

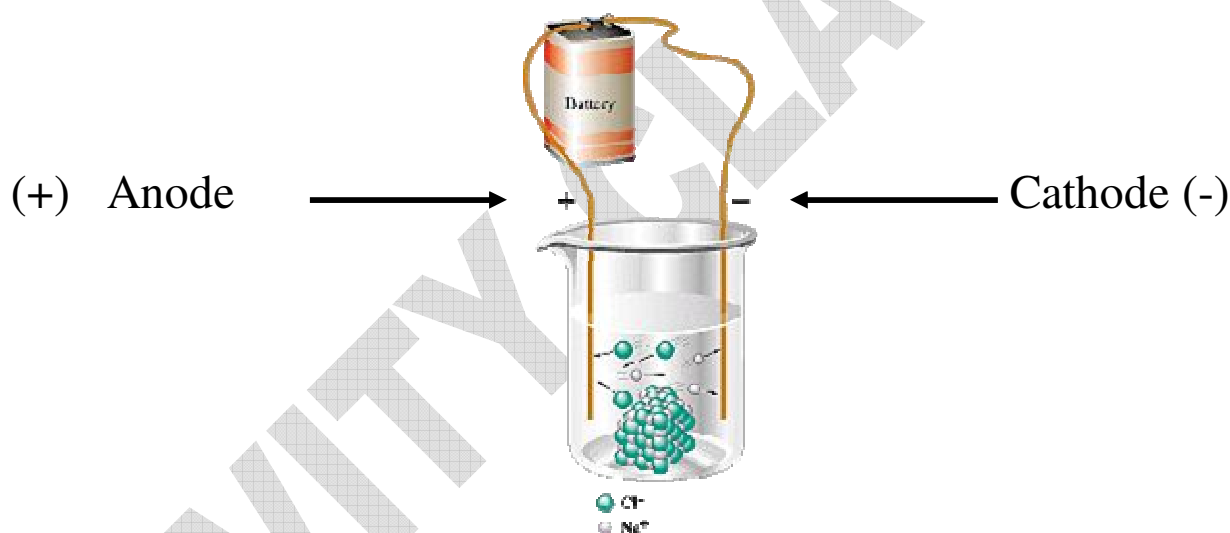
IONS IN AQUEOUS SOLUTION

Ionic Theory of Solut ions:

- Proposed by Svante Arrhenius (1884)
- Certain substances produce freely moving ions (mobile ions) when they dissolve in water; the mobile ions conduct an electric current

Substances which are able to conduct electricity by ionic movement are called ELECTROLYTES

- For example: An aqueous solution of NaCl is a good conductor of electricity





According to Arrhenius:

- Substances, which are able to conduct electricity by ionic movement, are called ELECTROLYTES
- Substances, which are not able to conduct electricity by ionic movement, are called NON-ELECTROLYTES

A particular substance must meet two conditions in order to be an electrolyte:

- The substance:
1. must contain ions,
 2. the ions must be mobile (free to move)

IONIC SUBSTANCES

PURE FORM		DISSOLVED IN WATER (AQUEOUS SOLUTION)
SOLID	MOLTEN	
$\text{Na}^+\text{Cl}^-(\text{s})$	$\text{Na}^+\text{Cl}^-(\text{s}) \xrightarrow[\text{dissociation}]{\text{melting}} \text{Na}^+(\text{l}) + \text{Cl}^-(\text{l})$	$\text{Na}^+\text{Cl}^-(\text{s}) \xrightarrow[\text{dissociation}]{\text{H}_2\text{O}} \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
<p>Ions are present, but they are not free to move</p>	<p>DISSOCIATION Process by which the ions of an ionic substance are separated and made mobile (free to move), by melting or dissolving in water</p>	
 <p>Bulb is off</p>	 <p>Bulb glows brightly</p>	
NO CONDUCTANCE	STRONG CONDUCTANCE	
NON ELECTROLYTE	STRONG ELECTROLYTE	

NOTE:

1. All soluble ionic compounds dissolved in water are **STRONG ELECTROLYTES**
2. The process by which a substance separates into ions (by melting or by dissolving in water) is referred to, as **DISSOCIATION**.
3. **SOLUBLE IONIC SUBSTANCES ARE COMPLETELY DISSOCIATED IN AQUEOUS SOLUTION** (all ions are separated and free to move).

EXAM PLES:

NOTE: **1** mole of **NaOH** produces by dissociation: 2 moles of ions: - **1** mole of **Na⁺** ions, and
- **1** moles of **OH⁻** ions






NOTE: **1** mole of **MgCl₂** produces by dissociation: 3 moles of ions:- **1** mole of **Mg²⁺** ions, and
- **2** moles of **Cl⁻** ions



NOTE: **1** mole of **Na₂SO₄** produces by dissociation: 3 moles of ions: - **2** moles of **Na⁺** ions, and
- **1** mole of **SO₄²⁻** ions

4. **PARTLY SOLUBLE IONIC SUBSTANCES ARE PARTIALLY DISSOCIATED IN AQUEOUS SOLUTION** (some, but not all, ions are separated and free to move)

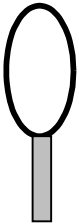
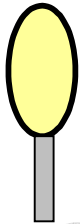

PURE MOLECULAR SUBSTANCES

SOLID STATE	LIQUID STATE	GASEOUS STATE
Solid Sucrose	Liquid Water	Gaseous Hydrogen Chloride
$C_{12}H_{22}O_{11}(s)$	$H_2O(l)$	$HCl(g)$
molecules only present	molecules only present	molecules only present
		
Bulb is off	Bulb is off	Bulb is off
NO CONDUCTANCE	NO CONDUCTANCE	NO CONDUCTANCE
NONELECTROLYTE	NONELECTROLYTE	NONELECTROLYTE

CONCLUSION:

- **Molecular Substances in pure form** are **NONELECTROLYTES**, since they contain **molecules only** (no ions)

MOLECULAR SUBSTANCES IN AQUEOUS SOLUTION

Sucrose dissolved in water	Acetic acid dissolved in water	Hydrogen chloride dissolved in water
 <p>Bulb is off</p>	 <p>Bulb glows dimly</p>	 <p>Bulb glows brightly</p>
No mobile ions present (mo lecu les o n ly p resent)	A few mobile ions present (mo stly mo lecu les)	On ly mo b ile i o n s present (no molecules)
Molecules separate $C_{12}H_{22}O_{11}(s) \rightarrow C_{12}H_{22}O_{11}(aq)$	Molecules separate into ions: $HC_2H_3O_2(aq) \rightarrow H^+(aq) + C_2H_3O_2^-(aq)$ at the same time: Ions combine and form molecules: $H^+(aq) + C_2H_3O_2^-(aq) \rightarrow HC_2H_3O_2(aq)$	Molecules separate into ions $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
No Ionization	Partial Ionization	Complete Ionization
No Conductance	Weak Conductance	Strong Conductance
NONELECTROLYTE	WEAK ELECTROLYTE LECTROLYTE	STRONG E

CONCLUSIONS :

1. Some molecular substances do not interact with water when they dissolve in it, and as such, they do not form ions.

They exist in aqueous solution as **MOLECULES ONLY** and are **NONELECTROLYTES (NE)**.

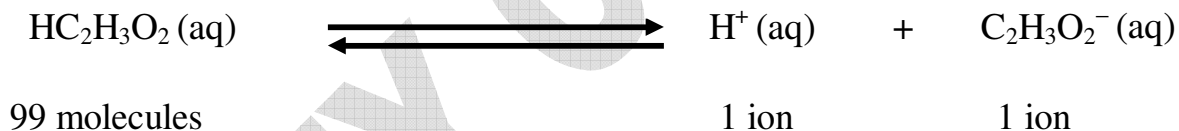
Example: Sucrose

2. Some molecular substances interact with water and their molecules form ions.

This is referred to as **IONIZATION**. Ionization can be of two types:

(A) PARTIAL IONIZATION

- Some molecular substances interact only partially with water and a very few of their molecules change into ions.
- In partial ionization, two processes take place at the same time, and a dynamic equilibrium is established.



- The predominant species in solution are molecules.
- The weak conductance is due to the very few ions present (one out of every hundred molecules ionizes)
- These substances exist in aqueous solution **MOSTLY AS MOLECULES** (a very few ions) and are called **WEAK ELECTROLYTES (WE)**

Example:

An aqueous solution of ammonia:



Mostly molecules

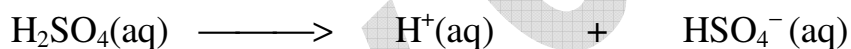
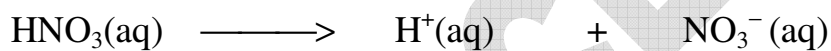
A very few ions

(B) COMPLETE IONIZATION

- For some molecular substances the interaction with the water molecules is essentially complete, and all their molecules change into ions.
- This is referred to as **complete ionization**.
- These substances exist in aqueous solution as **IONS** and as such are **ONLY STRONG ELECTROLYTES (SE)**

Examples:

HCl(aq), HNO₃(aq), H₂SO₄(aq) (for the loss of one H⁺)

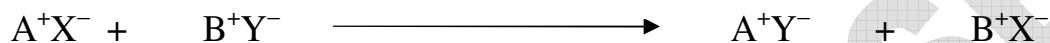


SUMMARY: ELECTROLYTES AND NONELECTROLYTES

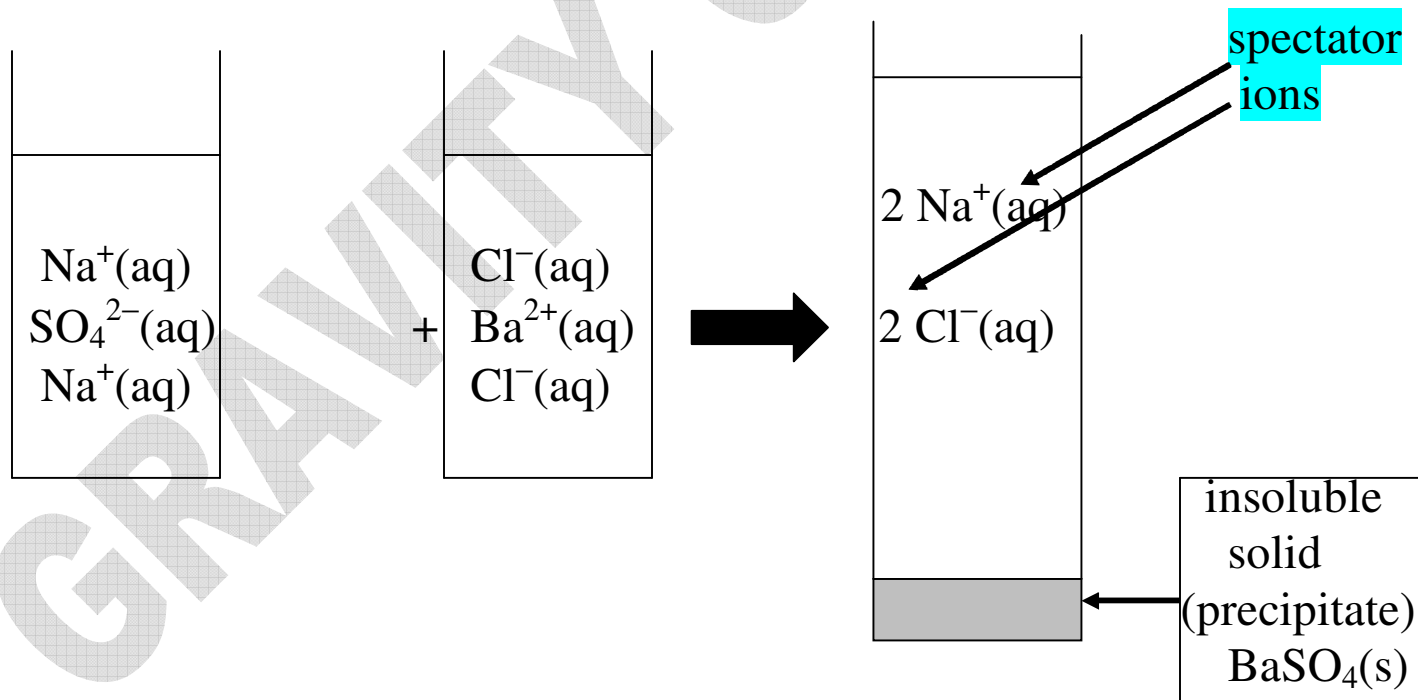
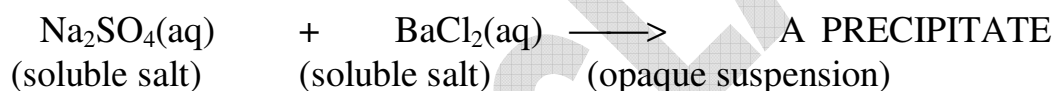
IONIC SUBSTANCES				MOLECULAR SUBSTANCES			
Solid	Liquid	Aqueous Solution		Solid Form	Liquid Form	Aqueous Solution	
		Soluble	Partly Soluble				
NaCl(s) NaOH(s)	NaCl(l) NaOH(l)	NaCl(aq) NaOH(aq)	PbCl ₂ (aq)	C ₁₂ H ₂₂ O ₁₁ (s) HC ₂ H ₃ O ₂ (s)	C ₁₂ H ₂₂ O ₁₁ (l) HC ₂ H ₃ O ₂ (l)	NH ₃ (aq) HC ₂ H ₃ O ₂ (aq)	HCl(aq) HNO ₃ (aq)
NE	SE	SE	WE	NE	NE	WE	SE
Ions present but not move	Ions present and free to move	Ions present and free to move	Few ions and free to move	No ions (molecules only)	No Ions (molecules only)	Few ions (mostly molecules free to move	Ions only (no molecules) to free to move
No Dissoc'n	Complete Dissoc'n	Complete Dissoc'n	Partial Dissoc'n	No Ionization	No Ionization	Partial Ionization	Complete Ionization

IONIC AND MOLECULAR EQUATIONS

- Chemical reactions which take place in aqueous solution are caused by the interactions between ions and are referred to as IONIC REACTIONS.
- Most IONIC REACTIONS are DOUBLE DISPLACEMENT REACTIONS (also called METATHESIS REACTIONS)



- Consider: the reaction between an aqueous solution of sodium sulfate and an aqueous solution of barium chloride forms a solid which is insoluble in water (in time, it settles at the bottom of the test tube and is referred to as A PRECIPITATE)

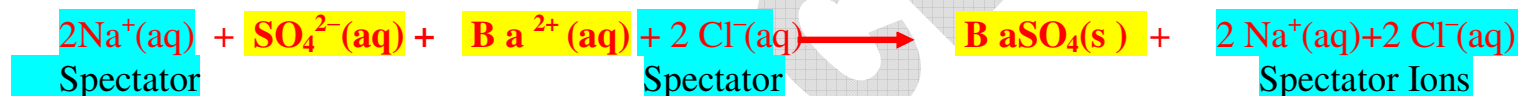


Molecular Equation:

- This equation does not show which substances exist in ionic form.

Complete (Total) Ionic Equation:

- Strong electrolytes are written as separate ions in solution (completely dissociated)



- Spectator Ions: Ions in an ionic equation which do not take part in the reaction



- This equation:
 - is called the **NET IONIC EQUATION** (focuses on the main event)
 - is obtained by canceling out the spectator ions:

