Equilibrium Review Problems

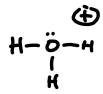
Acid/Base Problems

p. 557

1. $HClO_4 + H_2O \longrightarrow H_3O^+ + ClO_4^-$

Acid Base Acid Base

3. (a) HCl acid Cl^- base



3 (b) HCO_3^- CO_3^{-2}

acid

H_2O H_3O^+

4. a) HNO_3

Ionization Constants Ka and Kb

Text p. 587

1. Derive ionization constant expression

e.g. $CH_3COOH_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$

$$K_{eq} = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH][H_2O]}$$

constant

constant

$$\underbrace{K_{eq} \cdot [H_2O]}_{\text{new constant}} = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

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

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

Ka and Kb Problems

given $K_a \xrightarrow{\text{calc.}} [H_3O^+]$?

acid

Example - Find $[H_3O^+]$ in a 0.010 mol/L solution of CH_3COOH. $K_a = 1.8 \times 10^{-5}$

	CH_3COOH	$+ H_2O \rightleftharpoons$	H_3O^+	$+ CH_3COO^-$
I	0.010		0	0
C	$-x$		$+x$	$+x$
E	$0.010-x$		x	x

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]} \text{ (at equilibrium)}$$

$$1.8 \times 10^{-5} = \frac{x \cdot x}{0.010 - x}$$

assume x is small.

$$1.8 \times 10^{-5} = \frac{x^2}{0.010}$$

$$(1.8 \times 10^{-5})(0.010) = x^2$$

$$\sqrt{1.8 \times 10^{-7}} = \sqrt{x^2}$$

$$4.2 \times 10^{-4} = x = [H_3O^+]$$

0.010

0.00042 $- x$

Example 2 given $[H_3O^+]$ and [acid] $\xrightarrow{\text{find}}$ K_a

Calculate K_a for a 0.15 mol/L acid HA which has $[H_3O^+]$ = 0.0080 mol/L

	HA	$+ H_2O \rightleftharpoons$	H_3O^+	$+ A^-$
I	0.15		0	0
C	-0.0080		$+0.0080$	$+0.0080$
E	$0.15-0.0080$ $= 0.0142$		0.0080	0.0080

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$K_a = \frac{(0.0080)(0.0080)}{0.0142} = 4.5 \times 10^{-4}$$

Handouts - 18B, 18C problems

See text p. 850 (table)

% Ionization

Definition - $\% = \underbrace{\text{"out of"}}_{\text{division}}$ 100

$$\% \text{ ionization} = \frac{[H_3O^+]}{\text{initial [Acid]}} \times 100\%$$

Example - What is % ionization if an acid's initial concentration is 1.5 mol/L and $[H_3O^+]$ = 0.075 mol/L

$$\% \text{ ionization} = \frac{0.075}{1.5} \times 100\%$$

$$= 5.0\%$$

Example - A 1.2 mol/L solution of base ionizes 13%. Calculate K_b.

* $0.13 \times 1.2 = 0.156$ mol/L ← ionized

	B	$+ H_2O \rightleftharpoons$	BH^+	$+ OH^-$
I	1.2		0	0
C	-0.156		$+0.156$	$+0.156$
E	1.044		0.156	0.156

$$K_b = \frac{[BH^+][OH^-]}{1.044} = 0.023$$