VANCOUVER COMMUNITY COLLEGE

pH Problems

FORMULAS

pH < 7 for an acid ($[H^+] > 1 \times 10^{-7}$); pH > 7 for a base ($[H^+] < 1 \times 10^{-7}$)

$K_w = [H^+][OH^-] = 1.00 \times 10^{-14}$ (at 25° C)

$pH = -\log [H^+] = \log \frac{1}{[H^+]}$

$pOH = -\log [OH^-] = \log \frac{1}{[OH^-]}$

$[H^+] = 10^{-pH}$ = antilog (−pH)

$[OH^-] = 10^{-pOH}$ = antilog (−pOH)

pH + pOH = 14

$[H^+] = [OH^-] = 1.00 \times 10^{-7}$ M (for pure H_2O at 25°C)

Example 1: Calculate $[OH^-]$ in a solution in which $[H^+]$ is 3.72×10^{-3}.

Solution: $[OH^-] = \frac{K_w}{[H^+]} = \frac{1.00 \times 10^{-14}}{3.72 \times 10^{-3}} = 2.69 \times 10^{-12}$ M

Example 2: What is the pH of a solution if $[H^+] = 5.31 \times 10^{-9}$?

Solution: $pH = -\log [H^+] = -\log (5.31 \times 10^{-9}) = 8.27$

Example 3: Calculate $[H^+]$ for a solution having a pH of 1.57.

Solution: $[H^+] = 10^{-pH} = 10^{-1.57} = 0.0269$ M, or
$[H^+]$ = antilog (−pH) = antilog (−1.57) = 2.69×10^{-2} M

To perform the antilog function on most calculators, use [SHIFT] [log] or [2ndF] [log]. On old-style calculators, you'll type this after entering the number. On newer calculators that try to simulate algebraic notation, you'll have to type this key combination and then the number, or if the number is the result of your most recent calculation, use the [ANS] key.

Example 4: What is the pH in a solution having $[OH^-] = 2.75 \times 10^{-2}$?

Solution A: $[H^+] = \frac{K_w}{[OH^-]} = \frac{1.00 \times 10^{-14}}{2.75 \times 10^{-2}} = 3.64 \times 10^{-13}$ M
$pH = -\log [H^+] = -\log (3.64 \times 10^{-13}) = 12.439$

Solution B: $pOH = -\log [OH^-] = -\log (2.75 \times 10^{-2}) = 1.561$
$pH = 14 - pOH = 14 - 1.561 = 12.439$

Authored by Gordon Wong

EXERCISES

A. Identify the following as acidic, neutral or basic:

1) $[H^+] = 2.45 \times 10^{-12}$ M
2) $[H^+] = 1.44 \times 10^{-3}$ M
3) pH = 13.55
4) pH = 7.00
5) pH = 1.77
6) $[OH^-] = 5.79 \times 10^{-2}$ M
7) $[OH^-] = 7.00 \times 10^{-7}$ M
8) pOH = 8.22
9) pOH = 6.25
10) $[H^+] > [OH^-]$
11) $[H^+] < [OH^-]$
12) $[H^+] = [OH^-]$

B. Calculate the concentrations of H^+ and OH^- in the following solutions:

1) lemon juice, pH = 2.30
2) carbonated water, pH = 3.00
3) urine, pH = 6.00
4) pure water, pH = 7.00
5) blood, pH = 7.40
6) 0.79 M HCℓ, pH = 0.10
7) 1.00 M NaOH, pH = 14.00
8) egg, pH = 7.80

C. Complete the following table. Under $[H^+]$ and $[OH^-]$, write "$< 10^{-7}$", "$> 10^{-7}$" or "10^{-7}". Under pH and pOH, write "< 7", "> 7" or "7".

Nature	$[H^+]$	$[OH^-]$	pH	pOH
acidic				
neutral				
basic				

D. Complete the following table. Under Nature, write "acidic", "basic" or "neutral". Elsewhere, use exact numbers.

Solution	pH	pOH	$[H^+]$	$[OH^-]$	Nature
A	7.00				
B	2.25				
C		5.57			
D			8.55×10^{-3}		
E				1.75×10^{-9}	

E. A sample of Vancouver rainwater was determined to have a pH of 6.22. What were the H^+ and OH^- concentrations of the sample, and what was its nature?

F. How many times more acidic is a solution with a pH of 3 compared to a solution with a pH of 6?

G. Milk of magnesia, $Mg(OH)_{2\,(aq)}$, has a pH of 10.5. Explain its effectiveness in overcoming indigestion.

H. What is the pH of a 2.00×10^{-3} M $HC\ell$ solution?

I. What is the pH of a 5.55×10^{-4} M NaOH solution?

J. What is the pH of a 1.50×10^{-2} M acetic acid solution in which the acid is only 4.3% dissociated?

K. A 3.00×10^{-2} M weak diprotic acid, H_2A, is found to be 2.0% dissociated. Calculate:
1) $[H^+]$
2) pH

L. Your new neighbour graciously offers you the use of his hot tub. “A pH of −1… total relaxation,” he says. Should you accept his generous offer, or should you stay home and play World of Warcraft?

SOLUTIONS

A. (1) basic (2) acidic (3) basic (4) neutral (5) acidic (6) basic (7) basic (8) acidic (9) basic (10) acidic (11) basic (12) neutral

B. (1) $[H^+]$: 5.0×10^{-3} M, $[OH^-]$: 2.0×10^{-12} M
(2) $[H^+]$: 1.0×10^{-3} M, $[OH^-]$: 1.0×10^{-11} M
(3) $[H^+]$: 1.0×10^{-6} M, $[OH^-]$: 1.0×10^{-8} M
(4) $[H^+]$: 1.0×10^{-7} M, $[OH^-]$: 1.0×10^{-7} M
(5) $[H^+]$: 4.0×10^{-8} M, $[OH^-]$: 2.5×10^{-7} M
(6) $[H^+]$: 0.79 M, $[OH^-]$: 1.3×10^{-14} M
(7) $[H^+]$: 1.0×10^{-14} M, $[OH^-]$: 1.0 M
(8) $[H^+]$: 1.6×10^{-8} M, $[OH^-]$: 6.3×10^{-7} M

C.

Nature	$[H^+]$	$[OH^-]$	pH	pOH
acidic	$> 10^{-7}$	$< 10^{-7}$	< 7	> 7
neutral	10^{-7}	10^{-7}	7	7
basic	$< 10^{-7}$	$> 10^{-7}$	> 7	< 7

D.

Solution	pH	pOH	$[H^+]$ (M)	$[OH^-]$ (M)	Nature
A	7.00	7.00	1.0×10^{-7}	1.0×10^{-7}	neutral
B	2.25	11.75	5.6×10^{-3}	1.8×10^{-12}	acidic
C	8.43	5.57	3.7×10^{-9}	2.7×10^{-6}	basic
D	2.068	11.932	8.55×10^{-3}	1.17×10^{-12}	acidic
E	5.243	8.757	5.71×10^{-6}	1.75×10^{-9}	acidic

E. $[H^+] = 6.0 \times 10^{-7}$ M; $[OH^-] = 1.7 \times 10^{-8}$ M; acidic

F. 1000 times

G. Milk of magnesia is basic, since its pH is greater than 7. It helps to neutralize excess stomach acid.

H. pH = 2.699

I. pH = 10.744

J. pH = 3.190

K. (1) $[H^+] = 1.2 \times 10^{-3}$ M (2) pH = 2.92

L. Assuming he's telling the truth about the pH, then the hot tub has a $[H^+]$ of 10 $^{mol}\!/_{L}$, which is ***<u>strongly</u>*** acidic. Since you would not survive going in that hot tub, stay home. Do you get the impression that your neighbour just doesn't like you?