

# **Properties of Aqueous Solutions**

## Definitions

**A solution is a homogeneous mixture of two or more substances.**

**The substance present in smaller amount is called the **solute**.**

**The substance present in larger amount is called the **solvent**.**

**For now we will discuss only **aqueous solutions**.**

# **Electrolytes vs Nonelectrolytes**

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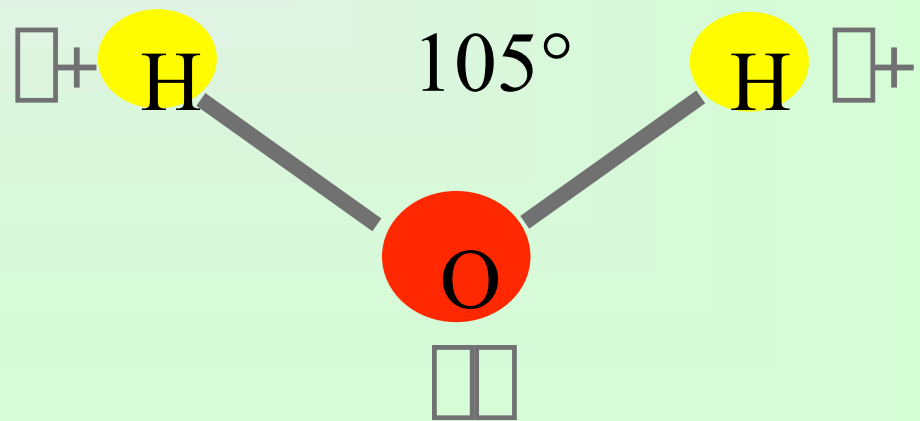
**An electrolyte is a substance that, when dissolved in water, gives a solution that can conduct electricity**

**A nonelectrolyte does not conduct electricity when dissolved in water.**

the most important property of water when dealing with aqueous solution is its **polarity**

Structure of water

O—H bonds are covalent but “polar”



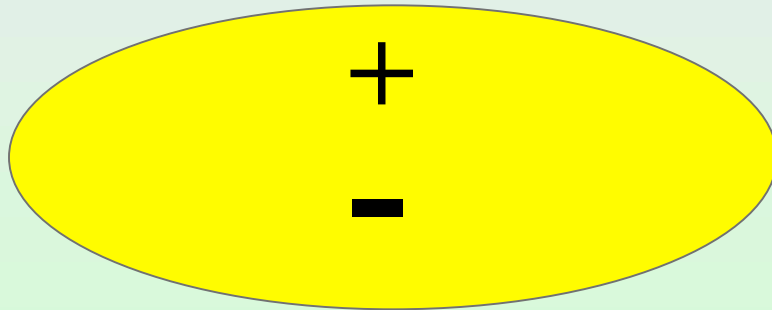
# Dipole Moments

# Dipole Moment

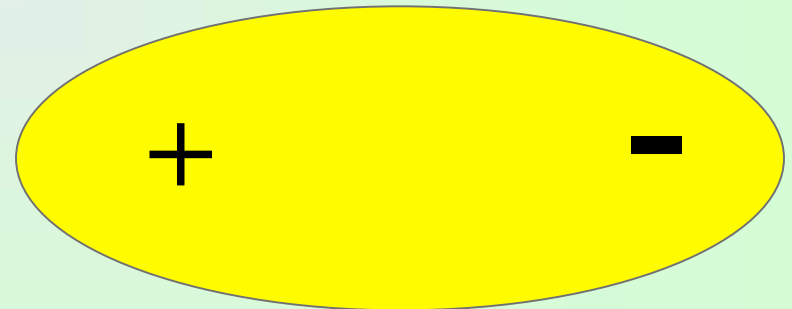
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**a substance possesses a dipole moment if its centers of positive and negative charge do not coincide**

$$\mu = e \times d \quad \text{Expressed in debye units}$$



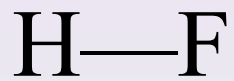
not polar



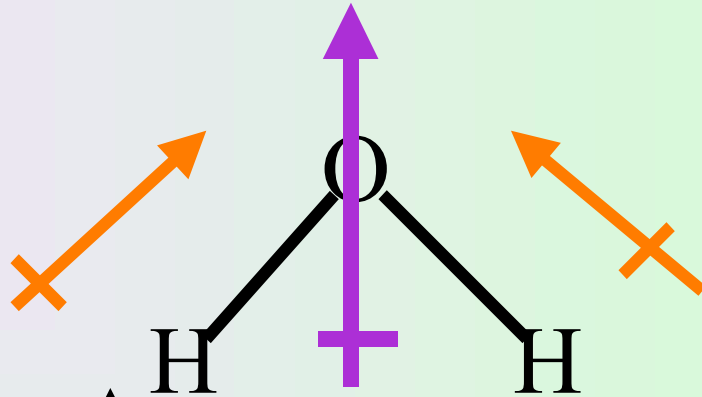
polar

# examples

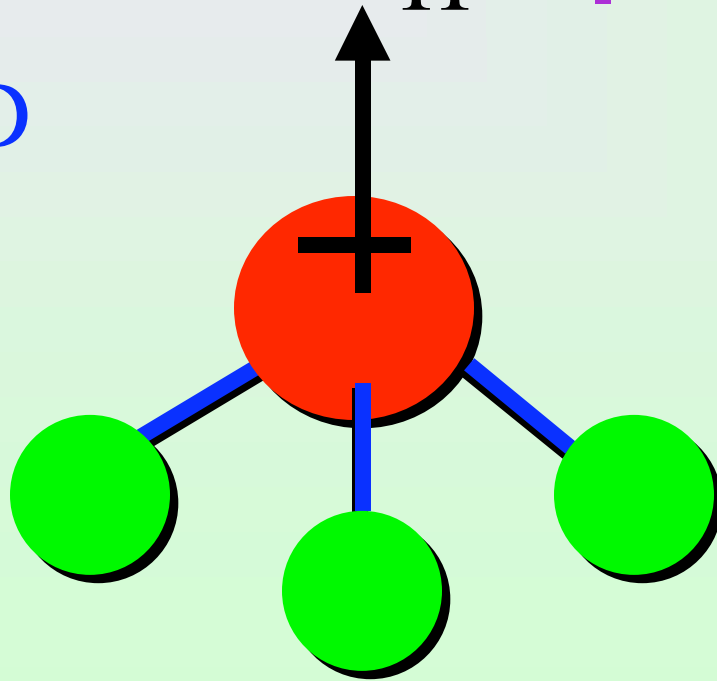
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$\square = 1.7 D$



$\square = 1.8 D$

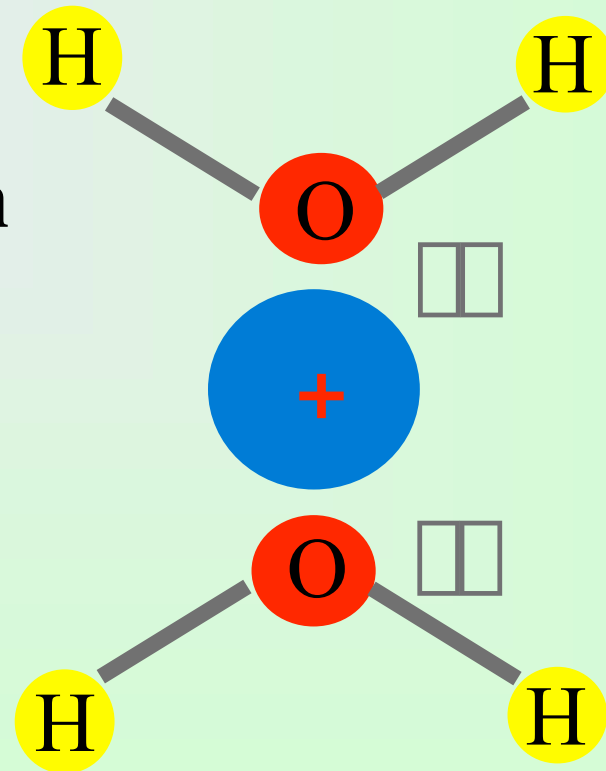


$\square = 1.5 D$

# Solvation

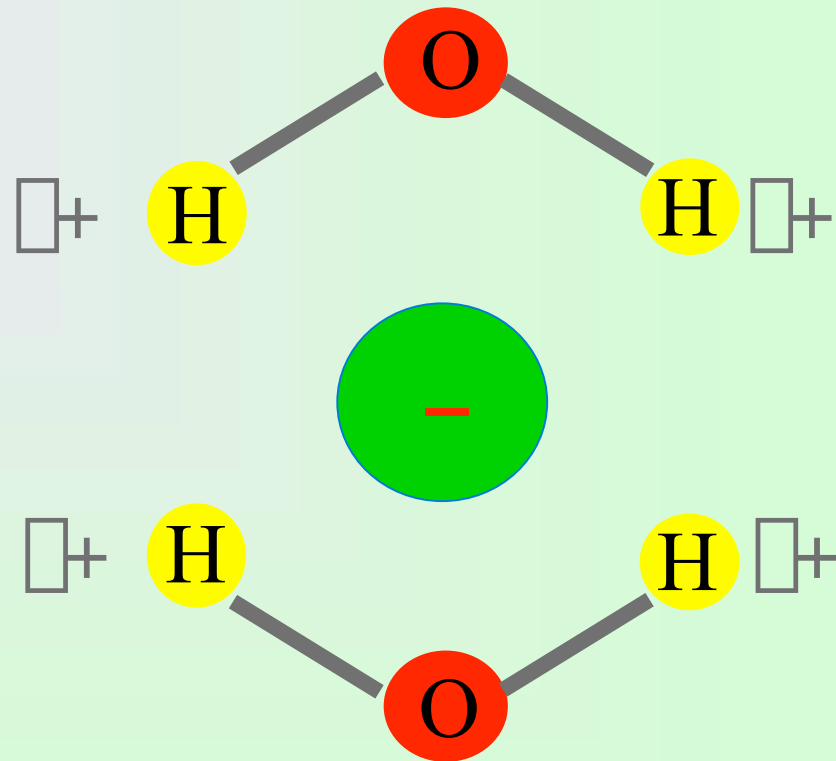
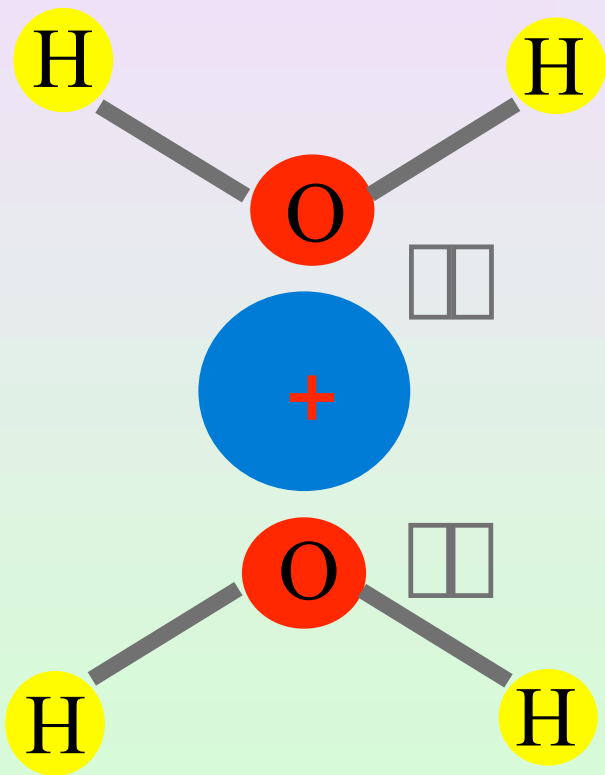
Clustering of molecules of solvent around solute:

**hydration** is specific term for solvation when water is solvent



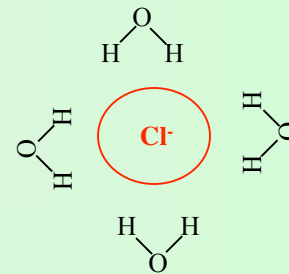
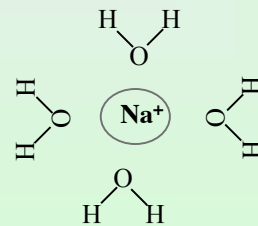
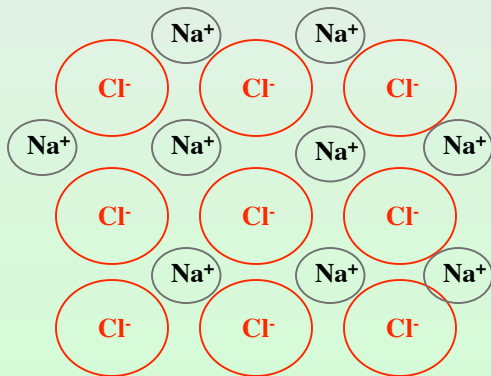
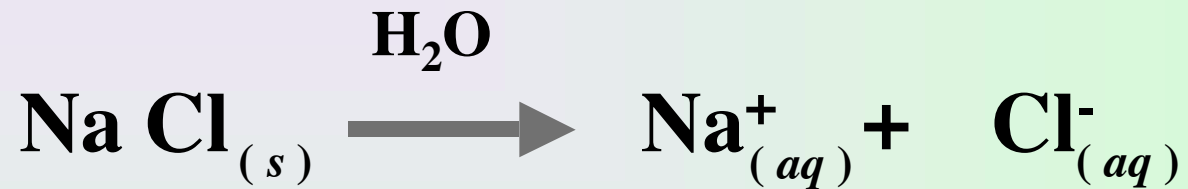
# Water can solvate both cations and anions

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# Dissociation

The breaking up of a compound into cations and anions



# Electrolytes vs Nonelectrolytes

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**Nonelectrolyte**

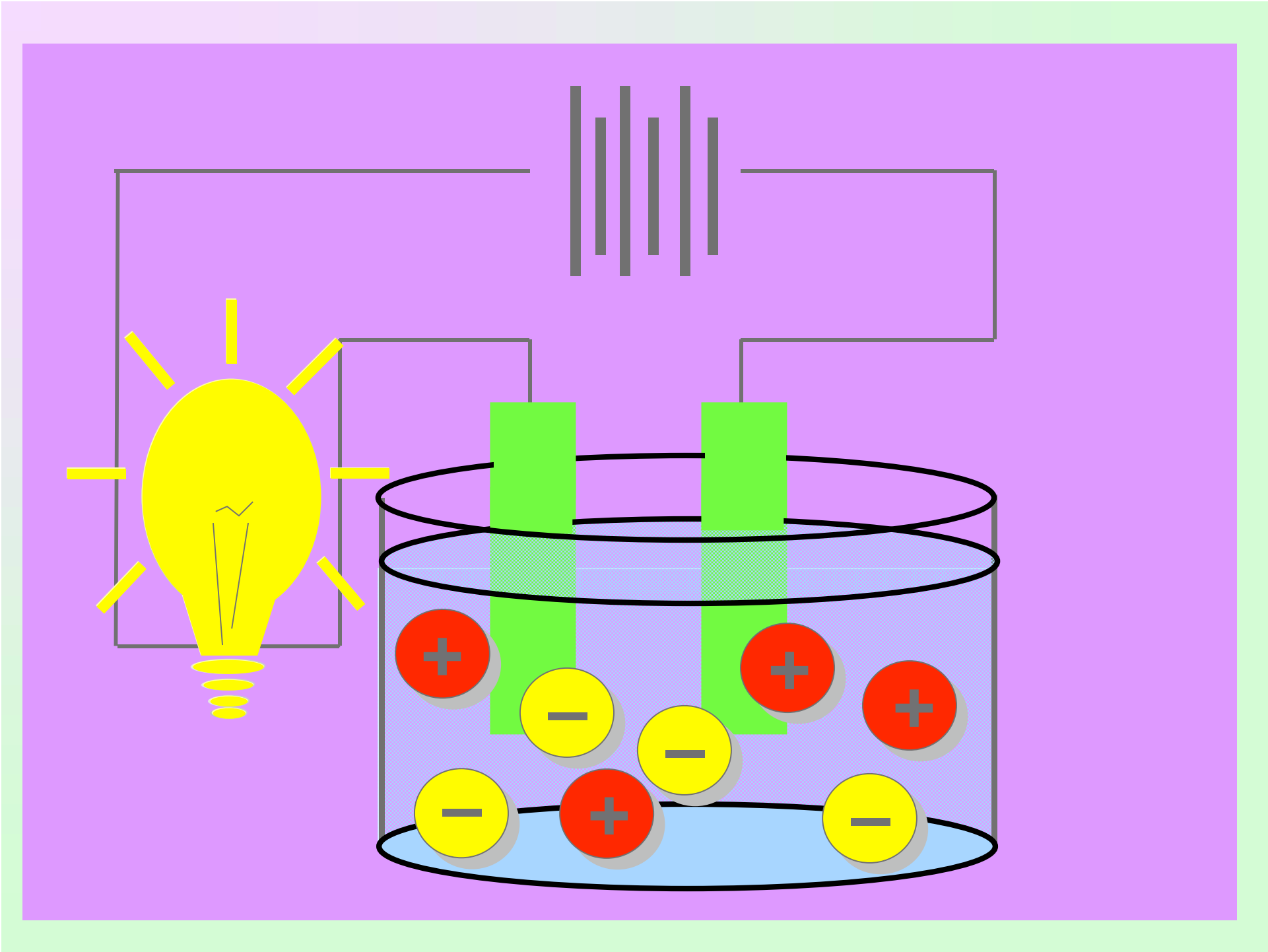
**not ionized in water**

**Weak electrolyte**

**incompletely ionized in water**

**Strong electrolyte**

**completely ionized in water**



# Solubility

**The amount of solute that can be dissolved in a given amount of a saturated solution at a fixed temperature is the **solubility** of the solute in the solvent.**

# Solubility

**Some compounds are very soluble : NaCl, KCl,  
NH<sub>4</sub>Cl**

**Some are slightly soluble : AgCl**

*slightly soluble and insoluble can be  
used interchangeably*

# Strong electrolytes

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Soluble Ionic compounds

Strong acids

Strong bases

# Arrhenius definitions of acids and bases

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An **acid** dissolves in water to yield protons



A **base** dissolves in water to yield hydroxide ions



# Examples of Strong acids

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**Hydrochloric acid: HCl(aq)**



**Nitric acid: HNO<sub>3</sub>(aq)**



**Sulfuric acid: H<sub>2</sub>SO<sub>4</sub>(aq)**



# Examples of Strong bases

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**Sodium hydroxide:**

**$\text{NaOH(aq)}$  is equivalent to  $\text{Na}^+ + \text{HO}^{\text{-}}(\text{aq})$**

**Likewise:  $\text{KOH}$ ,  $\text{Ba(OH)}_2$ , etc.**

# Weak electrolytes

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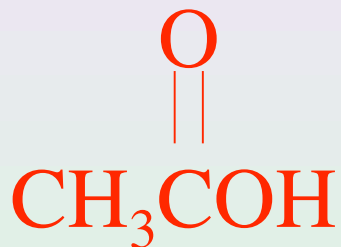
Weak acids

Weak bases

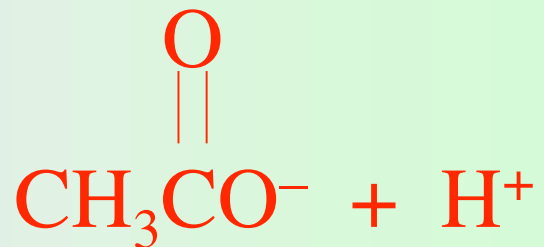
# A Weak Acid

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**Acetic acid:**



**>99%**



**<1%**

**Reversible reaction**

**the reaction can occur in both directions**

# A Weak Base

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**Ammonia:**



**>99%**

**<1%**

# Nonelectrolytes

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**produce no ions when dissolved in water**

**ethanol**

**ethylene glycol**

**sucrose**

# Concentration

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## Molarity ( M )

moles of solute /1L of solution

What is the molarity of a solution made up by dissolving 9.52g of NaCl in enough H<sub>2</sub>O to form 575 mL of solution?

$$M = n/L$$

$$9.52\text{g NaCl} \times \frac{1 \text{ mol}}{58.4\text{g NaCl}} \times \frac{1}{575 \text{ mL}} \times \frac{10^3 \text{ mL}}{1 \text{ L}} = 0.284 \text{ mol/L}$$

## Important point about concentration

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**Given:  $\text{Na}_2\text{SO}_4$  concentration = 0.683 M**

**What is the concentration of  $\text{Na}^+$**

**What is the concentration of  $\text{SO}_4^{2-}$  ?**

$$\text{Na}^+ = 2 \times 0.683 \text{ M} = 1.37 \text{ M}$$

$$\text{SO}_4^{2-} = 0.683 \text{ M}$$

# **Dilution of solutions**

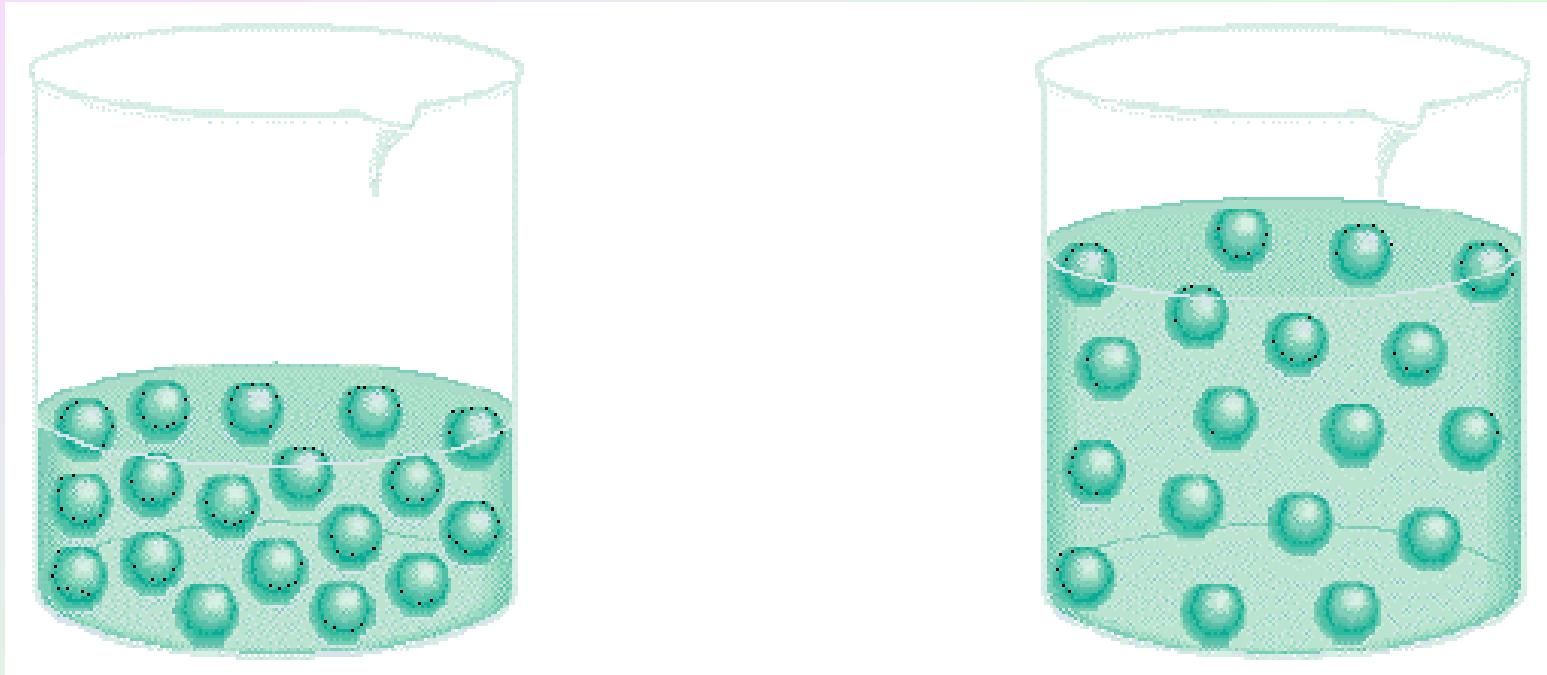
# Dilution of solutions

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**Preparation of a less concentrated solution from a more concentrated one**

$$M_{\text{initial}} \times V_{\text{initial}} = M_{\text{final}} \times V_{\text{final}}$$

$$\text{Moles of solute}_{\text{initial}} = \text{Moles of solute}_{\text{final}}$$



**The dilution of a more concentrated solution to a less concentrated one does not change the number of moles of solute**

## Dilution of solutions

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How much concentrated HCl ( 12.5 M HCl) is required in order to prepare 1 L of a 1 M solution?

$$M_{\text{initial}} \times V_{\text{initial}} = M_{\text{final}} \times V_{\text{final}}$$

$$( 12.5 \text{ mole / L} ) V_{\text{initial}} = ( 1 \text{ mol / L} )( 1 \text{ L} )$$

$$V_{\text{initial}} = 0.080 \text{ L} = 80 \text{ ml}$$