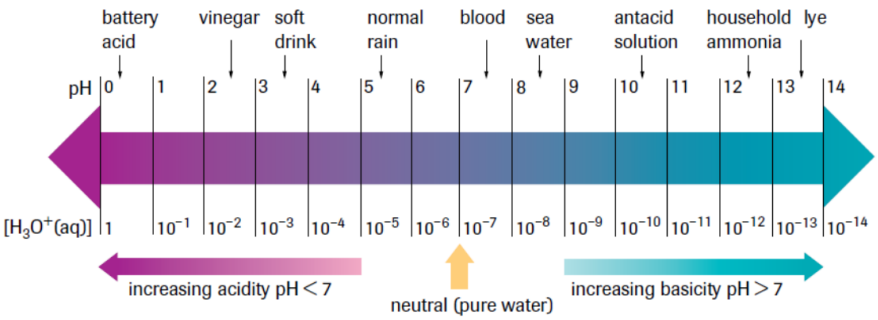
Outcome 2
Topic 2 – pH, pOH and the pH scale

- Aqueous solutions can have a wide range of hydronium ion concentrations

  - 10 mol/L for concentrated hydrochloric acid
  - 10^{-15} mol/L for concentrated sodium hydroxide

- pH scale was created to provide a more convenient way of communicating these concentrations

http://www.johnkyrk.com/pH.html



pH and hydronium ion concentration

- pH means the **power of hydrogen**

[ ]: amount conc. (mol/L)

- Formula for calculating pH from $[H_3O^+]$

$pH = -\log [H_3O^+]$ mol/L

- Formula for calculating $[H_3O^+]$ from pH

$[H_3O^+] = 10^{-pH}$

- **Significant digits:** The number of decimal places in the pH will tell you the number of significant digits for the concentration

decimal places in pH : sig digs in [ ]

Examples

What is the pH of a solution that has a hydronium ion concentration of 1.52×10^{-2} mol/L?

$pH = -\log(1.52 \times 10^{-2}\ mol/L)$

$= 1.8181\ldots = 1.818$

What is the concentration of the hydronium ion in a solution that has a pH of 7.65?

$[H_3O^+] = 10^{-pH} = 10^{-7.65} = 2.2387\ldots \times 10^{-8}\ mol/L$

$= 2.2 \times 10^{-8}\ mol/L$

pOH and hydroxide ion (OH^-) concentration

- pH is used more commonly, but occasionally it is more practical to describe hydroxide ion concentration in a similar way

- Formula for calculating pOH from $[OH^-]$

$pH + pOH = 14$

$$pOH = -\log [OH^-]$$

- Formula for calculating $[OH^-]$ from pOH

$$[OH^-] = 10^{-pOH}$$

Examples

A cleaning solution has a hydroxide ion concentration of 0.35mol/L. What is the pOH of this solution?

$pOH = -\log [OH^-] = -\log(0.35\ mol/L)$

$= 0.4559...$

$pOH = \boxed{0.46}$

Windex has a pOH of 3.2. What is the $[OH^-]$?

$[OH^-] = 10^{-pOH}$

$= 10^{-3.2}$

$= 6.309... \times 10^{-4}\ mol/L = \boxed{6 \times 10^{-4}\ mol/L}$

Practice Sheet 9

1. Measurements of pH can be made using pH paper to provide a quick estimate of the hydronium ion concentration in an aqueous solution. What is the estimated hydronium ion concentration in each of the following solutions?

(a) pure water: pH = 7 1×10^{-7} mol/L

(b) household ammonia: pH = 11 10^{-11} mol/L

(c) vinegar: pH = 2 10^{-2} mol/L

(d) soda pop: pH = 4 10^{-4} mol/L

(e) drain cleaner: pH = 14 10^{-14} mol/L

2. Hydronium ion concentration is a theoretical concept used to explain the properties of acids. Express each of the following concentrations as pH values:

(a) grapefruit juice: $[H_3O^+_{(aq)}] = 10^{-3}$ mol/L 3

(b) rainwater: $[H_3O^+_{(aq)}] = 10^{-5}$ mol/L 5

(c) milk: $[H_3O^+_{(aq)}] = 10^{-7}$ mol/L 7

(d) soap: $[H_3O^+_{(aq)}] = 10^{-10}$ mol/L 10

pH	$[H_3O^+]$
3	0.001
5	0.00001

3. If one water sample test shows a pH of 3 and another sample shows a pH of 5, by what factor do their hydronium ion concentrations differ? Justify your answer.

100 x

4. Knowing the pH of common substances is useful to a wide variety of people such as nutritionists, medical personnel, environmentalists, and consumers. Express each of the following concentrations as pH values.

(a) grapefruit juice: $[H_3O^+(aq)] = 2.1 \times 10^{-3}$ mol/L 2.68

(b) rainwater: $[H_3O^+(aq)] = 1 \times 10^{-5}$ mol/L 5.0

(c) milk: $[H_3O^+(aq)] = 2.50 \times 10^{-7}$ mol/L 6.602

(d) soap: $[H_3O^+(aq)] = 7.3 \times 10^{-9}$ mol/L 8.14

5. The technology of a pH meter provides an efficient way to obtain a pH that various people, such as chemists and biologists, often convert to a concentration. Calculate the hydronium ion concentration in each of the following household mixtures.

(a) ammonia cleaner: pH = 11.3 5×10^{-12} mol/L

(b) salad dressing: pH = 2.65 0.0022 mol/L

(c) carbonated drink: pH = 4.2 $[H_3O^+] = 6 \times 10^{-5}$ mol/L

(d) oven cleaner: pH = 13.755 1.76×10^{-14} mol/L

6. Fill in the following tables

Cleaning Solution	$[OH^-(aq)]$ (mol/L)	pOH
stain remover	6.7×10^{-2}	1.17
baking soda	1×10^{-5}	5.0
bleach	2.5×10^{-3}	2.60
drain cleaner	0.8	0.1

Food	$[H_3O^+(aq)]$ (mol/L)	pH
oranges	5.5×10^{-3}	2.26
asparagus	4×10^{-9}	8.4
olives	4.6×10^{-4}	3.34
blackberries	4×10^{-4}	3.4