

All Your Acids and Bases are Belong to us...Acid-Base Equilibria: Ch. 13-14
Acid-Base Def'ns.

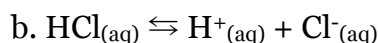
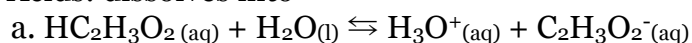
I. Properties

Acids	Bases

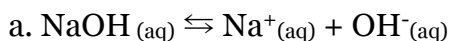
II. There are _____ to define acids and bases.

A. _____ - Focused on

1. Acids: dissolves into

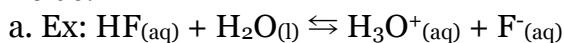


2. Bases: dissolves into

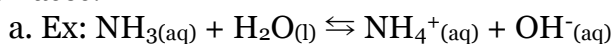


B. _____ - Focused on

1. Acids:

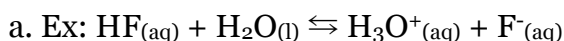


2. Bases:

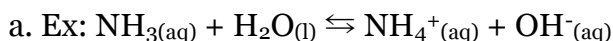


C. _____ - Focused on

1. Acids:



2. Bases:



D. Water

1. It is

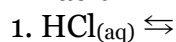
2. It is _____ or _____ (it can act _____)

III. Conjugate acids and bases:

A. A pair of compounds that

B. They are

C. An acid



D. A base



E. Label:

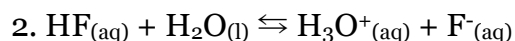
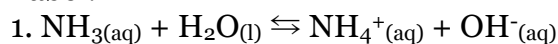
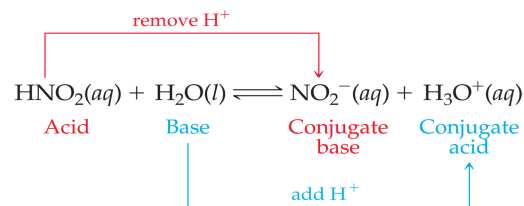


TABLE 14.10 Three Models for Acids and Bases

Model	Definition of Acid	Definition of Base
Arrhenius	H ⁺ producer	OH ⁻ producer
Brønsted-Lowry	H ⁺ donor	H ⁺ acceptor
Lewis	Electron-pair acceptor	Electron-pair donor



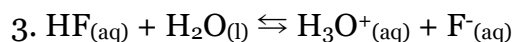
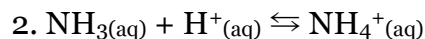
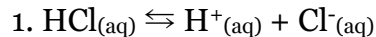
Acid-Base Strength

I. First, the

A. Measures the

B. It is the

C. Write the acid dissociation constant expression for:



D. The

II. Strong acids and bases

A.

B. Acids:

C. Bases:

D.

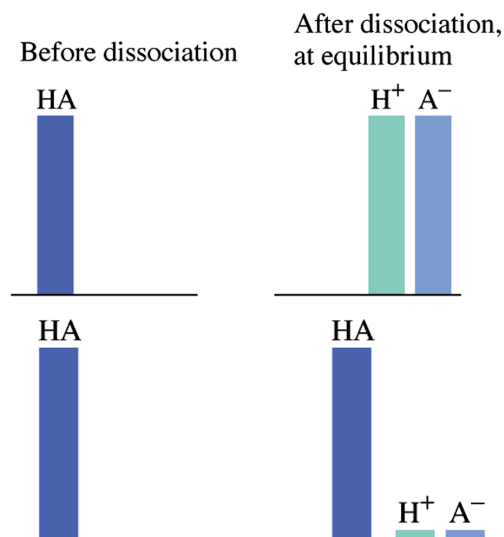
III. Weak acids and bases

A.

B. Weak acids:

C. Weak bases:

D.



Acid	Structural Formula	Conjugate Base	Equilibrium Reaction	K_a
Hydrofluoric (HF)		F^-	$\text{HF}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{F}^-_{(aq)}$	6.8×10^{-4}
Nitrous (HNO ₂)		NO_2^-	$\text{HNO}_2_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{NO}_2^-_{(aq)}$	4.5×10^{-4}
Benzoic (HC ₇ H ₅ O ₂)		$\text{C}_7\text{H}_5\text{O}_2^-$	$\text{HC}_7\text{H}_5\text{O}_2_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{C}_7\text{H}_5\text{O}_2^-_{(aq)}$	6.3×10^{-5}
Acetic (HC ₂ H ₃ O ₂)		$\text{C}_2\text{H}_3\text{O}_2^-$	$\text{HC}_2\text{H}_3\text{O}_2_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{C}_2\text{H}_3\text{O}_2^-_{(aq)}$	1.8×10^{-5}
Hypochlorous (HClO)		ClO^-	$\text{HClO}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{ClO}^-_{(aq)}$	3.0×10^{-8}
Hydrocyanic (HCN)		CN^-	$\text{HCN}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{CN}^-_{(aq)}$	4.9×10^{-10}
Phenol (HC ₆ H ₅ O)		$\text{C}_6\text{H}_5\text{O}^-$	$\text{HC}_6\text{H}_5\text{O}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_3\text{O}^+_{(aq)} + \text{C}_6\text{H}_5\text{O}^-_{(aq)}$	1.3×10^{-10}

*The proton that ionizes is shown in blue.

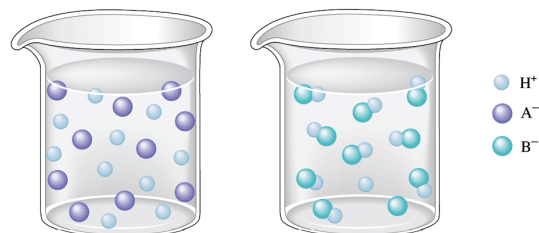
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Base	Lewis Structure	Conjugate Acid	Equilibrium Reaction	K_b
Ammonia (NH ₃)		NH ₄ ⁺	NH ₃ + H ₂ O ⇌ NH ₄ ⁺ + OH ⁻	1.8 × 10 ⁻⁵
Pyridine (C ₅ H ₅ N)		C ₅ H ₅ NH ⁺	C ₅ H ₅ N + H ₂ O ⇌ C ₅ H ₅ NH ⁺ + OH ⁻	1.7 × 10 ⁻⁹
Hydroxylamine (H ₂ NOH)		H ₃ NOH ⁺	H ₂ NOH + H ₂ O ⇌ H ₃ NOH ⁺ + OH ⁻	1.1 × 10 ⁻⁸
Methylamine (NH ₂ CH ₃)		NH ₃ CH ₃ ⁺	NH ₂ CH ₃ + H ₂ O ⇌ NH ₃ CH ₃ ⁺ + OH ⁻	4.4 × 10 ⁻⁴
Hydrosulfide ion (HS ⁻)		H ₂ S	HS ⁻ + H ₂ O ⇌ H ₂ S + OH ⁻	1.8 × 10 ⁻⁷
Carbonate ion (CO ₃ ²⁻)		HCO ₃ ⁻	CO ₃ ²⁻ + H ₂ O ⇌ HCO ₃ ⁻ + OH ⁻	1.8 × 10 ⁻⁴
Hypochlorite ion (ClO ⁻)		HClO	ClO ⁻ + H ₂ O ⇌ HClO + OH ⁻	3.3 × 10 ⁻⁷

IV. Comparing acid/base strength to conjugate acids/bases

A. Strong acids/bases have

B. Weak acids/bases have



	ACID	BASE	
100% ionized in H ₂ O	Strong	HCl	Cl ⁻
		H ₂ SO ₄	HSO ₄ ⁻
		HNO ₃	NO ₃ ⁻
	H ₃ O ⁺ (aq)	H ₂ O	Negligible
Acid strength increases ↑	Weak	HSO ₄ ⁻	SO ₄ ²⁻
		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⁻
Negligible	Strong	H ₂ O	OH ⁻
		OH ⁻	O ²⁻
		H ₂	H ⁻
	CH ₄	CH ₃ ⁻	100% protonated in H ₂ O

Acid	K_a	Base	K_b
HNO ₃	(Strong acid)	NO ₃ ⁻	(Negligible basicity)
HF	6.8 × 10 ⁻⁴	F ⁻	1.5 × 10 ⁻¹¹
HC ₂ H ₃ O ₂	1.8 × 10 ⁻⁵	C ₂ H ₃ O ₂ ⁻	5.6 × 10 ⁻¹⁰
H ₂ CO ₃	4.3 × 10 ⁻⁷	HCO ₃ ⁻	2.3 × 10 ⁻⁸
NH ₄ ⁺	5.6 × 10 ⁻¹⁰	NH ₃	1.8 × 10 ⁻⁵
HCO ₃ ⁻	5.6 × 10 ⁻¹¹	CO ₃ ²⁻	1.8 × 10 ⁻⁴
OH ⁻	(Negligible acidity)	O ²⁻	(Strong base)

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V. Measuring acid/base strength

A. Measured using

- 1.
- 2.
- 3.
- 4.
5. Sig. figs with logs.
 - a. When taking the antilog of a quantity,
 - b. When taking the log of a quantity,



	[H ⁺] (M)	pH	pOH	[OH ⁻] (M)
	1 (1×10 ⁻⁰)	0.0	14.0	1×10 ⁻¹⁴
Gastric juice	1×10 ⁻¹	1.0	13.0	1×10 ⁻¹³
Lemon juice	1×10 ⁻²	2.0	12.0	1×10 ⁻¹²
Cola, vinegar	1×10 ⁻³	3.0	11.0	1×10 ⁻¹¹
Wine	1×10 ⁻⁴	4.0	10.0	1×10 ⁻¹⁰
Tomatoes	1×10 ⁻⁵	5.0	9.0	1×10 ⁻⁹
Banana	1×10 ⁻⁶	6.0	8.0	1×10 ⁻⁸
Black coffee	1×10 ⁻⁷	7.0	7.0	1×10 ⁻⁷
Rain	1×10 ⁻⁸	8.0	6.0	1×10 ⁻⁶
Saliva	1×10 ⁻⁹	9.0	5.0	1×10 ⁻⁵
Milk	1×10 ⁻¹⁰	10.0	4.0	1×10 ⁻⁴
Human blood, tears	1×10 ⁻¹¹	11.0	3.0	1×10 ⁻³
Egg white, seawater	1×10 ⁻¹²	12.0	2.0	1×10 ⁻²
Baking soda	1×10 ⁻¹³	13.0	1.0	1×10 ⁻¹
Borax	1×10 ⁻¹⁴	14.0	0.0	1 (1×10 ⁻⁰)
Milk of magnesia				
Lime water				
Household ammonia				
Household bleach				
NaOH, 0.1 M				

B. The _____ of water:

1. $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ or $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$
2. The equilibrium conc. of H⁺ and OH⁻ is _____ because _____
- 3.
- 4.
- 5.
6. Therefore,

VI. Calculating pH or pOH

A. To find the [H⁺] or [OH⁻]

1. for strong acids/bases,

- a. Ex:
- b.

c. What is the pH of a solution prepared by dissolving 1.00g of barium hydroxide into 1 L of water?

2. For weak acids and bases,

- a. You will need
- b.
- c.
- d. Examples...

3. To calculate percent dissociation:

- a.
- b.

B. Always

C. A shortcut!!!

1. Many times, the value of x is _____ compared to the initial value.
2. If this is true, when sig figs are taken into account,
3. Thus, when solving for x using the constant expression, you can _____, making it easier to solve algebraically.
4. This assumption is good ONLY IF

5. If the quotient is greater than 5%, use solver.

VII. Polyprotic Acids:

A.

B. _____ acid and dissociation:

C. _____ acid and dissociation:

D. _____ acid and dissociation:

E.

F. Example: Calculate the pH and concentration of all species of a 3.0-M solution of phosphoric acid.

G.

1. Ex.

Acid-Base Prop's of Salts

I. Salts, when dissolved in water,

A. Salts of weak acids

- 1.
2. But there's
3. Don't worry about the sodium ion because
4. This is also happening:

5. Thus,

B. Salts of weak bases

- 1.
2. Don't worry about the chloride ion because

3. This is also happening:

4. Thus,

Calculating w/ Salts

I. First a bit about water again...

A.

B.

II. If

III. This is valid only for

IV. Example: What is the pH of a 0.140M solution of sodium acetate?

IV. Example: What is the pH of a 0.140M solution of diethyl amino chloride?

V. Predicting pH for a solution that has both acidic and basic properties.

A.

B.

C.

D. *Predict whether an aqueous solution of each of the following salts will be basic, acidic, or neutral*

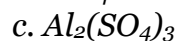
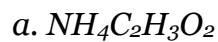


TABLE 14.6 Acid–Base Properties of Various Types of Salts

Type of Salt	Examples	Comment	pH of Solution
Cation is from strong base; anion is from strong acid	KCl, KNO ₃ , NaCl, NaNO ₃	Neither acts as an acid or a base	Neutral
Cation is from strong base; anion is from weak acid	NaC ₂ H ₃ O ₂ , KCN, NaF	Anion acts as a base; cation has no effect on pH	Basic
Cation is conjugate acid of weak base; anion is from strong acid	NH ₄ Cl, NH ₄ NO ₃	Cation acts as acid; anion has no effect on pH	Acidic
Cation is conjugate acid of weak base; anion is conjugate base of weak acid	NH ₄ C ₂ H ₃ O ₂ , NH ₄ CN	Cation acts as an acid; anion acts as a base	Acidic if $K_a > K_b$, basic if $K_b > K_a$, neutral if $K_a = K_b$
Cation is highly charged metal ion; anion is from strong acid	Al(NO ₃) ₃ , FeCl ₃	Hydrated cation acts as an acid; anion has no effect on pH	Acidic

Structure Effects on Acidity/Basicity

- I. Acid Halides ()
 - A. Acidity depends on
 - B. If bond strength is
 - C. If bond strength is
- II. Oxoacids
 - A. Oxygen is very
 - B. The more oxygen you have,
 - C. All things being equal,
 - D. Example: chlorines...

TABLE 14.7 Bond Strengths and Acid Strengths for Hydrogen Halides

H–X Bond	Bond Strength (kJ/mol)	Acid Strength in Water
H–F	565	Weak
H–Cl	427	Strong
H–Br	363	Strong
H–I	295	Strong

TABLE 14.8 Several Series of Oxyacids and Their K_a Values

Oxyacid	Structure	K_a Value
HClO ₄		Large (~10 ⁷)
HClO ₃		~1
HClO ₂		1.2 × 10 ⁻²
HClO		3.5 × 10 ⁻⁸
H ₂ SO ₄		Large
H ₂ SO ₃		1.5 × 10 ⁻²
HNO ₃		Large
HNO ₂		4.0 × 10 ⁻⁴

Rxn Prediction Review

- I. Soluble metal oxides + water -->
 - A.
- II. Nonmetal oxides + water -->
 - B.