Acids & Bases

Chapter 19

Naming Acids [REMINDER]

- First, cover the (H) and name the anion normally.
  - Sulfide.
- Next, use this key:

Example

[redacted]S^{2-}

Anion Suffix	Acid Name
-ide	Hydro___ic acid
-ate	___ic acid
-ite	___ous acid

Remembering Acid Names

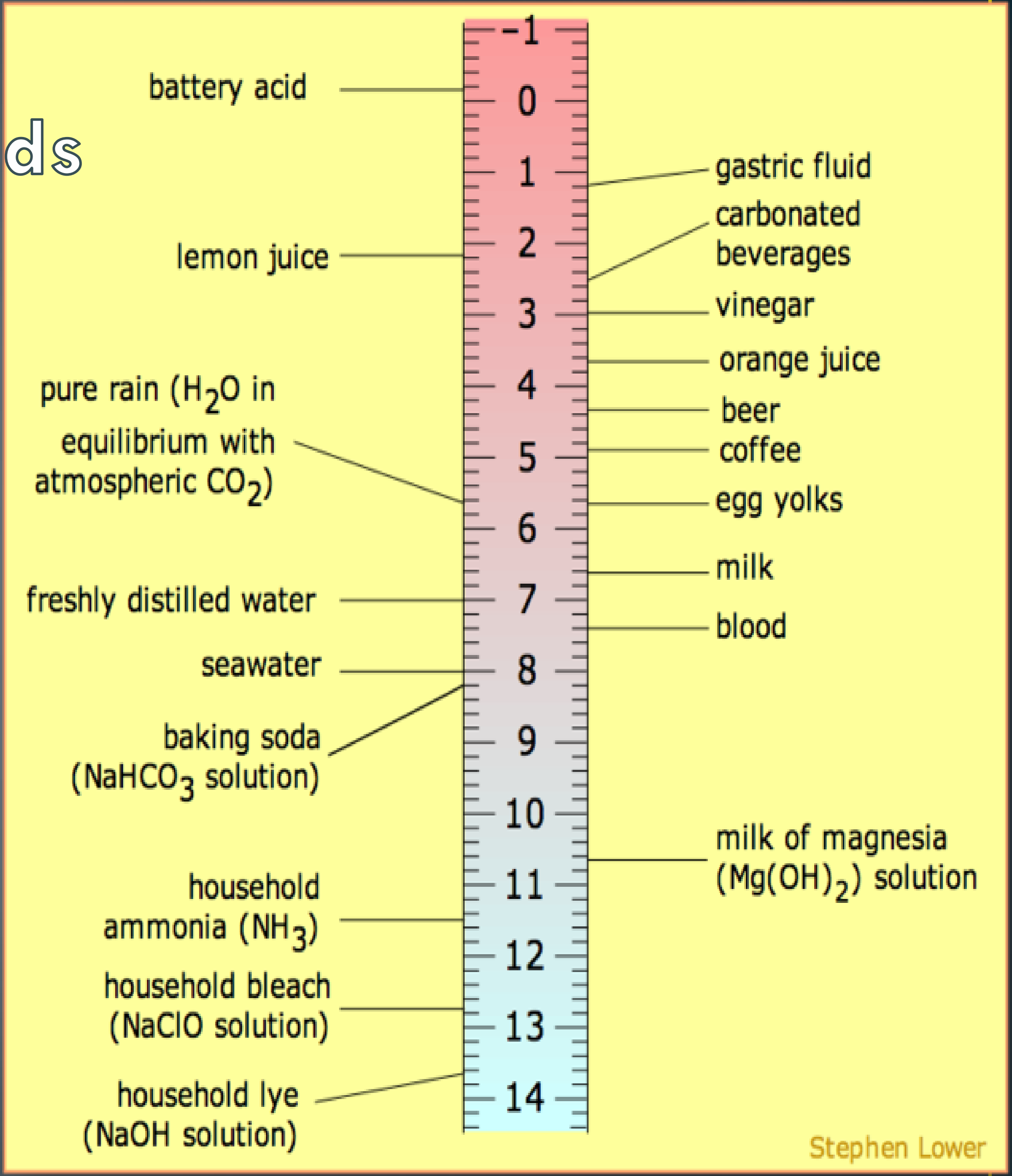
- "Ick, I ate it."
  - __ic is the acid suffix for stuff otherwise ending in __ate.
- "Ite, I oust it." OR "Rite*ous*"
  - __ous is the acid suffix for stuff otherwise ending in ___ite.
- hydro___ic acid.
  - Hydro goes with halogen

Practice

- HCl
  - Cl^- would be chlor<u>ide</u>, so it's <u>hydro</u>chlor<u>ic</u> <u>acid</u>.
- H_2SO_4
  - SO_4^{2-} would be sulf<u>ate</u>, so it's sulfur<u>ic</u> <u>acid</u>.
- $HClO_2$
  - ClO_2^- would be chlor<u>ite</u>, so it's chlor<u>ous</u> <u>acid</u>.

Properties of Acids

- pH is lower than 7
- Turn methyl orange and blue litmus paper red
- Taste sour
- React with active metals to produce H_2
- React with carbonates
- Acids neutralize bases

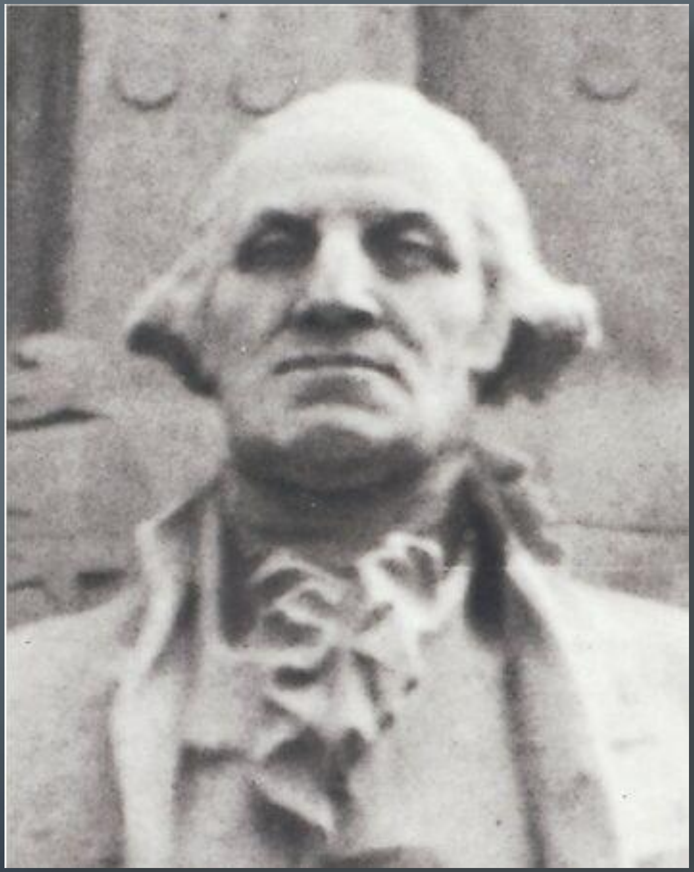


Acids React with Metals

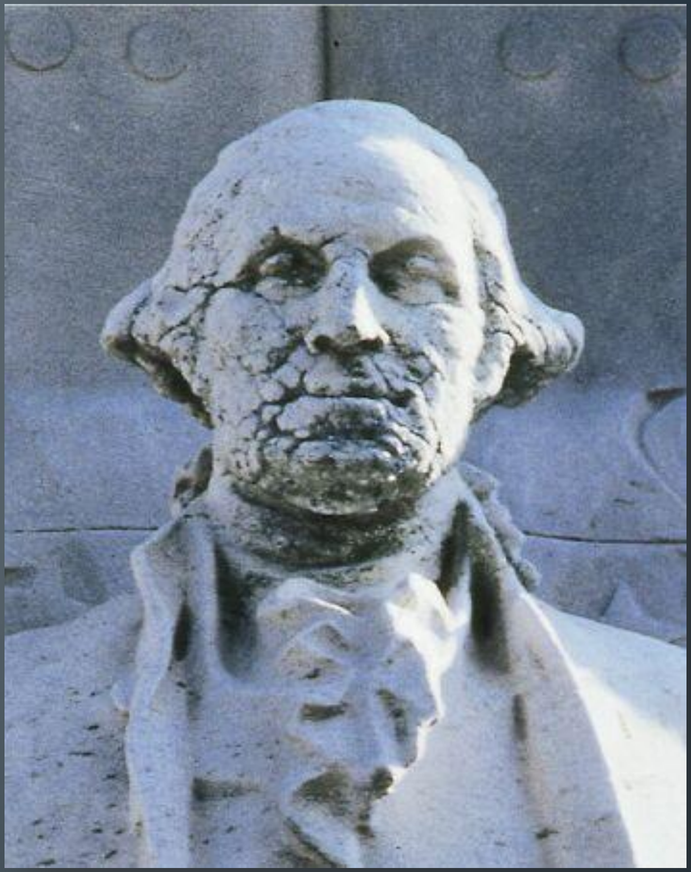
- Acids react with metals to form salts and hydrogen gas:
  - $Mg + 2HCl \rightarrow MgCl_2 + H_2 (g)$
  - $Zn + 2HCl \rightarrow ZnCl_2 + H_2 (g)$
  - $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2 (g)$

Acids React with Carbonates

- Acid rain's effect on marble ($CaCO_3$):



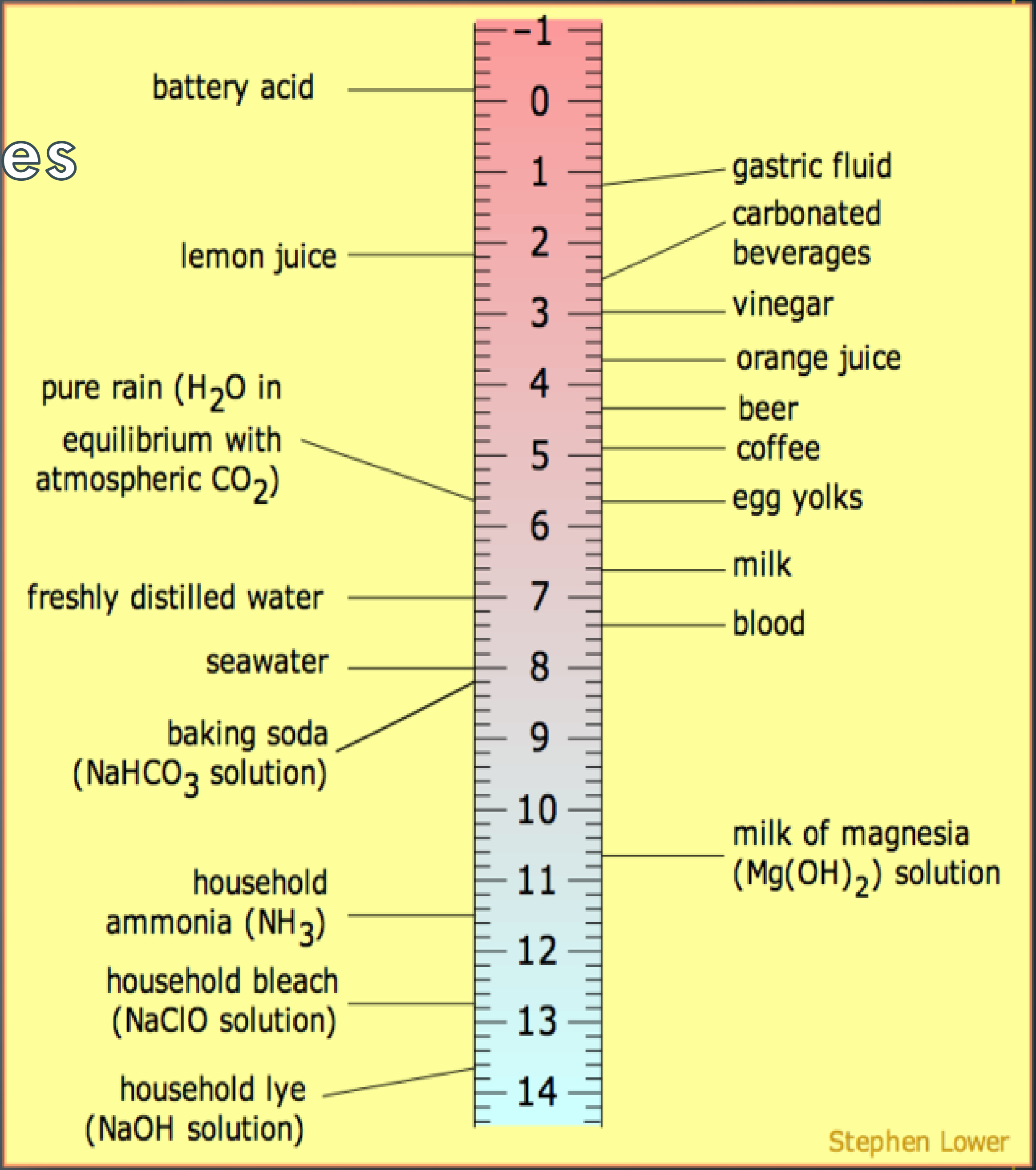
George Washington before…



George Washington after…

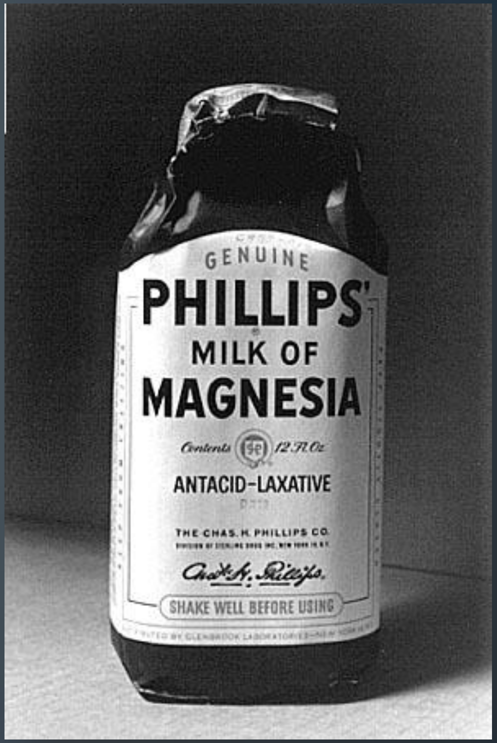
Properties of Bases

- pH is greater than 7
- Turn phenolphthalein purple and red litmus paper blue
- Taste bitter, feel slippery
- Bases neutralize acids



Bases Neutralize Acids

- Milk of Magnesia is an old-fashioned stomachache cure.
  - Contains $Mg(OH)_2$ – magnesium hydroxide.
- Magnesium hydroxide neutralizes stomach acid, producing water and magnesium chloride (a salt).
  - $2HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$



Acid/Base Definitions

- There are three different definitions of acids/bases:
- We will talk mainly about **one** of them:
  - **Arrhenius Acids/Bases**
    - **Acids are H^+ producers.**
    - **Bases are OH^- producers.**
  - Brønsted-Lowry Acids/Bases
    - Acids are proton (H^+) donors.
    - Bases are proton (H^+) acceptors.
  - Lewis Acids/Bases
    - Acids are electron pair donors.
    - Bases are electron pair acceptors.

Arrhenius Acids

- Under the Arrhenius definition of acids, you'll also see the term H_3O^+.
- When an Arrhenius acid dissolves, it gives off H^+ ions (protons).
- Many of those protons then join with existing water molecules, creating the **hydronium ion** (H_3O^+).

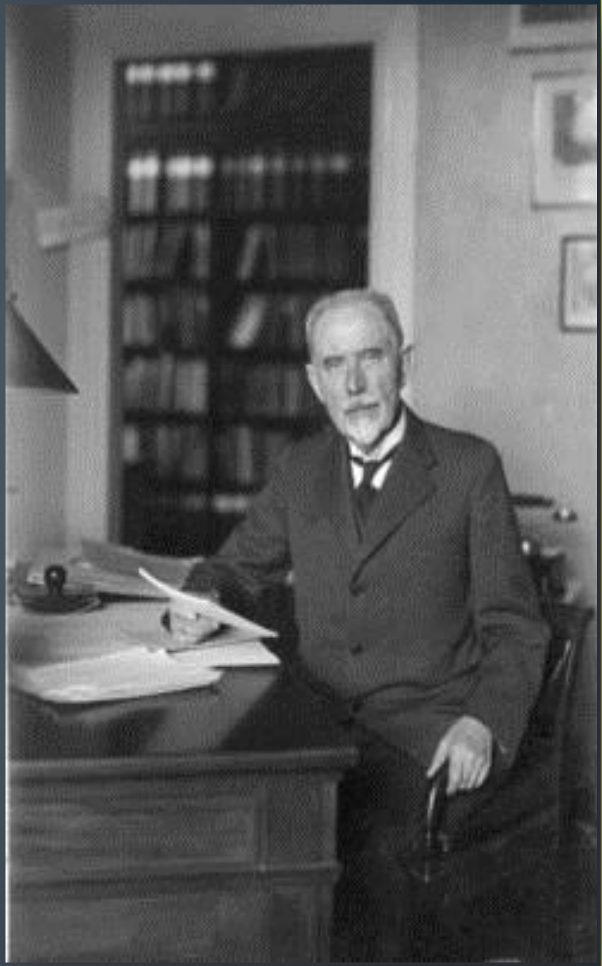
$$H^+ + H_2O \rightarrow H_3O^+$$

What to Look for...Acids and Bases

- Acids have these formulas:
  - HX (aq)
  - $H_aX_bO_c$ (aq)
- Bases are ionic compounds and contain either:
  - OH^- (hydroxide)
  - CO_3^{2-} (carbonate)
  - HCO_3^- (bicarbonate/hydrogen carbonate)
- NH_3 (ammonia) is also a base.

pH ("potential Hydrogen")

- In pH, chemistry is the measure of the concentration of an acid.
- It's a measure of the presence of hydrogen ions (H^+), which make solutions acidic.
- The pH scale ranges from 0 – 14.
- Anything above 7 is basic.
- Anything below 7 is acidic.
- Anything at 7 is neutral.
  - Water (neutral) has an [H^+] concentration of 1 x 10^{-7} M, or 0.0000001 M.



Søren Sørensen

Calculating pH

- To calculate pH from the concentration of hydrogen ions $[H^+]$, calculate its negative logarithm:
  - $pH = -\log [H^+]$
- To calculate $[H^+]$ from pH, use this formula:
  - $[H^+] = 10^{-pH}$
  - *Concentration is usually in the form of molarity (M).*

Calculating pH Examples

- **Example 1:** What is $[H^+]$ if pH = 9.9?
  - *Answer: $[H^+] = 10^{-9.9} = 1.259 \times 10^{-10}$ M*

- **Example 2:** $[H^+]$ in an acid solution is 1.5×10^{-3} M. What is the pH of the solution?
  - *Answer: pH = -log $[1.5 \times 10^{-3}] = 2.82$*

- **Example 3:** What is the pH of a solution with hydrogen ion concentration of 4.2×10^{-10} M? Is it acidic or basic?
  - *Answer: pH = -log $[4.2 \times 10^{-10}] = 9.38$*
  - *Answer:* It's basic.

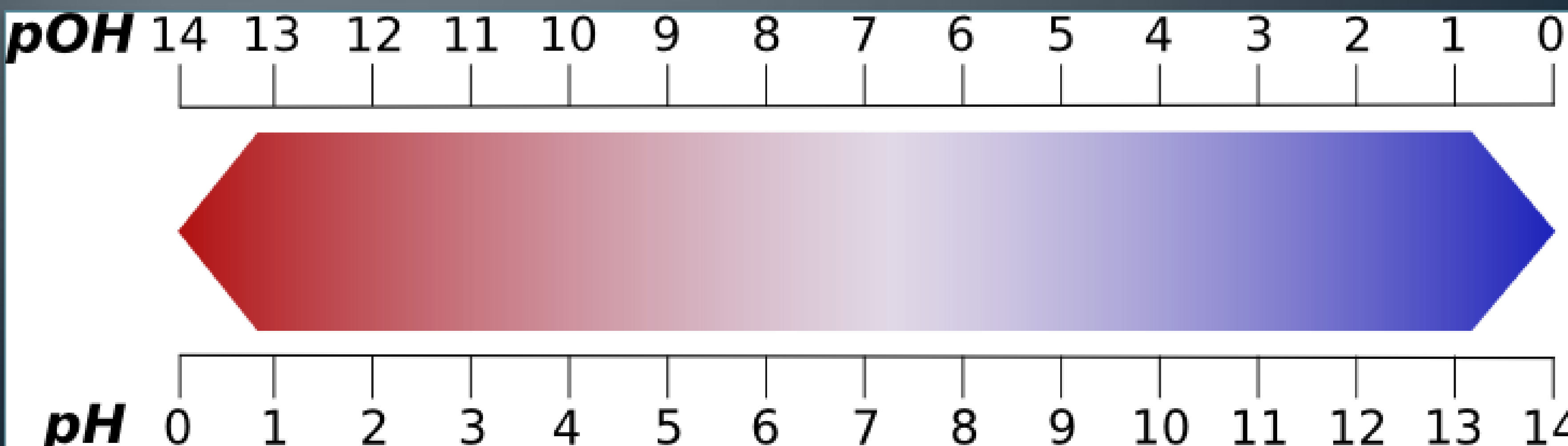
pOH

- Less frequently used is pOH, a similar but opposite scale.

- <7 = Basic

- >7 = Acidic

- **For the same substance, pH + pOH = 14.**



Calculating pOH

- To calculate pOH from the concentration of hydroxide ions $[OH^-]$, calculate its negative logarithm:
  - $pOH = -\log [OH^-]$

- To calculate $[OH^-]$ from pOH, use this formula:
  - $[OH^-] = 10^{-pOH}$
  - *Units are M again.*

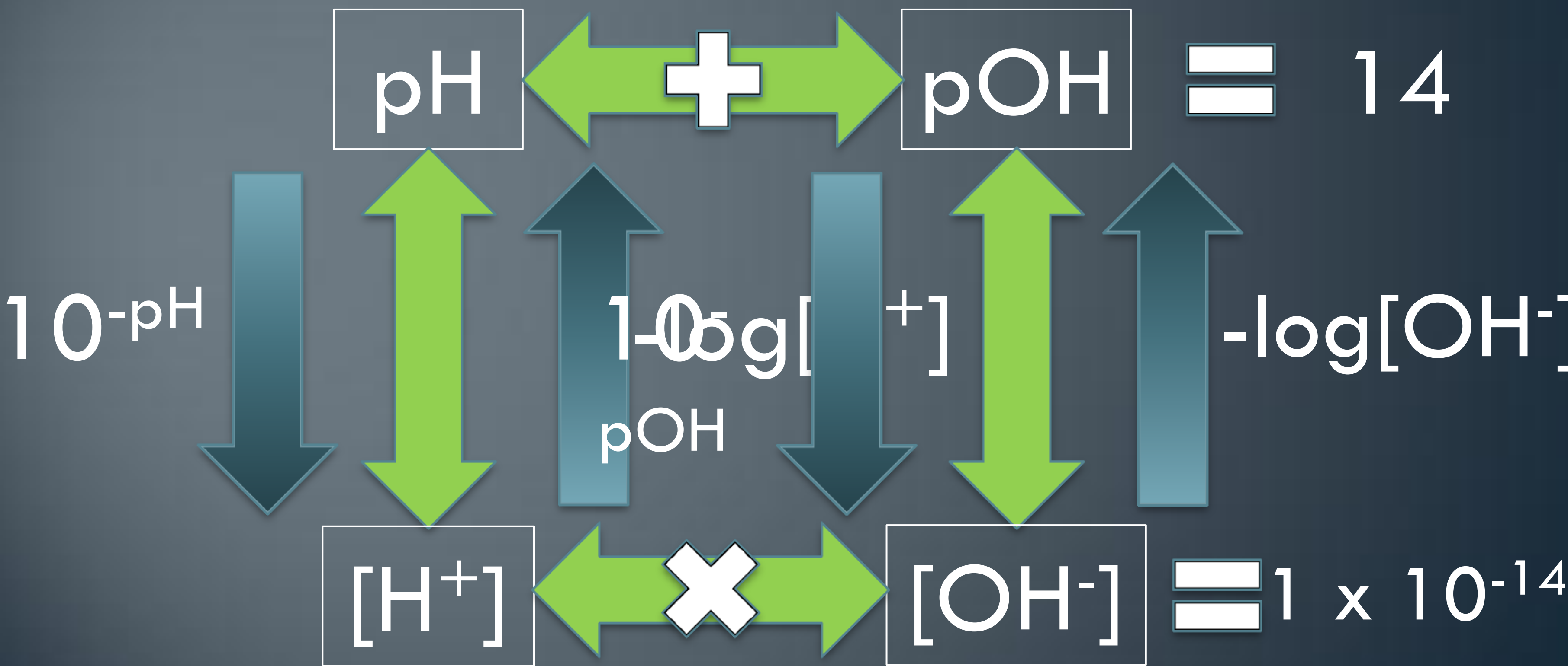
Calculating pOH Example

- **Example 1:** What is $[OH^-]$ if pOH = 2.3? Is it acidic or basic?
  - *Answer:* $[OH^-] = 10^{-2.3} = 5.01 \times 10^{-3}$ *M*
  - *Answer:* pOH is less than 7, so it's basic.

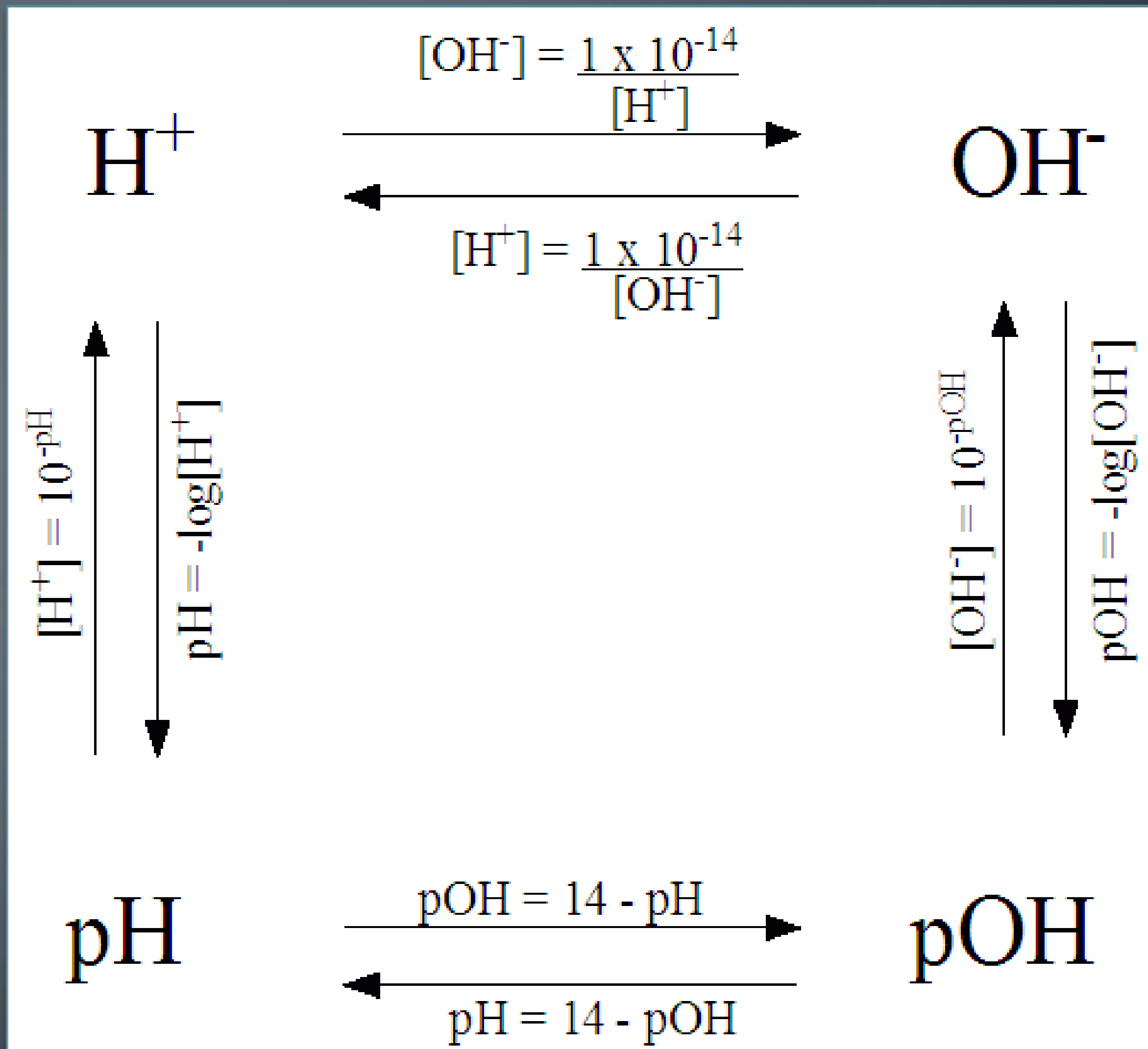
pH and pOH Summary

- Acidic solutions have higher $[H^+]$ than $[OH^-]$.
- Basic solutions have higher $[OH^-]$ than $[H^+]$.
- Neutral solutions have equal $[H^+]$ and $[OH^-]$.

pH and pOH Summary

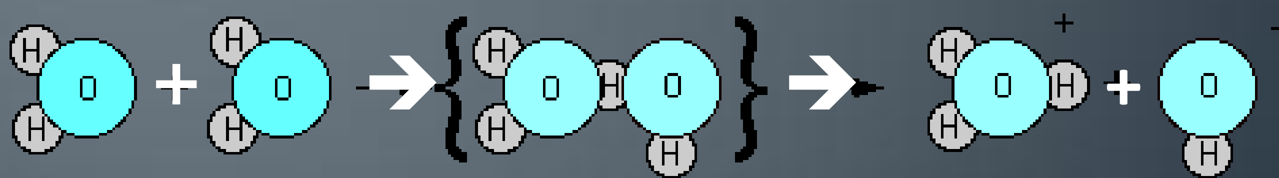


pH and pOH Summary



Self-Ionization of Water

- Though pure water is considered a non-conductor, there is a slight but measurable conductivity due to **self-ionization**.
  - Only about one in 2 billion water molecules does this.



$$H_2O + H_2O \rightarrow H_3O^+ + OH^-$$

Ionization of Water

- In pure water at 25 °C:
  - $[H_3O^+] = 1 \times 10^{-7}$ mol/L
  - $[OH^-] = 1 \times 10^{-7}$ mol/L
- Which is why water's neutral.
  - The concentration of acid-causing H_3O^+ and base-causing OH^- are equal.
- *Fun fact: Interestingly, the neutral pH value of 7 changes with different temperatures.*
  - *Neutral pH at 100 °C, for example, is 6.14.*
  - *At 0 °C, it's 7.47.*

Acids Neutralize Bases

- **Neutralization reactions** are double replacement reactions between an acid and a base.

- They always produce a salt and water.
  - $HCl + NaOH \rightarrow NaCl + H_2O$
  - $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
  - $2HNO_3 + Mg(OH)_2 \rightarrow Mg(NO_3)_2 + 2H_2O$

Neutralization Reaction Practice

- $\underline{H}Cl + K\underline{OH} \rightarrow$?
  - $KCl + H_2O$
- $\underline{H}_2SO_4 + Ca(\underline{OH})_2 \rightarrow$?
  - $CaSO_4 + 2H_2O$
- $HNO_3 + NaOH \rightarrow$?
  - $NaNO_3 + H_2O$
- $H_2CO_3 + Mg(OH)_2 \rightarrow$?
  - $MgCO_3 + 2H_2O$

Titrations

- Chemists frequently use neutralization reactions during the process of titration.

- **Titration** is a way for chemists to determine the concentration of an acid or base solution using the concentration of a known solution.
  - During titration, the solution whose concentration is known is called the **standard solution**.

Titration Demo

- Let's imagine that we've got an acid with an unknown concentration (molarity).
- We'll add a base indicator to the solution.
  - It shouldn't change color because we have an acid in there.

Titration Demo

- We'll then *slowly* add a base with a known concentration until the indicator changes color.
  - When the indicator changes, that tells us that the acid can no longer neutralize the base, meaning the neutralization reaction is done.
- When the indicator changes color permanently, we've reached our **endpoint** (when we stop titrating).
- The endpoint is close to, but not exactly, the **equivalence point**, which is when the acid and base have neutralized each other.

Titration Practice

- Step 1: Write the balanced reaction.
  - Remember, acids + bases form water and a salt.
- Step 2: Find the moles (using the molarity) of the known solution.
- Step 3: Use a mole ratio to find the number of moles of the unknown solution.
- Step 4: Calculate the molarity of the unknown solution using its volume and calculated moles.

Titration Problems

- Typically, you'll need to find these things in this order:
  1. Balanced equation.
  2. Concentration of known solution (usually given).
  3. Moles of known solution solute.
  4. Moles of unknown solution solute.
  5. Concentration of unknown solution.

Titration Example 1

- A 25 mL solution of H_2SO_4 (sulfuric acid) is completely neutralized by 18 mL of 1.0 M NaOH (sodium hydroxide). What is the concentration of the sulfuric acid solution?

- *Step 1: Find the balanced equation:*
  - $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

- *Step 2: Find the moles of the known solution.*
  - Remember, 25 mL of H_2SO_4 was neutralized by 18 mL of 1.0 M NaOH.
  - That means there are 0.018 moles of NaOH present.
- *Step 3: Use a mole ratio to find moles of unknown solution.*
  - By mole ratio, we would need 0.009 moles of H_2SO_4 with which to react.
- *Step 4: Calculate the molarity of the unknown solution.*
  - If there are 0.009 moles of H_2SO_4 in 0.025 L, that means the molarity of H_2SO_4 is 0.36 M.

Titration Example 2

- If it takes 30 mL of 0.05 M HCl to neutralize 345 mL of NaOH solution, what is the concentration of the sodium hydroxide solution?
  - *Answer: 0.0043 M NaOH*

Titration Example 3

- How many milliliters of 0.45 M HCl will neutralize 25.0 mL of 1.00 M KOH?
  - *Answer: 55.6 mL HCl*

Titration Example 4

- What is the molarity of sodium hydroxide if 20.0 mL of the solution is neutralized by 17.4 mL of 1.0 M H_3PO_4?
  - *Answer: 2.61 M NaOH*

Titration Example 5

- What is the molarity of carbonic acid if 25.0 mL of the solution is neutralized by 48.3 mL of 0.2 M NaOH?
  - *Answer: 0.19 M* H_2CO_3