8.1 EXPLAINING THE PROPERTIES OF ACIDS AND BASES

THE ARRHENIUS THEORY OF ACIDS AND BASES

- Arrhenius says that acid base reactions are combinations of $H^+_{(aq)}$ and $OH^-_{(aq)}$
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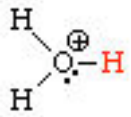
-eg. $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$ $\Delta H = -56$ kJ

T.I.E.

N.I.E.

- problems



THE BRONSTED - LOWRY THEORY

- more general than Arrhenius theory
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ACID:

BASE:

PROTON:

CONJUGATE ACID BASE PAIRS

Acetic acid dissociation in water is an equilibrium reaction

- The acid on the left and the base on the right differ by one proton – called **conjugate acid - base pair**

- the
- Bronsted-Lowry theory

-
-

- A substance that

e.g. Identify conjugate acid-base pairs in the following

$$H_3PO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + H_3O^+{}_{(aq)}$$

p.382 practice # 1-4

MOLECULAR STRUCTURE AND THE STRENGTH OF ACIDS AND BASES

2 reasons 1. electronegativity of atom bonded to H
2. Strength of bond

across period - electronegativity is major factor

down a group - bond strength is major factor

p.384 figure 8.6

monoprotic acids

polyprotic acids

$H_2SO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HSO4^-_{(aq)}$

$HSO4^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + SO4^{2-}_{(aq)}$

STRONG BASES

$O^{2-}_{(aq)} + H_2O_{(l)} \longrightarrow 2OH^-_{(aq)}$

CALCULATIONS THAT INVOLVE STRONG ACIDS AND BASES

e.g. 25.0 mL of 1.40 mol/L nitric acid is mixed with 15.0 mL of 2.00 mol/L sodium hydroxide. Is the resulting solution acidic or basic? What is the conc. of the ion that causes the solution to be acidic or basic?(have to find which ion is in excess and what its conc. is.)

p. 386 practice # 5-8

8.2 THE EQUILIBRIUM OF WEAK ACIDS AND BASES

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$$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

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- neutral water $[H_3O^+] = [OH^-] = 1.0 \times 10^{-7}$ mol/L at 25 ^oC

ION PRODUCT CONSTANT FOR WATER

Kc—> ion product constant for water.

$$Kc = \frac{[H_3O^+][OH^-]}{[H_2O]^2}$$

$Kc\,[H_2O]^2 = [H_3O^+][OH^-]$ -

=

=

=

- determined that a strong acid completely dissociates $\therefore [H_3O^+] = [HCl]$
- consider $[H_3O^+]$ in a solution of 0.1 mol/L HCl.
-
-

$$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

-

-

- can do the same with $[OH^-]$ using a strong base
  i.e. ignore the dissociation of water
- possible to use the ion product constant for water to determine the conc. of the other ion.
  1)

  2)

  3)

DETERMINING $[H_3O^+]$ and $[OH^-]$

e.g. find the $[H_3O^+]$ and $[OH^-]$ in each solution

a) 2.5 mol/L nitric acid

b) 0.16 mol/L barium hydroxide

- both are STRONG $\therefore$ molar conc. = $[H_3O^+]$ and $[OH^-]$

P. 390 practice # 9-12

pH and pOH -simple way to calculate acidity without using small numbers.

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pOH

e.g. A liquid shampoo has a hydroxide ion concentration of 6.8×10^{-5} mol/L at 25 ^{o}C

a) is the shampoo acidic, basic or neutral?

b) Calculate the hydronium ion concentration.

c) What is the pH and pOH of the shampoo?

a. Compare the $[OH^-]$ in water vs $[OH^-]$ in shampoo

b.

c.

Another way to calculate $[H_3O^+]$ and $[OH^-]$

-

e.g. Suppose that the pH of a urine sample was measured to be 5.54 at 25 ^{o}C. Calculate pOH, $[H_3O^+]$ and $[OH^-]$

a)

p.392 # 13-18

THE ACID DISSOCIATION CONSTANT

$$HA_{(aq)} + H_2O_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$$

$[H_2O]$ is constant in dilute solutions

eg. Reaction of a strong base and a weak acid

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

pH and Ka of a weak acid

p. 396 - table 8.2

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SOLVING EQUILIBRIUM PROBLEMS THAT INVOLVE ACIDS AND BASES

1. Write chemical equation. Set up ICE table - enter values given

2.

3. For problems that give initial conc. of acid [HA], compare that value with Ka

ie. a)

b)

PERCENT DISSOCIATION

eg. A student prepared a 0.10 mol/L solution of propanoic acid and found that the pH was 2.96. What is the acid dissociation constant? What % of its molecules were dissociated?

1. Write equation for dissociation. Set up ICE table

$CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2COO^-_{(aq)} + H_3O^+_{(aq)}$

I			
C			
E			

2. a) Write equation for acid dissociation constant.

b) Substitute equilibrium terms

3. Calculate $[H_3O^+]$ using $[H_3O^+] = 10^{-pH}$

4. Sub into expression for Ka

5. Calculate % dissociation

Calculating pH

Formic acid HCOOH is present in the sting of certain ants. What is the pH of a 0.025 mol/L solution of formic acid?

Given: [HCOOH] = 0.025 mol/L

The Ka of formic acid is 1.8×10^{-4}

1. Write ICE table based on dissociation of formic acid

$HCOOH_{(aq)} + H_2O_{(l)} \rightleftharpoons HCOO^-_{(aq)} + H_3O^+_{(aq)}$

I			
C			
E			

2. Write formula for Ka - sub in #'s

3. Check the value of $\frac{[HCOOH]}{Ka}$ to see if the amount that dissociates is negligible compared with the initial conc. of the acid.

Solve for x

p. 400 # 19 – 24

Polyprotic acids

eg. Phosphoric acid H_3PO_4 is used in fertilizers also giving cola its biting taste. Calculate the pH, $[H_2PO_4^-]$ and $[HPO_4^{2-}]$ of a 3.5 mol/L solution of phosphoric acid.

$Ka_1 = 7.0x10^{-3}$ $Ka_2 = 6.3x10^{-8}$

$H_3PO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + H_3O^+_{(aq)}$

I			
C			
E			

check

set up new ICE table of the next reaction

$H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_3O^+_{(aq)}$

I			
C			
E			

check

pH =

POLYPROTIC ACIDS AND [H_3O^+]

Sulfuric acid - only strong for 1st dissociation 2nd dissociation is weak

$H_2SO_{4(aq)} + H_2O \longrightarrow HSO_4^- + H_3O^+$ 100% dissociation

$HSO_{4(aq)}^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+$ $K_a = 1.0 \times 10^{-2}$

p. 402 # 25-28

8.3 BASES AND BUFFERS

- Caffeine is a weak base

$B_{(aq)} + H_2O_{(l)} \rightleftharpoons HB^+_{(aq)} + OH^-_{(aq)}$

the equilibrium expression

water is constant

(Kb = base dissociation constant)

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-
-

eg. Quinine - in tonic water is a weak base. Also used to treat malaria. Kb = 3.3×10^{-6}. Calculate the $[OH^-]$ and the pH of a 1.7×10^{-3} mol/L solution of quinine.

$Q + H_2O \rightleftharpoons HQ^+ + OH^-$

I			
C			
E			

Kb=

can we approximate?

CALCULATING Kb:

Pyridine (C_5H_5N) - used to manufacture vitamins

Calculate Kb for pyridine if a 0.125 mol/L solution has pH of 9.10.

$C_5H_5N_{(aq)} + H_2O_{(l)} \rightleftharpoons C_5H_5NH^+_{(aq)} + OH^-_{(aq)}$

I			
C			
E			

p.407 #29-34

ACIDS AND THEIR CONJUGATE BASES

Important relationship between Ka and Kb

i.e. Acetic acid and water

$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$

$$Ka = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

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$CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + OH^-_{(aq)}$

The salt acts as a base in water