Acids & Bases

MHR Chemistry 11, ch. 10

Acid or base?

Blue or pink? Acid or base?

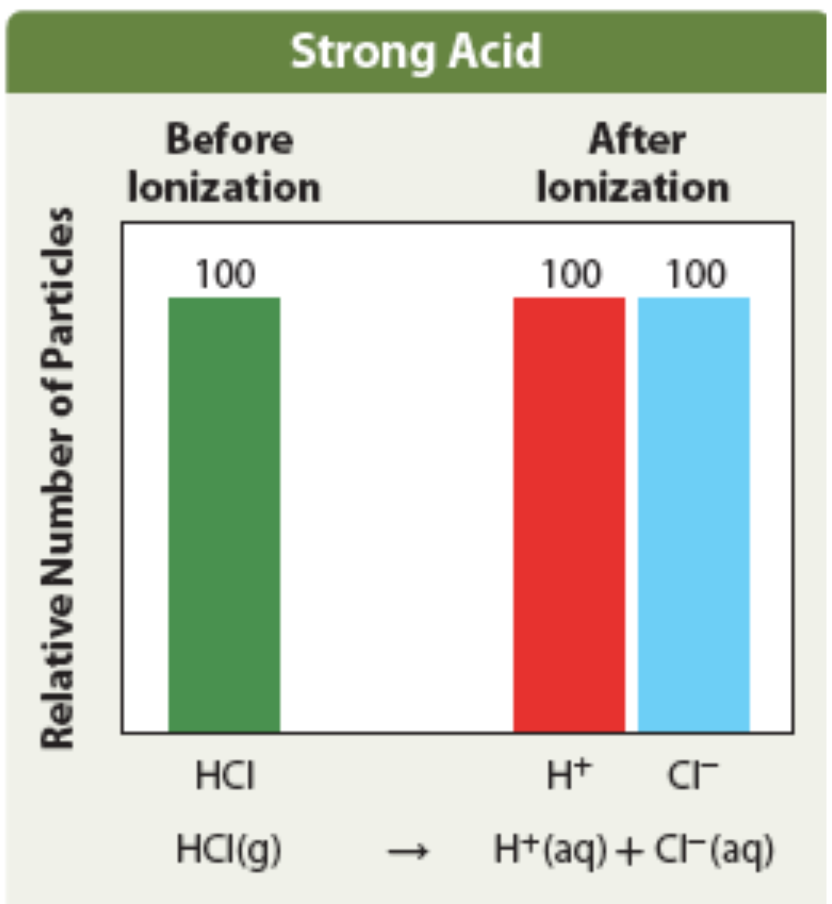
Hydrangeas are common flowering bushes found in many gardens. When grown in soils that are naturally acidic they produce blue flowers; if the soil is basic the flowers are pink. By altering the acidity or basicity of the soil, gardeners can change the colour of these flowers. This occurs because the flowers of hydrangeas contain a chemical that changes colour in acidic or basic conditions.

Make a chart like this:

Strong	**v.**	**Weak**
Concentrated	**v.**	**Diluted**

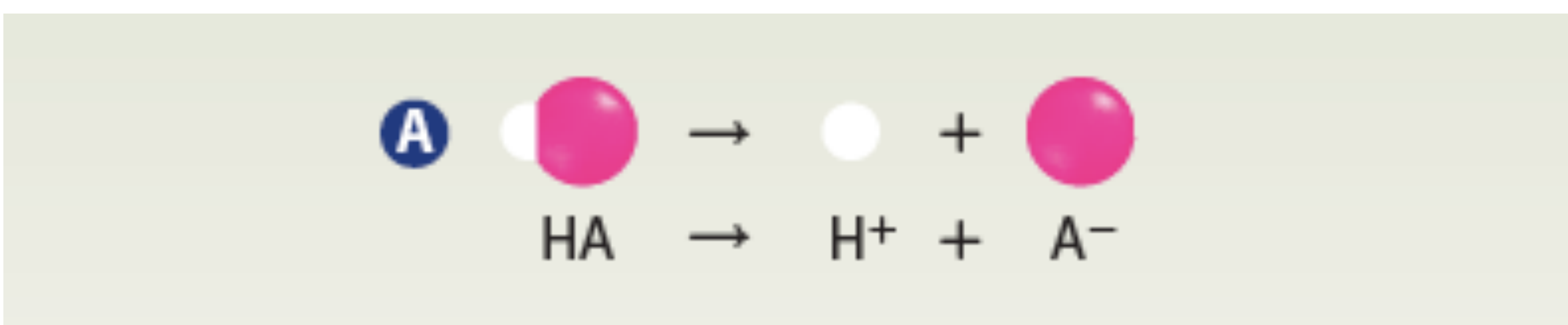
Acid Strength

- Acid strength depends on how much an acid dissociates.
- The more it dissociates (turns into H^+), the **stronger** it is
-



$HCl \longrightarrow$???

$HCl \longrightarrow H^+ + Cl^-$

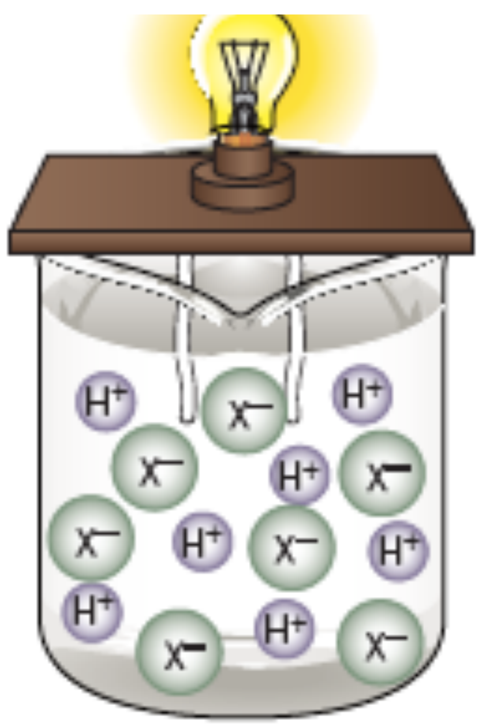


Acid Strength

Strong Acid - Completely ionized
- Strong electrolyte

Name	Formula
hydrochloric acid	$HCl(aq)$
hydrobromic acid	$HBr(aq)$
hydroiodic acid	$HI(aq)$
perchloric acid	$HClO_4(aq)$
nitric acid	$HNO_3(aq)$
sulfuric acid	$H_2SO_4(aq)$

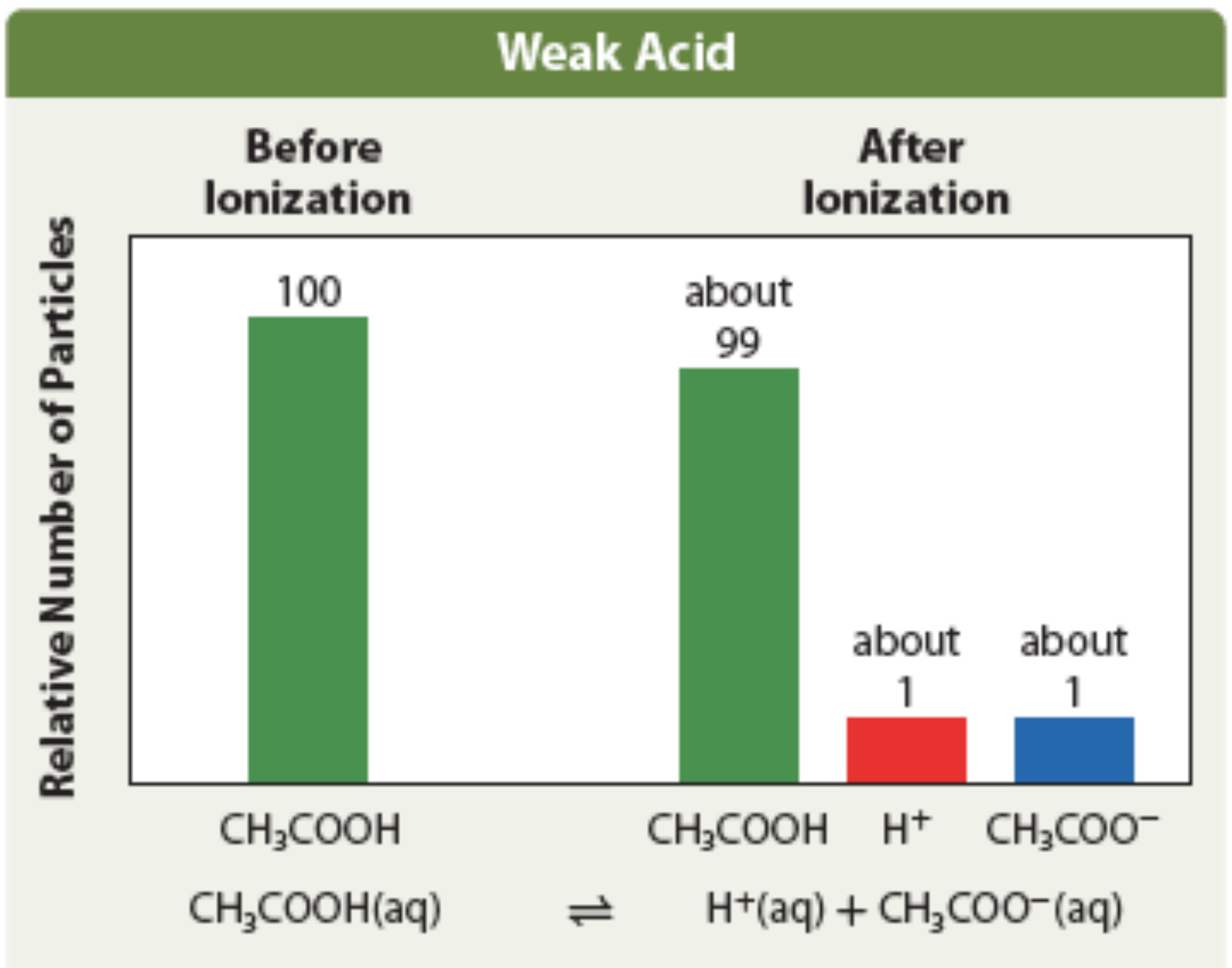
All of the acid is dissociated into ions!

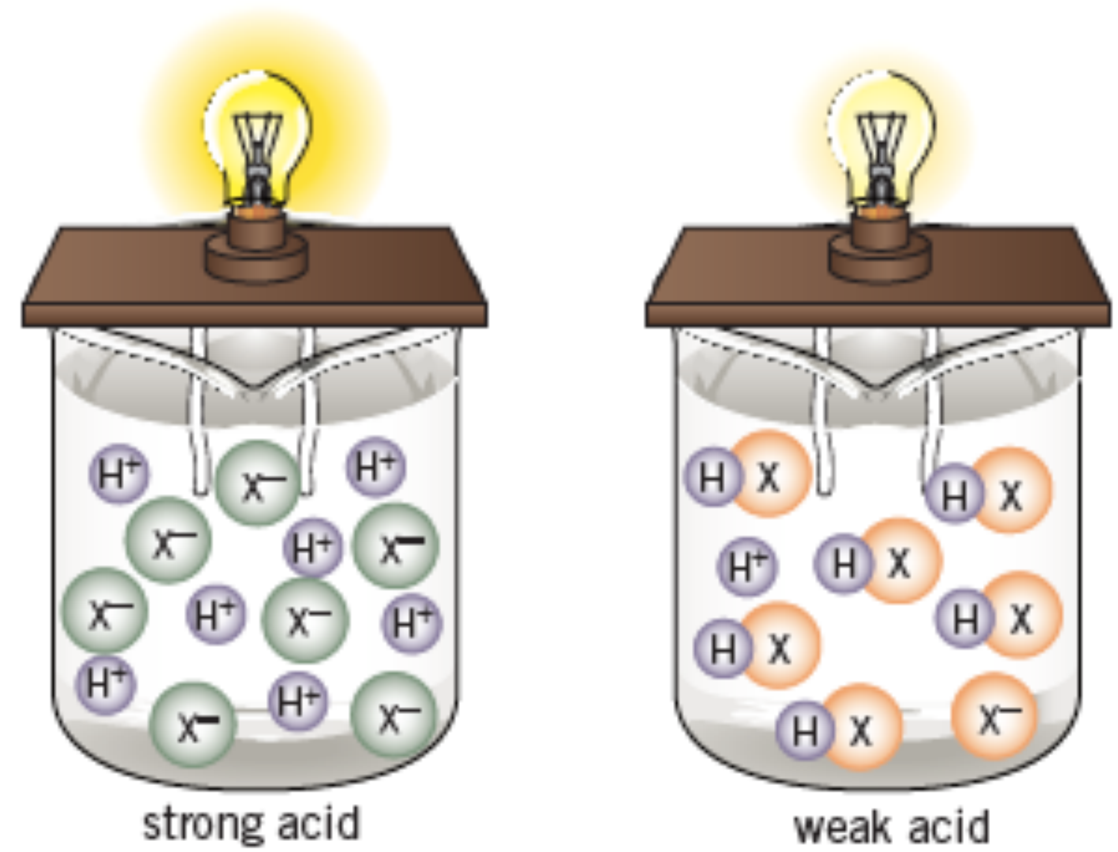


strong acid

Weak acids

- Transfers only a fraction of its protons to water; most of the acid remains entact
  - Partly ionized
  - Weak electrolyte



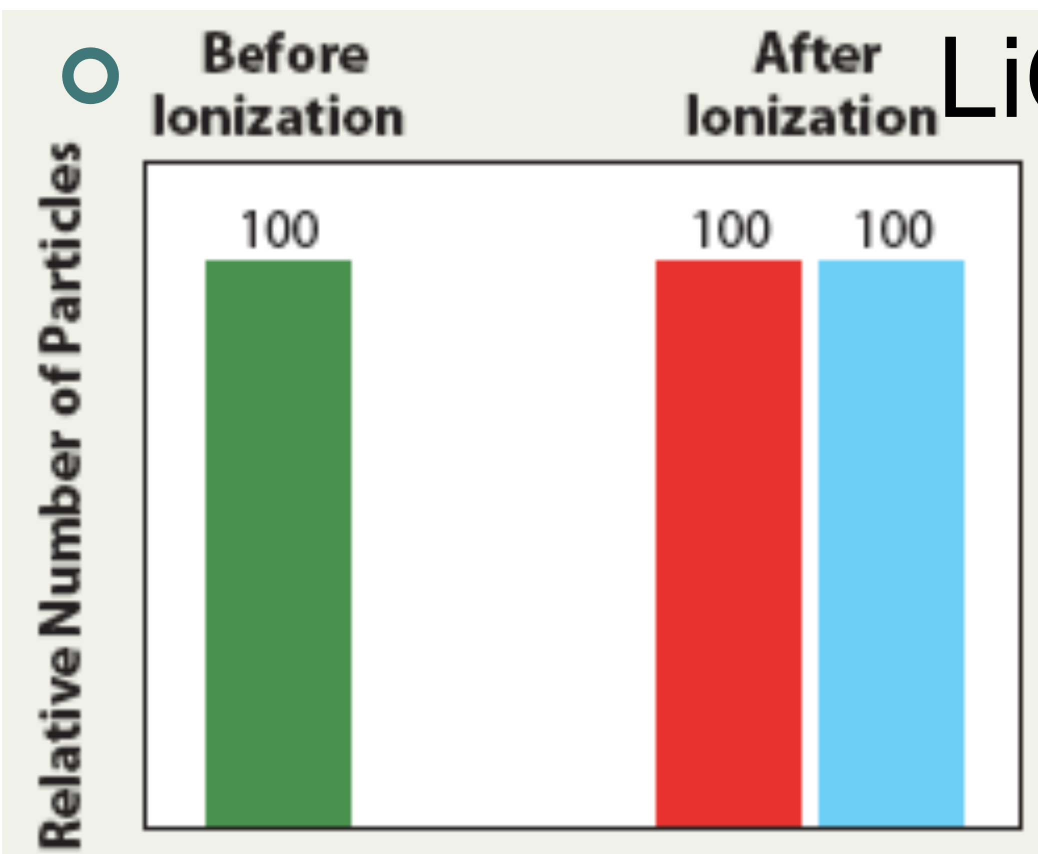


All of the acid is dissociated into ions!

Not much of the acid is dissociated into ions!

Base Strength

- Base strength depends on how much a base dissociates.
- The more it dissociates (turns into OH^-), the **stronger** it is
- $LiOH \rightarrow ???$
- $LiOH \rightarrow Li^+ + OH^-$



LiOH Li+ + OH-

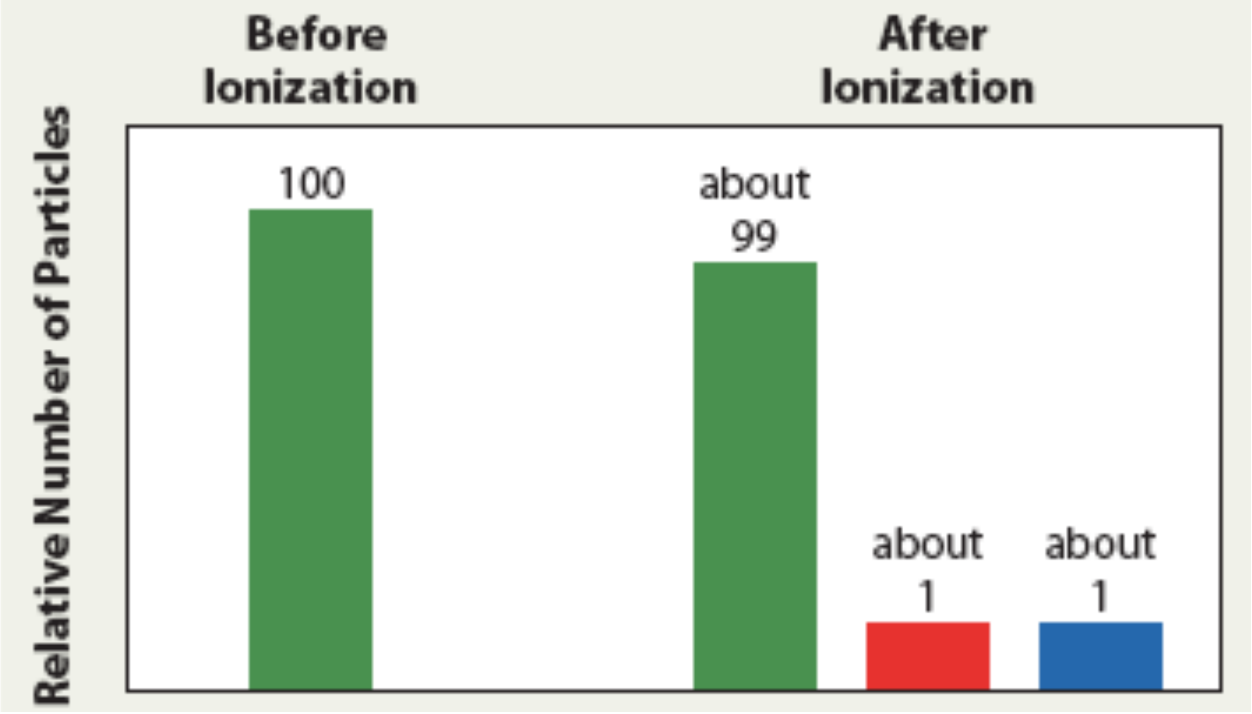
Name	Formula
lithium hydroxide	$LiOH(aq)$
sodium hydroxide	$NaOH(aq)$
potassium hydroxide	$KOH(aq)$
calcium hydroxide	$Ca(OH)_2(aq)$
barium hydroxide	$Ba(OH)_2(aq)$

Strong Base

- completely ionizes;
- strong electrolyte;

Base Strength

Weak Base - fraction of molecules accept proton;
- partly ionized;
- weak electrolyte;



Most common WEAK base:
Ammonia, NH_3

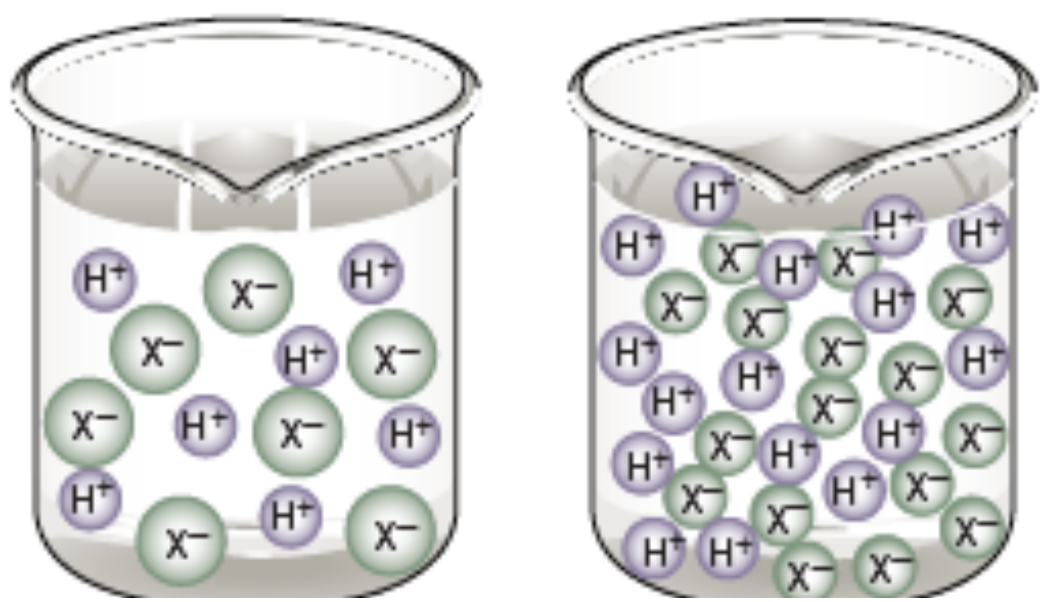
$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

CAUTION!

- Strong does NOT mean concentrated!
- Weak does NOT mean diluted!
- Imagine 2 beakers of HCl...
- Is HCl a strong or weak acid?

DILUTE STRONG ACID

ie) 0.01 mol/L HCl



CONCENTRATED STRONG ACID

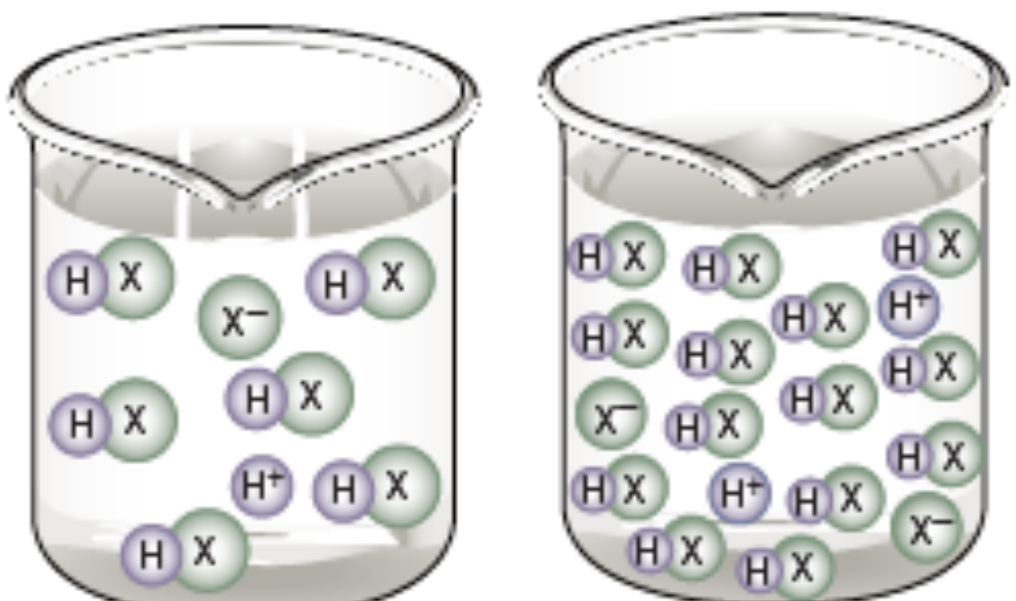
ie) 12 mol/L HCl

CAUTION!

- Strong does NOT mean concentrated!
- Weak does NOT mean diluted!
- Imagine 2 beakers of CH_3COOH...
- Is CH_3COOH a strong or weak acid?

DILUTE WEAK ACID

ie) 0.01 mol/L CH_3COOH



dilute solution of a weak acid

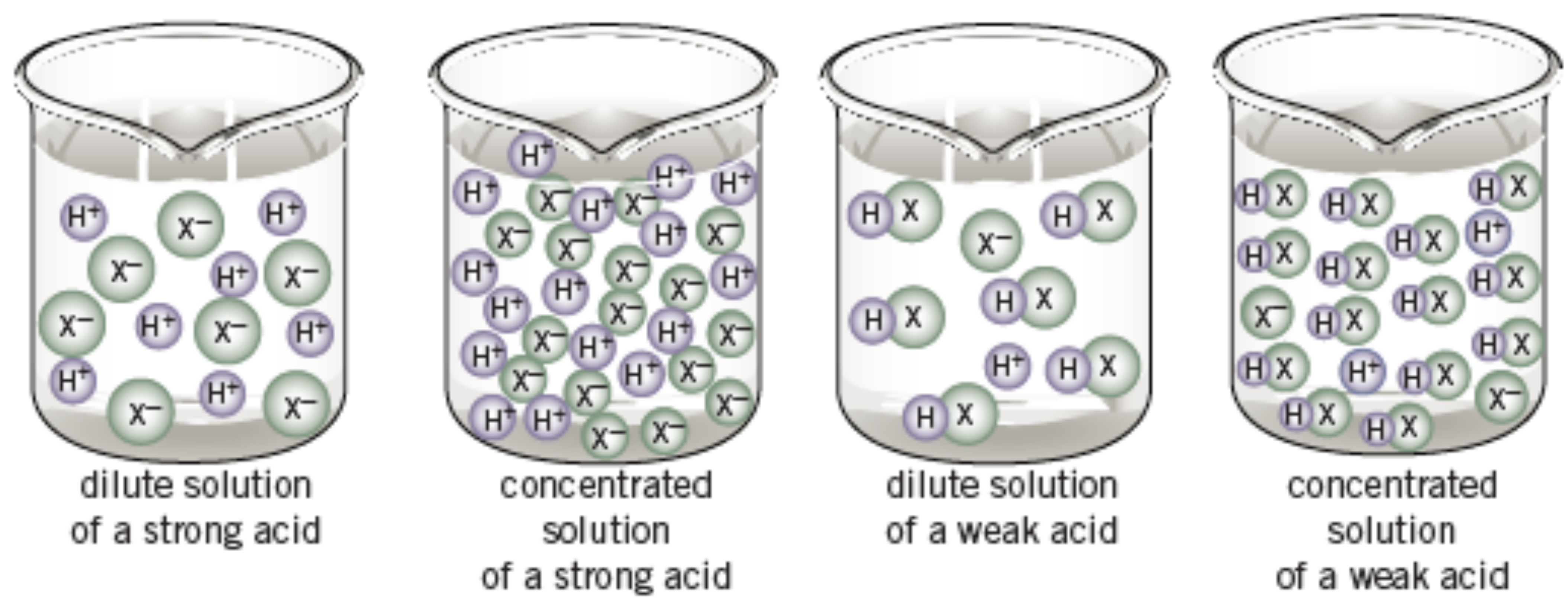
concentrated solution of a weak acid

CONCENTRATED WEAK ACID

ie) 12 mol/L CH_3COOH

Concentration vs. Strength

- Concentrations refers to how many moles are in a volume
- Strength refers to how much of the substance has ionized



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7. Summarize the difference between "strong" and "concentrated" when describing a solution of an acid. Give examples to illustrate this difference.

8. The terms "concentrated" and "dilute" can be used tc describe acids and bases.

  a. Give an example of a dilute solution of a strong base.

  b. Give an example of a concentrated solution of a weak acid.

Neutralization

An acid will neutralize a base, giving a salt and water as products

$$HCl(aq) + KOH(aq) \rightarrow HOH(\ell) + KCl(aq)$$

Examples

$$HCl + NaOH \rightarrow NaCl + H_2O$$

$$H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O$$

$$H_3PO_4 + 3\ KOH \rightarrow K_3PO_4 + 3\ H_2O$$

$$2\ HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2\ H_2O$$

Neutralization Calculations

- **Recall:** $n = v \times c$

Where:

n represents the number of moles in mol

v represents volume in L

c represents concentration in mol/L

Neutralization Problems

- **If an acid and a base combine in a 1 to 1 ratio, the moles of acid will equal the moles of base**
  - $n_{acid} = n_{base}$
- **Therefore the volume of the acid multiplied by the concentration of the acid is equal to the volume of the base multiplied by the concentration of the base**

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

If any three of the variables are known it is possible to determine the fourth

Neutralization Problems

Example 1: Hydrochloric acid reacts with potassium hydroxide according to the following reaction:

$$HCl + KOH \rightarrow KCl + H_2O$$

If 15.00 L of 0.500 M HCl exactly neutralizes 24.00 L of KOH solution, what is the concentration of the KOH solution?

Solution:

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

$$(15.00\ L)(0.500\ M) = (24.00\ L)\ C_{base}$$

$$C_{base} = \frac{(15.00\ L)(0.500\ M)}{(24.00\ L)}$$

$$C_{base} = 0.313\ M$$

Neutralization Problems

Whenever an acid and a base do not combine in a 1 to 1 ratio, a mole factor must be added to the neutralization equation

$$n \, V_{acid} \, C_{acid} = V_{base} \, C_{base}$$

The mole factor (n) is the number of times the moles the acid side of the above equation must be multiplied so as to equal the base side. (or vice versa)

Example

$$H_2SO_4 + 2\,NaOH \rightarrow Na_2SO_4 + 2\,H_2O$$

The mole factor is 2 and goes on the acid side of the equation. The number of moles of H_2SO_4 is one half that of NaOH. Therefore the moles of H_2SO_4 are multiplied by 2 to equal the moles of NaOH.

Neutralization Problems

Example 2: **Sulfuric acid reacts with sodium hydroxide according to the following reaction:**

$$H_2SO_4 + 2\,NaOH \rightarrow Na_2SO_4 + 2\,H_2O$$

If 20.00 L of 0.400 M H_2SO_4 exactly neutralizes 32.00 L of NaOH solution, what is the concentration of the NaOH solution?

Solution:

In this case the mole factor is 2 and it goes on the acid side, since the mole ratio of acid to base is 1 to 2. Therefore

$$2\,V_{acid}\,C_{acid} = V_{base}\,C_{base}$$

$$2\,(20.00\text{ L})(0.400\text{ M}) = (32.00\text{ L})\,C_{base}$$

$$C_{base} = \frac{(2)\,(20.00\text{ L})(0.400\text{ M})}{(32.00\text{ L})}$$

$$C_{base} = 0.500\text{ M}$$

Neutralization Problems

Example 3: **Phosphoric acid reacts with potassium hydroxide according to the following reaction:**

$$H_3PO_4 + 3\ KOH \rightarrow K_3PO_4 + 3\ H_2O$$

If 30.00 L of 0.300 M KOH exactly neutralizes 15.00 L of H_3PO_4 solution, what is the concentration of the H_3PO_4 solution?

Solution:

In this case the mole factor is 3 and it goes on the acid side, since the mole ratio of acid to base is 1 to 3. Therefore

$$3\ V_{acid}\ C_{acid} = V_{base}\ C_{base}$$

$$3\ (15.00\ L)(C_{acid}) = (30.00\ L)\ (0.300\ M)$$

$$C_{acid} = \frac{(30.00\ L)(0.300\ M)}{(3)\ (15.00\ L)}$$

$$C_{acid} = 0.200\ M$$

Neutralization Problems

Example 4: **Hydrochloric acid reacts with calcium hydroxide according to the following reaction:**

$$2\ HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2\ H_2O$$

If 25.00 L of 0.400 M HCl exactly neutralizes 20.00 L of $Ca(OH)_2$ solution, what is the concentration of the $Ca(OH)_2$ solution?

Solution:

In this case the mole factor is 2 and it goes on the base side, since the mole ratio of acid to base is 2 to 1. Therefore

$$V_{acid}\ C_{acid} = 2\ V_{base}\ C_{base}$$

$$(25.00L)\ (0.400) = (2)\ (20.00\ L)\ (C_{base})$$

$$C_{base} = \frac{(25.00\ L)\ (0.400\ M)}{(2)\ (20.00\ L)}$$

$$C_{base} = 0.250\ M$$

Try it !

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