H_2O \rightleftharpoons OH^-_{(aq)} + HA_{(aq)}$$

- Some compounds are added to water to make solutions. Fill in the table with the requested information about the resulting solutions. (HSO_4^-, H_2CO_3, NH_4^+, HF are all weak acids)

Compound	Ions present	Spectator ions	Ions that hydrolyze to affect pH	pH (<7, 7, >7)	Net ionic equation to explain pH
Na_2SO_4	$2Na^+$ SO_4^{2-}	Na^+	SO_4^{2-}	7	$SO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HSO_4^-{}_{(aq)} + OH^-$
Na_2CO_3	$2Na^+$ CO_3^{2-}	Na^+	CO_3^{2-}	7	$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^- + OH^-$
NaCl	Na^+ Cl^-	Na^+ Cl^-	none	7	$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$
NH_4NO_3	NH_4^+ NO_3^-	NO_3^-	NH_4^+	7	$NH_4^+{}_{(aq)} + H_2O \rightleftharpoons H_3O^+_{(aq)} + NH_3$
NaF	Na^+ F^-	Na^+	F^-	7	$F^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HF_{(aq)} + OH^-_{(aq)}$
$(NH_4)_2CO_3$	NH_4^+ CO_3^{2-}	none	$2NH_4^+$ CO_3^{2-}	7	$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^- + OH^-_{(aq)}$

NH_4^+ $K_a = 5.6 \times 10^{-10}$

$K_b = 2 \times 10^{-4}$

II. Why it is, if you need a little bit of OH^- in a solution, that it's smart to use $NH_3(aq)$ instead of NaOH as your source of OH^-? Support your answer with appropriate hydrolysis equations.

1.0 M NaOH vs. 1.0 M NH_3

100% ionized — weaker

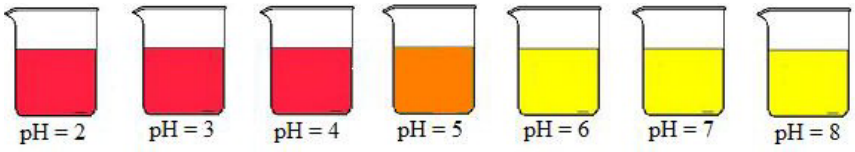
1.0 M $[OH^-]$

$NaOH_{(aq)} \rightarrow Na^+ + OH^-$ $[OH^-]$ = 1.0 M

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

III. Indicators

An indicator (**HIn**) is placed in several buffered solutions, pH 2 to 8.



- Which of the beakers contain mostly HIn? Which contains mostly In-?

2 – 4 6 – 8

- What is the ~pKa of the indicator?

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- Write an equation to show the equilibrium of HIn with In^- in water.

$HIn + H_2O \rightleftharpoons H_3O^+ + In^-$

red yellow

IV. Salts

a. What is the pH of a 1.0 M solution of ammonium nitrate?

K_a for NH_4^+ is 5.6×10^{-10}

$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+$

I: 1.0 M, 0, 0

C: $-x$, $+x$, $+x$

E: $1.0 - x$, x, x

$5.6 \times 10^{-10} = \frac{x^2}{1.0}$

$x = \sqrt{5.6 \times 10^{-10}}$

$x = [H_3O^+]$

$pH = -\log(H_3O^+)$

pH = 4.6 NH_4Cl

b. What is the pH of a 1.0 M solution of sodium fluoride?

$F^-(aq) + H_2O \rightleftharpoons HF(aq) + OH^-$

I: 1.0 M, 0, 0

C: $-x$, $+x$, $+x$

E: 1.0, x, x

$1.4 \times 10^{-11} = \frac{x^2}{1.0}$

$x = \sqrt{1.4 \times 10^{-11}}$

$x = [OH^-]$

$pOH = -\log([OH^-])$

$pH = 14 - pOH$

pH = 8.6 NaF

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