pH Calculations

pH

The degree of acidity of a solution is measured using the pH scale. The pH of acids is below 7, neutral substances have a pH of 7, and alkalis have a pH greater than 7.

$$\mathbf{pH = - \log_{10} [H_3O^+]} \text{ or } \mathbf{pH = - \log_{10} [H^+]}$$

[ ] = concentration in mol L^{-1}

Example: Calculate the pH of a solution whose hydrogen ion concentration is 3.65×10^{-5} mol L^{-1}

$$pH = - \log_{10} 3.65 \times 10^{-5}$$

$$pH = 4.44 \text{ (3 sf)}$$

To calculate $\log_{10}$ on your calculator use the log key.

$$\mathbf{[H_3O^+] = antilog (- pH)} \text{ or } \mathbf{[H^+] = antilog (- pH)}$$

To find the antilog use the 10^x key (usually the inverse of the log key).

Example: Calculate the $[H_3O^+]$ of a solution whose pH is 8.45

$$[H_3O^+] = \text{antilog} (- 8.45)$$

$$[H_3O^+] = 3.55 \times 10^{-9} \text{ mol } L^{-1}$$

K_W

Water has a pH of 7 which means $[H_3O^+]$ = antilog (- 7) = 10^{-7} mol L^{-1}. Since water is neutral, $[H_3O^+] = [OH^-]$, so $[OH^-] = 10^{-7}$ mol L^{-1}.

Water ionises only to a very small degree (equilibrium position lies very much to the left).

$$2H_2O \rightleftharpoons H_3O^+ + OH^- \text{ or more simply } H_2O \rightleftharpoons H^+ + OH^-$$

$$\mathbf{K_W = [H_3O^+] [OH^-]} \text{ or } \mathbf{K_W = [H^+] [OH^-]}$$

$$\mathbf{K_W = [1.00 \times 10^{-7}] [1.00 \times 10^{-7}] = 10^{-14}}$$

This rearranges to $\mathbf{[H_3O^+] = K_W / [OH^-]}$ & to $\mathbf{[OH^-] = K_W / [H_3O^+]}$

We can use K_W to find the pH of bases if their $[OH^-]$ is known

- Use $10^{-14} = [H_3O^+] [OH^-]$ to calculate $[H_3O^+]$
- Use $pH = - \log_{10} [H_3O^+]$ to calculate the pH

To find $[OH^-]$ when pH is known

- Use $[H_3O^+] = \text{antilog} (- pH)$ to calculate $[H_3O^+]$
- Use $10^{-14} = [H_3O^+] [OH^-]$ to calculate $[OH^-]$

The pH scale

$[H^+]$	1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}
$[OH^-]$	10^{-14}	10^{-13}	10^{-12}	10^{-11}	10^{-10}	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	1
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	STRONG ACID			WEAK ACID				*N	WEAK ALKALI				STRONG ALKALI		

*N Neutral

Calculators

Calculators are different. To obtain antilog you might use shift + log or 2nd function + log. Make sure you know how to do log and antilog on your particular calculator.

Also make sure you know how to enter numbers in standard form – and if the answer is given in standard form in your calculator display how to write it correctly.

Significant figures

Rule 1: All non-zero digits are significant.

Rule 2: Zeros in front of a number are <u>not</u> significant.

Rule 3: Zeros between non-zero digits are significant.

Rule 4: Zeros at the end of a number are significant if there is a decimal point in the number.

Examples:

0.0203 has 3 significant figures

2.50 has 3 significant figures

3.7×10^9 has 2 significant figures

5.05×10^4 has 3 significant figures

6 has 1 significant figures but 6.00 has 3 significant figures

There is more than one way to do pH calculations

You must learn

$pH = - \log_{10} [H^+]$ and **$[H^+] = \text{antilog} (- pH)$**

You will be given **$K_W = 10^{-14}$**

There is another way to do these calculations which you may prefer.

There is another scale, the **pOH scale**, which is not very much used.

$pOH = - \log_{10} [OH^-]$ and **$[OH^-] = \text{antilog} (- pOH)$**

This isn't really 2 more equations to be memorized…….

You also need to know that **pH + pOH = 14**

That's not really too difficult to remember either.

Example:

Calculate the $[OH^-]$ of a solution of pH 10.4

Answer:

pH + pOH = 14 so pOH = 14 – 10.4 = 3.60

$[OH^-]$ = antilog (- pOH) so $[OH^-]$ = antilog (- 3.60)

$[OH^-] = 2.51 \times 10^{-4}$ mol L^{-1} (3 sf)