EXPERIMENT 8 (DAY 2)
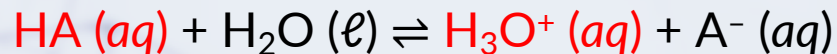## Acids, Bases, & Buffers

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CHEMISTRY 136L

YALE UNIVERSITY
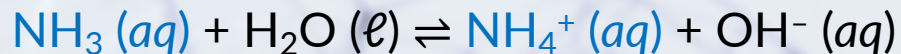
FALL 2018

ACIDS PROTON DONORS	$HA\ (aq) + H_2O\ (\ell) \rightleftharpoons H_3O^+\ (aq) + A^-\ (aq)$

BASES PROTON ACCEPTORS	$NH_3\ (aq) + H_2O\ (\ell) \rightleftharpoons NH_4^+\ (aq) + OH^-\ (aq)$

If $K_a > 1$, the acid is strong
examples: HCl, HNO₃, ...

If $K_a < 1$, the acid is weak

If $K_a \ll 1$, the acid is very weak
examples: CH₃COOH, HCOOH, ...

If $K_b > 1$, the base is strong
examples: NaOH, KOH, Ca(OH)₂ ...

If $K_b < 1$, the base is weak

If $K_b \ll 1$, the base is very weak
examples: CH₃COO⁻, any conjugate base

MONOPROTIC AND POLYPROTIC ACIDS

Polyprotic acids have more than one ionizable proton (H^+).

Some Examples

Sulfuric acid is diprotic

Oxalic acid is diprotic

Citric acid is triprotic

Phosphoric acid is triprotic

⋮

Amino acids are polyprotic

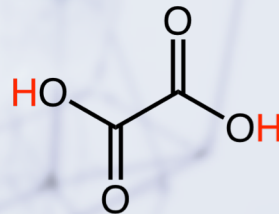Generally, ACID-BASE neutralization reactions are product favored.

↓

In principle, when a diprotic acid is titrated with NaOH (a monoprotic strong base), two steep rises can be expected.

↓

But, in practice, if the two K_a values are close to each other, then the two steep rises overlap.

The titration curve for oxalic acid with NaOH has two overlapping steps.

HOW DO WE DETERMINE EQUIVALENCE POINT #1?

In a polyprotic acid versus NaOH titration, how is the volume at the second equivalence point related to the volume at the first equivalence point?

Total volume of NaOH added to reach the second equivalence point
=
2 × volume of NaOH added to reach the first equivalence point

Titration Curve (oxalic acid/NaOH)
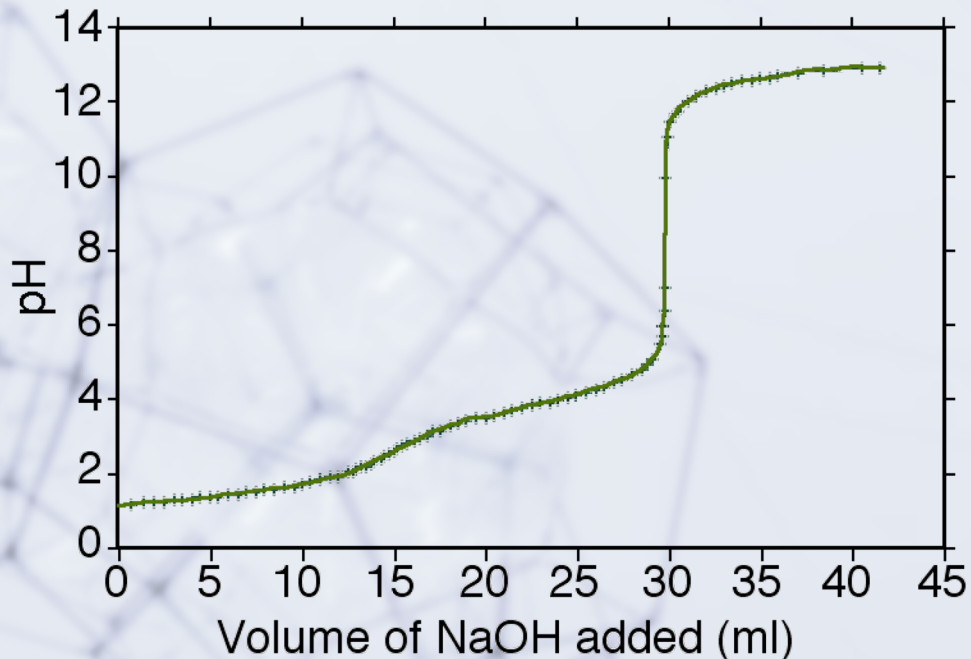
BUFFERS

Consists of a weak ACID-CONJUGATE BASE pair.
They are essential in all biochemical processes.

BUFFERS have the ability to *resist* change in pH when
a small amount of a strong ACID or BASE is added.

CALCULATING THE pH OF A BUFFER

$$[H^+]_{buffer} = K_a \times \frac{[HA]_{eq}}{[A^-]_{eq}} \approx K_a \times \frac{[HA]_{initial}}{[A^-]_{initial}}$$

THE HALF-EQUIVALENCE POINT

pK_a of a weak acid = pH at the half-equivalence point

In a weak ACID (HA)-strong BASE titration, at the half-equivalence point: one half of the initial moles of HA have been neutralized and converted to its CONJUGATE BASE (A$^-$); the other one half of HA moles are still there.

Thus, the solution in the beaker, at the half-equivalence point, is a BUFFER with equal [HA] and [A$^-$].

$$[H^+]_{buffer} \approx K_a \times \frac{[HA]_{initial}}{[A^-]_{initial}} = K_a$$

NOTES

1. The pH electrode is a delicate item, so handle it with care.
   To work well, it <u>needs to be well-immersed</u> in the solution.

2. Plot both pH and its first derivative ($\partial pH/\partial V$).
   → Use the latter to judiciously choose NaOH increments.

3. In the vicinity of the EQUIVALENCE POINT, you <u>must</u> use <u>very</u> small increments
   of base (one drop at a time).
   If not, you will <u>not</u> be able to determine the EQUIVALENCE POINT accurately.

4. No lab next week.