

Chemistry: pH and pOH calculations

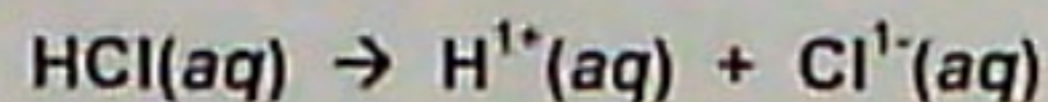
Part 1: Fill in the missing information in the table below.

| pH | $[H_3O^{1+}]$ | pOH | $[OH^{1-}]$ | ACID or BASE? |
|-------|----------------------------------|-------|----------------------------------|---------------|
| 3.78 | $1.66 \times 10^{-4} \text{ M}$ | 10.22 | $6.03 \times 10^{-11} \text{ M}$ | Acid |
| 3.41 | $3.89 \times 10^{-4} \text{ M}$ | 10.59 | $2.57 \times 10^{-11} \text{ M}$ | Acid |
| 8.81 | $1.55 \times 10^{-9} \text{ M}$ | 5.19 | $6.46 \times 10^{-6} \text{ M}$ | Base |
| 8.69 | $2.04 \times 10^{-9} \text{ M}$ | 5.31 | $4.88 \times 10^{-6} \text{ M}$ | Base |
| 8.46 | $3.47 \times 10^{-9} \text{ M}$ | 5.54 | $2.88 \times 10^{-6} \text{ M}$ | Base |
| 12.1 | $8.45 \times 10^{-13} \text{ M}$ | 1.90 | $1.26 \times 10^{-2} \text{ M}$ | Base |
| 11.86 | $1.38 \times 10^{-12} \text{ M}$ | 2.14 | $7.24 \times 10^{-3} \text{ M}$ | Base |
| 3.40 | $3.98 \times 10^{-4} \text{ M}$ | 10.6 | $2.31 \times 10^{-11} \text{ M}$ | Acid |
| 10.91 | $1.23 \times 10^{-11} \text{ M}$ | 3.09 | $8.13 \times 10^{-4} \text{ M}$ | Base |
| 5.13 | $7.49 \times 10^{-6} \text{ M}$ | 8.87 | $1.35 \times 10^{-9} \text{ M}$ | Acid |
| 4.06 | $8.71 \times 10^{-5} \text{ M}$ | 9.94 | $1.15 \times 10^{-10} \text{ M}$ | Acid |
| | $1.00 \times 10^{-7} \text{ M}$ | 7.50 | $3.17 \times 10^{-8} \text{ M}$ | Acid |

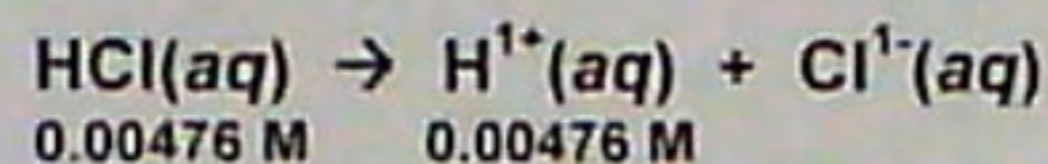
| | | | | |
|-------|--------------------------|-------|--------------------------|-------|
| 10.91 | 1.23×10^{-11} M | 3.09 | 8.13×10^{-4} M | Base |
| 5.13 | 7.49×10^{-6} M | 8.87 | 1.35×10^{-9} M | Acid |
| 4.06 | 8.71×10^{-5} M | 9.94 | 1.15×10^{-10} M | Acid |
| 6.41 | 3.89×10^{-7} M | 7.59 | 2.57×10^{-8} 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 |

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

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



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



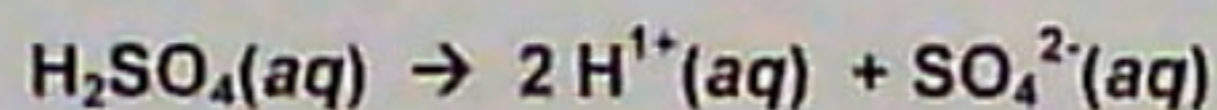
$$\text{pH} = -\log[\text{H}^+]$$

$$\text{pH} = -\log[0.00476 \text{ M}]$$

$$\text{pH} = 2.32$$

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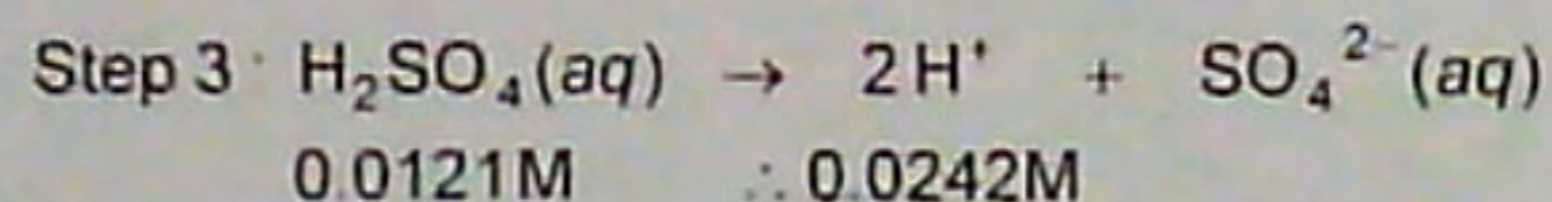
- A. Write the equation for the dissociation of sulfuric acid.



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

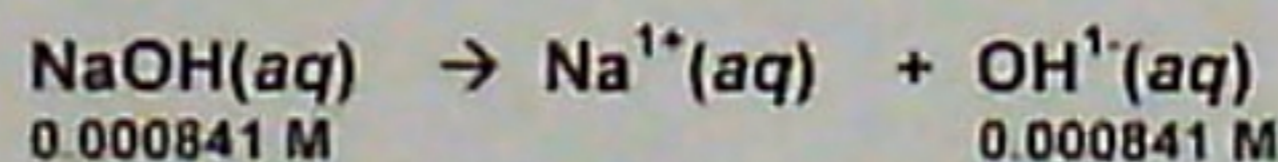
$$\text{Step 1: } x \text{ mol H}_2\text{SO}_4 = 3.25 \text{ g H}_2\text{SO}_4 \left(\frac{1 \text{ mol H}_2\text{SO}_4}{98 \text{ g H}_2\text{SO}_4} \right) = 0.033 \text{ mol H}_2\text{SO}_4$$

$$\text{Step 2: } M = \frac{\text{mol}}{\text{L}} \Rightarrow M = \frac{0.033 \text{ mol H}_2\text{SO}_4}{2.75 \text{ L}} \Rightarrow M = 0.0121 \text{ M H}_2\text{SO}_4$$



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

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



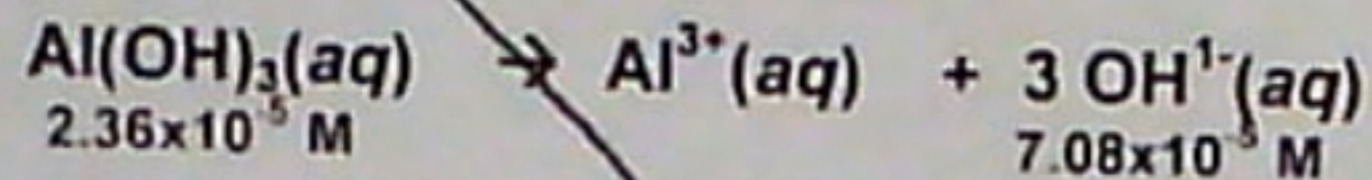
I don't like the way this is solved in this key. It's actually only the 1st Hydrogen removed that determines the pH. The second

Part 2: continued

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



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

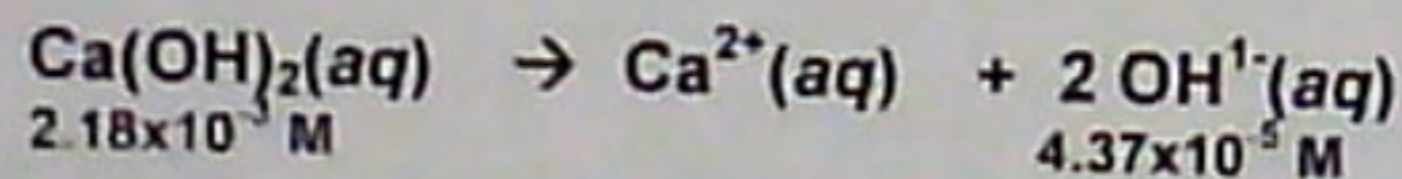
$$\begin{aligned} \text{pH} + \text{pOH} &= 14 \\ 9.85 + \text{pOH} &= 14 \\ \text{pOH} &= 4.15 \end{aligned}$$

$$\begin{aligned} \text{pOH} &= -\log[\text{OH}^{-}] \\ 4.15 &= -\log[\text{OH}^{-}] \end{aligned}$$

$$\begin{aligned} 2^{\text{nd}} \log - 4.15 &= [\text{OH}^{-}] \\ [\text{OH}^{-}] &= 7.08 \times 10^{-5} \text{ M} \end{aligned}$$

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

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



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?

$$\begin{aligned} \text{pH} + \text{pOH} &= 14 \\ 11.64 + \text{pOH} &= 14 \\ \text{pOH} &= 2.36 \end{aligned}$$

$$\begin{aligned} \text{pOH} &= -\log[\text{OH}^{-}] \\ 2.36 &= -\log[\text{OH}^{-}] \end{aligned}$$

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

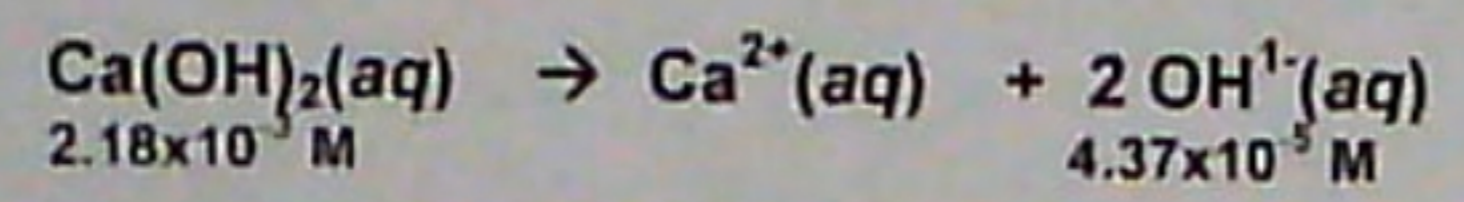
$$\begin{array}{r} 2.18 \times 10^{-3} \text{ M} \\ 2 \overline{) 4.37 \times 10^{-3} \text{ M}} \end{array}$$

pOH = 4.15

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

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

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



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?

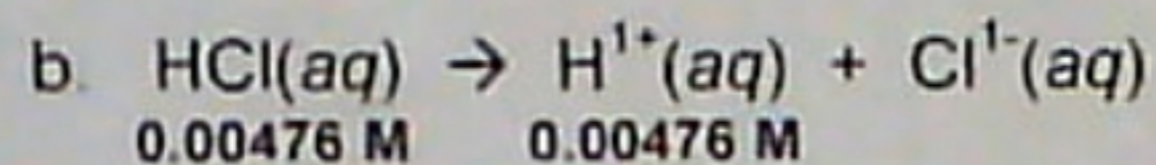
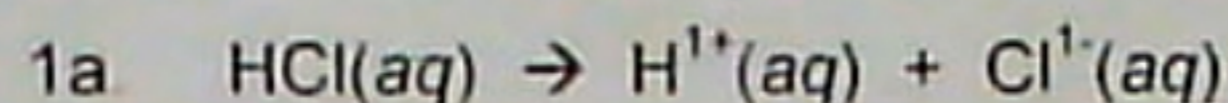
$\text{pH} + \text{pOH} = 14$
 $11.64 + \text{pOH} = 14$
 $\text{pOH} = 2.36$
 $2^{\text{nd}} \log - 2.36 = [\text{OH}^-]$
 $[\text{OH}^-] = 4.37 \times 10^{-3} \text{ M}$

$\text{pOH} = -\log[\text{OH}^-]$
 $2.36 = -\log[\text{OH}^-]$

$\frac{2.18 \times 10^{-3} \text{ M}}{2} = 4.37 \times 10^{-3} \text{ M}$

$M = \frac{\text{mol}}{\text{L}} \Rightarrow 2.18 \times 10^{-3} \text{ M} \Rightarrow \frac{x \text{ mol Ca(OH)}_2}{2.55 \text{ L}} \Rightarrow x = 5.57 \times 10^{-3} \text{ mol Ca(OH)}_2$

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



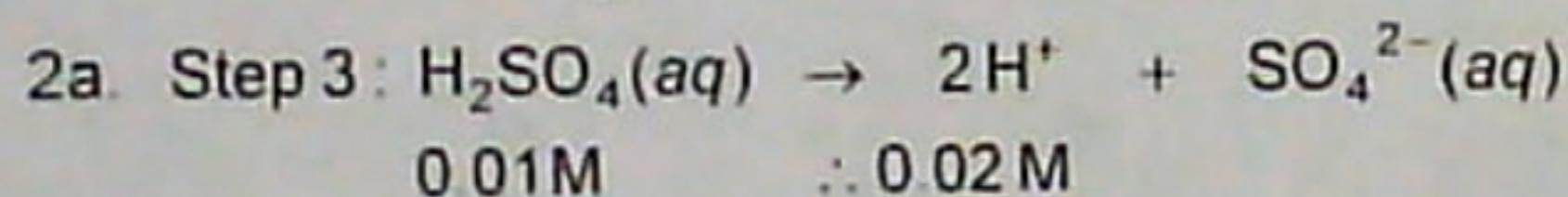
$$\text{pH} = -\log[\text{H}^+]$$

$$\text{pH} = -\log[0.00476 \text{ M}]$$

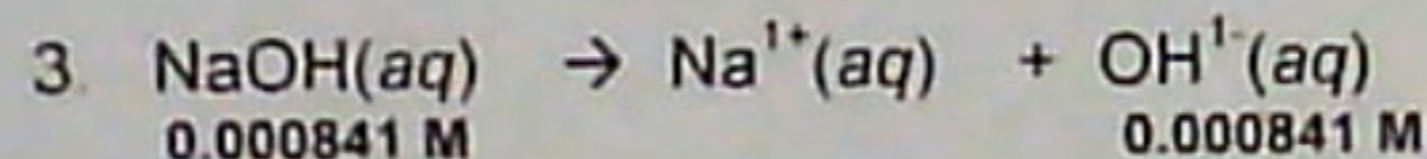
$$\text{pH} = 2.32$$

$$\text{Step 1: } x \text{ mol H}_2\text{SO}_4 = 325 \text{ g H}_2\text{SO}_4 \left(\frac{1 \text{ mol H}_2\text{SO}_4}{98 \text{ g H}_2\text{SO}_4} \right) = 0.03 \text{ mol H}_2\text{SO}_4$$

$$\text{Step 2: } M = \frac{\text{mol}}{\text{L}} \Rightarrow M = \frac{0.03 \text{ mol H}_2\text{SO}_4}{2.75 \text{ L}} \Rightarrow M = 0.01 \text{ M H}_2\text{SO}_4$$



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



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

$$\text{pOH} = -\log[0.000841 \text{ M}]$$

$$\text{pOH} = 3.08$$

$$\text{pH} + \text{pOH} = 14$$

$$\text{pH} + 3.08 = 14$$

$$\text{pH} = 10.92$$

$$K_w = [\text{H}^+][\text{OH}^-]$$

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

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

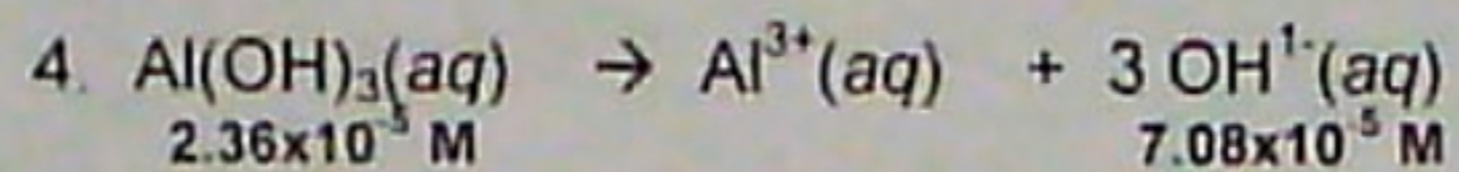
$$\text{pH} = -\log[\text{H}^+]$$

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

$$\text{pH} = 10.92$$

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

$$\text{pH} = 10.92$$



$$\text{pH} + \text{pOH} = 14$$

$$9.85 + \text{pOH} = 14$$

$$\text{pOH} = 4.15$$

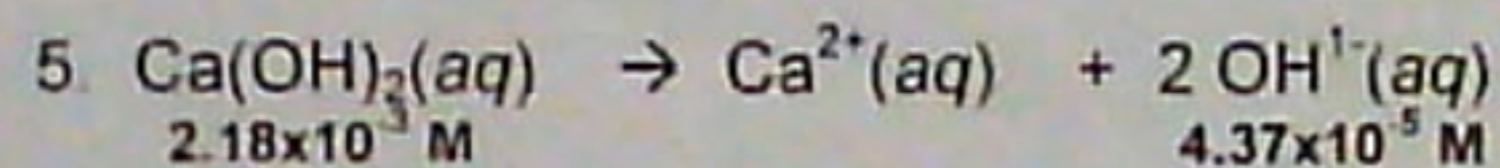
$$\text{pOH} = -\log[\text{OH}^{-}]$$

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

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

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

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



$$\text{pH} + \text{pOH} = 14$$

$$11.64 + \text{pOH} = 14$$

$$\text{pOH} = 2.36$$

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

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

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

$$\frac{2.18 \times 10^{-3} \text{ M}}{2} = 4.37 \times 10^{-3} \text{ M}$$

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

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