

# Important Notice

**Group 1:** You are in the Tutorial: Stoichiometry 1 and 2

**Group 2:** You are doing the lab: Synthesis

## Section 003

Student Number	Initials
250377285	N. G.
250417065	Z. Mc.
250419357	Z. Mo.
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Find Jan or Sandy  
asap in the Chem. labs

## Section 006

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## Review Quiz Section 003

- **Class Average:** 51.8 % (172 wrote)
- **Breakdown:**  
A: 5% B: 9% C: 17% D: 28% F: 42%

Strong Acids and Bases

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## Strong Acids and Bases C020

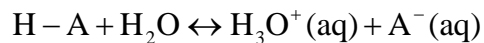
Strong Acids and Bases

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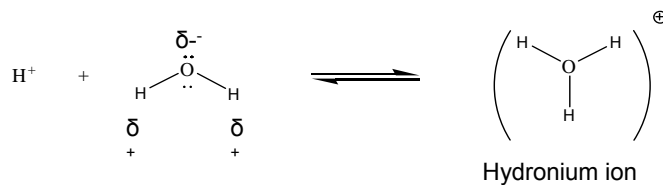
Start with a General Definition:

### Brønsted Acid

A Brønsted definition of an acid is “any substance that can donate a H<sup>+</sup> to another substance”.



In water, the association of H<sup>+</sup> with water is so extensive that the solvated species is written H<sub>3</sub>O<sup>+</sup> (aq) where H<sub>3</sub>O<sup>+</sup> is the hydronium ion.



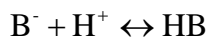
All molecules with a H<sup>δ+</sup> are capable of acting as acids (e.g. H<sup>δ+</sup>-O<sup>δ-</sup>-R; H<sup>δ+</sup>-X<sup>δ-</sup>)

Strong Acids and Bases

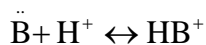
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### Brønsted Base

A Brønsted definition of a base is “any substance that is capable of accepting a H<sup>+</sup> from another substance; (by forming some sort of bond with it).



or even



All anions are generally good bases:

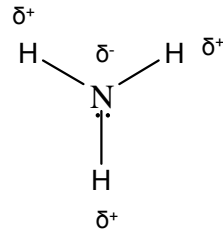
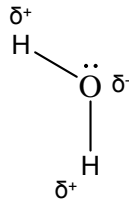
For example: HO<sup>-</sup> H<sub>2</sub>N<sup>-</sup> H<sub>3</sub>C<sup>-</sup>

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Similarly so are most molecules containing atoms with a lone pair and a partial negative charge.

For example:



etc.

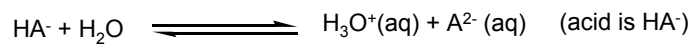
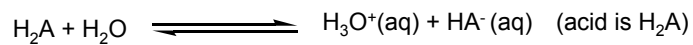
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An acid capable of losing more than 1 H is termed a **polyprotic acid**.

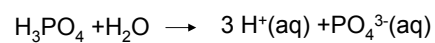
For example:  
H<sub>2</sub>SO<sub>4</sub> sulfuric acid

In general:



Such acids are **di**protic

Phosphoric acid is an example of a **tri**protic acid

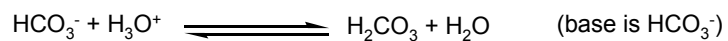


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A base capable of accepting more than 1 H is termed a **polyprotic base**.

For example:  
CO<sub>3</sub><sup>2-</sup> carbonate anion



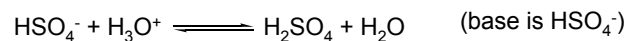
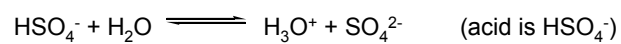
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It is not unusual for a single substance to be able to function as either an acid or a base.

These are called **amphiprotic** substances

For example:

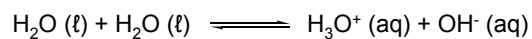


Therefore, HSO<sub>4</sub><sup>-</sup> is amphiprotic

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The most common amphiprotic substance is H<sub>2</sub>O which can autoionize:



**acid**   **base**

For this reaction, the equilibrium constant K is given by:

$$K = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}]^2}$$

But in dilute solution  $[\text{H}_2\text{O}]^2 \sim \text{constant}$

Therefore:

$$K[\text{H}_2\text{O}]^2 = K_w \equiv \text{water ionization constant}$$

$$\text{At } 25^\circ\text{C}, K_w = 1.008 \times 10^{-14} \sim 10^{-14}$$

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Therefore:

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14}$$

This leads to the concept of pH and pOH

Since in pure "neutral" water  $[\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14}$  and  $[\text{H}_3\text{O}^+] = [\text{OH}^-] = 1.0 \times 10^{-7} \text{ mol L}^{-1}$

⇒ water is arbitrarily accepted as the measure of neutrality for defining acids and base.

If  $[\text{H}_3\text{O}^+] > 1.0 \times 10^{-7} \text{ M}$ , the solution is said to be **acidic**

If  $[\text{H}_3\text{O}^+] < 1.0 \times 10^{-7} \text{ M}$ , the solution is said to be **basic**

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[H<sub>3</sub>O<sup>+</sup>] and [OH<sup>-</sup>] are usually given as simple numbers instead of exponents by using the following conversions:

$$\text{pH} = -\log_{10}[\text{H}_3\text{O}^+]$$

and

$$\text{pOH} = -\log_{10}[\text{OH}^-]$$

**Example:**

Given [H<sub>3</sub>O<sup>+</sup>] = 0.00357 M

$$\therefore \text{pH} = -\log_{10}(3.57 \times 10^{-3}) = 2.45$$

Given [OH<sup>-</sup>] = 3.0 × 10<sup>-7</sup> M

$$\therefore \text{pOH} = -\log_{10}(3.0 \times 10^{-7}) = 6.52$$

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You can work backwards too.

For example:

If pH = 2.49

$$\Rightarrow [\text{H}_3\text{O}^+] = 10^{-2.49} = 3.24 \times 10^{-3} \text{ M}$$

If pOH = 9.08

$$\Rightarrow [\text{OH}^-] = 10^{-9.08} = 8.32 \times 10^{-10} \text{ M}$$

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For neutral water at equilibrium

$$[\text{H}_3\text{O}^+] = [\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}$$

$$\therefore \text{pH} = \text{pOH} = 7.0$$

$$\begin{aligned} \therefore K_w = [\text{H}_3\text{O}^+][\text{OH}^-] &\Rightarrow -\log_{10}(K_w) = -\log_{10}([\text{H}_3\text{O}^+][\text{OH}^-]) \\ &= -\log_{10}([\text{H}_3\text{O}^+]) - \log_{10}([\text{OH}^-]) \end{aligned}$$

$$\therefore \boxed{\text{p}K_w = \text{pH} + \text{pOH} = 14}$$

Note: pH or pOH can be negative for very high concentrations

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**Example:**

What will be the pH and pOH of a solution where 0.73 g HCl are dissolved in 100 mL of  $\text{H}_2\text{O}$ ?

HCl is a strong acid and therefore fully dissociated.

$$\Rightarrow [\text{H}_3\text{O}^+] = [\text{HCl}]_0 = \text{initial concentration of hydrochloric acid}$$

$$\therefore [\text{HCl}]_0 = \frac{0.73 \text{ g}}{(0.1 \text{ L})(36.5 \text{ g mol}^{-1})} = 0.20 \text{ M}$$

$$\therefore \text{pH} = -\log_{10}(0.2) = 0.7$$

and

$$\text{pOH} = 14 - 0.7 = 13.3$$

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Concentration of Hydrogen ions compared to distilled water		Examples of solutions at this pH
10,000,000	pH = 0	Battery acid, Strong Hydrofluoric Acid
1,000,000	pH = 1	Hydrochloric acid secreted by stomach lining
100,000	pH = 2	Lemon Juice, Gastric Acid Vineger
10,000	pH = 3	Grapefruit, Orange Juice, Soda
1,000	pH = 4	Tomato Juice      Acid rain
100	pH = 5	Soft drinking water Black Coffee
10	pH = 6	Urine      Saliva
1	pH = 7	"Pure" water
1/10	pH = 8	Sea water
1/100	pH = 9	Baking soda
1/1,000	pH = 10	Great Salt Lake Milk of Magnesia
1/10,000	pH = 11	Ammonia solution
1/100,000	pH = 12	Soapy water
1/1,000,000	pH = 13	Bleaches Oven cleaner
1/10,000,000	pH = 14	Liquid drain cleaner

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**Strong acids** are fully dissociated in water.

There are **six** common strong acids:

HCl, HBr, HI, HNO<sub>3</sub>, HClO<sub>4</sub> and H<sub>2</sub>SO<sub>4</sub> (first ionization only)

All strong acids HA will dissociate **completely** to H<sub>3</sub>O<sup>+</sup> and A<sup>-</sup>

$$\therefore [\text{H}_3\text{O}^+] = \text{initial concentration of HA} = [\text{HA}]_0$$

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All species containing  $\text{OH}^-$ , and molecules with atoms having a negative charge will be **strong bases**.

For example:  $\text{LiOH}$ ,  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{Ca}(\text{OH})_2$ ,  $\text{Sr}(\text{OH})_2$ ,  $\text{Ba}(\text{OH})_2$ ,  $\text{H}_3\text{C}^-$ ,  $\text{H}_2\text{N}^-$ , etc.

All halogen ions,  $\text{X}^- = \text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ , and neutral atoms with a lone pair of electrons will be weaker bases

A strong base B will react **completely** with water to form  $\text{BH}$  and  $\text{OH}^-$

$\therefore$  at equilibrium  $[\text{OH}^-] = \text{initial concentration of base} = [\text{B}]_0$