Brønsted-Lowry Definition of Acids/Bases:

**Acids:** Proton Donors  
**Bases:** Proton Acceptors

- Conjugate acid/base pairs differ by a proton

**Examples of Acids:**

\[
\text{HF (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{H}_3\text{O}^+ (aq) + \text{F}^- (aq)
\]

Acid Base Conjugate Acid Conjugate Base

Other examples: CH₃COOH, H₂SO₄

**Examples of Bases:**

\[
\text{NH}_3 (aq) + \text{H}_2\text{O (l)} \rightleftharpoons \text{NH}_4^+ (aq) + \text{OH}^- (aq)
\]

Base Acid Conjugate Acid Conjugate Base

Other examples of bases: KOH, NaOCH₃

**Acid Dissociation Reaction (Kₐ)**

- We differentiate between acids by how well they donate a proton to water.
- Quantified by Kₐ

**General:**

\[
\text{HA (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{H}_3\text{O}^+ (aq) + \text{A}^- (aq)
\]

\[
K_a = [\text{H}_3\text{O}^+][\text{A}^-]/[\text{HA}]
\]

- Always refers to an acid reacting with water to produce its conjugate base (A⁻) and H₃O⁺.
- Often omit H₂O but it is there.

Write out the acid dissociation reactions for the following:

(a) HCN  
(b) HNO₃  
(c) HC₂H₃O₂
The simplified expression is:

\[ \text{HA} \text{(aq)} \rightleftharpoons \text{H}^+ \text{(aq)} + \text{A}^- \text{(aq)} \]

- \( K_a \text{ HNO}_3 = 1 \times 10^7 \)
- \( K_a \text{ HC}_2\text{H}_3\text{O}_2 = 1.8 \times 10^{-5} \)
- \( K_a \text{ HCN} = 6.2 \times 10^{-10} \)

- If \( K_a >>> 1 \) the forward reaction dominates
- This is the case for strong acids
- Strong acids to memorize: HCl, HI, HBr, HNO_3, HClO_4, H_2SO_4
- Assume 100% dissociation in water.
- If \( K_a << 1 \) these are weak acids and are only 1-10% dissociated
- H_2C_2H_3O_2 and HCN are weak acids
- Any acid that is not on your list of strong acids to memorize is a weak acid.

**Question:** Which is a stronger weak acid, H_2C_2H_3O_2 or HCN?

**Answer:**

**Strong Bases:**

- We also categorize bases as strong or weak.
- All bases have the same effect of adding OH\(^-\) to H\(_2\)O but strong bases do this differently than weak bases.
- Strong bases are soluble ionic compounds containing OH\(^-\).
- Strong bases to memorize: LiOH, NaOH, RbOH, CsOH, Ca(OH)_2, Sr(OH)_2, Ba(OH)_2.
- We don’t characterize strong bases using \( K_b \).

**Weak Bases (\( K_b \))**:

**General:**

\[ \text{B} \text{(aq)} + \text{H}_2\text{O} \text{(l)} \rightleftharpoons \text{BH}^+ \text{(aq)} + \text{OH}^- \text{(aq)} \]

\[ K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} \]

- When \( K_b << 1 \) we classify bases as weak.
- \( K_b \) is directly proportional to base strength, as \( K_b \) increases the ability of a base to accept a proton from water increases resulting in an increased concentration of hydroxide.
Write out the $K_b$ expressions for the following bases:

(a) $NH_3$ \hspace{1cm} $K_b = 1.8 \times 10^{-5}$  
(b) $HONH_2$ \hspace{1cm} $K_b = 1.1 \times 10^{-8}$  
(c) $C_6H_5NH_2$ \hspace{1cm} $K_b = 3.8 \times 10^{-10}$

**Question:** Which weak base is the strongest?  
**Answer:**

 Relative Strengths of Conjugate Acids and Bases

- The stronger the acid the weaker the conjugate base.

**Question:** Which of the following correctly completes the following sentence?

The fact that acetic acid ($HC_2H_3O_2$) is a stronger acid than HCN implies that:

- (a) Acetate ion ($C_2H_3O_2^-$) is a stronger base than $CN^-$
- (b) $CN^-$ is a stronger base than $C_2H_3O_2^-$
- (c) A 0.1 M solution of HCN has a higher concentration of $H^+$ than 0.1 M HC$_2$H$_3$O$_2$
- (d) A 0.1 M solution of NaC$_2$H$_3$O$_2$ has a higher concentration of $OH^-$ than 0.1 M NaCN.

**Answer:**

**Conjugate Acid-Base Pairs:**

Consider HC$_2$H$_3$O$_2$, $K_a = 1.8 \times 10^{-5}$

$$HC_2H_3O_2 (aq) \rightleftharpoons H^+ (aq) + C_2H_3O_2^- (aq) \hspace{1cm} K_a = 1.8 \times 10^{-5} = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$
What is the $K_b$ for $\text{C}_2\text{H}_3\text{O}_2^-$?

$\text{C}_2\text{H}_3\text{O}_2^-$ (aq) + $\text{H}_2\text{O}$ (l) $\rightleftharpoons$ $\text{HC}_2\text{H}_3\text{O}_2$ (aq) + $\text{OH}^-$ (aq)  

$K_b = \frac{[\text{HC}_2\text{H}_3\text{O}_2][\text{OH}^-]}{[\text{C}_2\text{H}_3\text{O}_2^-]}$

- at 25°C, holds true for all conjugate acid-base pairs.

**Question:** Calculate the value of $K_b$ for $\text{CN}^-$ and $\text{C}_2\text{H}_3\text{O}_2^-$.  
**Answer:**

**Question:** Why are answers c and d false?  
**Answers:**
The pH scale

- We use the pH scale to quantify (measure) relative acidity and basicity.
- The midpoint of the pH scale is 7.00
- pH = 7.00 is neutral (neither acidic nor basic)
- Acids have a pH less than 7.00
- Bases have a pH greater than 7.00
- \( \text{pH} = -\log[\text{H}^+] \)

For neutral pH:

For pH < 7.00:

Questions: Calculate the \([\text{H}^+]\) and \([\text{OH}^-]\) or the pH for the following:

(a) Stomach acid pH = 2.00
(b) Vinegar pH = 3.00
(c) 1.0 M HCl
**pOH:**

\[ \text{pOH} = -\log[\text{OH}^-] \] also \( \text{pH} + \text{pOH} = 14 \) (take log of \( K_w \) expression)

**Question:** Calculate the pOH of the previous examples.

**Answer:**

- As acid strength increases \([H^+]\) increases, pH decreases and pOH increases.
- As base strength increases \([OH^-]\) increases, pH increases and pOH decreases.

**Question:** Calculate the \([H^+], [OH^-]\) and pOH for the following:

- **(a)** Ammonia pH = 12.00
- **(b)** 1.0 M NaOH at a pH = 14.00

- The homework tonight involves a lot of conversions between these values, make sure how to perform the calculations but also the significance of the calculations.
- pH values are typically reported to two decimal places.