**pH and pOH**

 **Objectives**

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| * Use the hydronium ion concentration of a solution to calculate pH.
* Use the hydroxide ion concentration of a soultion to calculate pOH.
* When given either pH or pOH, calculate the other.
* Use indicators to determine the pH of a solution.
* Predict the characteristics of a solution produced by hydrolysis.
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| pH is a measure of the [H3O +] in solution. Developing the concept of pH: Water ionizes according to the equation: 2H2O(l) H3O+(aq) + OH -(aq) The equalibrium expression for the reaction would be: Keq = [H3O+] [OH -] / [H2O]2 Experimental evidence indicates that pure water contains 1 X 10 -7 mole of both H3O+ and OH - The concentration of water in pure water is calculated as 55.6 moles/dm3 This information allows us to get an expression: Ksp(55.6)2 = [H3O+] [OH -] = 1 X 10 -14 Ksp(55.6)2 becomes a new constant, the ion product constant of water, K w  |  |
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|  | The expression becomes | K w = [H3O+] [OH -] = 1 X 10 -14  |

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| The importance of K w * **K w is a constant for all dilute aqueous solutions at room temperature.**
* **Although the [H3O+] and [OH -] may change, the product is always 1 X 10 -14**
* **This provides the basis for the pH scale.**

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|  | Base strength increases  |  |
|  | Acid strength increases |  |  |
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|  | The "strength" of an acid or base increases with distance from pH=7  |  |
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| pH of some common substances:  |  |
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| Acid | Neutral | Base |
| stomach acid - 2cola drinks - 3tomatoes - 4coffee - 5**milk - 6.5** | **pure water - 7** | blood - 7.5sea water - 8detergent - 10household cleaners - 11**oven cleaners - 14** |

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| Calculating pH: * The equation is: pH = - log [H3O+]
* [H3O+] is expressed in powers of 10 from 10 -14 to 10 0
* If [H3O+] = 1 X 10 -7, the negative log of [H3O+] = 7. The pH equals 7, indicating a neutral solution.
* The calculation of pH always gives a number between 0 and 14.
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|  Sample pH Calculations:Two ways are shown to work many of these problems:? The left column shows the problem worked using logarithm tables found on pages 865 and 866 in your textbook.? The right column shows the problems worked using a calculator.You are expected to understand logarithm tables, but you are allowed to work all problems in this class using a calculator.Remember that you must show the equation to be used, then the numbers plugged into the equation, then the answer circled. 1. What is the pH of a solution with a [H3O+] of 1.00 X 10 -4 M?

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| Using Log Tables | Using Calculator |
| pH = - log [H3O+] | pH = - log [H3O+] |
| pH = - log (1 X 10-4) | pH = - log (1 X 10-4) |
| pH = - (log 1.00 + log 10-4) | Do the following on your calculator: |
| pH = - (0 + (-4)) | Enter 1 X 10-4 |
| pH = - (-4) | Press " LOG " |
| pH = 4 | Press " +/- " |
|  | Hint: when the interger of the scientific notation is 1, the pH is the exponent of 10 as a positive number. |
|  | pH = 4 |

 2. 0.01 moles of HCl is added to water to make 1dm3 of solution. Assuming the HCl is completely ionized, what is the pH of the solution?

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| Using Log Tables | Using Calculator |
| [H3O+] = 1 X 10-2 M | pH = - log [H3O+] |
| pH = - log [H3O+] | pH = - log (1 X 10-2) |
| pH = - log (1 X 10-2) | Do the following on your calculator: |
| pH = - (log 1.00 + log 10-2) | Enter 1 X 10-2 |
| pH = - (0 + (-2)) | Press " LOG " |
| pH = - (-2) | Press " +/- " |
| pH = 2 | Hint: when the interger of the scientific notation is 1, the pH is the exponent of 10 as a positive number. |
|  | pH = 2 |

 3. Calculate the [H3O+] of a solution with a pH of 3.70.Using Calculator* **pH = - log [H3O+]**
* **- pH = log [H3O+] . . . . (you may begin with this equation)**
* **-3.70 = log [H3O+]**
* **antilog -3.70 = [H3O+]**
* **Do the following on your calculator:**
* **Enter -3.70**
* **antilog is usually "INV", "shift", or "2nd" + "log" on a calculator. Now is the time to find out which of these it is on your calculator.**
* **[H3O+] = 2 X 10-4 M**
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| Practice Problem Set #1:1. What is the pH of a solution whose [H3O+] is 1 X 10-5 M?2. What is the [H3O+] concentration of a solution with a pH of 9?3. What is the pH of a solution whose [H3O+] concentration is 3 X 10-3 M?4. What is the pH of a solution with a [H3O+] concentration of 1 X 10-12 M?5. What is the [H3O+] concentration of a solution whose pH is 8.9?**pOH** |

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| pOH   is a measure of the [OH -] in solution. **Calculating pOH:** * The equation is: pOH = - log [OH -]

[OH -] is expressed in powers of 10 from 10 -14 to 10 0 [H3O**+**] [OH **-**] = 1 X 10 **-14** pH + pOH = 14  |  |
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| Sample pOH Calculations:1. What is the pOH of a solution with [OH -] = 3.98 X 10-5 M?

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| Using Log Tables | Using Calculator |
| pOH = - log [OH -] | pOH = - log [OH -] |
| pOH = - log (3.98 X 10-5) | pOH = - log (3.98 X 10-5) |
| pOH = - (log 3.98 + log 10-5) | Do the following on your calculator: |
| pOH = - (.5999 + (-5)) | Enter 3.98 X 10-5 |
| pOH = - (-4.4) | Press " LOG " |
| pOH = 4.40 | Press " +/- " |
|  | pOH = 4.40 |

2. Find the pH of a solution that contains 0.0035 moles of H3O+ /dm3.

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| Using Log Tables | Using Calculator |
| pH = - log [H3O+] | pH = - log [H3O+] |
| pH = - log (3.5 X 10-3) | pH = - log (3.5 X 10-3) |
| pH = - (log 3.50 + log 10-3) | Do the following on your calculator: |
| pH = - (.5441 + (-3)) | Enter 3.5 X 10-3 |
| pH = - (-2.46) | Press " LOG " |
| pH = 2.46 | Press " +/- " |
|  | pH = 2.46 |

 3. What is the pOH of the solution above?Using Calculator* **pH + pOH = 14**
* **pOH = 14 - 2.46**
* **pOH = 11.54**

4. Calculate the pOH of a solution with a [H3O+] of 4.09 X 10-2 M.Using Calculator* **[H3O+] [OH -] = 1.00 X 10-14**
* **[OH -] = 1.00 X 10-14 / [H3O+]**
* **[OH -] = 1.00 X 10-14 / 4.09 X 10-2**
* **[OH -] = 2.44 X 10-13 M**
* **pOH = - log [OH -]**
* **pOH = - log (2.44 X 10-13)**
* **Do the following on your calculator:**
* **Enter 2.44 X 10 -13**
* **Press " LOG "**
* **Press " +/- "**
* **pOH = 12.6**

Use this webtest to practice pH calculations. |

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| Practice Problem Set #2:1. Find the pH of a solution whose [H3O+] is 9.5 X 10-8 M.2. What is the [H3O+] concentration of a solution with a pH of 5.45?3. Find the pH of a solution whose pOH is 1.36.4. What is the pOH of a solution with a [OH -] concentration of 2.97 X 10-10 M?5. Calculate the pH of a solution with a [OH -] concentration of 1 X 10-4 M. |

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| Determining pH experimentally: pH meter: * An electronic device that measures pH directly.
* pH meters are used in most professional lab settings today.

Indicators: * Weak organic acids and bases whose colors differ from the colors of their conjugate acids or bases.
* The color is best viewed from above against a white background.
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|  | **Acid / Base Indicators** |  |
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| Indicator | **Lower Color** | **pH Range** | **Upper Color** |
| methyl violet | **yellow-green** | **0.0 - 2.5** | **violet** |
| methyl orange | **red** | **2.5 - 4.4** | **yellow** |
| congo red | **blue** | **3.0 - 5.0** | **red** |
| bromocresol green | **yellow** | **4.5 - 5.5** | **blue** |
| methyl red | **red** | **4.8 - 6.0** | **yellow** |
| bromocresol purple | **yellow-green** | **5.4 - 6.8** | **violet** |
| bromothymol blue | **yellow** | **6.0 - 7.6** | **blue** |
| phenol red | **yellow** | **6.4 - 8.2** | **red-violet** |
| cresol red | **yellow** | **7.1 - 8.8** | **violet** |
| phenolphthalein | **colorless** | **8.3 - 10.0** | **dark pink** |

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| Phenolphthalein is a common indicator to use in neutralization titrations. The solution is considered neutral when the solution holds a very faint pink color for half a minute or more. |

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| alizarin yellow R | yellow | 9.9 - 11.8 | dark orange |

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|  Universal indicator solution has a wide range of color changes:Hydrion paper: * A paper that goes through changes similar to the universal indicator solution.

Litmus paper: * **Red litmus paper turns blue in a base.**
* **Blue litmus paper turns red in an acid.**
* **There is a litmus liquid with similar color response.**
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| Buffer systems: * Solutions that can absorb moderate amounts of acid or base without a significant change in pH.
* **Buffers provide ions that react with H3O+ or OH -, if they are introduced into the solution. As either ion is neutralized, the pH of the system remains nearly constant.**
* **Buffer solutions are prepared using a weak acid or base with one of its salts. The weak acid or base reacts with one of the added ions, the salt reacts with the other ion. The combination keeps the pH fairly constant, up to a point.**
* **By choosing the correct weak acid or base, a buffer solution can be prepared that will maintain almost any pH.**
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| **Hydrolysis:** the reaction of a salt with water to form an acidic or basic solution. The type of solution produced when a salt dissolves in water depends on the properties of the acid and base that combine to form the salt. The following table summarizes hydrolysis.  |  |
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| Positive ion source | Negative ion source | Resulting solution |
| strong base | strong acid | neutral |
| strong base | weak acid | basic |
| weak acid | strong base | acidic |
| weak acid | weak acid | unpredictable |

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|  | To use the table to predict the resulting solution from hydrolysis, one must be able to recognize strong and weak acids and bases.  |  |
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| Practice Problem Set #3:Predict the characteristic of the solutions of the following salts.1. CrBr32. NH4ClO43. NaCl4. NiSO45. GaI36. MgC4H4O57. K2CO3 |

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|     Answers to "Try These"1. 52. 1 X 10-9 M3. 2.54. 125. 1.26 X 10-9 M **Practice Problem Answers:**1. pH = 7.022. [H3O+] = 3.5 X 10-6 M3. pH = 12.644. pOH = 9.535. pH = 10     **Practice Problem Answers:**1. acidic2. acidic3. neutral4. acidic5. acidic6. basic7. basic |  |
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