# N36 – Acid Base

# **Quick Review**

Link to YouTube Presentation: <a href="https://youtu.be/uS0P-Qp9tB8">https://youtu.be/uS0P-Qp9tB8</a>

# N36 – Acid Base

# **Quick Review**

**Target:** I can review Acid Base definitions and perform pH calculations for strong acids/bases

#### **Acid/Base Definitions**

Arrhenius Model	$\frac{\text{HNO}_3 \rightarrow \text{H}^+ + \text{NO}_3^-}{\text{KOH} \rightarrow \text{K}^+ + \text{OH}^-}$		
Bronsted-Lowry Model	$\mathbf{HCI} + \mathbf{NH}_3 \leftrightarrow \mathbf{CI}^{-} + \mathbf{NH}_4^{+}$		
Lewis Acid Model	$ \begin{array}{c} \mathbf{H} \\ \mathbf$		

### **Acid/Base Definitions**

Arrhenius Model •Acids produce H+ •Bases produce OH <sup>-</sup>	$\frac{\text{HNO}_3 \rightarrow \text{H}^+ + \text{NO}_3^-}{\text{KOH} \rightarrow \text{K}^+ + \text{OH}^-}$	
Bronsted-Lowry Model •Acids are proton donors •Bases are proton acceptors	$\mathbf{HCI} + \mathbf{NH}_3 \leftrightarrow \mathbf{CI}^{-} + \mathbf{NH}_4^{+}$	
Lewis Acid Model •Acids are electron pair acceptors •Bases are electron pair donors	$ \begin{array}{c} \mathbf{H} \\ \mathbf$	

#### **Acid/Base Definitions**



- Lewis Brønsted-Lowry :B Arrhenius H+--:OH
  - Arrhenius is MOST specific
  - Brønsted-Lowry is less specific
  - Lewis is LEAST specific

# **Problems with Arrhenius Theory**

#### **Does not explain why:**

- Some molecular substances, (NH<sub>3</sub>) dissolve in water to form basic solutions, even though they do not contain OH<sup>-</sup> ions.
- How some ionic comp, (Na<sub>2</sub>CO<sub>3</sub> or Na<sub>2</sub>O) dissolve in water to form basic sol'ns, even though they don't contain OH<sup>-</sup>
- Why some molecular substances, (CO<sub>2</sub>) dissolve in water to form acidic solutions, even though they do not contain H<sup>+</sup> ions.
- Acid-base reactions that take place outside aqueous solution.

# **Brønsted–Lowry Acid–Base Theory**

- It defines acids and bases based on what happens in a rxn.
- Any reaction involving H<sup>+</sup> (proton) that transfers from one molecule to another is an acid—base reaction, regardless of whether it occurs in aqueous solution or if there is OH<sup>-</sup> present.
- All reactions that fit the Arrhenius definition also fit the Brønsted–Lowry definition.



### **Brønsted–Lowry Theory**

In a Brønsted–Lowry acid–base reaction, the acid molecule donates an H<sup>+</sup> to the base molecule.

 $H-A + :B \leftrightarrow :A^- + H-B^+$ 

 $\mathsf{HCI} + \mathsf{NH}_3 \leftrightarrow \mathsf{CI}^{-} + \mathsf{NH}_4^{+}$ 

- The acid is an H<sup>+</sup> donor.
- The **base** is an H<sup>+</sup> acceptor.
  - Base structure must contain an atom with an unshared pair of electrons.

# **Brønsted–Lowry Acids**

- H<sup>+</sup> donors.
  - Any material that has H can potentially be a Brønsted–Lowry acid.
  - Because of the molecular structure, often one H in the molecule is easier to transfer than others.
- When HCI dissolves in water, the HCI is the acid because HCI transfers an H<sup>+</sup> to H<sub>2</sub>O, forming H<sub>3</sub>O<sup>+</sup> ions.

– Water acts as base, accepting H<sup>+</sup>.

# $\begin{array}{ll} \mathsf{HCl}(aq) + \mathsf{H}_2\mathsf{O}(I) \to \mathsf{Cl}^-(aq) + \mathsf{H}_3\mathsf{O}^+(aq) \\ \texttt{Acid} & \texttt{Base} \end{array}$

### **Amphoteric Substances**

Amphoteric substances can act as either an acid or a base because they have both a transferable H and an atom with lone pair electrons.

 $NH_3 + H(OH) \rightarrow NH_4^+ + OH^-$ Water is donating a proton...ACID!

HCI + H(OH)  $\rightarrow$  H<sub>3</sub>O<sup>+</sup> + CI<sup>-</sup> Water is accepting a proton...BASE!

# **Conjugate Acid–Base Pairs**

Acids turn into "Conjugate Bases" once they have lost their proton/hydrogen

Bases turn into "Conjugate Acids" once they have gained a proton/hydrogen



# **Conjugate Pairs**





#### **Tips for Finding Each**

- Find the Acid First usually easiest!
- Find It's Conjugate Base the part left after donating its H+!
- Repeat with Base and Conjugate Acid

### **Acid Dissociation**

Back to equilibrium!!!! Woohoo!



Can also H<sup>+</sup> be written in its hydrated form, H<sub>3</sub>O<sup>+</sup> (hydronium ion)

# **Dissociation of Strong Acids**

Strong acids are assumed to dissociate completely in solution.

![](_page_14_Figure_2.jpeg)

Reactant favored or product favored?

Product Favored

Large  $K_a$  or small  $K_a$ ?

Large K<sub>a</sub>

### **Dissociation Constants: Strong Acids**

Acid	Formula	Conjugate Base	K <sub>a</sub>
Perchloric	HCIO <sub>4</sub>	CIO <sub>4</sub> -	Very large
Hydriodic	HI	l-	Very large
Hydrobromic	HBr	Br⁻	Very large
Hydrochloric	HCI	Cl-	Very large
Nitric	HNO <sub>3</sub>	NO <sub>3</sub> -	Very large
Sulfuric	$H_2SO_4$	HSO <sub>4</sub> -	Very large
Hydronium ion	H <sub>3</sub> O+	H <sub>2</sub> O	1.0

# **Dissociation of Weak Acids**

Weak acids are assumed to dissociate only slightly (less than 5%) in solution.

![](_page_16_Figure_2.jpeg)

# **Dissociation Constants: Weak Acids**

Acid	Formula	Conjugate Base	K <sub>a</sub>
Iodic	HIO <sub>3</sub>	10 <sub>3</sub> -	1.7 x 10 <sup>-1</sup>
Oxalic	$H_2C_2O_4$	$HC_2O_4^-$	5.9 x 10 <sup>-2</sup>
Sulfurous	H <sub>2</sub> SO <sub>3</sub>	HSO <sub>3</sub> -	1.5 x 10 <sup>-2</sup>
Phosphoric	H <sub>3</sub> PO <sub>4</sub>	H <sub>2</sub> PO <sub>4</sub> -	7.5 x 10 <sup>-3</sup>
Citric	$H_3C_6H_5O_7$	$H_2C_6H_5O_7^{-1}$	7.1 x 10 <sup>-4</sup>
Nitrous	HNO <sub>2</sub>	NO <sub>2</sub> -	4.6 x 10 <sup>-4</sup>
Hydrofluoric	HF	F <sup>-</sup>	3.5 x 10 <sup>-4</sup>
Formic	НСООН	HCOO-	1.8 x 10 <sup>-4</sup>
Benzoic	C <sub>6</sub> H <sub>5</sub> COOH	C <sub>6</sub> H <sub>5</sub> COO <sup>-</sup>	6.5 x 10 <sup>-5</sup>
Acetic	CH <sub>3</sub> COOH	CH <sub>3</sub> COO <sup>-</sup>	1.8 x 10 <sup>-5</sup>
Carbonic	H <sub>2</sub> CO <sub>3</sub>	HCO <sub>3</sub> -	4.3 x 10 <sup>-7</sup>
Hypochlorous	HCIO	CIO	3.0 x 10 <sup>-8</sup>
Hydrocyanic	HCN	CN <sup>-</sup>	4.9 x 10 <sup>-10</sup>

\*Random fact\*

Weak acids will dissociate more when they are dilute! The lower the concentration the higher % dissociation they will have.

$$K_w$$
 is a constant at 25 °C:  
 $K_w = [H_3O^+][OH^-]$  At 25°,  $[H_3O^+] = [OH^-] = 1 \times 10^{-7}$   
 $K_w = (1 \times 10^{-7})(1 \times 10^{-7}) = 1 \times 10^{-14}$ 

#### $H_{2}O_{(1)} + H_{2}O_{(1)} \longrightarrow OH_{(aq)}^{-} + H_{3}O_{(aq)}^{+}$ *K<sub>w</sub>* is a constant at 25 °C:

![](_page_18_Figure_2.jpeg)

# **Self-Ionization of Water**

## **Self-Ionization of Water**

![](_page_19_Figure_1.jpeg)

- *K<sub>w</sub>* is only 1 x 10<sup>-14</sup> when at 25 °C
- Neutral is only pH 7 when at 25 °C
- K<sub>w</sub> increases as temp increases more dissociates!
- pH of neutral gets lower as temp increases

# pH and pOH Calculations

![](_page_20_Figure_1.jpeg)

# pH and pOH Calculations

![](_page_21_Figure_1.jpeg)

![](_page_21_Picture_2.jpeg)

# pH and pOH Calculations

![](_page_22_Figure_1.jpeg)

## pH Scale

![](_page_23_Figure_1.jpeg)

Courtesy of Environment Canada (http://www.ns.ec.dc.caA

# **pH Indicators**

Some substances turn colors when the pH changes into a certain range, because their structure is changing. This is a very handy tool for us!

#### **Example:**

Phenolphthalein turns from clear to pink when the pH reaches ~ 8 - 10.

![](_page_24_Picture_4.jpeg)

# **pH Indicators**

You can predict the effective color change region of an indicator by looking at it's pKa.

Color Change Region = +/- 1 pH unit from the indicator's pKa.

The pKa of phenolphthalein is 9.3, therefore it will change colors between a pH of ~ 8 - 10

![](_page_25_Picture_4.jpeg)

#### YouTube Link to Presentation

https://youtu.be/uS0P-Qp9tB8