PHARM.D • YEAR 1

Pharmaceutical Organic Chemistry

CHAPTER 1.2

Acids and Bases

PPT CHAPTER COVER



DOCTOR OF PHARMACY

THREE ACID–BASE THEORIES

1 ARRHENIUS THEORY

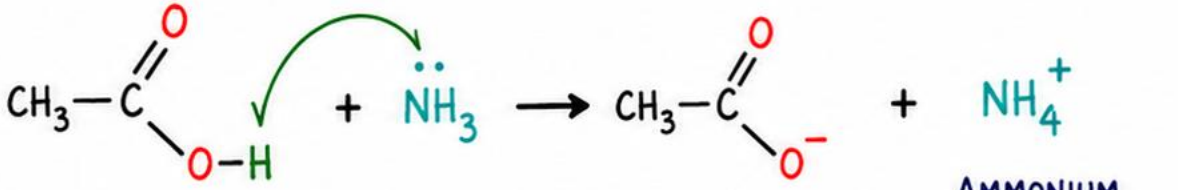
- Acid: produces H^+ in water.
- Base: produces OH^- in water.
- Limited to aqueous solutions.



HYDROCHLORIC ACID (ACID) | HYDRONIUM ION (H^+) | CHLORIDE ION

2 BRØNSTED–LOWRY THEORY

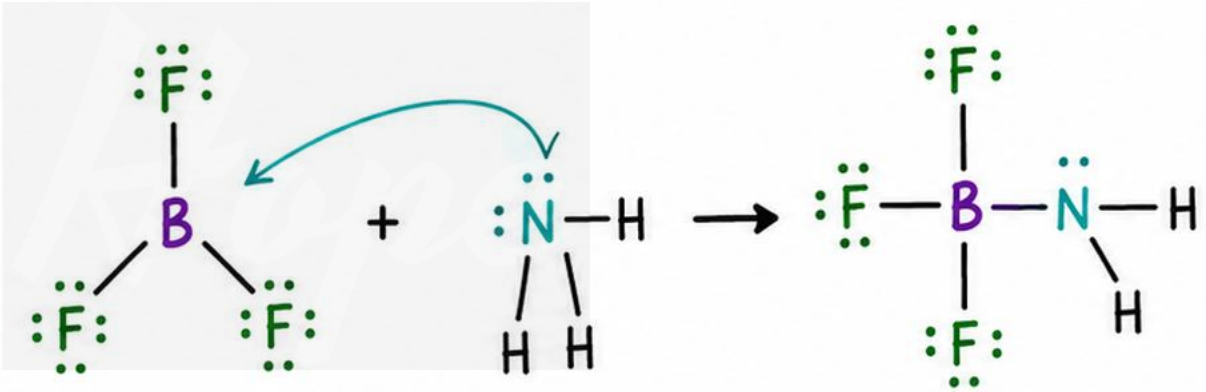
- Acid: proton (H^+) donor.
- Base: proton (H^+) acceptor.
- Broader: not limited to water.



ACETIC ACID (ACID) | AMMONIA (BASE) | ACETATE ION (CONJUGATE BASE) | AMMONIUM ION (CONJUGATE ACID)

3 LEWIS THEORY

- Acid: electron pair acceptor.
- Base: electron pair donor.
- Widest scope; not limited by solvent or H^+.



BORON TRIFLUORIDE (LEWIS ACID) | AMMONIA (LEWIS BASE) | LEWIS ADDUCT (DATIVE BOND)

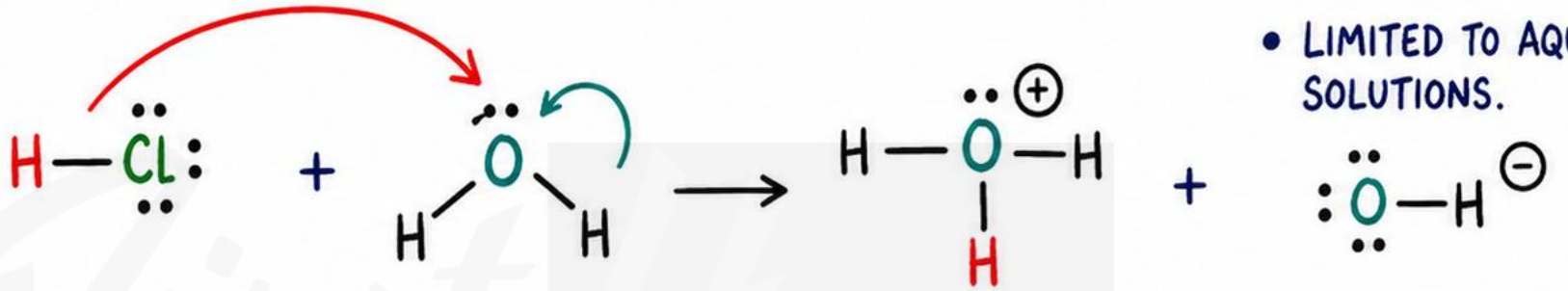
★ SAME ACID–BASE BEHAVIOR, EXPLAINED AT DIFFERENT LEVELS!

ARRHENIUS ACIDS AND BASES

DEFINITION (ARRHENIUS)

- ARRHENIUS ACID PRODUCES H^+ IN WATER.
- ARRHENIUS BASE PRODUCES OH^- IN WATER.

TYPICAL ARRHENIUS ACID-BASE REACTION



HYDROCHLORIC ACID (ACID) + WATER (BASE) → HYDRONIUM ION (H_3O^+) + HYDROXIDE ION (OH^-)

ACID DONATES H^+ TO WATER; WATER ACCEPTS H^+ TO FORM H_3O^+ AND OH^-.

SCOPE

- LIMITED TO AQUEOUS SOLUTIONS.

KEY POINTS

- ACIDS INCREASE $[H^+]$ IN WATER.
- BASES INCREASE $[OH^-]$ IN WATER.
- NEUTRALIZATION: ACID + BASE → SALT + WATER.

TAKEAWAY

ARRHENIUS THEORY IS SIMPLE BUT RESTRICTED TO WATER — ACIDS GIVE H^+, BASES GIVE OH^-.

STRONG VERSUS WEAK ACIDS AND BASES

A. STRONG ACIDS:

- Completely dissociate in water.
- Examples: HCl, HBr, HI, HNO_3, $HClO_4$, H_2SO_4 (first proton)

B. WEAK ACIDS:

- Partially dissociate.
- Examples: CH_3COOH (acetic acid), HF, H_2CO_3

C. STRONG BASES:

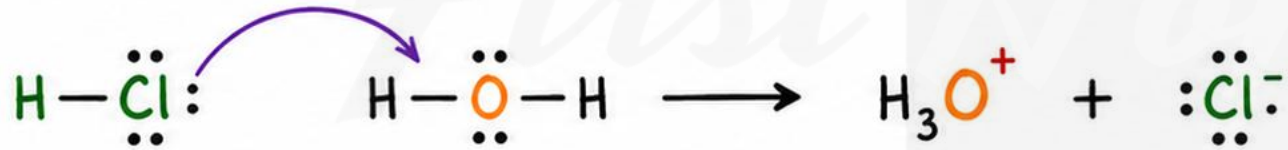
- Fully dissociate into OH^-.
- Examples: NaOH, KOH, $Ba(OH)_2$

D. WEAK BASES:

- Partially accept protons (often produce OH^- indirectly).
- Examples: NH_3, CH_3NH_2

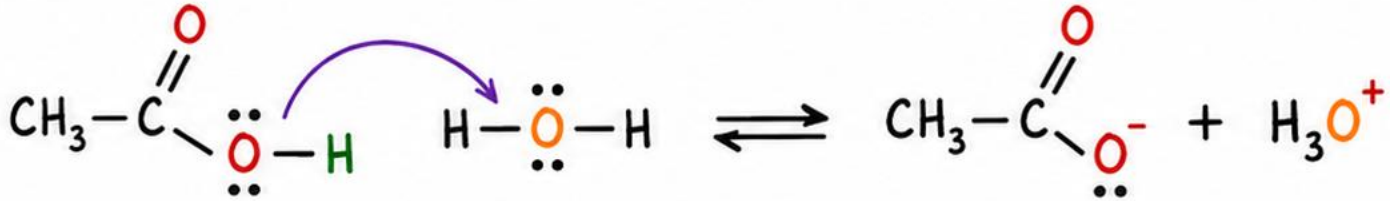
ACID DISSOCIATION IN WATER

STRONG ACID (e.g., HCl)



(in water) (complete dissociation)

WEAK ACID (e.g., CH_3COOH)



(in water) (partial dissociation)

QUANTIFYING STRENGTH

A. FOR ACIDS:

K_a = Acid dissociation constant

$$HA \rightleftharpoons H^+ + A^-$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$pK_a = -\log(K_a)$$

Lower pK_a = Stronger acid

BRØNSTED-LOWRY PROTON TRANSFER

DEFINITION

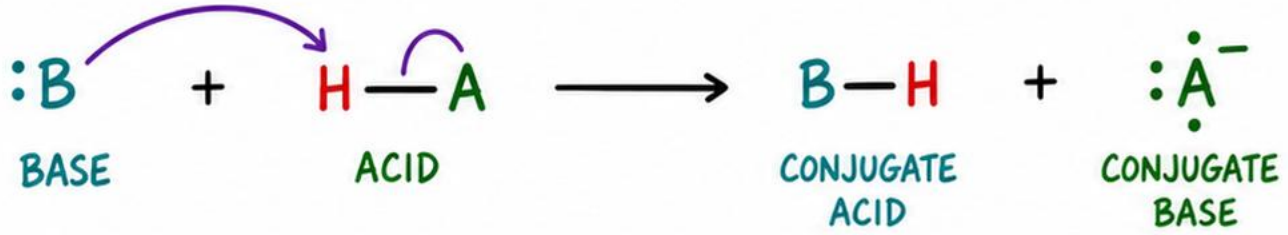
A BRØNSTED-LOWRY ACID DONATES A PROTON (H^+) AND A BASE ACCEPTS A PROTON.

KEY POINTS

1. PROTON TRANSFERS ARE GOVERNED BY RELATIVE STRENGTHS (ΔpKa). FAVOR THE FORMATION OF THE WEAKER ACID-BASE PAIR.
2. CONJUGATE ACID-BASE PAIRS:
   - EVERY ACID HAS A CONJUGATE BASE (WHAT REMAINS AFTER IT DONATES H^+).
   - EVERY BASE HAS A CONJUGATE ACID (WHAT FORMS AFTER IT ACCEPTS H^+).

   STRONGER ACID → WEAKER CONJUGATE BASE, AND VICE VERSA.
3. AMPHOTERIC SUBSTANCES CAN ACT AS BOTH ACID AND BASE, DEPENDING ON THE ENVIRONMENT. EXAMPLE: WATER (H_2O).

WORKED EXAMPLE: GENERIC PROTON TRANSFER



THE ACID (HA) DONATES H^+ TO THE BASE (B:). CONJUGATE ACID (BH^+) AND CONJUGATE BASE (A^-) FORM.

EXAMPLES

1) $HCl + NH_3 \longrightarrow NH_4^+ + Cl^-$

HCl: ACID ($pKa \approx -7$) — NH_3: BASE (pKa of $NH_4^+ \approx 9.25$) — NH_4^+: CONJUGATE ACID — Cl^-: CONJUGATE BASE

2) $H_2O + NH_3 \rightleftharpoons NH_4^+ + OH^-$

H_2O: ACID (DONATES H^+) — NH_3: BASE (ACCEPTS H^+) — NH_4^+: CONJUGATE ACID — OH^-: CONJUGATE BASE

NON-AQUEOUS SOLVENTS

ACID-BASE BEHAVIOR CAN DIFFER OUTSIDE WATER. IN LIQUID AMMONIA, FOR EXAMPLE: NH_4^+ IS AN ACID.

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