Acids and Bases

Arrhenius Theory

The Swedish chemist **Svante Arrhenius** proposed the first definition of **acids** and **bases**.
(Substances A and B became known as acids and bases)
According to the Arrhenius model:

"acids are substances that dissociate in water to produce H^+ ions and bases are substances that dissociate in water to produce OH^- ions"

$NaOH\ (aq) \rightarrow Na^+\ (aq) + OH^-\ (aq)$ **Base**

$HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$ **Acid**

Properties of Acids and Bases

Acids

- Sour taste
- pH<7
- Vinegar, lemon juice, orange juice,
- Releases H+ ion in water
- Turns litmus paper red
- HCl, HNO_3, H_2SO_4
- electrolyte

Bases

- Bitter taste
- pH > 7
- Baking soda, bleach, soap
- Releases OH- ion in water
- Turns litmus paper blue
- NH_4OH, NaOH, KOH
- electrolyte

- How do you know it is an acid?
- The compound starts with an “H”.

Naming Acids

Rules for Naming Acids

- Rule #1-If the acid has only two elements, then it starts with HYDRO- and end in –IC Acid
- Rule #2-If the acid has 3 elements and the anion ends in –ATE, the acid ends in –IC ACID, if the anion ends in –ITE, the acid ends in –OUS ACID

In other words…

- I –**ATE** something –**IC**ky and got a disease called **–ITE –OUS**.

Naming Acids

Acid	Ion Name	Stem	Acid Name
H_3N	Nitride	Nitr	Hydronitric acid
HNO_2	Nitrite	Nitr	Nitrous acid
HNO_3	Nitrate	Nitr	Nitric acid

- HCl
- HYDRO chlor IC ACID
- HI
- HYDRO iod IC ACID
- H_2S
- HYDRO sulfur IC ACID

Binary Acids

Ternary Acids-End in ATE

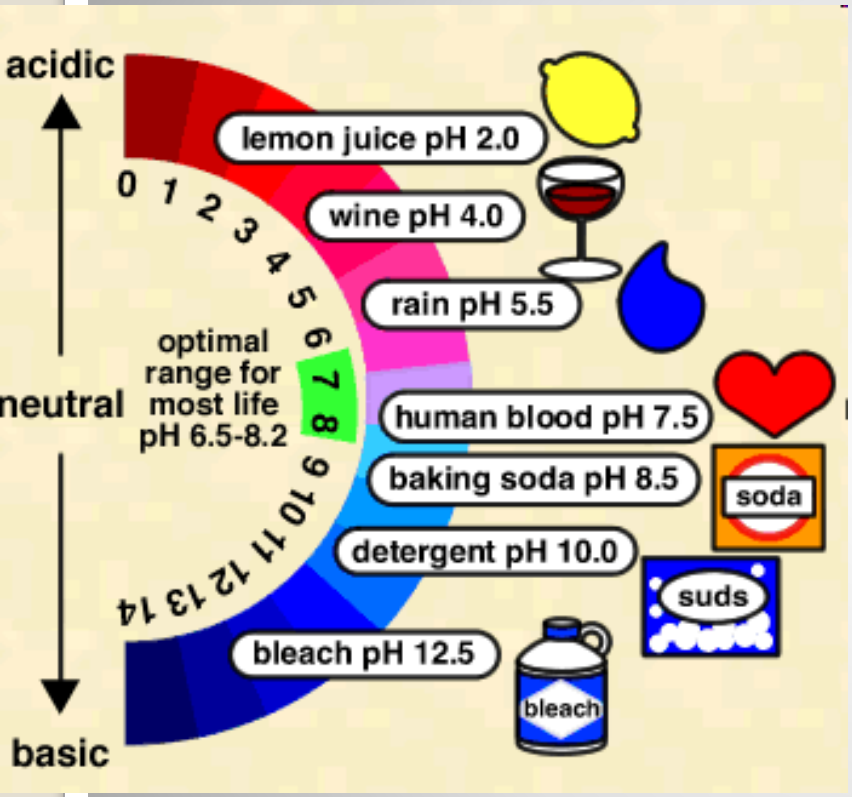
- HNO_3
- NitrIC ACID
- H_3PO_4
- PhosphorIC ACID
- H_2SO_4
- sulfurIC ACID

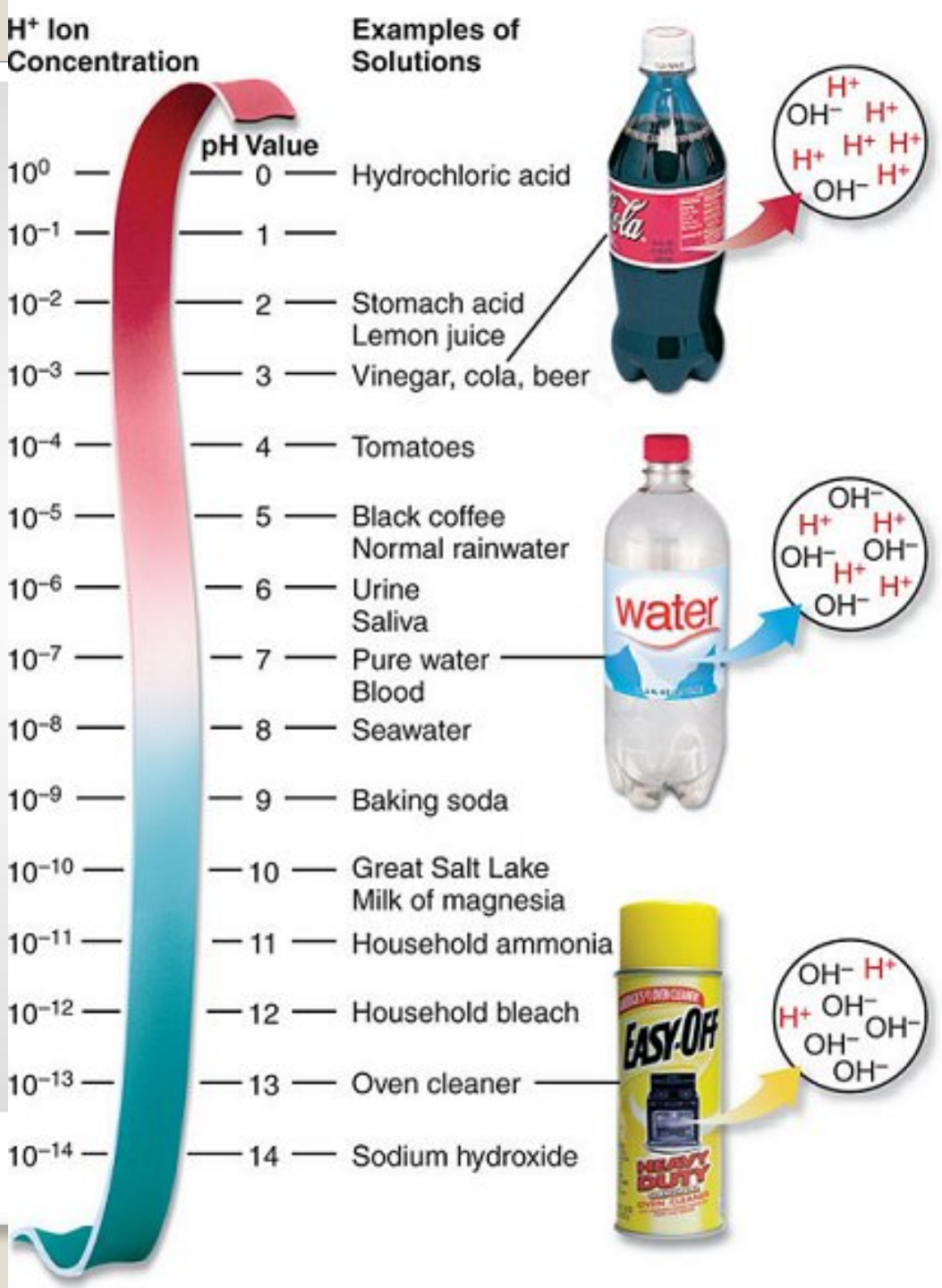
- HNO_2
- nitrOUS ACID
- H_3PO_3
- phosphorOUS ACID
- H_2SO_3
- sulfurOUS ACID

Ternary Acids-End in ITE

Bases

- KOH
- Potassium hydroxide
- $Ca(OH)_2$
- Calcium hydroxide
- NH_4OH
- Ammonium hydroxide
- Na_2SO_4
- Sodium sulfate


acidic
neutral
basic
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
lemon juice pH 2.0
wine pH 4.0
rain pH 5.5
optimal range for most life pH 6.5-8.2
human blood pH 7.5
baking soda pH 8.5
detergent pH 10.0
bleach pH 12.5
soda
suds
bleach


H+ Ion Concentration
pH Value
Examples of Solutions
10^0 — 0 — Hydrochloric acid
10^-1 — 1
10^-2 — 2 — Stomach acid
Lemon juice
10^-3 — 3 — Vinegar, cola, beer
10^-4 — 4 — Tomatoes
10^-5 — 5 — Black coffee
Normal rainwater
10^-6 — 6 — Urine
Saliva
10^-7 — 7 — Pure water
Blood
10^-8 — 8 — Seawater
10^-9 — 9 — Baking soda
10^-10 — 10 — Great Salt Lake
Milk of magnesia
10^-11 — 11 — Household ammonia
10^-12 — 12 — Household bleach
10^-13 — 13 — Oven cleaner
10^-14 — 14 — Sodium hydroxide
water
EASY-OFF
HEAVY DUTY

What does pH mean?

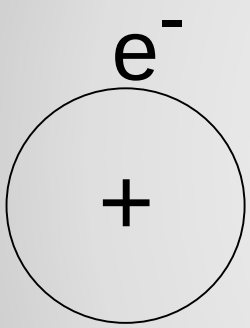
- It is a way to measure the hydrogen ion concentration.
- Water breaks apart to hydrogen and hydroxide ions:
- $H_2O \longleftrightarrow H^+ + OH^-$
- $pH + pOH = 14$

What does pH mean?

- pH = -log [H^+]
- pOH = -log[OH-]
- Brackets indicate Molarity

[H+]	pH
10^{-1} 0.1 M	1
10^{-2} 0.01 M	2
10^{-3} 0.001 M	3

What is H^+?



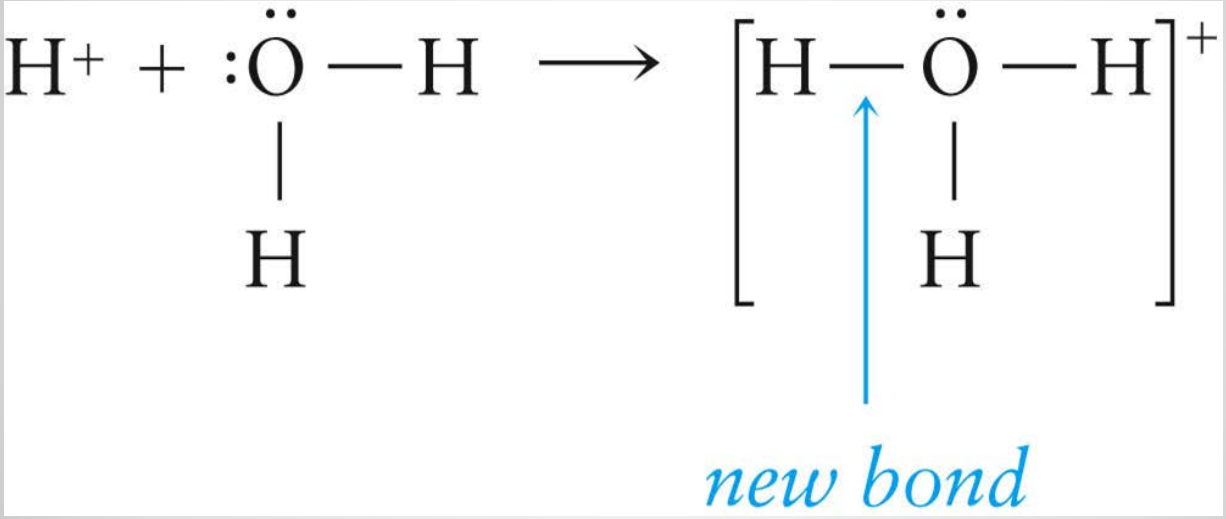
Hydrogen (H)

+

Proton (H^+)

Hydronium Ion

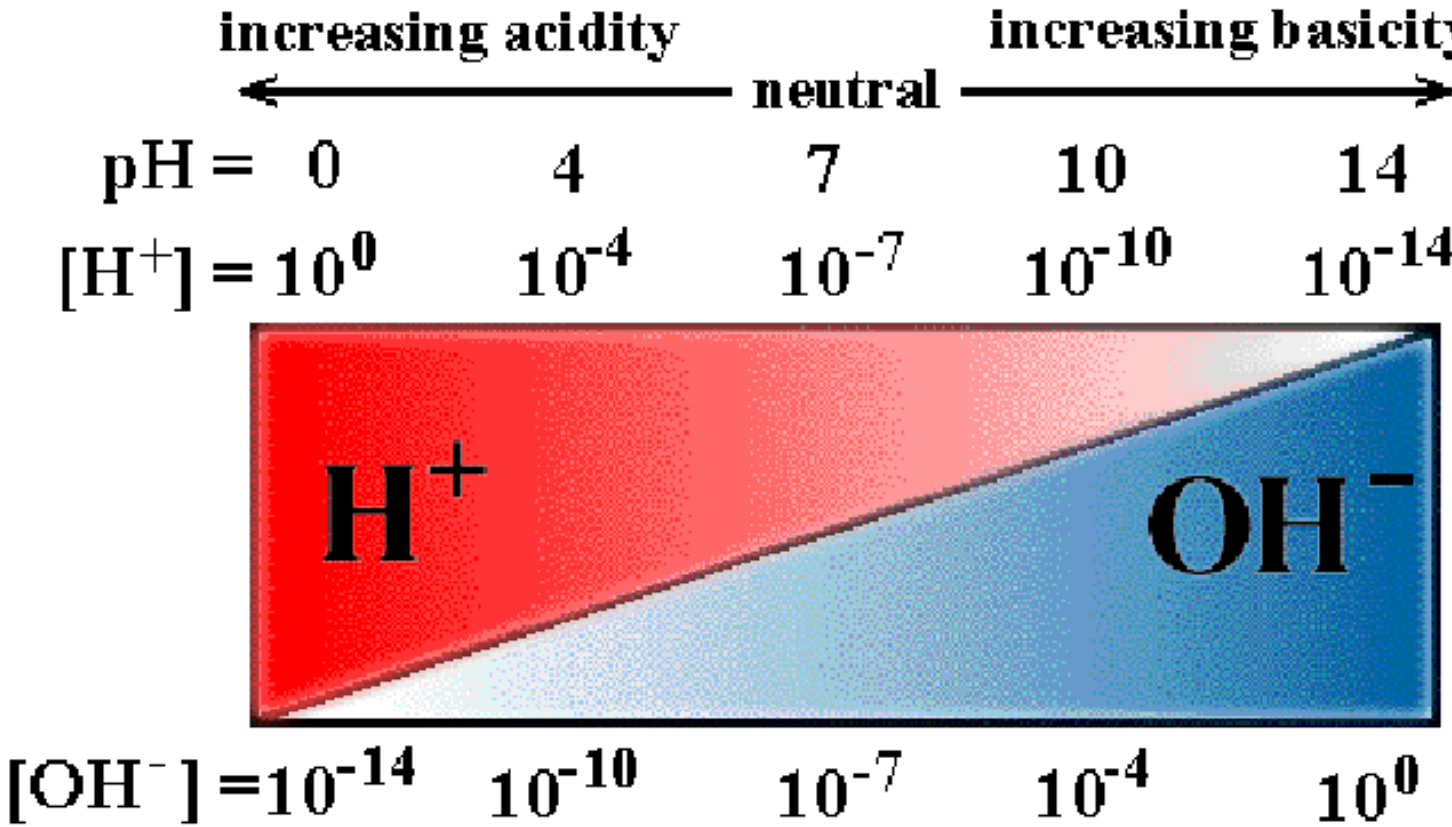
Unknown to Arrhenius **free H^+** ions **do not** exist in water. They **covalently** react with water to produce **hydronium ions**, H_3O^+.



or:

$$H^+(aq) + H_2O(l) \rightarrow H_3O^+(aq)$$

This new bond is called a **coordinate covalent** bond since both new bonding electrons come from the same atom


increasing acidity
neutral
increasing basicity
pH = 0 4 7 10 14
[H+] = 10^0 10^-4 10^-7 10^-10 10^-14
H+
OH−
[OH−] = 10^-14 10^-10 10^-7 10^-4 10^0

Examples

1. Find the pH and pOH, when $[H^+] = 10^{-4}$

pH = 4 and pOH = 10, since they must add to 14

using the calculator pH = -log $[H^+]$, type in 10^{-4}, push the log button and pH = -(-4) = 4. Same for pOH

pH and pOH

[H+]	pH	[OH-]	pOH	Acid or Base
10^{-5}				

pH and pOH

[H+]	pH	[OH-]	pOH	Acid or Base
10^{-5}	5	10^{-9}	9	acid
			6	

pH and pOH

[H+]	pH	[OH-]	pOH	Acid or Base
10^{-5}	5	10^{-9}	9	acid
10^{-8}	8	10^{-6}	6	base
10^{0}				

pH and pOH

[H+]	pH	[OH-]	pOH	Acid or Base
10^{-5}	5	10^{-9}	9	Base
10^{-8}	8	10^{-6}	6	Acid
10^{0}	0	10^{-14}	14	Base
				Neutral

pH and pOH

[H+]	pH	[OH-]	pOH	Acid or Base
10^{-5}	5	10^{-9}	9	acid
10^{-8}	8	10^{-6}	6	base
10^{0}	0	10^{-14}	14	acid
10^{-7}	7	10^{-7}	7	neutral

Other “p” Scales

- The “p” in pH tells us to take the negative log of the quantity (in this case, hydronium ions).
- Some similar examples are
  - pOH $-\log [OH^-]$
  - pK_w $-\log K_w$

Because

$$[H_3O^+]\,[OH^-] = K_w = 1.0 \times 10^{-14},$$

we know that

$$-\log [H_3O^+] + -\log [OH^-] = -\log K_w = 14.00$$

or, in other words,

$$pH + pOH = 14.00$$

Watch This!

If you know one, you know them all:

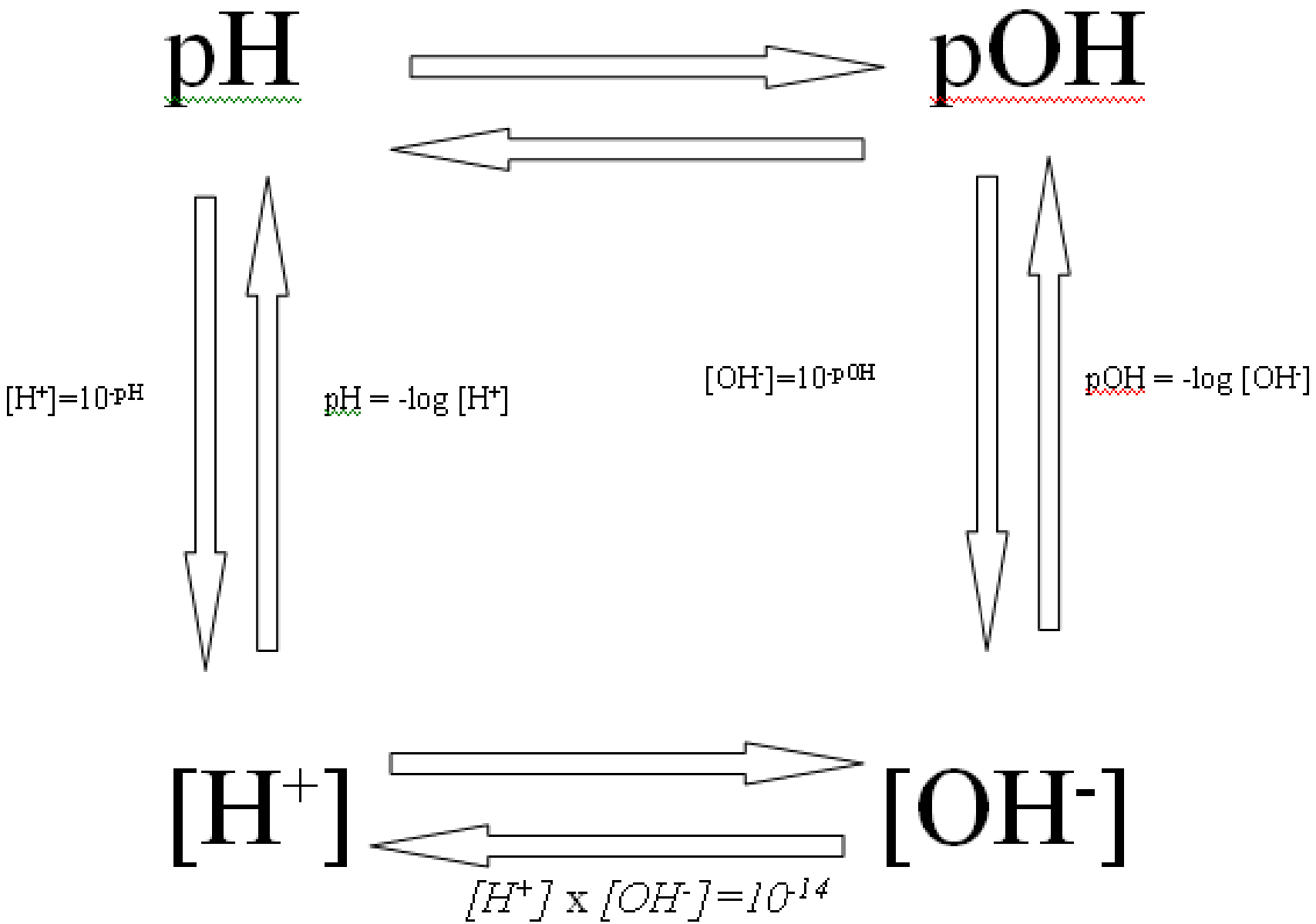
$[H^+]$

$[OH^-]$

pH

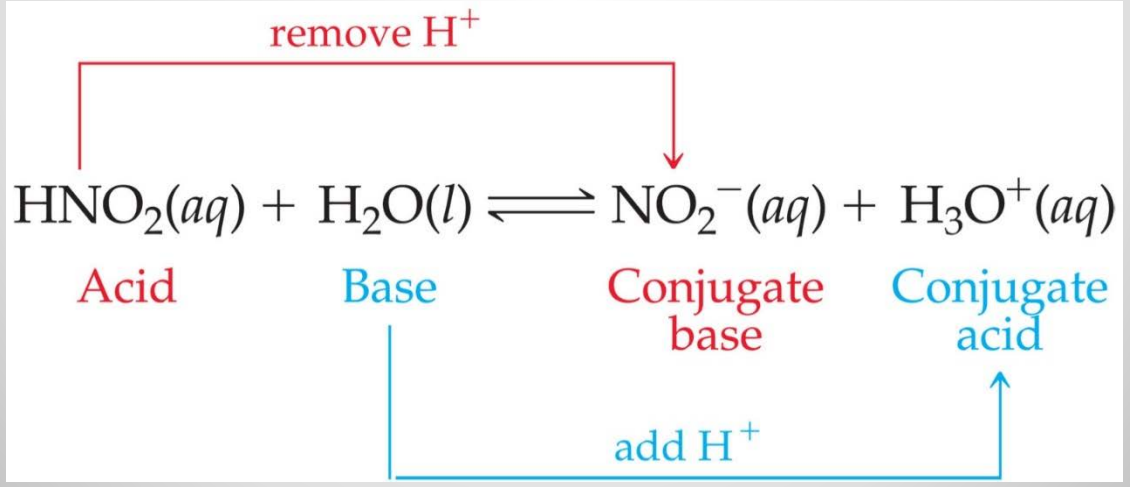
pOH

$$pH + pOH = 14$$

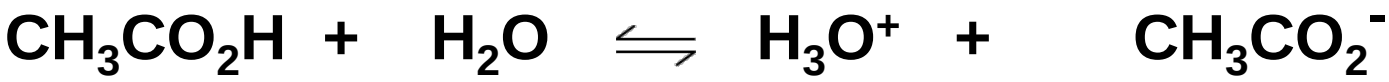


Conjugate Acids and Bases:

- Reactions between acids and bases always yield their conjugate bases and acids.



$$HNO_2 + H_2O \rightleftharpoons [NO_2^- \cdots H^+ \cdots H_2O] \rightleftharpoons NO_2^- + H_30^+$$



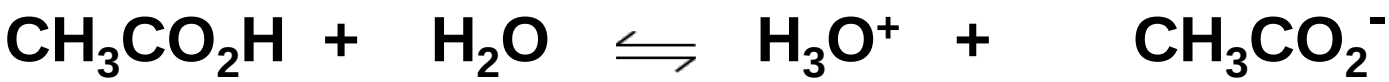
Acetic Acid

Acetate Ion

Pairs

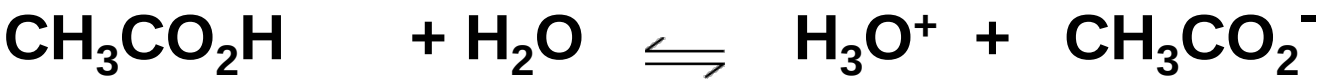
1	2	2	1
acid	base	acid	base

Point of View #1



acid	base	Conjugate acid of H_2O	Conjugate base of CH_3CO_2H

Point of View #2



Conjugate acid of $CH_3CO_2^-$	Conjugate base of H_3O^+	acid	base

- $HCN + H_2O \rightarrow H_3O^+ + CN^-$
- Acid + base → CA + CB
- $NaHCO_3 + HBr \rightarrow NaBr + H_2CO_3$
- Base + Acid → CB + CA
- $H_2O + NH_3 \rightarrow NH_4^+ + OH^-$
- Acid + Base → CA + CB

Label the Acid, Base, Conjugates