1 Acids and Bases

1.1 Acids & Bases

Acids and bases are two types of chemicals that have special properties.

They react with each other in a certain way - but they are not exact opposites of each other.

Acids:

- Acids are substance that dissociate in water to form hydrogen ions, which combine with water to form hydronium ions.
- The presence of these ions are what give a substance acidic properties.
- The H^+ can come directly from the acid molecule or from the acid's interaction with water. Either way, the chemical yields H^+.

Physical and Chemical Properties of Acids:

- Taste sour
- Produce hydrogen gas when they react with metals
- React with carbonates to form carbon dioxide and water.
- Turns litmus paper red.
- Electrolytes.

Strong acids dissociate nearly 100% and weak acids dissociate very little.

Polyprotic acids are acids that have more than one ionizable hydrogen. The hydrogens are dissociated one at a time.

Bases:

- Bases are substances that react in water to form hydroxide ions.
- The presence of hydroxide is what gives bases their basic properties.
- The OH^- can come from the basic molecule or from an interaction with water.

  Properties:

  - Taste bitter
  - Feel slippery
  - Turns litmus paper blue
  - Electrolytes in water solution
  - Can damage tissue if strong.

Acids and bases react with each other to produce neutral products.

Acid + Base → Water + Salt

Arrhenius Definition:

- Arrhenius acids contain hydrogen ions.
- Arrhenius bases contain hydroxide ions.

Bronsted-Lowry Acids & Bases

- Bronsted-Lowry acids are any substances that donate hydrogen ions (which is a proton, so called "proton donors".)
- Bronsted-Lowry bases are any substances that can accept hydrogen ions (from an acid or water - "proton acceptors")
- Lewis acids are electron pair acceptors.
- Lewis bases are electron pair donors.

Recall that when an acid dissolves in water, it donates a H^+ ion to a water molecule, forming hydronium.

The reverse reaction is also an acid/base reaction. In the reverse reaction, we call them conjugates.

We've seen water act like an acid and a bse.

This is called amphoteric. Several substances can act as acid or base, depending on what it is paired with.

The pH scale is used to indicate how acidic or basic a solution is.

- pH = 7 = neutral
- pH < 7 = acidic
- pH > 7 = basic

Because H^+ ions make something acidic, the more H^+ ions present, the more acidic the solution is.

The molar concentrations of H^+ are usually small, written in scientific notation, and hard to compare.

The pH scale, 0-14, is easier to interpret.

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

A change of one pH unit represents a tenfold change in H^+ concentration.

The pOH is a similar scale that mirrors the pH and $[\mathrm{H}^+]$ relationship in the pH scale.

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

pH + pOH = 14 for any given solution.

If you know the pH or pOH, you can figure out the ion concentrations by working backwards.

$[\mathrm{H}^+] = 10^{-\mathrm{pH}}$ and $[\mathrm{OH}^-] = 10^{-\mathrm{pOH}}$

Substances that change color as pH changes are acid base indicators.

1.2 Titrations

The purpose of titrations are to determine the concentration of a solution.

To determine the concentration, if the unknown is the base, you titrate it with an acid of known concentration.

You titrate until the unknown is neutralized as indicated by a change in pH which will change the color of an indicator.

Moles H^+ will equal moles OH^-.

Neutralization is a reaction of an acid and a base to produce a salt and water.

- Water is produced from a union of a H^+ from the acid and an OH^- from the base.
- Salt: ionic compound formed from the positive ion of an aqueous base and the negative ion of an aqueous acid. The salt is not always NaCl.
- Equal amounts of H^+ and OH^- will neutralize completely.
- Salts produced from neutralization may or may not be neutral in solution.

The titration formula:

$$V_a M_a(\#\mathrm{H}^+) = V_b M_b(\#\mathrm{OH}^-)$$

Where V is volume, M is molarity, and $\#H^+$ or $\#OH^-$ is the # of hydrogen or hydroxide ions in the chemical formula of the acid or base.

Titration: lab procedure in which a carefully measured solution of known concentration is slowly added to a known volume of a second solution to experimentally determine its concentration.

Equivalence point: point of neutralization where $[H^+] = [OH^-]$

Endpoint: point where the color change of the indicator occurs.

Performing a titration:

- Buret: a measuring instrument with very small volume increments used to perform titrations.
- Before beginning a titration, rinse the buret with 5 mL of distilled water. Discard the water.
- Then rinse the buret with $\tilde{5}$ mL of the known concentration solution. Discard the rinse solution.
- THEN fill the buret with the known concentration solution.
- Record your initial volume and begin the titration.
- The buret showhs how much solution has been emptied.
- Be careful not to overshoot the end point.

1.3 Molar Mass through Titrations

Titrations are a method to determine many things:

- The molarity of an acid or base
- The molar mass of an acid or base
- The K_a or K_b value of an acid or base.

If you know bot hte mass and number of moles of any substance, you can determine its molar mass by dividing the grams by moles.

1.4 Acid-Base Equilibrium: Ka & Kb

The general reaction for a weak acid is

$$HA + H_2O \leftrightarrow H_3O^+ + A^-$$

Often we leave out the water part and just show:

$$HA \leftrightarrow H^+ + A^-$$

The general equilibrium constant expression for weak acids is shown below:

$$K_a = \frac{[H^+][A^-]}{[HA]} < 1$$

The general equation for weak base reactions is

$$B + H_2O \leftrightarrow HB^+ + OH^-$$

The general equilibrium constant expression for weak bases is shown below:

$$K_b = \frac{[HB^+][OH^-]}{[B]} < 1$$

Note that the concentrations that you substitute in are at equilibrium, meaning after the acid/base has dissociated to its maximum extent. Notice that water is not included in the K expression even if it is in the ionization/dissociation equation.

The K value can help us determine how much of the acid or base will ionize, called "x". We use RICE tables to organize our calculations and information.

- Reaction

- Initial Amount
- Change
- Equilibrium

There are two basic types of acid/base equilibria problems:

- You need to calculate K_a or K_b (you have x)
- You need to calculate x (you have K_a or K_b)

Exercise - The weak acid hydrogen fluoride can be used to etch glass. In a 0.25 M solution of HF, the fluoride ion concentration is found to be 0.012 M. Find the K_a value for HF. (6.0×10^{-4})