4.6: Acid-Base Reactions and pH

Acids react with metals in single displacement reactions

Eg.

Acids react with carbonates in double displacement reactions

Eg.

Acids react with some ionic compounds to form new acids and precipitates

Eg.

Acids react with bases in double displacement reactions called ***neutralization reactions***

Eg.

Titration Reactions

Eg.

- Adding base to an acid neutralizes both the acidic and basic properties ( )
- When a strong acid reacts with a strong base in balanced stoichiometric amounts a neutral salt solution is produced
- To observe the reaction we use indicators to monitor the change in the $[H^+_{(aq)}]$
- Indicators are usually weak _____ (only one acidic H^+, _____ more than one H^+) acids that change colour when they dissociate
- The point as which the indicator changes colour is called the _____
- To obtain precise and reliable results, the concentration of one of the reactants must be known, a _____ must be used.

Sample problem:
An acid rain sample containing sulfurous acid was analyzed in a laboratory using a titration with a standard solution of sodium hydroxide. Use the evidence given in the following table to determine the concentration of the sulfurous acid.

Titration of 25.0 mL of $H_2SO_{3(aq)}$ with 0.105 mol/L $NaOH_{(aq)}$

Trial	1	2	3
final buret reading (mL)	11.1	21.7	32.4
initial buret reading (mL)	0.3	11.1	21.7
volume of $NaOH_{(aq)}$ added	10.8	10.6	10.7

pH

Ionization of water

Even pure water contains trace amounts of H^+ and OH^- ions

at about 2 ppb or $1x10^{-7}$ mol/L

*So extremely sensitive meters will detect conductivity in pure water.

- In a neutral solution, $[H^+_{(aq)}] = 1 \times 10^{-7}$ mol/L.
- In an acidic solution, $[H^+_{(aq)}] > 1 \times 10^{-7}$ mol/L.
- In a basic solution, $[H^+_{(aq)}] < 1 \times 10^{-7}$ mol/L.

SCH3U: Solutions and Solubility

The molar concentration of hydrogen ions is extremely important in chemistry.
(↑[H^+] the more acidic a solution becomes)

pH is a way of indicating the concentration of hydrogen ions present in a solution

Because writing concentrations of $1x10^{-6}$, $1x10^{-12}$, $1x10^{-4}$, became tedious to use, a mathematical function was designed to simplify them.

Sample Problems
What is the pH of each of the following solutions?
(a) 1×10^{-2} mol/L hydrogen ion concentration in vinegar

(b) $[H^+_{(aq)}] = 1.0 \times 10^{-12}$ mol/L in household ammonia

What is the hydrogen ion concentration for the following solutions?
(a) a carbonated beverage with a pH of 3.0

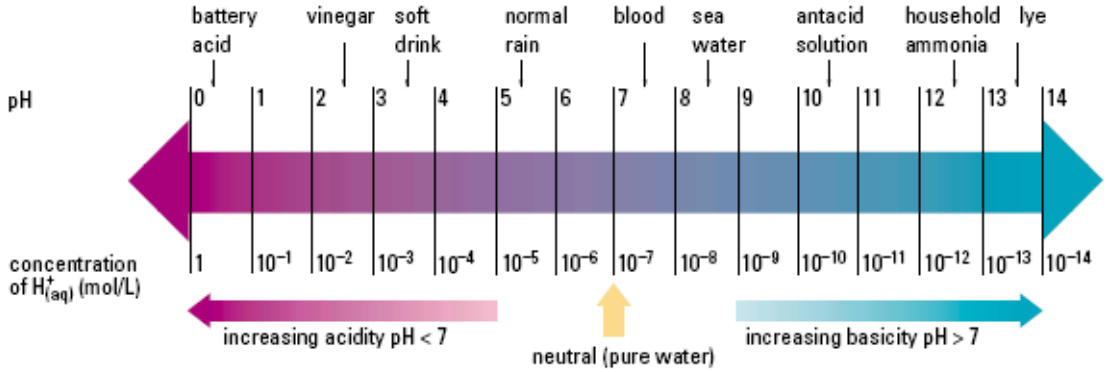
(b) an antacid solution for which pH = 10.00

pH simplifies concentration

-a change in pH by 1 means the concentration increases or decreases by a factor of 10

-a change in pH by 2 means the concentration increases or decreases by a factor of 100

Neutralization:



Calculating pH

When calculating pH, you should always use 2 decimal places. When calculating concentration, you should always have one decimal place.

An antacid solution has a hydrogen ion concentration of 4.7×10^{-11} mol/L. What is its pH?

The pH reading of a solution is 10.33. What is its hydrogen ion concentration? Be sure to indicate your answer with the correct certainty.

Hydrogen Ion Concentration and pH

pH is the negative power of ten of the hydrogen ion concentration.

$pH = -\log[H^+_{(aq)}]$ or $[H^+_{(aq)}] = 10^{-pH}$

solution:	acidic	neutral	basic
$[H^+_{(aq)}]$:	>10–7	10–7	<10–7
pH:	<7	7	>7

Note the inverse relationship between [H+(aq)] and pH. The higher the hydrogen ion molar concentration, the lower the pH.

Worksheet 4.6: Acid-Bases Reactions

1. Write specific balanced chemical equations to illustrate each of the three types of characteristic reactions of acids.

2. An antacid tablet contains 0.912 g aluminum hydroxide to neutralize excess stomach acid. What volume of 0.10 mol/L stomach acid (assume $HCl_{(aq)}$) can one tablet neutralize?

3. Slaked lime, $Ca(OH)_{2(s)}$, can be used to neutralize the water in lakes that have been "killed" by acid rain. Ecologists hope that the original plants and animals will become reestablished. If the concentration of sulfuric acid in an acid lake is 1.2×10^{-3} mol/L, and 1.0 t of slaked lime is added to the lake, then what is the volume of the lake that could be neutralized?

4. A household cleaner has a pH of 12 and some fruit juice has a pH of 3.
   (a) What is the hydrogen ion concentration in each solution?
   (b) Compare the concentration of hydrogen ions in the fruit juice to that of the hydrogen ions in the cleaner. How many times more concentrated is the hydrogen ion in the juice than the cleaner?

5. What is the pH of each of the following water samples?
   (a) tap water: $[H^+_{(aq)}] = 1 \times 10^{-8}$ mol/L
   (b) pure water: $[H^+_{(aq)}] = 1 \times 10^{-7}$ mol/L
   (c) normal rainwater: $[H^+_{(aq)}] = 2.5 \times 10^{-6}$ mol/L
   (d) acid rain: $[H^+_{(aq)}] = 1.3 \times 10^{-4}$ mol/L

6. Common household vinegar has a pH of 2.4 and some pickling vinegar has a pH of 2.2.
   (a) Which vinegar solution is more acidic?
   (b) Which has a greater hydrogen ion concentration?
   (c) Calculate the hydrogen ion concentration in each solution.

7. A student tested the pH of 0.1 mol/L solutions of hydrochloric acid and acetic acid. The pH of the hydrochloric acid solution was 1.1 and the pH of the acetic acid was 2.9.
   (a) Explain the difference in pH.
   (b) Communicate the difference by writing ionization equations for each of the acids.
   (c) Which of the solutions deserves greater caution when being used? Why?

8. The pH of a cleaning solution was determined using a variety of technologies. Convert the pH into a molar concentration of hydrogen ions, with the correct certainty in the answer. Suggest what technology might have been used in each of these measurements.
   (a) pH = 10
   (b) pH = 9.8
   (c) pH = 9.84
   (d) pH = 9.836

9. Hydrangeas are garden shrubs that may produce blue, purple, or pink flowers. Research has indicated that the colour is dependent on the pH of the soil: blue at pH 5.0–5.5, purple at pH 5.5–6.0, and pink at pH 6.0–6.5.
   Convert the following expressions of acidity from pH to $[H^+_{(aq)}]$.
   (a) pH = 5.4 (blue) (b) pH = 5.72 (purple)
   Convert these concentrations to pH and predict the colour of the flower.
   (c) $[H^+_{(aq)}]$ = 5 x 10–7 mol/L (d) $[H^+_{(aq)}]$ = 7.9 x 10–6 mol/L