# Acids/Bases/pH/pOH/Ionization of Water Practice:

name: Solutions

1) According to the Arrhenius theory of acids/bases, complete the following dissociations:

a) $HCl_{(aq)}$ → $H^+_{(aq)} + Cl^-_{(aq)}$

b) $NaOH_{(aq)}$ → $Na^+_{(aq)} + OH^-_{(aq)}$

c) $Al(OH)_{3\,(aq)}$ → $Al^{+3}_{(aq)} + 3\,OH^-_{(aq)}$

d) $H_3PO_{4\,(aq)}$ → $3H^+_{(aq)} + PO_4^{3-}{}_{(aq)}$

e) $Ca(OH)_{2\,(aq)}$ → $Ca^{+2}_{(aq)} + 2OH^-_{(aq)}$

f) $CH_3COOH_{(aq)}$ → $H^+_{(aq)} + CH_3COO^-_{(aq)}$

2) Fill in the table below:

| *Acid* | *Conjugate Base* | *Base* | *Conjugate Acid* |
|---|---|---|---|
| HF | $F^-$ | $C_5H_5N$ | $C_5H_5NH^+$ |
| $H_2CO_3$ | $HCO_3^-$ | $HF^-$ | $H_2F$ |
| $NH_4^+$ | $NH_3$ | $BrO^-$ | $HBrO$ |
| $H_3O^+$ | $H_2O$ | $H_2PO_4^-$ | $H_3PO_4$ |

3) Given the following equations, fill in the table below:

| *Reaction* | *Acid* | *Conj.Base* | *Base* | *Conj.Acid* |
|---|---|---|---|---|
| $CH_3NH_2 + H_2O \rightarrow CH_3NH_3^+ + OH^-$ | $H_2O$ | $OH^-$ | $CH_3NH_2$ | $CH_3NH_3^+$ |
| $N_2H_5^+ + CH_3COO^- \rightarrow N_2H_4 + CH_3COOH$ | $N_2H_5^+$ | $N_2H_4$ | $CH_3COO^-$ | $CH_3COOH$ |
| $PO_4^{3-} + HBrO \rightarrow HPO_4^{2-} + BrO^-$ | $HBrO$ | $BrO^-$ | $PO_4^{3-}$ | $HPO_4^{2-}$ |

4)

a) Calculate the pH of a solution with a hydronium concentration $[H_3O^+] = 5.4\times10^{-4}$ mol/L

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

$pH = -\log(5.4\times10^{-4})$

$pH = 3.27$

b) Calculate the pH of a solution of HCl solution with a concentration of $6.44\times10^{-2}$ mol/L
(note that HCl is a strong acid that dissociates completely) (see #1)

$[HCl] = [H_3O^+]$

1 : 1

$pH = -\log(6.44\times10^{-2})$

$pH = 1.19$

c) Calculate the pOH of a solution with a $[OH^-] = 2.2 \times 10^{-10}$ mol/L

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

$pOH = -\log(2.2 \times 10^{-10})$

$pOH = 9.66$

d) Calculate the pOH of a solution of NaOH solution with a concentration of 0.045 mol/L
(note that NaOH is a strong base that dissociates completely) (see #1)

$[NaOH] : [OH^-]$

1 : 1

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

$pOH = -\log(0.045)$

$pOH = 1.35$

5) A solution has a pH of 5.2

a) Calculate the Hydronium ion concentration

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

$[H_3O^+] = 10^{-5.2}$

$[H_3O^+] = 6.31 \times 10^{-6}$ mol/L

b) Calculate the Hydroxide ion concentration

$[H_3O^+] \cdot [OH^-] = 10^{-14}$

$[OH^-] = \frac{10^{-14}}{6.31 \times 10^{-6}}$

$[OH^-] = 1.58 \times 10^{-9}$ mol/L

c) Calculate the pOH

$pH + pOH = 14$

$5.2 + pOH = 14$

$pOH = 8.8$

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

$pOH = -\log(1.58 \times 10^{-9})$

$pOH = 8.8$

6) Calculate the pH and pOH of the following *(before you start this question refer to question#1)*

a) An HCl solution with a concentration of $1.33 \times 10^{-4}$ mol/L (note that HCl is a strong acid that dissociates completely)

① $[HCl] = [H_3O^+] = [Cl]$
1 : 1 : 1

② $pH = -\log[H_3O^+]$
$pH = -\log(1.33 \times 10^{-4})$
$pH = 3.88$

③ $pH + pOH = 14$
$3.88 + pOH = 14$
$pOH = 10.12$

b) An NaOH solution with a concentration $8.5 \times 10^{-5}$ mol/L (note that NaOH is a strong base that dissociates completely)

① $[NaOH] = [Na^+] = [OH^-]$
1 : 1 : 1

② $pOH = -\log[OH^-]$
$pOH = -\log(8.5 \times 10^{-5})$
$pOH = 4.07$

③ $pH + pOH = 14$
$pH + 4.07 = 14$
$pH = 9.93$

c) A $Ca(OH)_2$ solution with a concentration of 0.0888 mol/L (note that $Ca(OH)_2$ is a strong base that dissociates completely)

① $[Ca(OH)_2] = [Ca^{+2}] = 2 \cdot [OH^-]$
1 : 1 : 2

$[OH^-] = 2 \cdot (0.0888) = 0.1776$ mol/L

② $pOH = -\log[OH^-]$
$pOH = -\log(0.1776)$
$pOH = 0.75$

③ $pH + pOH = 14$
$pH + 0.75 = 14$
$pH = 13.25$

7) Calculate the concentration Hydronium $[H_3O^+]$ and Hydroxide [OH -] in each of the following situations.

a) A soap solution with a pOH of 6.25

$[OH^-] = 10^{-pOH}$
$[OH^-] = 10^{-6.25}$
$[OH^-] = 5.62 \times 10^{-7}$ mol/L

$[OH^-] \cdot [H_3O^+] = 10^{-14}$
$[H_3O^+] = \frac{10^{-14}}{5.6 \times 10^{-7}}$

$[H_3O^+] = 1.78 \times 10^{-8}$ mol/L

b) An acid with a pH of 4.23

$[H_3O^+] = 10^{-pH}$
$[H_3O^+] = 10^{-4.23}$
$[H_3O^+] = 5.88 \times 10^{-5}$ mol/L

$[OH^-] \cdot [H_3O^+] = 10^{-14}$
$[OH^-] = \frac{10^{-14}}{5.88 \times 10^{-5}}$

$[OH^-] = 1.7 \times 10^{-10}$ mol/L

c) An alkaline solution with a pOH of 1.79

$[OH^-] = 10^{-pOH}$
$[OH^-] = 10^{-1.79}$
$[OH^-] = 0.0162$ mol/L

$[OH^-] \cdot [H_3O^+] = 10^{-14}$
$[H_3O^+] = \frac{10^{-14}}{0.0162}$

$[H_3O^+] = 6.17 \times 10^{-13}$ mol/L

d) Lemon jus with a pH of 2.72

$[H_3O^+] = 10^{-pH}$
$[H_3O^+] = 10^{-2.72}$
$[H_3O^+] = 1.9 \times 10^{-3}$ mol/L

$[OH^-] \cdot [H_3O^+] = 10^{-14}$
$[OH^-] = \frac{10^{-14}}{1.9 \times 10^{-3}}$

$[OH^-] = 5.26 \times 10^{-12}$ mol/L

8) Perchloric acid $HClO_4$ is a strong acid that dissociates completely into its ions:

$$1\ HClO_{4\,(aq)} + 1\ H_2O_{(l)} \rightarrow 1\ H_3O^+_{(aq)} + 1\ ClO_4^-{}_{(aq)}$$

What mass of perchloric acid must be dissolved in 280mL of water to obtain a solution with a pOH of 12.1

① $pH + pOH = 14$

$pH + 12.1 = 14$

$pH = 1.9$

② $[H_3O^+] = 10^{-pH}$

$[H_3O^+] = 10^{-1.9}$

$[H_3O^+] = 0.0126\ mol/L$

③ $[H_3O^+] = [HClO_4]$ (1:1 ratio)

$[HClO_4] = 0.0126\ mol/L$

④ $C_{HClO_4} = \frac{n}{V}$

$0.0126 = \frac{n}{0.28}$ $\quad n = 0.00353\ moles$

⑤ $n = \frac{m}{M}$

$0.00353 = \frac{m}{100.5}$ $\quad \boxed{m = 0.355g}$

9) A 1L solutions contains 0.85g of base dissolved in it. The pH of the solutions is measured to be 12.2 using universal indicator. Which of the following bases most likely was used in this situation: NaOH, KOH, or $Ba(OH)_2$ ?

① $pH + pOH = 14$

$12.2 + pOH = 14$

$pOH = 1.8$

② $[OH^-] = 10^{-pOH}$

$[OH^-] = 10^{-1.8}$

$[OH^-] = 0.0158\ mol/L$

③ $C = \frac{n}{V}$

$0.0158 = \frac{n}{1}$

$n = 0.0158\ moles$

④ $n = \frac{m}{M}$

$0.0158 = \frac{0.85}{M}$

$M = 53.8\ g/mole$ → Most resembles KOH

⑤ $M_{NaOH} = 40\ g/mole$

$M_{KOH} = 56\ g/mole$

$M_{Ba(OH)_2} = 171.33\ g/mole$