

Unit Two: Acids and Bases

Section One: Theoretical Stuff

The concept of acids and bases has existed for centuries.

We can discuss them two ways, operational definitions and theoretical definitions.

1. Operational Definitions - these are based on experimental evidence:

ACIDS	BASES
pH<7	pH>7
turns blue litmus paper red	turns red litmus paper blue
neutralize bases	neutralize acids
sour	bitter
react with active metals	slippery
conduct electricity in solution	conduct electricity in solution
presence detected by indicators	presence detected by indicators

* An operational definition can classify an unknown species as an acid or a base but it cannot help you derive the formula.

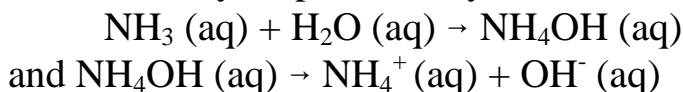
2. Theoretical Definitions

Historically, operational definitions evolved into theoretical definitions in attempt to explain the noted behaviours of acids and bases.

A) Arrhenius's Theory

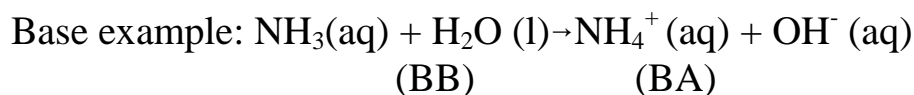
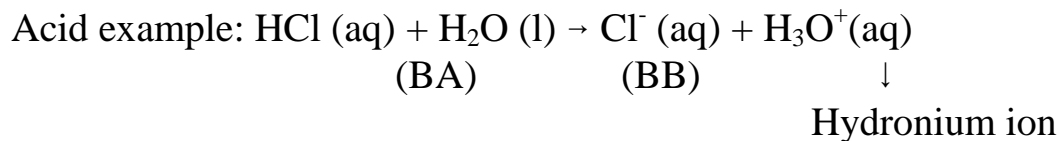
- ▶ acids release H^+ in solution
Ex. $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
- ▶ bases release OH^- in solution
Ex. $NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

Arrhenius's theory explained the behaviours of most acids and bases, however there are limitations. For example, $NH_3(aq)$ would be classified as an Arrhenius acid, yet operationally it is a base.



B) Brønsted-Lowry Theory

- ▶ acids are proton donors
 - ▶ bases are proton acceptors
- (OF COURSE THE PROTON IS THE HYDROGEN ION, H^+)



Compare the two:



* If there is a Brønsted-Lowry base there must be a Brønsted-Lowry acid in the system and vice versa.

C) Modern Arrhenius

Attempts have been made to modify Arrhenius's theory to make up for its limitations. The updated version includes:

An acid is any substance that dissociates to form H_3O^+ in aqueous solution

A base is any substance that dissociates to form OH^- in aqueous solution

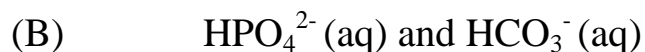
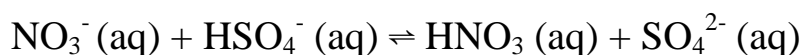
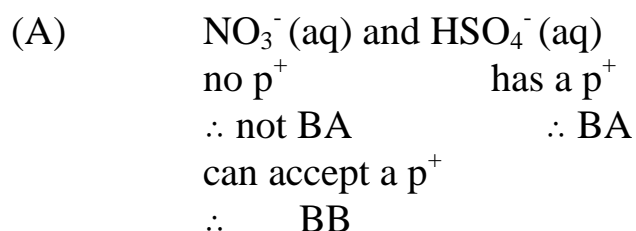
To summarize all three, copy the chart on page 558 of your text into the space below:

Theory	Arrhenius	Modern Arrhenius	Brønsted - Lowry

WRITING BRØNSTED-LOWRY ACID-BASE SYSTEMS

- ▶ When two chemical species react, an acid-base system may or may not exist, combustion, for example, is **NOT** an acid/base system
- ▶ You must determine whether the species can behave as an acid or a base
- ▶ If both species have the ability to be an acid or a base use the **acid-base table** to determine the pecking order

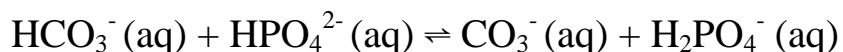
Example: Determine the BL acid-base system when the following species react:



Both have a proton to donate, so how do you know which one will be the acid and which one the base?

Use your acid-base strength table! Whichever one is higher up on the list is the stronger acid.

In this case, HCO_3^- is higher up so it will act as BL acid and the HPO_4^{2-} will be the BL base.



TIPS:

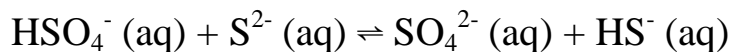
- ▶ charges on both sides must balance
- ▶ use the acid-base table to determine the conjugate base form of the acid
- ▶ always use the equilibrium arrows unless a strong acid/base is present (there are several strong acids but the only strong base is OH^-)
- ▶ be aware of organic acids, like CH_3COOH - is an acid because it can donate a proton
- ▶ use your polyatomic ion table to help you determine the charges

EXAMPLES:

1) HSO_4^- (aq) and S^{2-} (aq)

HSO_4^- Could give a proton or could accept a proton

S^{2-} could only accept \therefore must be the base and the HSO_4^- is the acid in this system.



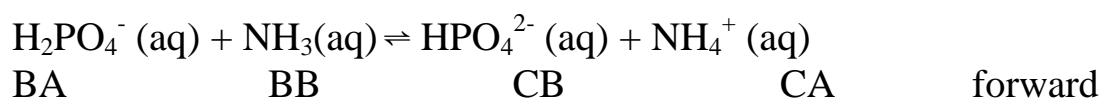
2) CH_4 (g) and O_2 (g)

Cannot donate protons, so there is no acid-base system.

CONJUGATE ACID-BASE PAIRS (CABP)

- A Brønsted-Lowry conjugate acid-base pair is the form of a Brønsted-Lowry acid on the product side of an equilibrium and vice versa.
- They can only be found in equilibrium systems
- There will be two pairs in a system: BA - CA, and BB-CA

example: NH_3 and H_2PO_4^-



CABP are H_2PO_4^- , HPO_4^{2-} and NH_3 , NH_4^+

