Chem 1062

Note Title 7/23/2008

* Exams Returned
* D2L Quizzes

Finding the pH of a strong acid.

$[H_3O^+] = [\text{acid}]$ ✓

Finding the pH of a strong base.

$[OH^-] = [\text{base}] \times$ # of hydroxide ions in formula ✓

Calculate the pH of:

0.0038 M HNO_3

$[H_3O^+] = 0.0038\ M$

$pH = -\log[H_3O^+] = -\log(0.0038) = \boxed{2.42}$

0.028 M $Sr(OH)_2$

$[OH^-] = 0.028\ M \times 2 = 0.056\ M$

$pOH = -\log[OH^-] = -\log(0.056) = 1.25$

$pH = 14.00 - pOH = 14.00 - 1.25 = \boxed{12.75}$

pH of 2.0 M HCl

$[H_3O^+] = 2.0\ M$

$$pH = -\log(2.0) = -0.30$$

Calculate the concentration of:

a) a solution of HCl (strong acid) that has a pH = 4.77

$[HCl] = [H_3O^+]$

$-pH = \log[H_3O^+]$

$10^{-pH} = 10^{\log[H_3O^+]}$

$10^{\log x} = x$

$[H_3O^+] = 10^{-pH} = 10^{-4.77} = 1.7 \times 10^{-5} M$

b) a solution of KOH (strong base) that has a pH = 12.50

$[OH^-] = [base]$

$pOH = 14.00 - pH$

$= 14.00 - 12.50$

$pOH = 1.50$

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

$10^{-pOH} = 10^{\log[OH^-]}$

$[OH^-] = 10^{-pOH} = 10^{-1.50} = 0.032 M$

Calculate the pH of 0.20 M $HC_2H_3O_2$ (weak acid)

$HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$

(equil M) $0.20 - x$ $\quad x \quad x$

$K_a = \dfrac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$

K_a: acid ionization constant

$$1.7\times10^{-5} = \frac{x^2}{0.20 - x}$$

Assume $x \ll 0.20$ ✓

$0.20 - x \cong 0.20$ ✓

$$\sqrt{3.4\times10^{-6}} = \sqrt{x^2}$$

$$0.00184 = x = [H_3O^+]$$

Check to see if the assumption was true. Assumption is valid.

$$pH = -\log[H_3O^+] = -\log(0.00184) = \boxed{2.73}$$

$$1.7\times10^{-5} = \frac{x^2}{0.20 - x}$$

$$x = 0.00183\underline{5}$$

When can simplifying assumption be made?

$$\frac{[acid]}{K_a} > 100$$

(this yields < 5% error in $[H_3O^+]$)

represents a generic weak acid

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

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

acrylic acid

17.29

$$HAcr_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + Acr^-_{(aq)}$$

(equil'm)

$0.10 - x$ $\quad$ x $\quad$ x

$$K_a = \frac{[H_3O^+][Acr^-]}{[HAcr]}$$

$$= \frac{x^2}{0.10 - x}$$

$$= \frac{(10^{-2.63})^2}{0.10 - 10^{-2.63}}$$

$$= \boxed{5.6\times10^{-5}}$$

$x = [H_3O^+]$

$pH = 2.63$

$[H_3O^+] = 10^{-pH}$

$x = [H_3O^+] = 10^{-2.63}$

Polyprotic acids

* For a solution of 0.050 M H_2CO_3, find

a) pH = 3.83

b) $[HCO_3^-] = 1.5 \times 10^{-4}$ M

c) $[CO_3^{2-}] = 4.8 \times 10^{-11}$ M

d) $[OH^-] = 6.8 \times 10^{-11}$ M

H_2CO_3 ← weak acid

diprotic acid

→ will also be true for most polyprotic acids

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$$

(equil M): $0.050 - x$; x ; x

$$K_{a1} = \frac{[H_3O^+][HCO_3^-]}{[H_2CO_3]}$$

$$4.3 \times 10^{-7} = \frac{x^2}{0.050 - x}$$

Assume $x << 0.050$

$$\sqrt{2.15 \times 10^{-8}} = \sqrt{x^2}$$

1.47×10^{-4} M $= x = [H_3O^+] = [HCO_3^-]$

Assumption valid

$pH = -\log[H_3O^+]$

$pH = -\log(1.47 \times 10^{-4})$

$= 3.83$

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$$

(equil M): $1.47 \times 10^{-4} - y$; $1.47 \times 10^{-4} + y$; y

$$K_{a2} = \frac{[H_3O^+][CO_3^{2-}]}{[HCO_3^-]}$$

$$4.8 \times 10^{-11} = \frac{(1.47 \times 10^{-4} + y)(y)}{1.47 \times 10^{-4} + y}$$

Assume $y << 1.47 \times 10^{-4}$

Assumption valid

4.8×10^{-11} M $= y = [CO_3^{2-}]$

$pOH = 14.00 - pH = 14.00 - 3.83 = 10.17$

$$[OH^-] = 10^{-pOH} = 10^{-10.17} = 6.8 \times 10^{-11}$$

Weak Bases

Consider a generic weak base, B

$$B(aq) + H_2O(l) \rightleftharpoons HB^+(aq) + OH^-(aq)$$

$$K_b = \frac{[HB^+][OH^-]}{[B]}$$

K_b: base ionization constant

Find the pH of 0.20 M N_2H_4. (hydrazine)

	$N_2H_4(aq)$	+ $H_2O(l)$	$\rightleftharpoons$	$N_2H_5^+(aq)$	+	$OH^-(aq)$
(equil M)	$0.20 - x$			x		x

$$K_b = \frac{[N_2H_5^+][OH^-]}{[N_2H_4]}$$

$$1.7 \times 10^{-6} = \frac{x^2}{0.20 - x}$$

Assume $x << 0.20$

$$\sqrt{3.4 \times 10^{-7}} = \sqrt{x^2} = x = 5.83 \times 10^{-4} M = [OH^-]$$

$$pOH = -\log[OH^-] = -\log(5.83 \times 10^{-4}) = 3.23$$

$$pH = 14.00 - pOH = 14.00 - 3.23 = \boxed{10.77}$$

(17.45) 0.15 M $HOC_2H_4NH_2$ ⇒ pH = 11.34

K_b = ?

pOH = 14.00 − 11.34 = 2.66

$$HOC_2H_4NH_{2(aq)} + H_2O_{(l)} \rightleftharpoons HOC_2H_4NH_3^+{}_{(aq)} + OH^-_{(aq)}$$

(equil M)	0.15 − x	x	x

$$K_b = \frac{[HOC_2H_4NH_3^+][OH^-]}{[HOC_2H_4NH_2]} = \frac{x^2}{(0.15-x)}$$

$x = [OH^-]$

$[OH^-] = 10^{-pOH} = 10^{-2.66}$

$$= \frac{(10^{-2.66})^2}{0.15 - 10^{-2.66}} = \boxed{3.2 \times 10^{-5}}$$

Tell whether the following salts are acidic, basic, or neutral.

acid + base → salt + water

(1) NaCl ⇒ neutral salt

from strong acid & strong base

(2) NH_4NO_3 ⇒ acid salt

from weak base & strong acid

(3) KCN ⇒ basic salt

from weak acid & strong base

(4) NH_4CN ⇒ basic salt

$K_b(NH_3) = 1.8 \times 10^{-5}$ ← stronger

$K_a(HCN) = 4.9 \times 10^{-10}$