- **Acid–Base Properties of Salts**
  - $K_a \times K_b = K_w$
  - Q1: You dissolve ammonium sulfate, $(NH_4)_2SO_4$, in water. **What is the pH of the resulting solution?**
    - $(NH_4)_2SO_4\ (aq) \rightarrow 2\ NH_4^+\ (aq) + SO_4^{2-}(aq)$
      NH_4^+ is the conjugate acid of NH_3, a weak base. Thus, a weak acid.
      SO_4^{2-} is the conjugate base of HSO_4^-, a weak acid. Thus, a weak base.
      K_b for $NH_3 = 1.8 \times 10^{-5}$
      $K_a = K_w / K_a = 1.0*10^{-14} / 1.8 \times 10^{-5} = 5.6*10^{-10}$
      K_a for $HSO_4^- = 1.02 \times 10^{-2}$
      $K_b = K_w / K_a = 1.0*10^{-14} / 1.02 \times 10^{-2} = 9.9*10^{-13}$
  - Q2: You dissolve ammonium acetate (NH_4OAc) in water. **What is the pH of the resulting solution?**
    - $NH_4OAc\ (aq) \rightarrow NH_4^+\ (aq) + OAc^-(aq)$
    - NH_4^+ is the conjugate acid of NH_3, a weak base. Thus, a weak acid.
    - OAc^- is the conjugate base of acetic acid, a weak acid. Thus, a weak base.
    - K_b for $NH_3 = 1.8 \times 10^{-5}$
    - K_a for $HOAc = 1.8 \times 10^{-5}$
  - Q3: You dissolve sodium bicarbonate ($NaHCO_3$) in water. **What is the pH of the resulting solution?**
    - $NaHCO_3\ (aq) \rightarrow Na^+\ (aq) + HCO_3^-(aq)$
    - Na^+ does not gain or accept H^+.
    - HCO_3^- is the conjugate base of H_2CO_3, a weak acid. But it's also an acid. (polyprotic acid)
    - $HCO_3^-(aq) + H_2O \rightleftharpoons H_2CO_3(aq) + OH^-(aq)\ K_b = 2.4 \times 10^{-8}$
    - $HCO_3^-(aq) + H_2O \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)\ K_a = 4.8 \times 10^{-11}$
    - $K_b > K_a$

- **Harder Cases**

Type of Salt	Examples	Comment	pH of solution
Cation is the conjugate acid of a weak base, anion is conjugate base of a weak acid	$NH_4C_2H_3O_2$ NH_4CN	Cation is acidic, Anion is basic	See below

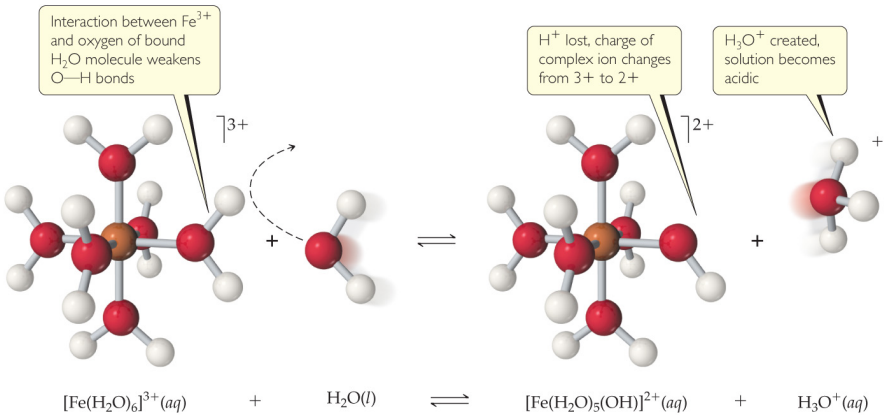
- IF K_a for the acidic ion is greater than K_b for the basic ion, the solution is acidic
- IF K_b for the basic ion is greater than K_a for the acidic ion, the solution is basic
- IF K_b for the basic ion is equal to K_a for the acidic ion, the solution is neutral

- **Hydrated Cations**
  - Transition and post-transition
  - H_2O attached to a metal ion is more acidic than free H_2O, making hydrated metal ions acidic.

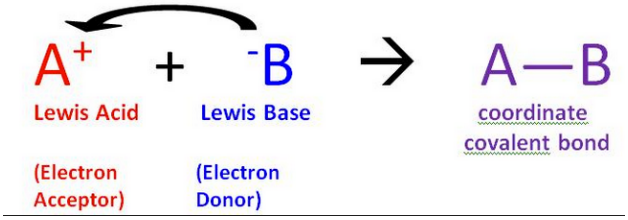
Table 16.6 Acid-Dissociation Constants for Metal Cations in Aqueous Solution at 25 °C

Cation	K_a
Fe^{2+}	3.2×10^{-10}
Zn^{2+}	2.5×10^{-10}
Ni^{2+}	2.5×10^{-11}
Fe^{3+}	6.3×10^{-3}
Cr^{3+}	1.6×10^{-4}
Al^{3+}	1.4×10^{-5}

  - E.g. Al^{3+} or Fe^{3+} with six H_2O molecules bound.



- **Lewis Acid/Base Chemistry**
  - Metal ions are Lewis acids, electron pair acceptors.
  - Water is a Lewis base, electron pair donors



  - Coordination Compound
    - Lewis acid-base complex of a metal cation (the Lewis acid) associated with a group of neutral molecules or anions (the Lewis base/ligand).

- **Factors that Affect Acid Strength**
  - ***Polarity*:** H—A bond must be polarized with $\delta+$ on the H atom and $\delta-$ on the A atom
  - ***Bond strength*:** Weaker bonds can be broken more easily, making the acid stronger.
    - *Example 1*: CH_4
      - *Polarity*: C—H bond is not polar.
      - *Bond strength*: C—H bond is strong.
      - CH_4 is NOT an acid.
    - *Example 2*: HCl
      - *Polarity*: H—Cl bond is very polar.
      - *Bond strength*: H—Cl bond is pretty strong, but polarity dominates.
      - HCl is a good acid.

Binary Acids

- Binary acids consist of H and one other element.

	GROUP			
	4A	5A	6A	7A
Period 2	CH_4 No acid or base properties	NH_3 Weak base	H_2O ---	HF Weak acid
Period 3	SiH_4 No acid or base properties	PH_3 Weak base	H_2S Weak acid	HCl Strong acid

Increasing acid strength

Increasing acid strength

- Increasing electronegativity, thus more polar bond to -H.

- **Oxyacids**
  - H, O, and another nonmetal.
  - the electronegativity of the nonmetal increases, the acidity increases for acids with the same structure.
  - If an element can form more than one oxyacid, the oxyacid with more O atoms is more acidic.

- **Carboxylic Acids**
  - Carboxylic acids are organic acids containing the —COOH group.
  - Factors contributing to their acidic behavior:
    - The other oxygen atom draws electron density from the O—H bond, increasing polarity.
    - The conjugate base (carboxylate anion) has resonance forms to stabilize the anion.