

Introduction to Acids and Bases

Acid-Base Introduction

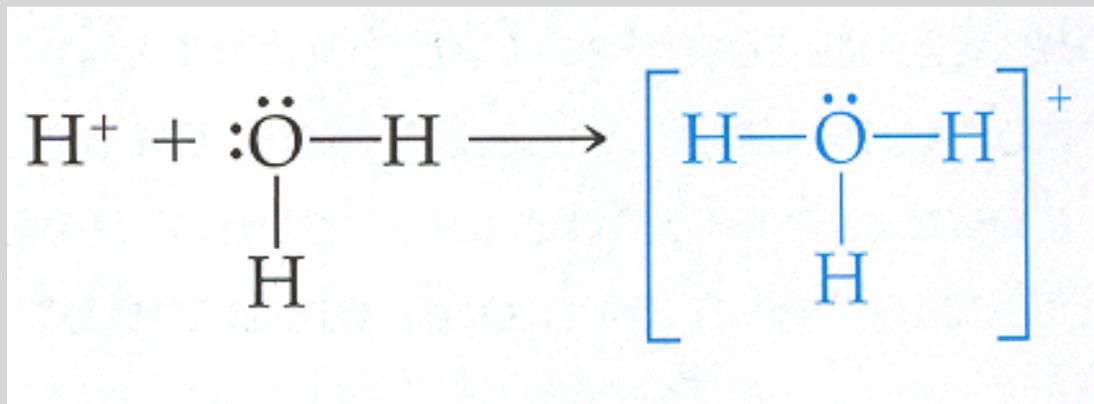
Definitions

- The Arrhenius Definition (what they do to water)
 - Acids
 - Substances that increase the H^+ concentration when dissolved in water
 - Bases
 - Substances that increase the OH^- concentration when dissolved in water
- The Brønsted-Lowry Definition (what they do to each other)
 - Acids
 - Proton Donors
 - Bases
 - Proton Acceptors
 - For the majority of our study, we will understand acids and bases using the Brønsted-Lowry definitions.
- To better understand the action of acids in aqueous solution, we need to understand how free protons interact with water molecules

Acid-Base Introduction

Hydronium Ion

- When an acid ionizes in water, the hydrogen ions (protons; H^+) react with the water to form hydronium ions (H_3O^+)



- Hydronium ions give acids their characteristic properties.
- We can represent them two different ways
 - H^+
 - H_3O^+ } used interchangeably

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Conjugates

- When an acid and base react, they form a new acid and a new base, termed conjugates



- Conjugate Acid
 - Particle formed when the base accepts a proton
 - $\text{Base} + \text{H}^+ \Rightarrow \text{Conjugate Acid}$
 - Conjugate Base
 - Particle formed when the acid loses a proton
 - $\text{Acid} - \text{H}^+ \Rightarrow \text{Conjugate Base}$
- An important rule....
 - Strong acids/bases form worthless (negligible) conjugates
 - The stronger an acid, the weaker its conjugate base
 - The stronger a base, the weaker its conjugate acid

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Relative Strengths of Acids/Bases

- Strong Acids
 - Completely transfer their protons to water
 - HCl, HBr, HI, HNO₃, HClO₃, HClO₄, H₂SO₄
- Weak Acids
 - Partly ionize in water
- Parent/Conjugate Relationship
 - The stronger the acid, the weaker the conjugate base (& vice-versa)

T-153
Figure 16.4

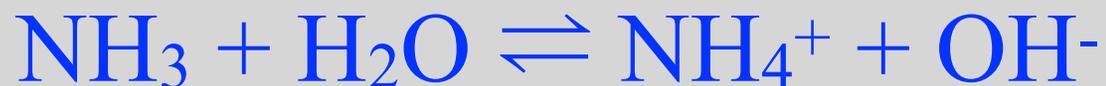
Conjugate Acid-Base Pairs

	ACID	BASE	
100 percent ionized in H ₂ O	HCl	Cl ⁻	Negligible
	H ₂ SO ₄	HSO ₄ ⁻	
	HNO ₃	NO ₃ ⁻	
	H ₃ O ⁺ (aq)	H ₂ O	
Acid strength increases ↑	HSO ₄ ⁻	SO ₄ ²⁻	Weak
	H ₃ PO ₄	H ₂ PO ₄ ⁻	
	HF	F ⁻	
	HC ₂ H ₃ O ₂	C ₂ H ₃ O ₂ ⁻	
	H ₂ CO ₃	HCO ₃ ⁻	
	H ₂ S	HS ⁻	
	H ₂ PO ₄ ⁻	HPO ₄ ²⁻	
	NH ₄ ⁺	NH ₃	
	HCO ₃ ⁻	CO ₃ ²⁻	
	HPO ₄ ²⁻	PO ₄ ³⁻	
	H ₂ O	OH ⁻	
Negligible	OH ⁻	O ²⁻	Strong
	H ₂	H ⁻	
	CH ₄	CH ₃ ⁻	
			100 percent protonated in H ₂ O

Base strength increases ↓

Acid-Base Introduction

Conjugates

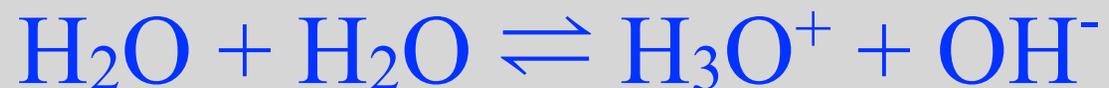


- Notice that water acts as a base in the first example and as an acid in the second
 - What causes the difference?
- This property is termed amphoteric
 - Able to act as either an acid or a base

Acid-Base Introduction

Autoionization of Water

- Because water is amphoteric, it has the ability to ionize itself
 - Write the balanced equation for this process



- Write the equilibrium expression for the reaction

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Ion Product Constant of Water

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

- Through experimental observation, the value for K_w has been determined
 - 1.0×10^{-14}
- This relationship not only holds for pure water, but also for aqueous acidic or basic solutions
 - This creates a “seesaw” about which we can interconvert $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$
- The question then becomes....
 - How do we determine the H_3O^+ concentration?

Acid-Base Introduction

pH

$$\text{pH} = -\log [\text{H}^+] \quad \text{or} \quad \text{pH} = -\log[\text{H}_3\text{O}^+]$$

- pH
 - A mathematical expression of acid/basic concentration (strength)
 - Low pH's are acidic, high pH's are basic
 - Allows us to quantitatively study water based solutions



	pH	[H ⁺]	[OH ⁻]	pOH
	14	1 × 10 ⁻¹⁴	1 × 10 ⁻⁰	0
NaOH, 0.1M -----	13	1 × 10 ⁻¹³	1 × 10 ⁻¹	1
Household bleach -----				
Household ammonia -----	12	1 × 10 ⁻¹²	1 × 10 ⁻²	2
	11	1 × 10 ⁻¹¹	1 × 10 ⁻³	3
Lime water -----				
Milk of magnesia -----	10	1 × 10 ⁻¹⁰	1 × 10 ⁻⁴	4
Borax -----	9	1 × 10 ⁻⁹	1 × 10 ⁻⁵	5
Baking soda -----				
Egg white, seawater -----	8	1 × 10 ⁻⁸	1 × 10 ⁻⁶	6
Human blood, tears -----				
Milk -----	7	1 × 10 ⁻⁷	1 × 10 ⁻⁷	7
Saliva -----				
Rain -----	6	1 × 10 ⁻⁶	1 × 10 ⁻⁸	8
Black coffee -----	5	1 × 10 ⁻⁵	1 × 10 ⁻⁹	9
Banana -----				
Tomatoes -----	4	1 × 10 ⁻⁴	1 × 10 ⁻¹⁰	10
Wine -----				
Cola, vinegar -----	3	1 × 10 ⁻³	1 × 10 ⁻¹¹	11
Lemon juice -----	2	1 × 10 ⁻²	1 × 10 ⁻¹²	12
Gastric juice -----	1	1 × 10 ⁻¹	1 × 10 ⁻¹³	13
	0	1 × 10 ⁰	1 × 10 ⁻¹⁴	14

Acid-Base Introduction

pH

- What about a solution with $[\text{OH}^-] = 2.0 \times 10^{-3}$? What is its pH?
- This brings up an interesting new idea
 - pOH

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

By combining our K_w equation with our definitions of pH and pOH, we get this.....

$$\text{pH} + \text{pOH} = 14$$

Acid-Base Introduction

Strong Acids and Bases

- In the case of strong acids, we consider the concentration of the acid to equal the concentration of H_3O^+ ion
 - Why is this appropriate?
 - What about the concentration of H_3O^+ created by the autoionization of water?
- In the case of strong bases, we consider the concentration of the base to equal the concentration of OH^- ion

Acid-Base Introduction

Homework

- 16.1 / 16.3 / 16.6
- 16.11 - Although HCl and H₂SO₄ have very different properties as pure substances, their aqueous solutions possess many common properties. List some general properties of these solutions and explain their common behavior in terms of species present.
- 16.13 - (a) What is the difference between the Arrhenius and the Bronsted/Lowry definitions of an acid? (b) NH₃ and HCl react to form the ionic solid NH₄Cl. Which substance is the BL acid in the reaction? The BL base?
- 16.14 - (a) What is the difference between the Arrhenius and the Bronsted/Lowry definitions of an base? (b) Can a substance behave as an Arrhenius base if it does not contain an OH group. Explain.
- 16.21 / 16.22 / 16.23 / 16.31 / 16.32 / 16.33 / 16.37 / 16.39
- 16.41 - (a) What is a strong acid? (b) A solution is labeled 0.500M HCl. What is [H⁺] for the solution? (c) Which of the following are strong acids: HF, HCl, HBr, HI?
- 16.42 - (a) What is a strong base? (b) A solution is labeled 0.035M Sr(OH)₂. What is [OH⁻] for the solution? (c) Is the following statement true or false? Because Mg(OH)₂ is not very soluble it cannot be a strong base. Explain.
- 16.47a&d / 16.48a&c / 16.49a&d / 16.50a&c / 16.51