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AP Chemistry

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Period ____

Acids & Bases: Worksheet #2
Weak Acid Problems (2009)

1. What is the $[H^+]$ of a 0.25 M solution of benzoic acid, $HC_7H_5O_2$? $K_a = 6.46 \times 10^{-5}$

$HC_7H_5O_2 + H_2O \rightleftarrows H_3O^+ + C_7H_5O_2^-$

.25 M	0	0
$-x$	$+x$	$+x$
$.25-x$	x	x

$$6.46 \times 10^{-5} = \frac{x^2}{.25-x}$$

$x = .00399$

$[H_3O^+] = .00399\ M$

$[H_3O^+] = 0.00399$ M

2. Hydrocyanic acid, **H**CN, has a K_a of 4.93×10^{-10}. Calculate the pH and $[H^+]$ of a 0.100 M solution of hydrocyanic acid.

$HCN + H_2O \rightleftarrows H_3O^+ + CN^-$

.100 M	0	0
$-x$	$+x$	$+x$
$.100-x$	x	x

$$4.93 \times 10^{-10} = \frac{x^2}{[.100-x]}$$

$x = 7.02 \times 10^{-6}$

$[H_3O^+] = 7.02 \times 10^{-6}\ M$

$pH = -\log[7.02 \times 10^{-6}] = 5.154$

$[H_3O^+] = 7.02 \times 10^{-6}$ M
pH = 5.154

3. Nitrous acid, **H**NO_2, has a K_a of 7.1×10^{-4}. What are the $[H^+]$, $[NO_2^{1-}]$, $[OH^{1-}]$ in 0.50 M **H**NO_2 ?

$HNO_2 + H_2O \rightleftarrows H_3O^+ + NO_2^-$

.50 M	0	0
$-x$	$+x$	$+x$
$.50-x$	x	x

$$7.1 \times 10^{-4} = \frac{x^2}{.50-x}$$

$x = .018$

$[H_3O^+] = [NO_2^-] = .018\ M$

Recall $[H^+][OH^-] = 1 \times 10^{-14}$

$[.018][OH^-] = 1 \times 10^{-14}$

$[OH^-] = 5.6 \times 10^{-13}\ M$

$[H_3O^+] = 0.018$ M
$[NO_2^{1-}] = 0.018$ M
$[OH^{1-}] = 5.6 \times 10^{-13}$ M

4. Lactic acid ($HC_3H_5O_3$) is a monoprotic acid. A 0.10 M solution of lactic acid has a pH of 2.44. Calculate the K_a for lactic acid.

$HC_3H_5O_3 + H_2O \rightleftarrows H_3O^+ + C_3H_5O_3^-$

.10 M	0	0
$-x$	$+x$	$+x$
$.10-x$	x	x

from pH 2.44 $[H_3O^+] = 3.6 \times 10^{-3}\ M = x$

$$K_a = \frac{[3.6 \times 10^{-3}]^2}{[.10 - 3.6 \times 10^{-3}]} = 1.3 \times 10^{-4}$$

Ka = 1.3 x 10^{-4}

5. Acetic acid, $HC_2H_3O_2$, has a $K_a = 1.78 \times 10^{-5}$.
   (a) Determine the pH of a 0.100 M solution.
   (b) What percentage of acetic acid is ionized?

$HC_2H_3O_2 + H_2O \rightleftarrows H_3O^+ + C_2H_3O_2^-$

.100 M	0	0
$-x$	$+x$	$+x$
$.100-x$	x	x

$$1.78 \times 10^{-5} = \frac{x^2}{.100-x}$$

$x = .00133$

$[H_3O^+] = .00133\ M$

$pH = -\log[.00133]$

$pH = 2.876$

% ionized

$$\frac{[H_3O^+]}{[HC_2H_3O_2]} \times 100 =$$

$$\frac{.00133}{.100} \times 100 = 1.33\%$$

$[H_3O^+]$ = 0.00133 M
pH = 2.876
1.33% ionized

6. A 0.100 M solution of a certain monoprotic acid (HA) is 11.0% ionized. Using this information, calculate the equilibrium concentrations of $[A^{1-}]$, $[H^+]$, [HA], and the Ka for this acid.

$HA + H_2O \rightleftarrows H_3O^+ + A^-$

.100 M	0	0
$-x$	$+x$	$+x$
$.100-x$	x	x

$$\%\ \text{ionized} = \frac{[H_3O^+]}{[.100]} \times 100 = 11.0$$

$[H_3O^+] = .011\ M$

$[A^-] = .011\ M$

$[HA] = .100 - .011 = .089\ M$

$$K_a = \frac{x^2}{.100-x}$$

$$K_a = \frac{[.011]^2}{[.100 - .011]} = 1.36 \times 10^{-3}$$

$[H_3O^+]$ = 0.011 M
$[A^{1-}]$ = 0.011 M
[HA] = 0.089 M
Ka = 1.36 x 10^{-3}