

Acid – Base Reactions

Reading: Ch 4 section 8 Homework: Chapter 4: 79, 81*, 83*, 108 (optional)

* = 'important' homework question

Background

Recall: Acids and bases are 'special' in two ways:

What is special about their formulas?

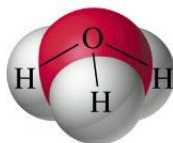
Acids:

Bases:

What is special about the state of matter they (typically acids) exist as in the:
(a) pure and (b) aqueous (dissolved) states?

Pure:

Dissolved (aq):



Task: Write formulas for the following common lab reagents:

Hydrochloric acid

Sodium hydroxide

Nitric acid

Calcium hydroxide

Sulfuric acid

Potassium hydroxide

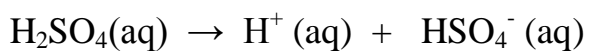
Assuming each of the above is of the same concentration, which acid and which base are the 'strongest'? Why?



**Monoprotic acids dissociate to give 1 H⁺(aq) ion per formula unit
e.g.: HCl, HNO₃**

**Diprotic acids dissociate to give 2 H⁺(aq) ions per formula unit
e.g. H₂SO₄**

Details: Polyprotic acids undergo *sequential dissociation* when dissolved in water. For Sulfuric acid:



(Combine the equations to obtain the overall reaction for the dissolution of Sulfuric acid)

Similarly....



**Monobasic alkalis dissociate to give 1 OH⁻(aq) ion per formula unit
e.g.: NaOH, KOH**

**Dibasic alkalis dissociate to give 2 OH⁻(aq) ions per formula unit
e.g. Ca(OH)₂**

Example: The dissociation of calcium hydroxide

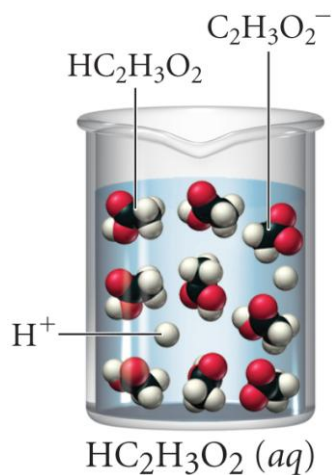
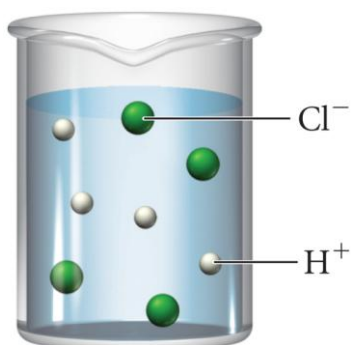
Strong and Weak Acids and Bases (recall previous packet)



Strong (mineral) acids undergo complete (~100%) dissociation, so give a high conc. of $H^+(aq)$ ions in solution. E.g. HCl , HNO_3

Weak (organic) acids undergo partial ($\ll 100\%$) dissociation, so give a low conc. of $H^+(aq)$ ions in solution E.g. $H(C_2H_3O_2)$

Discussion: A student measured the pH of equal volumes of 0.5 M HCl (hydrochloric acid) and 0.5M $HC_2H_3O_2$ (acetic acid). Which solution would you expect to have the lower pH (i.e. the highest conc. of $H^+(aq)$ in solution)? Hint: Recall analogous ICF tables for strong and weak electrolytes.



Strong (mineral) acids and bases give the best ‘bang for the buck’ (most $H^+(aq)$ or $OH^-(aq)$ ions respectively in solution per formula unit), so are used as lab reagents.

OK, what about weak bases then....

Case study: The weak base, aqueous ammonia (NH_3 (aq))

Background: You may have noticed in lab that aqueous ammonia is used as a 'gentle' base, (i.e. it is a weak base). How can this be? Can NH_3 (aq) dissociate to give OH^- (aq) ions??

Answer:

Explanation:

Equation:

Task: Write a ICF table for a solution of NH_3 (aq) that is '10% basic'

Eqn.	
I	
C	
F	

Neutralization Reactions

Recall: Acids and bases react with each other (often via a *titration*) in a 'special' double replacement reaction called a *neutralization reaction*.

Word Equation:

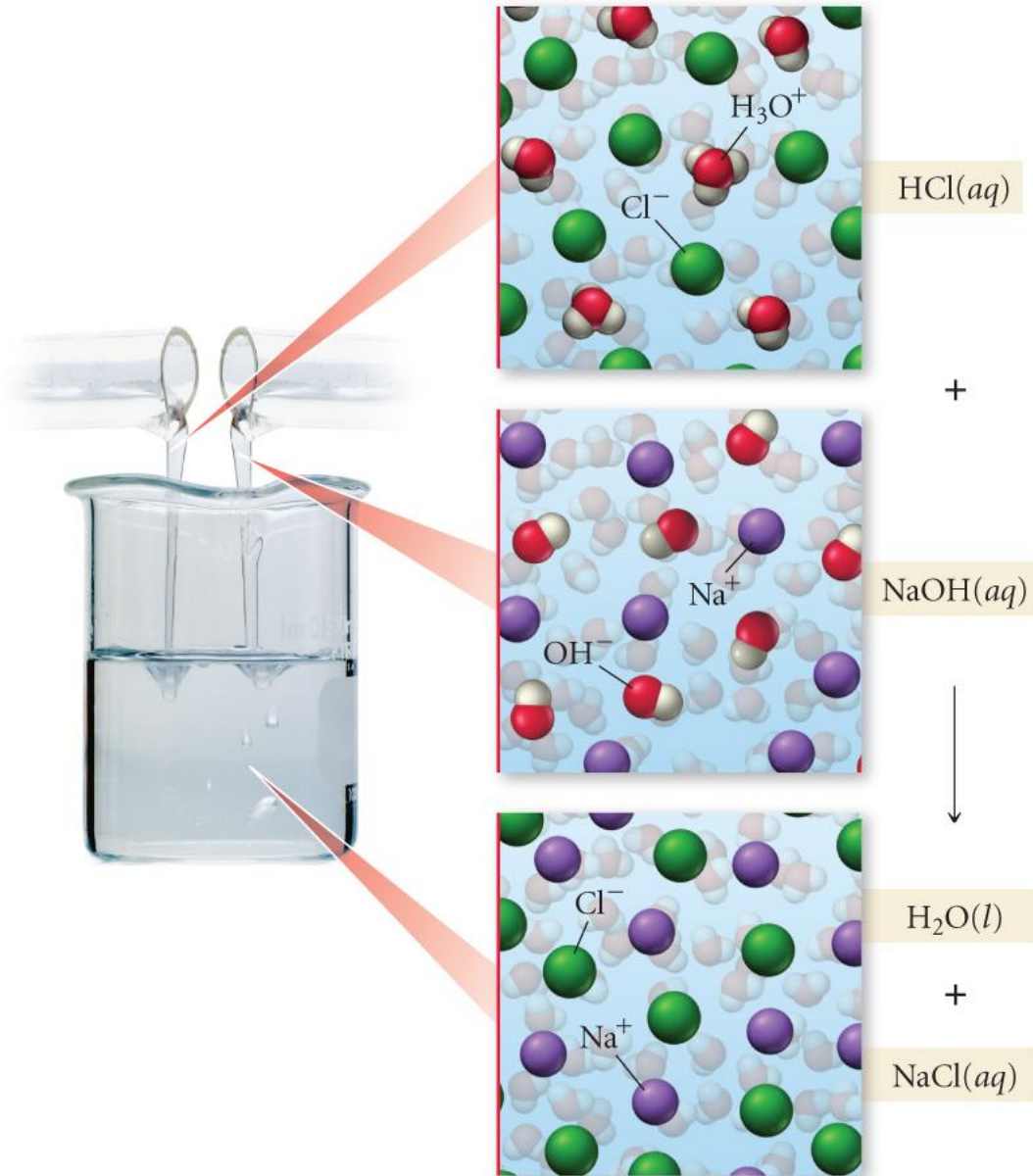
Generic Equation:

Task: Write *balanced*, *complete* and *net* ionic equations for the reaction of hydrochloric acid solution with sodium hydroxide solution.

Summary

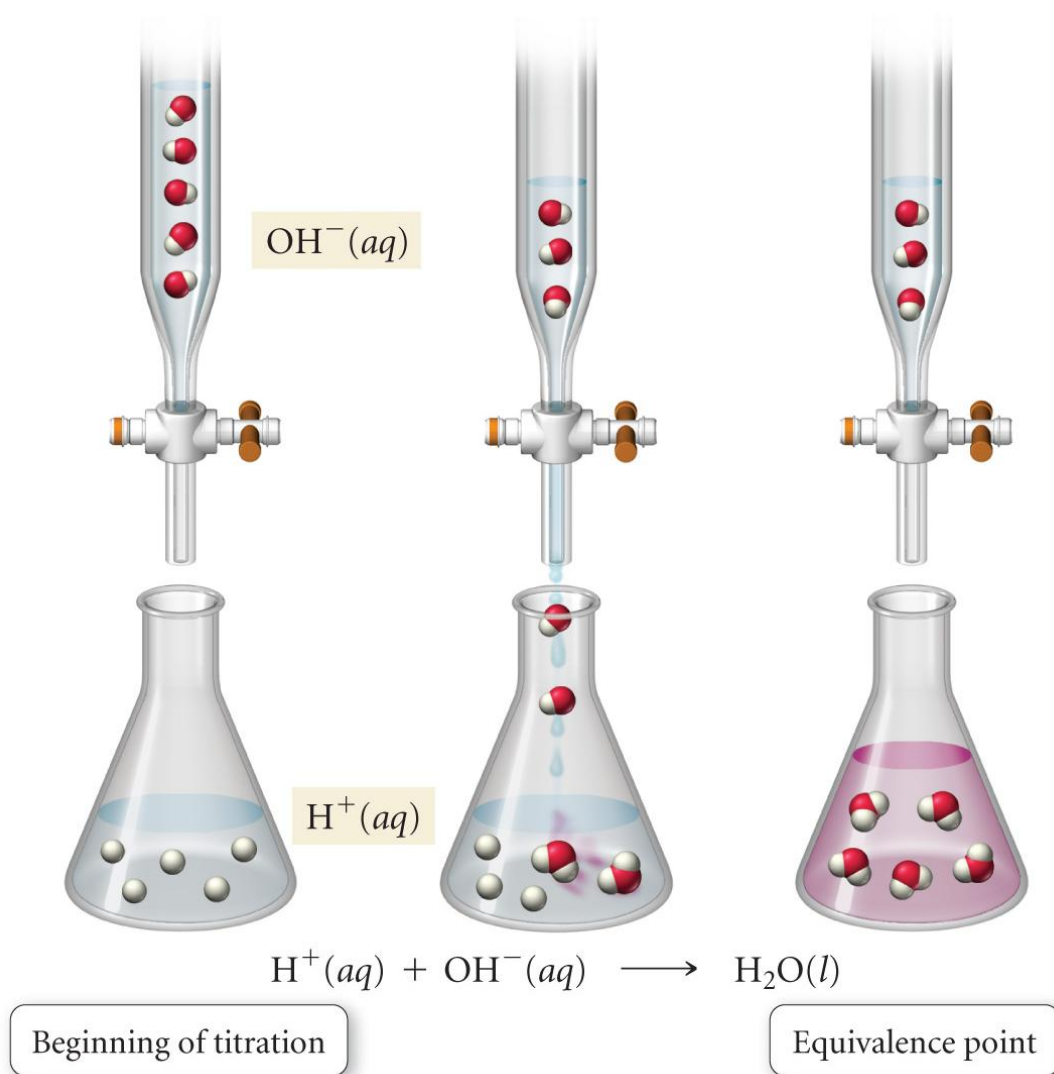


The reaction between hydrochloric acid and sodium hydroxide forms water and a salt, sodium chloride, which remains dissolved in the solution.



Review of Titrations

In practice, an *acid solⁿ* (eg. HCl) is placed in a flask, with a few drops of an *indicator*, and then *titrated* with a *base solⁿ* (eg. NaOH) via a buret:



The equivalence point of any acid plus base titration (reaction) is reached when:

Moles acid (H^{+}) = Moles base (OH^{-})

i.e. when (for a pair of *mono* reagents):

$$C_{\text{acid}} V_{\text{acid}} = C_{\text{base}} V_{\text{base}}$$

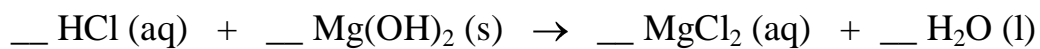


The *indicator* in an acid base titration *changes color* at the *equivalence point* – i.e. where the moles of acid (H^+) is equivalent to the moles base (OH^-) added – *this is when you stop the buret!!*



Titration is just a specific application of slides and ladders – the reactants are always an acid and a base (while the products are always a salt and water)

Example: What volume of 0.128 M HCl (aq) is needed to neutralize 2.87 g of $\text{Mg}(\text{OH})_2$? Careful! – the alkali is *dibasic*.



Acid plus Carbonate Reactions



An acid plus carbonate reactions always produce a salt, water and carbon dioxide gas. The word equation is:



Example question: Write an equation illustrating the reaction between solid calcium carbonate and hydrochloric acid solution*.

*See the 'Aqueous Reactions' notes for details on a slides and ladders exercise using this equation

Details: 'Acid plus carbonate' reactions are really a sequential double replacement / decomposition series:

Task: Balance and then combine the double replacement and decomposition reactions featured in the above example:

