KEY

Chemistry: *pH and pOH calculations*

Part 1: *Fill in the missing information in the table below.*

pH	$[H_3O^{1+}]$	pOH	$[OH^{1-}]$	ACID or BASE?
3.78	1.66×10^{-4} M	10.22	6.03×10^{-11} M	Acid
3.41	3.89×10^{-4} M	10.59	2.57×10^{-11} M	Acid
8.81	1.55×10^{-9} M	5.19	6.46×10^{-6} M	Base
8.69	2.04×10^{-9} M	5.31	4.88×10^{-6} M	Base
8.46	3.47×10^{-9} M	5.54	2.88×10^{-6} M	Base
12.1	8.45×10^{-13} M	1.90	1.26×10^{-2} M	Base
11.86	1.38×10^{-12} M	2.14	7.24×10^{-3} M	Base
3.40	3.98×10^{-4} M	10.6	2.31×10^{-11} M	Acid
10.91	1.23×10^{-11} M	3.09	8.13×10^{-4} M	Base
5.13	7.49×10^{-6} M	8.87	1.35×10^{-9} M	Acid
4.06	8.71×10^{-5} M	9.94	1.15×10^{-10} M	Acid

10.91	1.23×10^{-11} M	3.09	8.13×10^{-4} M	Base
5.13	7.49×10^{-6} M	8.87	1.35×10^{-9} M	Acid
4.06	8.71×10^{-5} M	9.94	1.15×10^{-10} M	Acid
6.41	3.89×10^{-7} M	7.59	2.57×10^{-8} M	Acid
4.16	6.92×10^{-5} M	9.84	1.45×10^{-10} M	Acid
0.98	1.06×10^{-1} M	13.0	1.00×10^{-13} M	Acid
10.18	6.61×10^{-11} M	3.82	1.51×10^{-4} M	Base
7.93	1.17×10^{-8} M	6.07	8.53×10^{-7} M	Base
7.05	8.91×10^{-8} M	6.95	1.12×10^{-7} M	~Base
9.33	4.73×10^{-10} M	4.67	2.14×10^{-5} M	Base
12.67	2.14×10^{-13} M	1.33	4.68×10^{-2} M	Base
12.0	1.0×10^{-12} M	2.01	9.87×10^{-3} M	Base
11.68	2.09×10^{-12} M	2.32	4.79×10^{-3} M	Base
7.04	9.22×10^{-8} M	6.96	1.10×10^{-7} M	~Base
1.76	1.74×10^{-2} M	12.24	5.75×10^{-13} M	Acid
2.70	2.00×10^{-3} M	11.3	5.39×10^{-12} M	Acid

KEY

Part 2: *For each of the problems below, assume 100% dissociation.*

1. A. Write the equation for the dissociation of hydrochloric acid.

$$HCl(aq) \rightarrow H^{1+}(aq) + Cl^{1-}(aq)$$

B. Find the pH of a 0.00476 M hydrochloric acid solution.

$$\underset{0.00476\ M}{HCl(aq)} \rightarrow \underset{0.00476\ M}{H^{1+}(aq)} + Cl^{1-}(aq)$$

$$pH = -\log[H^+]$$
$$pH = -\log[0.00476\ M]$$
$$pH = 2.32$$

2 ~~A.~~ Write the equation for the dissociation of sulfuric acid.

$$H_2SO_4(aq) \rightarrow 2\,H^{1+}(aq) + SO_4^{2-}(aq)$$

I don't like the way this is solved in this Key. It's actually only the 1st Hydrogen removed that determines the pH. The second

B. Find the pH of a solution that contains 3.25 g of H_2SO_4 dissolved in 2.75 liters of solution.

Step 1: $x\ mol\ H_2SO_4 = 3.25\ g\ H_2SO_4\left(\frac{1\ mol\ H_2SO_4}{98\ g\ H_2SO_4}\right) = 0.033\ mol\ H_2SO_4$

Step 2: $M = \frac{mol}{L} \Rightarrow M = \frac{0.033\ mol\ H_2SO_4}{2.75\ L} \Rightarrow M = 0.0121\ M\ H_2SO_4$

Step 3: $\underset{0.0121M}{H_2SO_4(aq)} \rightarrow \underset{\therefore 0.0242M}{2\,H^+} + SO_4^{2-}(aq)$

Step 4: $pH = -\log[H^+] \Rightarrow pH = -\log[0.0242\ M] \Rightarrow pH = 1.62$

3. A. Write the equation for the dissociation of sodium hydroxide.

$$\underset{0.000841\ M}{NaOH(aq)} \rightarrow Na^{1+}(aq) + \underset{0.000841\ M}{OH^{1-}(aq)}$$

Step 2 : $M = \frac{mol}{L} \Rightarrow M = \frac{0.033\ mol\ H_2SO_4}{2.75\ L} \Rightarrow M = 0.0121\ M\ H_2SO_4$

Step 3 : $H_2SO_4(aq) \rightarrow 2H^+ + SO_4^{2-}(aq)$

$0.0121\ M \quad \therefore 0.0242\ M$

Step 4 : $pH = -\log[H^+] \Rightarrow pH = -\log[0.0242\ M] \Rightarrow pH = 1.62$

3. A. Write the equation for the dissociation of sodium hydroxide.

$$\underset{0.000841\ M}{NaOH(aq)} \rightarrow Na^{1+}(aq) + \underset{0.000841\ M}{OH^{1-}(aq)}$$

B. Find the pH of a 0.000841 M solution of sodium hydroxide.

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

$pOH = -\log[0.000841\ M]$

$pOH = 3.08$

$pH + pOH = 14$

$pH + 3.08 = 14$

$pH = 10.92$

or

$K_w = [H^+][OH^-]$

$1 \times 10^{-14} = [H^+][0.000841\ M]$

$[H^+] = [1.19 \times 10^{-11}\ M]$

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

$pH = -\log[1.19 \times 10^{-11}\ M]$

$pH = 10.92$

only the 1st Hydrogen removed that determines the pH. The second Hydrogen removed has such a small Ka value that the pH doesn't change.

You will learn about this in AP Chem or college

Part 2: continued

omit this one

4 A. Write the equation for the dissociation of aluminum hydroxide.

$$\underset{2.36\times10^{-5}\ M}{Al(OH)_3(aq)} \rightarrow Al^{3+}(aq) + \underset{7.08\times10^{-5}\ M}{3\ OH^{1-}(aq)}$$

B. If the pH is 9.85, what is the concentration of the aluminum hydroxide solution?

$pH + pOH = 14$

$9.85 + pOH = 14$

$pOH = 4.15$

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

$4.15 = -\log[OH^-]$

$2^{nd}\ \log\ -4.15 = [OH^-]$

$[OH^-] = 7.08\times10^{-5}\ M$

$$\frac{7.08\times10^{-5}\ M}{3} = 2.36\times10^{-5}\ M$$

5 A. Write the equation for the dissociation of calcium hydroxide.

$$\underset{2.18\times10^{-3}\ M}{Ca(OH)_2(aq)} \rightarrow Ca^{2+}(aq) + \underset{4.37\times10^{-5}\ M}{2\ OH^{1-}(aq)}$$

B. If the pH is 11.64 and you have 2.55 L of solution, how many grams of calcium hydroxide are in the solution?

$pH + pOH = 14$

$11.64 + pOH = 14$

$pOH = 2.36$

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

$2.36 = -\log[OH^-]$

$2^{nd}\ \log\ -2.36 = [OH^-]$

$$2\overline{)4.37\times10^{-3}\ M}\quad \frac{2.18\times10^{-3}\ M}{}$$

pOH = 4.15

2^{nd} log - 4.15 = $[OH^-]$

$[OH^-] = 7.08 \times 10^{-5}$ M

5 A. Write the equation for the dissociation of calcium hydroxide.

$$\underset{2.18\times10^{-3}\ M}{Ca(OH)_2(aq)} \rightarrow Ca^{2+}(aq) + \underset{4.37\times10^{-3}\ M}{2\,OH^{1-}(aq)}$$

B. If the pH is 11.64 and you have 2.55 L of solution, how many grams of calcium hydroxide are in the solution?

$pH + pOH = 14$

$11.64 + pOH = 14$

$pOH = 2.36$

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

$2.36 = -\log[OH^-]$

2^{nd} log - 2.36 = $[OH^-]$

$[OH^-] = 4.37 \times 10^{-3}$ M

$$2\overline{)4.37\times10^{-3}\ M} \quad \frac{2.18\times10^{-3}\ M}{}$$

$$M = \frac{mol}{L} \Rightarrow 2.18\times10^{-3}\ M \Rightarrow \frac{x\ mol\ Ca(OH)_2}{2.55\ L} \Rightarrow x = 5.57\times10^{-3}\ mol\ Ca(OH)_2$$

$$x\ g\ Ca(OH)_2 = 5.57\times10^{-3}\ mol\left(\frac{74\ g\ Ca(OH)_2}{1\ mol\ Ca(OH)_2}\right) = 0.412\ g\ Ca(OH)_2$$

pH and pOH

1a. $HCl(aq) \rightarrow H^{1+}(aq) + Cl^{1-}(aq)$

b. $\underset{\textbf{0.00476 M}}{HCl(aq)} \rightarrow \underset{\textbf{0.00476 M}}{H^{1+}(aq)} + Cl^{1-}(aq)$

$$pH = -\log[H^+]$$
$$pH = -\log[0.00476\,M]$$
$$pH = 2.32$$

Step 1: $x\,mol\,H_2SO_4 = 325\,g\,H_2SO_4\left(\frac{1\,mol\,H_2SO_4}{98\,g\,H_2SO_4}\right) = 0.03\,mol\,H_2SO_4$

Step 2: $M = \frac{mol}{L} \Rightarrow M = \frac{0.03\,mol\,H_2SO_4}{2.75\,L} \Rightarrow M = 0.01M\,H_2SO_4$

2a. Step 3: $H_2SO_4(aq) \rightarrow 2H^+ + SO_4^{2-}(aq)$

$0.01M \qquad \therefore 0.02\,M$

Step 4: $pH = -\log[H^+] \Rightarrow pH = -\log[0.02\,M] \Rightarrow pH = 1.70$

3. $\underset{\textbf{0.000841 M}}{NaOH(aq)} \rightarrow Na^{1+}(aq) + \underset{\textbf{0.000841 M}}{OH^{1-}(aq)}$

$pOH = -\log[OH^-]$
$pOH = -\log[0.000841\,M]$
$pOH = 3.08$

$pH + pOH = 14$
$pH + 3.08 = 14$
$pH = 10.92$

or

$K_w = [H^+][OH^-]$
$1\times10^{-14} = [H^+][0.000841\,M]$
$[H^+] = [1.19\times10^{-11}\,M]$

$pH = -\log[H^+]$
$pH = -\log[1.19\times10^{-11}\,M]$
$pH = 10.92$

$pH = -\log[1.19 \times 10^{-11}\ M]$

$pH = 10.92$

4. $\underset{2.36\times10^{-5}\ M}{Al(OH)_3(aq)} \rightarrow Al^{3+}(aq) + \underset{7.08\times10^{-5}\ M}{3\ OH^{1-}(aq)}$

$pH + pOH = 14$

$9.85 + pOH = 14$

$pOH = 4.15$

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

$4.15 = -\log[OH^-]$

$\boxed{2^{nd}}\ \boxed{\log}\ -4.15 = [OH^-]$

$[OH^-] = 7.08 \times 10^{-5}\ M$

$\frac{7.08 \times 10^{-5}\ M}{3} = 2.36 \times 10^{-5}\ M$

5. $\underset{2.18\times10^{-3}\ M}{Ca(OH)_2(aq)} \rightarrow Ca^{2+}(aq) + \underset{4.37\times10^{-5}\ M}{2\ OH^{1-}(aq)}$

$pH + pOH = 14$

$11.64 + pOH = 14$

$pOH = 2.36$

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

$2.36 = -\log[OH^-]$

$\boxed{2^{nd}}\ \boxed{\log}\ -2.36 = [OH^-]$

$[OH^-] = 4.37 \times 10^{-3}\ M$

$2\overline{)4.37 \times 10^{-3} M}$ $\quad 2.18 \times 10^{-3}\ M$

$M = \frac{mol}{L} \Rightarrow 2.18 \times 10^{-3}\ M \Rightarrow \frac{x\ mol\ Ca(OH)_2}{L} \Rightarrow x = 5.57 \times 10^{-3} mol\ Ca(OH)_2$

$x\ g\ Ca(OH)_2 = 5.57 \times 10^{-3}\ M\left(\frac{74\ g\ Ca(OH)_2}{1 mol\ Ca(OH)_2}\right) = 0.412\ g\ Ca(OH)_2$