Hydrogen and Hydroxide Ion Concentration

In an aqueous solution at 25°C, the product of \([\text{H}^+]\) and \([\text{OH}^-]\) equals \(1.0 \times 10^{-14}\). This fact allows the calculation of the concentration of either of the ions, given the concentration of the other ion. The negative logarithm of \([\text{H}^+]\) is called pH. When \([\text{H}^+]\) is simply 1 multiplied by some power of 10, pH equals the absolute value of that power.

Solve each of the following problems and questions. Show your calculations or state the reasons for your answers.

1. a. What is the hydroxide ion concentration in pure water?  
   b. What is the pH of pure water?

2. a. What is the concentration of hydrogen ion in a 0.1M solution of NaOH?  
   b. What is the pH of this solution?

3. a. What is the concentration of hydroxide ion in a 0.001M solution of HCl?  
   b. What is the pH of this solution?

4a. What is the concentration of hydrogen ion in a solution whose pH = 5?  
   b. What is the concentration of hydroxide ion in this solution?  
   c. Is the solution acidic, basic, or neutral? Explain.
How Strong is an Acid?
Ionization Constants for Acids

1. Write the dissociation constant expression for acetic acid.

2. What is the value of the constant for acetic acid at 25°C?

3. What does the numerical value for $K_a$ and $K_b$ represent?

4. Using the table below, answer the following questions.
   a. Which is the strongest acid? Why?

   b. Which acid dissociates the least? Why?

<table>
<thead>
<tr>
<th>Acid</th>
<th>Formula</th>
<th>Value of $K_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>H$_3$AsO$_4$</td>
<td>5.62 x 10$^{-3}$</td>
</tr>
<tr>
<td>Acetic</td>
<td>CH$_3$COOH</td>
<td>1.76 x 10$^{-5}$</td>
</tr>
<tr>
<td>Benzoic</td>
<td>C$_6$H$_5$COOH</td>
<td>6.5 x 10$^{-5}$</td>
</tr>
<tr>
<td>Cyanic</td>
<td>HCNO</td>
<td>7.4 x 10$^{-4}$</td>
</tr>
<tr>
<td>Phosphoric</td>
<td>H$_3$PO$_4$</td>
<td>7.5 x 10$^{-3}$</td>
</tr>
<tr>
<td>Hydrofluoric</td>
<td>HF</td>
<td>6.8 x 10$^{-4}$</td>
</tr>
<tr>
<td>Carbonic</td>
<td>H$_2$CO$_3$</td>
<td>4.3 x 10$^{-7}$</td>
</tr>
</tbody>
</table>

5. What is the molar hydrogen ion concentration in a 2.00 liter solution of hydrogen chloride in which 3.65 g of HCl are dissolved?

6. What is the molar concentration of hydrogen ions in solution containing 4.90 g of H$_2$SO$_4$ in 250 mL of solution?

7. An acetic acid solution is 0.25$M$. What is the molar concentration of hydrogen ions?

8. A solution of acetic acid contains 12.0 g of HC$_2$H$_3$O$_2$ in 500 mL of solution. What is the molar concentration of hydrogen ions?