



## **whats molaer conductivity** Class 12th Chemistry | Electrochemistry ✂ Super One Shot | By Ashu Sir - YouTube

Molar conductivity ( $\Lambda_m$ ) is a measure of how well an electrolytic solution conducts electricity when one mole of electrolyte is dissolved in a certain volume of solution.<sup>[1]</sup>

### **Definition and Formula**

Molar conductivity is defined as the conductivity ( $\kappa$ ) of a solution divided by its molar concentration ( $C$ ), usually multiplied by 1000 to adjust for units:

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$

- $\kappa$  = conductivity of the solution ( $\text{S cm}^{-1}$  or  $\text{S m}^{-1}$ )
- $C$  = concentration in  $\text{mol L}^{-1}$

### **Units**

- The common unit of molar conductivity is  $\text{S cm}^2 \text{ mol}^{-1}$  in chemistry.<sup>[1]</sup>

### **Physical Meaning**

- Molar conductivity shows the conducting power of all the ions produced by completely dissolving one mole of electrolyte in solution.
- It takes into account not just how many ions are present but also how easily they can move and thus contribute to current flow.<sup>[1]</sup>

### **Behavior with Dilution**

- For most electrolytes, as dilution increases (concentration decreases), molar conductivity increases.
  - This is because ions can move more freely in a dilute solution due to less ionic interaction.
- For strong electrolytes, the increase becomes smaller at high dilution.
- For weak electrolytes, molar conductivity increases more sharply with dilution.

## Key Points

- Molar conductivity is highest at infinite dilution — the value at this point is called  $\Lambda_m^0$  or "molar conductivity at infinite dilution."
- Graphs of  $\Lambda_m$  versus  $\sqrt{C}$  are used to classify strong and weak electrolytes.

## Summary Table

Property	Symbol	Formula	SI Unit
Conductivity	$\kappa$	-	$\text{S cm}^{-1}$
Concentration	$C$	-	$\text{mol L}^{-1}$
Molar Conductivity	$\Lambda_m$	$\frac{\kappa \times 1000}{C}$	$\text{S cm}^2 \text{ mol}^{-1}$

\*\*

# whats elecrolytes

Electrolytes are substances that dissociate into charged particles called ions when dissolved in water or melted, allowing them to conduct electricity. <sup>[3]</sup> <sup>[4]</sup> <sup>[5]</sup>

## Chemistry Definition

- Electrolytes split into cations (positively charged ions) and anions (negatively charged ions) in solution. <sup>[3]</sup>
- Common examples include acids, bases, and salts, such as sodium chloride (NaCl), hydrochloric acid (HCl), and potassium hydroxide (KOH). <sup>[6]</sup> <sup>[7]</sup>
- These ions are responsible for conducting electric current through the solution or molten substance instead of the flow of electrons, as in metals. <sup>[4]</sup> <sup>[5]</sup>

## Types of Electrolytes

- **Strong electrolytes:** Completely ionize in solution (e.g., NaCl, HCl). <sup>[6]</sup> <sup>[7]</sup>
- **Weak electrolytes:** Partially ionize in solution (e.g., acetic acid, ammonia). <sup>[7]</sup>

## Importance

- Electrolytes play critical roles in both chemical reactions and biological systems, including maintaining electrical neutrality, pH balance, and triggering nerve and muscle functions. <sup>[8]</sup> <sup>[9]</sup>

## Key Properties

- Conduct electricity when dissolved or molten. <sup>[4]</sup> <sup>[5]</sup>
- Essential in electrochemical cells and many biological processes. <sup>[9]</sup>

Electrolytes are vital for understanding how solutions conduct electricity and are a major topic in electrochemistry. <sup>[3]</sup> <sup>[5]</sup> <sup>[4]</sup>



## Class 12th Chemistry | Electrochemistry ✂ Super One Shot | By Ashu Sir - YouTube **what is going to happen in dilute molar conductivity**

When you dilute (increase the amount of solvent, usually water) in a solution, **molar conductivity ( $\Lambda_m$ ) increases**. This is a KEY concept in Class 12 Electrochemistry.

### Reason for This Trend

- **On dilution**, the concentration of ions decreases because the solution becomes less crowded.
- **Ions can move more freely** since there are fewer electrostatic interactions with other ions, so they contribute more effectively to carrying electric current.
- As a result, the **molar conductivity increases** as you dilute the solution.

### At Infinite Dilution

- If you keep diluting, eventually you'll reach **infinite dilution** (practically, just a very large amount of water).
- At this point, **molar conductivity ( $\Lambda_m^0$ ) reaches its maximum value**, because all ions are completely free and don't interact with each other.
- This maximum is called **molar conductivity at infinite dilution ( $\Lambda_m^0$  or  $\Lambda_m^\infty$ )**.

### Summary Statements

- **On dilution:** Molar conductivity increases.
- **At infinite dilution:** It is maximum; all ions are completely free.
- **Strong electrolyte:**  $\Lambda_m$  increases slightly but approaches a constant ( $\Lambda_m^0$ ) at infinite dilution.
- **Weak electrolyte:**  $\Lambda_m$  increases sharply with dilution, as more of the electrolyte ionizes.

**Ashu Sir's explanation (Class 12 Electrochemistry Super One Shot):**

"अगर मैं डाइल्यूशन करता हूँ तो कंसंट्रेशन कम हो जाती है... मोलर कंडक्टिविटी बढ़ती है। डाइल्यूशन करने पे पानी डालने पे कंसंट्रेशन कम होती है। मोलर कंडक्टिविटी बढ़ती है।"

*(On dilution, concentration decreases and molar conductivity increases.)*

"अगर मैं इनफाइनइट डाइल्यूशन कर दूँ... तो मोलर कंडक्टिविटी मैक्सिमम हो जाएगी।"

*(At infinite dilution, molar conductivity becomes maximum.)* <sup>[13]</sup>

This directly answers your question!

#### References:

<sup>[13]</sup> Class 12th Chemistry | Electrochemistry ✗ Super One Shot | By Ashu Sir (YouTube, relevant transcript near 01:54:00–01:56:00+)

Let me know if you want a quick summary table or graph for exam revision!



## so what is going to happen to conductivity

When you dilute (add more solvent to) an electrolyte solution, the **conductivity (also known as specific conductivity or  $\kappa$ )** generally decreases. <sup>[15] [16] [17]</sup>

### Explanation

- **Conductivity depends on the number of ions per unit volume.**
- When dilution occurs, the solution gets bigger but the total number of dissolved ions is spread out in more volume—so the number of ions per  $\text{cm}^3$  decreases.
- Fewer ions in each small volume means **less charge is available to carry current**, and thus, the solution's ability to conduct electricity (conductivity) decreases. <sup>[16] [17] [15]</sup>

### Key Points

- **Conductivity ( $\kappa$ ) decreases with dilution** for both strong and weak electrolytes. <sup>[15] [16]</sup>
- However, **molar conductivity increases** upon dilution, because the ions can move more freely in the larger volume, even though there are fewer of them in each part of the solution. <sup>[16]</sup>

### Summary Table:

Property	On Dilution
Conductivity ( $\kappa$ )	Decreases
Molar conductivity	Increases

This decrease in conductivity on dilution is a fundamental concept in electrochemistry. <sup>[17] [16]</sup>



**Okay, so like conductivity means how well can charges flow or current flow in a solution. So if I'm going to dilute that solution, it means the ions are going to spread out and So the conductivity is going to decrease because there are going to be less ions in a specific area. So now let's talk about the molar conductivity. So molar conductivity is going to increase if I dilute that. So if conductivity is going to decrease it means the flow rate is also going to decrease for the current. So for molar conductivity it is going to increase what? Like it is going to increase make the flow more better for ions or like what is going to do**

When molar conductivity increases upon dilution, it does **not** mean that the total current flowing through the solution is increasing. Instead, it means that the **conducting ability of one mole of electrolyte becomes greater** as the ions become more mobile and able to move more freely. <sup>[25]</sup>  
<sup>[26]</sup> <sup>[27]</sup> <sup>[28]</sup> <sup>[29]</sup>

### **What Actually Happens**

- **Conductivity ( $\kappa$ ) is decreasing** because the number of ions per unit volume goes down. <sup>[26]</sup>  
<sup>[29]</sup>
- **Total flow of current in a given volume becomes less on dilution** since there are fewer charge carriers overall in any small section. <sup>[26]</sup>
- However, **molar conductivity ( $\Lambda_m$ ) increases** because:
  - The existing ions experience less crowding and fewer inter-ionic attractions,
  - Each ion can move more freely and quickly through the solvent,
  - Especially for weak electrolytes, more molecules actually dissociate into ions as you dilute, greatly increasing ionic contribution from each mole. <sup>[27]</sup> <sup>[28]</sup> <sup>[25]</sup>
- So: **Molar conductivity measures how efficiently one mole of electrolyte conducts electricity when allowed to expand in a large solution**—at infinite dilution, this efficiency is at its maximum. <sup>[29]</sup>

### **Simple Analogy**

Think of a running race:

- If runners (ions) are packed on a narrow track (high concentration), they are constantly bumping into each other (ionic interactions limit movement).

- If you spread them out over a big stadium (dilute solution), each runner can sprint more freely (greater mobility).
- **Total runners per meter (charge per cm<sup>3</sup>): lower in dilute solution** (so overall current per small sample is less).
- **How well one team (one mole) performs overall: increases with more space** (molar conductivity rises as running gets easier!).

## Conclusion

- **Molar conductivity increases on dilution:** Each mole of electrolyte conducts much better, mainly due to greater freedom of movement for the ions, not because the solution's total current increases. <sup>[25] [27] [29] [26]</sup>
- **Overall current flow** in the solution goes down with dilution, since there are fewer ions per area, but each mole's effectiveness at carrying current is higher.

This difference is key for exam and concept clarity in electrochemistry!



# Class 12th Chemistry | Electrochemistry ✂ Super One Shot | By Ashu Sir - YouTube **Kohlrausch Law and Applications**

Kohlrausch's Law—also known as the Law of Independent Migration of Ions—states that at infinite dilution, the limiting molar conductivity of an electrolyte equals the sum of the individual limiting conductivities of its cation and anion. This principle enables the calculation of the conductivity and many important parameters for both strong and weak electrolytes, even when direct measurement is not feasible. <sup>[35] [36] [37] [38]</sup>

## Definition & Mathematical Formula

- **Kohlrausch's Law:**

At infinite dilution, each ion in an electrolyte migrates independently, contributing a fixed amount to total conductivity.

$$\Lambda_m^0(\text{electrolyte}) = \Lambda^0(\text{cation}) + \Lambda^0(\text{anion})$$

Example: For NaCl,

$$\Lambda_m^0(\text{NaCl}) = \Lambda^0(\text{Na}^+) + \Lambda^0(\text{Cl}^-)$$

<sup>[36] [37] [35]</sup>

## Applications of Kohlrausch's Law

- **1. Determining Limiting Molar Conductivity for Weak Electrolytes:**

Direct measurement is challenging for weak electrolytes, as their molar conductivity does not linearly extrapolate to zero concentration. Kohlrausch's Law enables calculation using the known limiting conductivities of constituent ions. [\[39\]](#) [\[38\]](#) [\[35\]](#) [\[36\]](#)

- **2. Degree of Dissociation ( $\alpha$ )**

*Calculation :* *The ratio of measured molar conductivity ( $\Lambda_m$ ) to limiting molar conductivity ( $\Lambda_m^0$ ) gives the degree of dissociation:*

$$\alpha = \frac{\Lambda_m}{\Lambda_m^0}$$

[\[40\]](#) [\[39\]](#)

- **3. Determination of Dissociation Constant ( $K_a$ ) for Weak Electrolytes:**

Once  $\alpha$  is known, the equilibrium constant can be calculated, supporting ionic equilibrium analysis. [\[35\]](#) [\[39\]](#) [\[40\]](#)

- **4. Calculation of Salt Solubility:**

Solubility of sparingly soluble salts (e.g., AgCl, BaSO<sub>4</sub>) can be deduced by relating measured conductivity to the sum of ion conductivities at infinite dilution. [\[38\]](#) [\[39\]](#)

- **5. Transport (Transference) Number Calculation:**

The law aids in finding the fraction of current carried by individual ions, crucial for understanding current flow in electrochemical cells. [\[39\]](#)

## How Ashu Sir Teaches This Law (Summary of Key Points)

- The law is covered after explaining resistance, conductance, and molar conductivity, emphasizing its role in handling weak electrolytes and establishing the behavior of strong electrolytes at infinite dilution. [\[35\]](#)
- Data from various known weak/strong electrolytes help to indirectly determine the limiting molar conductivity for any target electrolyte using the above formula. [\[35\]](#)
- Several board and competitive exam problems (including those based on  $\alpha$ ,  $K_a$ , and weak/strong electrolytes) directly benefit from applying Kohlrausch's Law. [\[35\]](#)

## Quick Table: Formula & Uses

Application	What Kohlrausch's Law Enables	Formula/Method	Citation
Limiting conductivity	For weak electrolyte (cannot measure direct)	Sum of ion conductivities	<a href="#">[36]</a> <a href="#">[38]</a> <a href="#">[35]</a>
Degree of dissociation	Find $\alpha$ for weak electrolyte	$\alpha = \frac{\Lambda_m}{\Lambda_m^0}$	<a href="#">[39]</a> <a href="#">[40]</a> <a href="#">[35]</a>
Dissociation constant	Calculate equilibrium constant	Use $\alpha$ and concentration	<a href="#">[39]</a> <a href="#">[40]</a> <a href="#">[35]</a>
Salt solubility	Find solubility via conductivity	Relate to ion values in solution	<a href="#">[38]</a> <a href="#">[35]</a>

## Core Takeaway

Kohlrausch's Law is a fundamental concept for board exams and practical chemistry, enabling insights into ionic behavior even when direct measurements are impossible. Its formula is essential for analyzing strong/weak electrolytes, determining dissociation, and solving advanced electrochemistry questions. [\[37\]](#) [\[36\]](#) [\[38\]](#) [\[35\]](#)



**So this law tells us This law says that at infinity of the dilution, every ion in that electrolytic solution is going to contribute a fixed amount into the total conductivity.**

Yes, that's correct. Kohlrausch's Law states that at infinite dilution, **each ion in the electrolyte contributes a fixed, characteristic amount to the total molar conductivity of the solution**. This individual contribution is independent of which other ion is present—the ions move freely without interacting. [\[48\]](#) [\[49\]](#) [\[50\]](#)

## Key Concept

- **Infinite Dilution:** Means the solution is so dilute that all ions are far apart and inter-ionic interactions disappear. [\[50\]](#)
- **Independent Migration:** Each ion migrates on its own—the limiting molar conductivity ( $\Lambda_m^0$ ) is the sum of the limiting conductivities of the cation and anion. [\[49\]](#) [\[50\]](#)

$$\Lambda_m^0(\text{electrolyte}) = \Lambda^0(\text{cation}) + \Lambda^0(\text{anion})$$

### Example:

For NaCl at infinite dilution:

$$\Lambda_m^0(\text{NaCl}) = \Lambda^0(\text{Na}^+) + \Lambda^0(\text{Cl}^-)$$

## Practical Meaning

- The total conductivity at infinite dilution can be predicted by adding up each ion's "fixed" contribution. [\[49\]](#)
- This principle allows chemists to find limiting conductivities for electrolytes (even weak ones) that can't be measured directly. [\[48\]](#) [\[50\]](#)

This law forms the foundation for how limiting molar conductivity is used in electrochemistry and helps calculate key properties for strong and weak electrolytes. [\[50\]](#) [\[48\]](#) [\[49\]](#)





# So what is those other thing in the application? What does that say?

Kohlrausch's Law has several important applications beyond just calculating the limiting molar conductivity of an electrolyte. Here are the key uses that you'll encounter in your Class 12 electrochemistry syllabus and for competitive exam prep: [\[58\]](#) [\[59\]](#) [\[60\]](#)

## Main Applications of Kohlrausch's Law

- **1. Calculation of Limiting Molar Conductivity ( $\Lambda_m^0$ ) for Weak Electrolytes:**
  - Weak electrolytes do not ionize completely, and their limiting molar conductivity cannot be measured directly.
  - By using Kohlrausch's Law, you calculate  $\Lambda_m^0$  for a weak electrolyte by adding known values for strong electrolytes that have the same ions. [\[59\]](#) [\[60\]](#) [\[58\]](#)
  - Example: For acetic acid ( $\text{CH}_3\text{COOH}$ ):
$$\Lambda_m^0(\text{CH}_3\text{COOH}) = \Lambda_m^0(\text{CH}_3\text{COONa}) + \Lambda_m^0(\text{HCl}) - \Lambda_m^0(\text{NaCl})$$
- **2. Determining Degree of Dissociation ( $\alpha$ ):**
  - Once you know  $\Lambda_m^0$ , you can find the degree of dissociation at any concentration:
$$\alpha = \frac{\Lambda_m}{\Lambda_m^0}$$
- **3. Calculating Dissociation Constant ( $K_a$ ):**
  - Use the degree of dissociation ( $\alpha$ ) and the concentration to determine the dissociation constant of weak electrolytes. [\[60\]](#) [\[61\]](#) [\[59\]](#)
- **4. Determining Solubility of Sparingly Soluble Salts:**
  - For salts like  $\text{AgCl}$  or  $\text{BaSO}_4$  that don't dissolve much, conductance measurement allows calculation of solubility using limiting molar conductivity. [\[60\]](#)
- **5. Calculating Transport (Transference) Numbers:**
  - Kohlrausch's Law allows you to find what fraction of the total current is carried by each ion in a solution. [\[59\]](#)

## Why These Are Useful

- These methods help when direct measurements are impossible (as with weak electrolytes or sparingly soluble salts).
- They are essential for chemical analysis, making solutions, and understanding ionic movement in real-world electrochemical cells. [\[58\]](#) [\[59\]](#) [\[60\]](#)

Let me know if you want an example of how to use any of these applications in practice!



# whats weak electrolytes so what is going to happen in the calculation of weak electrolytes

A weak electrolyte is a substance that **partially dissociates into ions when dissolved in water**, resulting in a solution that contains both ions and undissociated molecules. Because only a small fraction of its molecules ionize, weak electrolytes conduct electricity poorly compared to strong electrolytes, which fully dissociate and produce many ions. <sup>[62] [63] [64] [65]</sup>

## Examples of Weak Electrolytes

- **Acetic acid** ( $\text{CH}_3\text{COOH}$ )
- **Ammonium hydroxide** ( $\text{NH}_4\text{OH}$ )
- **Carbonic acid** ( $\text{H}_2\text{CO}_3$ )
- **Ammonia** ( $\text{NH}_3$ ) <sup>[63] [64] [62]</sup>

## Key Properties

- Only a portion of molecules ionize; most remain as neutral species. <sup>[62] [63]</sup>
- The solution exists in dynamic equilibrium between ions and neutral molecules. <sup>[62]</sup>
- They are poor conductors since there are fewer ions to carry charge. <sup>[64] [65] [62]</sup>

## Calculation for Weak Electrolytes Using Kohlrausch's Law

- **Direct measurement of limiting molar conductivity ( $\Lambda_m^0$ ) for weak electrolytes is not possible.**
- The graph of molar conductivity vs. concentration for weak electrolytes does not have a simple linear intercept at zero concentration (infinite dilution). <sup>[64]</sup>
- Instead, **Kohlrausch's Law is used:**
  - Values for ionic species, obtained from strong electrolytes, are added to find the limiting conductivity for the weak electrolyte. <sup>[64]</sup>
  - Example:  $\Lambda_m^0(\text{CH}_3\text{COOH}) = \Lambda_m^0(\text{CH}_3\text{COONa}) + \Lambda_m^0(\text{HCl}) - \Lambda_m^0(\text{NaCl})$ . <sup>[66]</sup>  
<sup>[64]</sup>

## Why This is Important

- This allows the determination of properties like degree of dissociation ( $\alpha$ ) and dissociation constant ( $K_a$ ), which are critical for understanding chemical equilibrium and ionic behavior. <sup>[66] [64]</sup>
- Without Kohlrausch's Law, these calculations would be impossible for weak electrolytes.

## In summary:

Weak electrolytes only partially ionize and conduct poorly. For calculations, their limiting molar

conductivity must be found indirectly using Kohlrausch's Law and data from strong electrolytes, enabling further chemical analysis. [\[63\]](#) [\[66\]](#) [\[62\]](#) [\[64\]](#)

\*  
\*\*

## what are ions

Ions are atoms or molecules that have a net electrical charge because they have either gained or lost one or more electrons. [\[73\]](#) [\[74\]](#) [\[75\]](#) [\[76\]](#) [\[77\]](#)

### Types of Ions

- **Cations:** Positively charged ions (fewer electrons than protons), e.g.,  $\text{Na}^+$ ,  $\text{K}^+$ . [\[74\]](#) [\[77\]](#) [\[73\]](#)
- **Anions:** Negatively charged ions (more electrons than protons), e.g.,  $\text{Cl}^-$ ,  $\text{OH}^-$ . [\[77\]](#) [\[73\]](#) [\[74\]](#)

### How Ions Form

- **Ionization:** An atom loses electrons to become a cation or gains electrons to become an anion. [\[76\]](#)
- **Examples:** Sodium atom ( $\text{Na}$ ) loses an electron to form  $\text{Na}^+$ . Chlorine atom ( $\text{Cl}$ ) gains an electron to form  $\text{Cl}^-$ . [\[73\]](#) [\[74\]](#) [\[77\]](#)

### Importance

- Ions are responsible for electrical conductivity in electrolytes.
- The attraction between cations and anions forms ionic compounds like table salt ( $\text{NaCl}$ ). [\[75\]](#) [\[74\]](#) [\[73\]](#)

### Summary Table

Ion Type	Charge	Example
Cation	Positive	$\text{Na}^+$
Anion	Negative	$\text{Cl}^-$

Ions play a crucial role in chemistry, forming compounds and conducting electricity in solutions. [\[74\]](#) [\[76\]](#) [\[77\]](#) [\[73\]](#)

\*  
\*\*

## so na is not ion but na+2 is

That's a good question! Here's the clear difference:

- **Na (sodium atom)** is NOT an ion. It is a neutral atom with 11 protons and 11 electrons, so its net charge is zero. [\[83\]](#) [\[84\]](#) [\[85\]](#)

- **Na<sup>+</sup> (sodium ion)** IS an ion. It has 11 protons and only 10 electrons—meaning it has lost one electron and now has a positive charge (+1). [\[84\]](#) [\[85\]](#) [\[83\]](#)
- **Na<sup>2+</sup> (Na+2)** is not a common or stable ion for sodium in chemistry. Sodium typically forms only the +1 ion (Na<sup>+</sup>), not +2. So Na<sup>2+</sup> basically does not exist in normal chemistry. [\[85\]](#)

## Summary Table

Species	Charge	Exists as Ion?
Na	Zero	No, it's neutral
Na <sup>+</sup>	+1	Yes, sodium ion
Na <sup>2+</sup>	+2	No, not typical

## Conclusion:

Na is a neutral atom, not an ion. Na<sup>+</sup> is a sodium ion (cation), but Na<sup>2+</sup> is not a normal ion for sodium. [\[83\]](#) [\[84\]](#) [\[85\]](#)



# why did we put hcl and nacl for calculation of weak electrolytes

HCl and NaCl are used alongside sodium acetate (CH<sub>3</sub>COONa) to calculate the limiting molar conductivity of a weak electrolyte like acetic acid (CH<sub>3</sub>COOH) **because of ion composition and Kohlrausch's Law**. [\[93\]](#) [\[94\]](#) [\[95\]](#) [\[96\]](#)

## Why These Electrolytes?

- **Kohlrausch's Law:**  
At infinite dilution, the ions migrate independently. The limiting molar conductivity ( $\Lambda_m^0$ ) of weak electrolytes like acetic acid cannot be measured directly, so it is calculated by combining strong electrolytes that provide the needed ions separately. [\[94\]](#) [\[95\]](#)
- **NaCl, HCl, and CH<sub>3</sub>COONa** all are strong electrolytes. Their limiting molar conductivities are known and easily measured. [\[95\]](#) [\[93\]](#) [\[94\]](#)
- Using the conductivities of these, you can algebraically "build" the conductivity for CH<sub>3</sub>COOH (which is weak and can't be directly determined) by using this formula:  

$$\Lambda_m^0(\text{CH}_3\text{COOH}) = \Lambda_m^0(\text{CH}_3\text{COONa}) + \Lambda_m^0(\text{HCl}) - \Lambda_m^0(\text{NaCl})$$
- This formula effectively adds the conductivities of the CH<sub>3</sub>COO<sup>-</sup> and H<sup>+</sup> ions, subtracting the common ion Na<sup>+</sup>, because it appears in both CH<sub>3</sub>COONa and NaCl. [\[94\]](#) [\[95\]](#)

## What Happens in the Calculation

- Measure  $\Lambda_m^0$  for NaCl, HCl, and CH<sub>3</sub>COONa (all strong electrolytes).
- Use the Kohlrausch formula to calculate  $\Lambda_m^0$  for acetic acid, which is a weak electrolyte.

By using these strong electrolytes, we can indirectly determine the limiting molar conductivity for the weak electrolyte. This is a classic method in electrochemistry! <sup>[96]</sup> <sup>[95]</sup> <sup>[94]</sup>



## Class 12th Chemistry | Electrochemistry ✂ Super One Shot | By Ashu Sir - YouTube **whats farades law first** **one**

Faraday's First Law of Electrolysis states that the mass of a substance deposited or liberated at any electrode during electrolysis is directly proportional to the quantity of electricity (charge) passed through the electrolyte. This relationship forms the basis for quantitative chemical analysis through electrochemical methods. <sup>[103]</sup> <sup>[104]</sup> <sup>[105]</sup>

### Statement and Formula

- **Statement:** The mass (\$ m \$) of a substance deposited or liberated at an electrode during electrolysis is proportional to the quantity of electricity (\$ Q \$) passed through the solution.

- **Mathematical form:**

$$m = ZQ$$

Where:

- \$ m \$ = mass of substance deposited (grams)
  - \$ Q \$ = total charge passed (coulombs)
  - \$ Z \$ = electrochemical equivalent (grams per coulomb), which is the mass deposited per unit charge.
- In terms of current and time:

$$m = ZIt$$

Where \$ I \$ is the current (amperes), and \$ t \$ is the time (seconds).

This law means if you double the electric charge (by increasing current or time), the amount of material deposited or liberated also doubles. <sup>[104]</sup> <sup>[105]</sup> <sup>[106]</sup>

### Key Points

- The proportionality constant \$ Z \$ is specific for each substance and is called its **electrochemical equivalent**. <sup>[105]</sup> <sup>[103]</sup>
- 1 Faraday (F) = 96,485 coulombs is the charge required to deposit one gram equivalent of a substance. <sup>[107]</sup>

- The law applies to both deposition (at cathodes) and liberation (at anodes) in an electrolytic cell. <sup>[108]</sup>

This fundamental law is the first of Faraday's quantitative laws of electrolysis and is indispensable in analytical and industrial electrochemistry. <sup>[108]</sup> <sup>[103]</sup> <sup>[105]</sup>

\*\*

## so that $z$ is $F$

The value  $Z$  in Faraday's first law of electrolysis (electrochemical equivalent) is **not exactly  $F$  (the Faraday constant)**—but they are closely related.

### Relationship Between $Z$ and $F$

- $Z$  (electrochemical equivalent) is the **mass of substance deposited per coulomb of charge** passed.
- $F$  (Faraday constant) is the **charge required to deposit one gram equivalent (mole of electrons)** for a substance. Its value is approximately 96,485 Coulombs per mole.

The connection:

$$Z = \frac{E}{F}$$

where:

- $Z$  = electrochemical equivalent (g/C)
- $E$  = equivalent weight of the substance (g/equivalent)
- $F$  = Faraday constant (C/equivalent) <sup>[116]</sup> <sup>[117]</sup>

### Simplified

- $Z$  tells you how many grams are deposited per 1 coulomb
- $F$  tells you how many coulombs are needed to deposit one equivalent (mole) of substance

They are **not the same**, but are related by the equivalent weight:

- Larger equivalent weight → larger  $Z$
- $F$  is universal (for all substances, same value)

### Summary Table:

Symbol	Meaning	Value/Formula
$Z$	Electrochemical equiv.	$Z = E / F$
$F$	Faraday constant	96,485 C/mol

So,  $Z \neq F$ . The electrochemical equivalent depends on both the Faraday constant and the equivalent weight of the substance. <sup>[117]</sup> <sup>[116]</sup>

\*\*

## now explaine faradays second law

Faraday's Second Law of Electrolysis states that **when the same amount of electric charge (same quantity of electricity) is passed through different electrolytes, the masses of substances deposited or liberated at the electrodes are directly proportional to their chemical equivalent weights (equivalent masses)**. <sup>[126]</sup> <sup>[127]</sup> <sup>[128]</sup> <sup>[129]</sup>

### Statement and Mathematical Form

- **Statement:** If the same quantity of charge passes through solutions of different electrolytes, then:

$$\frac{m_1}{E_1} = \frac{m_2}{E_2} = \frac{m_3}{E_3} = \dots$$

Where:

- $m_1, m_2, m_3, \dots$  = mass of substances deposited or liberated (grams)
- $E_1, E_2, E_3, \dots$  = equivalent weights of these substances
- **Equivalent Weight:**

$$E = \frac{\text{Molar Mass (M)}}{\text{Valency (n)}}$$

### What It Means

- If you pass the same amount of current for the same amount of time through different electrolytic cells **in series** (so the charge is identical), the ratio of masses deposited is equal to the ratio of their equivalent weights. <sup>[127]</sup> <sup>[128]</sup> <sup>[126]</sup>
- This law helps compare deposition or liberation of elements (e.g., silver and copper) during electrolysis.

### Practical Example

Suppose a current is passed through two solutions: one has copper ions ( $\text{Cu}^{2+}$ ), another has silver ions ( $\text{Ag}^+$ ). If both cells receive the same total charge, then:

$$\frac{\text{Mass of Cu deposited}}{\text{Equivalent weight of Cu}} = \frac{\text{Mass of Ag deposited}}{\text{Equivalent weight of Ag}}$$

or simply,

$$\frac{m_{\text{Cu}}}{E_{\text{Cu}}} = \frac{m_{\text{Ag}}}{E_{\text{Ag}}}$$

Thus, more massive ions (per equivalent) will deposit in proportion to their chemical equivalent.  
[128] [126] [127]

This law is useful for determining the relative amounts of different elements or compounds produced in multiple electrolysis reactions using the same applied charge. [126] [127] [128]



तो मुझे जितना समझ नहीं आ रहा है मुझे बता देता हूँ तो होगा ये फैरेडेस के सेकंड लॉ में कि जैसे कि मैंने एलेक्ट्रिक एनर्जी काफी सारे डिफरेंट एलेक्ट्रोलाइट्स के अंदर पास करी सेम एलेक्ट्रिक एनर्जी डिफरेंट एलेक्ट्रोलाइट्स के अंदर पास करी तो उसको सीरीज में मैंने कनेक्ट करा तो उससे यह होगा कि उनका जो मास होगा जो भी सबस्टेंस उन इलेक्ट्रोलाइट्स का सब्सक्राइब जो भी आकर डिक्पोस्ट होगा इलेक्ट्रोल्स के ऊपर वह डायरेक्टली प्रोपोशनल होगा उसके इक्विवेलेंट वेट पर ठीक है तो इसका फॉर्मूला आना चाहिए **M is proportional to E ठीक है**

Yes, you've explained the heart of **Faraday's Second Law** very well! Let me restate and clarify a bit for strong understanding:

### Faraday's Second Law (in simple words)

If you send **the same amount of charge (current × time)** through different electrolytes (in series), the mass of substance deposited or liberated at each electrode is **directly proportional to the equivalent weight** of that substance.

- In symbols:

$$m \propto E$$

- Or, for different substances with the same charge:

$$\frac{m_1}{E_1} = \frac{m_2}{E_2} = \frac{m_3}{E_3} = \dots$$

where:

- \$ m\_1, m\_2 \$ = mass deposited (g)
- \$ E\_1, E\_2 \$ = equivalent mass (g/equivalent)

**Equivalent mass (E)** = Molar Mass / n (n = number of electrons involved per ion)



## Visual analogy

Think of sending the same number of “electron packets” through different solutions—each element uses a different number of electrons to deposit one atom, so you get more mass for elements with a larger equivalent weight.

### In short:

- **Same charge:** Heavier or lighter mass deposited according to the chemical equivalent weight.
- **Key formula:**

$$m \propto E \text{ (for same } Q\text{)}$$

This is a fundamental rule for electrolysis in chemistry and matches your summary perfectly!

If you'd like, we can solve a short question using this law for full clarity.

✱

**कि ओके तो मैं गा सेम अमाउंट ऑफ चार्ज डिफरेंट के साथ अगर मैं चार्ज को पास करूंगा तो मुझे ऐसा लिखना पड़ेगा  $M_1$  upon  $E_1$  ठीक है और equals में  $M_2$  upon  $E_2$  है ना**

बिल्कुल सही समझा आपने!

Faraday का द्वितीय नियम (Second Law of Electrolysis) यही कहता है:

अगर एक ही मात्रा का चार्ज ( $Q$ ) अलग-अलग electrolytes के solutions में पास करें (सीरीज में जोड़े), तो इलेक्ट्रोड पर जमा पदार्थों की मात्रा उनके equivalent weight ( $E$ ) के अनुपाती (directly proportional) होती है।

**गणितीय फॉर्मूला:**

$$\frac{M_1}{E_1} = \frac{M_2}{E_2}$$

या

$$M_1 : M_2 = E_1 : E_2$$

यहाँ

- $M_1$  = पहले इलेक्ट्रोलाइट में जमा हुआ मास (ग्राम)
- $E_1$  = पहले पदार्थ का तुल्यांकी भार
- $M_2$  = दूसरे इलेक्ट्रोलाइट में जमा हुआ मास
- $E_2$  = दूसरे पदार्थ का तुल्यांकी भार

तो अगर आप सेम मात्रा का चार्ज पास करेंगे, तो यह फॉर्मूला लिखना सही है! <sup>[146]</sup> <sup>[147]</sup> <sup>[148]</sup>

हिंदी में सरल समझ:

जितना ज्यादा तुल्यांकी भार होगा, उतना ज्यादा जमा होगा — लेकिन दोनों का अनुपात यह बताएगा कि किसने कितना डिपॉजिट किया।

यह नियम सीधे आपके **competitive** और **बोर्ड exams** के लिए बहुत **important** है। <sup>[147]</sup> <sup>[148]</sup> <sup>[146]</sup>

✱

## always responded in english

Yes, that's exactly right! According to Faraday's Second Law of Electrolysis, if you pass the same amount of electric charge through different electrolytes (in series), the ratio of the masses deposited or liberated at each electrode equals the ratio of their equivalent weights. <sup>[156]</sup> <sup>[157]</sup> <sup>[158]</sup>

### Mathematical Expression

$$\frac{M_1}{E_1} = \frac{M_2}{E_2} = \frac{M_3}{E_3} = \dots$$

Where,

- \$ M\_1, M\_2 \$ = masses of substances deposited (in grams)
- \$ E\_1, E\_2 \$ = equivalent weights of the respective substances

### What This Means

If you pass the same charge (current × time) through different solutions, each element gets deposited in an amount proportional to its equivalent weight (which is the molar mass divided by its valency).

**This formula and concept are key for solving many electrolysis and electrochemistry problems in exams!** <sup>[157]</sup> <sup>[158]</sup> <sup>[156]</sup>

✱

## explain gibbs free energy

Gibbs free energy (symbol \$ G \$) is a core concept in thermodynamics and chemistry. It measures the amount of energy in a system that is available to do useful work at constant temperature and pressure. <sup>[166]</sup> <sup>[167]</sup> <sup>[168]</sup>

### Formula

The change in Gibbs free energy, \$ \Delta G \$, is given by:

$$\Delta G = \Delta H - T\Delta S$$

Where:

- $\Delta H$ : change in enthalpy (total heat content)
- $T$ : temperature (in Kelvin)
- $\Delta S$ : change in entropy (degree of randomness/disorder) <sup>[167]</sup> <sup>[166]</sup>

## What Does It Mean?

- If  $\Delta G < 0$ : The process or reaction is **spontaneous** (it can happen on its own, releasing energy).
- If  $\Delta G > 0$ : The process is **non-spontaneous** (it needs extra energy from outside to occur).
- If  $\Delta G = 0$ : The system is at **equilibrium** (no net change happens). <sup>[166]</sup> <sup>[167]</sup>

## Why Is It Important?

Gibbs free energy helps predict:

- Whether a reaction will occur naturally ("spontaneously")
- The direction a chemical process will go
- The point of equilibrium for chemical reactions
- How much work (maximum useful work) a chemical or electrochemical process can do <sup>[168]</sup> <sup>[167]</sup>

## Examples

- A chemical reaction with negative  $\Delta G$  will proceed on its own (like iron rusting).
- Water freezing at temperatures below 0°C has a negative  $\Delta G$ , so it happens naturally.
- Electrochemical cells (like batteries) use  $\Delta G$  to measure how much electrical work can be extracted.

## In Short

**Gibbs free energy tells you "Will this process or reaction happen by itself?" and "How much energy can you get out of it as useful work?"** <sup>[167]</sup> <sup>[168]</sup> <sup>[166]</sup>

Let me know if you want a simple solved example or more on its applications!



# Gibbs Free Energy Explained

**Gibbs free energy** (symbol  $G$ ) tells us about the maximum energy available from a chemical reaction or process to do useful work, under constant temperature and pressure.

## Gibbs Free Energy Formula

The change in Gibbs free energy is given by:

$$\Delta G = \Delta H - T\Delta S$$

- $\Delta G$ : Change in Gibbs free energy
- $\Delta H$ : Change in enthalpy (heat content)
- $T$ : Absolute temperature (Kelvin)
- $\Delta S$ : Change in entropy (disorder/randomness)

## What Does It Mean?

- If  $\Delta G < 0$ : The process is **spontaneous** (can happen naturally)
- If  $\Delta G > 0$ : The process is **non-spontaneous** (requires input energy)
- If  $\Delta G = 0$ : The system is at **equilibrium**

## Importance in Electrochemistry

Gibbs free energy decides if an electrochemical reaction (cell reaction, electrolytic process, battery function) will occur on its own and how much electrical work can be extracted. In Ashu Sir's class, you'll see:

- It links chemical reactions to electrical energy in batteries and cells
- It helps predict and calculate direction and feasibility of reactions

## Example

If a cell reaction gives  $\Delta G < 0$ , the cell can **produce electric current** without external input. If  $\Delta G > 0$ , you must supply energy for the reaction to happen (like in electrolysis).

## In Summary

**Gibbs free energy helps us answer:**

- "Will this reaction happen by itself?"
- "How much usable energy can we get?"

If you'd like to see a solved problem or a connection between  $\Delta G$  and cell potential, just ask!



# by using the formula what are we gonna get

By using the formula for Gibbs free energy,

$$\Delta G = \Delta H - T\Delta S$$

you can determine whether a chemical reaction or process is **spontaneous (can happen on its own)**, **non-spontaneous (requires energy input)**, or at **equilibrium**. Specifically: <sup>[178]</sup> <sup>[179]</sup>

- If  $\Delta G < 0$ : The reaction is **spontaneous**; energy is available for useful work.
- If  $\Delta G > 0$ : The reaction is **non-spontaneous**; you need to supply external energy.
- If  $\Delta G = 0$ : The reaction/system is **at equilibrium**; no net change occurs.

You also get the **maximum work** that can be extracted from the system (at constant temperature/pressure) before it reaches equilibrium. <sup>[179]</sup> <sup>[180]</sup> <sup>[178]</sup>

## In summary:

Using the Gibbs free energy formula gives you a direct answer to "Will the reaction happen by itself?" and "How much energy is available for work in the process?". <sup>[180]</sup> <sup>[178]</sup> <sup>[179]</sup>

✱

1. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ](https://www.youtube.com/watch?v=nPQ-mvll_bQ)
2. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
3. <https://byjus.com/chemistry/electrolytes/>
4. <https://www.britannica.com/science/electrolyte>
5. <https://en.wikipedia.org/wiki/Electrolyte>
6. [https://chem.libretexts.org/Bookshelves/Inorganic\\_Chemistry/Supplemental\\_Modules\\_and\\_Websites\\_\(Inorganic\\_Chemistry\)/Chemical\\_Reactions/Chemical\\_Reactions\\_Examples/Electrolytes](https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_and_Websites_(Inorganic_Chemistry)/Chemical_Reactions/Chemical_Reactions_Examples/Electrolytes)
7. <https://www.aakash.ac.in/important-concepts/chemistry/electrolytes>
8. <https://my.clevelandclinic.org/health/diagnostics/21790-electrolytes>
9. [https://chem.libretexts.org/Bookshelves/Introductory\\_Chemistry/Introductory\\_Chemistry\\_\(CK-12\)/15:\\_Water/15.07:\\_Electrolytes\\_and\\_Nonelectrolytes](https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/15:_Water/15.07:_Electrolytes_and_Nonelectrolytes)
10. [https://www.shaalaa.com/question-bank-solutions/define-term-electrolyte\\_87851](https://www.shaalaa.com/question-bank-solutions/define-term-electrolyte_87851)
11. <https://www.youtube.com/watch?v=a6Dw9vtnwns>
12. <https://www.chemicool.com/definition/electrolyte.html>
13. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ](https://www.youtube.com/watch?v=nPQ-mvll_bQ)
14. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
15. <https://www.doubtnut.com/qna/74449398>
16. <https://www.vedantu.com/question-answer/effect-of-dilution-on-conductivity-and-class-11-chemistry-cbse-5f6dcd7fd053ee34aebf8a32>
17. [https://www.shaalaa.com/question-bank-solutions/why-does-the-conductivity-of-a-solution-decrease-with-dilution\\_4736](https://www.shaalaa.com/question-bank-solutions/why-does-the-conductivity-of-a-solution-decrease-with-dilution_4736)
18. <https://allen.in/dn/qna/555575665>

19. [https://www.shaalaa.com/question-bank-solutions/answer-the-following-in-brief-explain-the-effect-of-dilution-of-the-solution-on-conductivity\\_157532](https://www.shaalaa.com/question-bank-solutions/answer-the-following-in-brief-explain-the-effect-of-dilution-of-the-solution-on-conductivity_157532)
20. <https://www.youtube.com/watch?v=oZdeoa3GsjY>
21. <https://www.youtube.com/watch?v=v2OAFI4C87o>
22. [https://www.reddit.com/r/chemhelp/comments/ugm9g4/why\\_does\\_electrolytic\\_conductance\\_increase\\_with/](https://www.reddit.com/r/chemhelp/comments/ugm9g4/why_does_electrolytic_conductance_increase_with/)
23. <https://www.doubtnut.com/qna/20598263>
24. <https://byjus.com/chemistry/variations-molar-conductivity/>
25. <https://www.vedantu.com/jee-main/chemistry-molar-conductivity>
26. <https://www.vedantu.com/question-answer/effect-of-dilution-on-conductivity-and-class-11-chemistry-cbse-5f6dcd7fd053ee34aebf8a32>
27. <https://www.doubtnut.com/qna/541511604>
28. [https://en.wikipedia.org/wiki/Molar\\_conductivity](https://en.wikipedia.org/wiki/Molar_conductivity)
29. <https://allen.in/jee/chemistry/molar-conductivity>
30. [https://www.shaalaa.com/question-bank-solutions/answer-the-following-in-brief-explain-the-effect-of-dilution-of-the-solution-on-conductivity\\_157532](https://www.shaalaa.com/question-bank-solutions/answer-the-following-in-brief-explain-the-effect-of-dilution-of-the-solution-on-conductivity_157532)
31. <https://www.doubtnut.com/qna/12659126>
32. <https://www.youtube.com/watch?v=40DhMTqW9-A>
33. [https://www.shaalaa.com/question-bank-solutions/dilution-affects-both-conductivity-as-well-as-molar-conductivity-effect-of-dilution-on-both-is-as-follows\\_394170](https://www.shaalaa.com/question-bank-solutions/dilution-affects-both-conductivity-as-well-as-molar-conductivity-effect-of-dilution-on-both-is-as-follows_394170)
34. <https://byjus.com/chemistry/variations-molar-conductivity/>
35. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ](https://www.youtube.com/watch?v=nPQ-mvll_bQ)
36. <https://byjus.com/chemistry/kohlrachsch-law/>
37. <https://www.geeksforgeeks.org/chemistry/kohlrachsch-law/>
38. <https://www.vedantu.com/chemistry/kohlrachsch-law>
39. <https://allen.in/jee/chemistry/kohlrachsch-law>
40. <https://www.doubtnut.com/qna/74449607>
41. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
42. <https://www.khanacademy.org/science/class-12-chemistry-india/x6a5fb67b43bb54b9:electrochemistry/x6a5fb67b43bb54b9:electrolytic-cells-electrolysis/v/kohlrachsch-s-law-of-independent-migration>
43. <https://www.youtube.com/watch?v=ExoR98GwjSs>
44. [https://www.shaalaa.com/question-bank-solutions/state-kohlrachsch-law\\_2954](https://www.shaalaa.com/question-bank-solutions/state-kohlrachsch-law_2954)
45. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
46. <https://sathee.iitk.ac.in/article/chemistry/kohlrachsch-law/>
47. <https://gdchoysang.ac.in/About/droid/uploads/Electrochemistry.pdf>
48. <https://byjus.com/chemistry/kohlrachsch-law/>
49. <https://allen.in/jee/chemistry/kohlrachsch-law>
50. <https://www.vedantu.com/chemistry/kohlrachsch-law>
51. [https://www.shaalaa.com/question-bank-solutions/state-kohlrachsch-law-how-is-it-useful-to-determine-the-molar-conductivity-of-weak-electrolytes-at-infinite-dilution\\_244334](https://www.shaalaa.com/question-bank-solutions/state-kohlrachsch-law-how-is-it-useful-to-determine-the-molar-conductivity-of-weak-electrolytes-at-infinite-dilution_244334)

52. <https://byjus.com/chemistry/kohlrausch-law-questions/>
53. <https://www.doubtnut.com/qna/644034347>
54. <http://calistry.org/calculate/kohlrauschLawCalculator>
55. <https://www.askiitians.com/iit-jee-chemistry/physical-chemistry/kohlrausch-law.aspx>
56. <https://www.doubtnut.com/qna/404698006>
57. [https://www.shaalaa.com/question-bank-solutions/write-mathematical-expression-molar-conductivity-given-solution-infinite-dilution\\_14949](https://www.shaalaa.com/question-bank-solutions/write-mathematical-expression-molar-conductivity-given-solution-infinite-dilution_14949)
58. <https://byjus.com/chemistry/kohlrausch-law/>
59. <https://allen.in/jee/chemistry/kohlrausch-law>
60. <https://www.vedantu.com/chemistry/kohlrausch-law>
61. <https://www.doubtnut.com/qna/74449607>
62. <https://www.vedantu.com/chemistry/weak-electrolytes>
63. <https://www.geeksforgeeks.org/chemistry/strong-and-weak-electrolytes/>
64. <https://www.doubtnut.com/qna/642794559>
65. <https://www.vedantu.com/neet/difference-between-strong-electrolyte-and-weak-electrolyte>
66. <https://byjus.com/chemistry/kohlrausch-law/>
67. <https://study.com/learn/lesson/video/what-is-a-weak-electrolyte.html>
68. [https://www.shaalaa.com/question-bank-solutions/define-the-following-term-weak-electrolytes\\_39415](https://www.shaalaa.com/question-bank-solutions/define-the-following-term-weak-electrolytes_39415)
69. <https://www.youtube.com/watch?v=2U2DBWWo6nc>
70. <https://study.com/learn/lesson/what-is-a-weak-electrolyte.html>
71. [https://chem.libretexts.org/Courses/Heartland\\_Community\\_College/CHEM\\_120:\\_Fundamentals\\_of\\_Chemistry/07:\\_Solutions/7.07:\\_Weak\\_Electrolytes](https://chem.libretexts.org/Courses/Heartland_Community_College/CHEM_120:_Fundamentals_of_Chemistry/07:_Solutions/7.07:_Weak_Electrolytes)
72. <https://www.doubtnut.com/qna/642780979>
73. <https://en.wikipedia.org/wiki/Ion>
74. <https://byjus.com/chemistry/ion-definition/>
75. <https://www.vedantu.com/chemistry/ion-definition>
76. <https://www.vedantu.com/chemistry/ion>
77. <https://www.chemicool.com/definition/ion.html>
78. <https://www.mountsinai.org/health-library/special-topic/ions>
79. <https://www.britannica.com/science/ion-physics>
80. <https://www.chemicals.co.uk/blog/what-is-an-ion-in-chemistry>
81. <https://www.youtube.com/watch?v=WWc3k2723IM>
82. <https://www.youtube.com/watch?v=900dXBWgx3Y>
83. [https://www.shaalaa.com/question-bank-solutions/compare-sodium-atom-and-sodium-ion\\_94440](https://www.shaalaa.com/question-bank-solutions/compare-sodium-atom-and-sodium-ion_94440)
84. <https://www.doubtnut.com/qna/643742281>
85. <https://www.mytutor.co.uk/answers/21857/GCSE/Chemistry/What-is-the-difference-between-an-atom-and-an-ion-Explain-the-difference-between-an-Na-sodium-atom-and-Na-ion/>
86. <https://www.doubtnut.com/pcmb-questions/124721>
87. <https://allen.in/dn/qna/643742281>

88. <https://www.youtube.com/watch?v=jpts6gTcth8>
89. <https://www.vedantu.com/question-answer/sodium-atom-and-sodium-ion-a-are-chemically-the-class-10-chemistry-cbse-5f8d9780bba4935631f5c562>
90. <https://www.knowledgeboat.com/question/compare-a-sodium-atom-and-sodium-ion-b-chlorine-atom-and--585513557760416300>
91. <https://homework.study.com/explanation/analyze-the-properties-of-a-sodium-atom-and-a-sodium-ion-what-are-the-differences-in-mass-stability-and-reactivity-that-are-caused-due-to-the-differences-between-the-sodium-atom-and-sodium-ion.html>
92. [https://www.shaalaa.com/question-bank-solutions/compare-sodium-atom-sodium-ion-i-atomic-structure-ii-electrical-state-iii-chemical-action-iv-toxicity-formation-of-an-electrovalent-or-ionic-bond\\_39083](https://www.shaalaa.com/question-bank-solutions/compare-sodium-atom-sodium-ion-i-atomic-structure-ii-electrical-state-iii-chemical-action-iv-toxicity-formation-of-an-electrovalent-or-ionic-bond_39083)
93. <https://www.doubtnut.com/qna/34507788>
94. <https://www.vedantu.com/question-answer/molar-conductivities-at-infinite-dilution-of-class-11-chemistry-cbse-60388b0001af1c3cf87733c9>
95. <https://byjus.com/chemistry/kohlrausch-law-questions/>
96. <https://www.vedantu.com/question-answer/equivalent-conductance-at-infinite-dilution-for-class-11-chemistry-cbse-602c89535d26633d0bd0d6c1>
97. <https://allen.in/dn/qna/644491712>
98. <https://testbook.com/question-answer/mfornacl-hcl-andn--5e2850aef60d5d6182ab0590>
99. [https://www.shaalaa.com/question-bank-solutions/electrolyte-kcl-kno3-hcl-naoac-nacl--s-cm-mol-1-1499-1450-4262-910-1265-calculate-xhoac-using-appropriate-molar-conductances-of-the-electrolytes\\_244176](https://www.shaalaa.com/question-bank-solutions/electrolyte-kcl-kno3-hcl-naoac-nacl--s-cm-mol-1-1499-1450-4262-910-1265-calculate-xhoac-using-appropriate-molar-conductances-of-the-electrolytes_244176)
100. <https://askfilo.com/user-question-answers-smart-solutions/at-infinite-dilution-equivalent-conductivity-of-hcl-nacl-and-3231313137393839>
101. <https://www.scribd.com/doc/16348982/Determination-of-the-conductance-of-strong-and-weak-electrolyte>
102. <https://www.doubtnut.com/qna/645306340>
103. [https://en.wikipedia.org/wiki/Faraday's\\_laws\\_of\\_electrolysis](https://en.wikipedia.org/wiki/Faraday's_laws_of_electrolysis)
104. <https://www.vedantu.com/chemistry/faradays-laws-of-electrolysis>
105. <https://study.com/learn/lesson/faradays-laws-electrolysis-concept-equations.html>
106. <https://www.doubtnut.com/qna/449641393>
107. <https://www.britannica.com/science/Faradays-laws-of-electrolysis>
108. <https://byjus.com/chemistry/laws-of-electrolysis/>
109. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
110. [https://www.shaalaa.com/question-bank-solutions/state-faradays-first-law-of-electrolysis\\_47636](https://www.shaalaa.com/question-bank-solutions/state-faradays-first-law-of-electrolysis_47636)
111. [https://chem.libretexts.org/Bookshelves/Analytical\\_Chemistry/Supplemental\\_Modules\\_\(Analytical\\_Chemistry\)/Electrochemistry/Faraday's\\_Law](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Faraday's_Law)
112. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
113. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ](https://www.youtube.com/watch?v=nPQ-mvll_bQ)
114. <https://www.youtube.com/watch?v=sLq6DoNwn3g>
115. <https://www.youtube.com/watch?v=sZ8Z54E4WXI>
116. <https://www.vedantu.com/physics/faraday-constant>
117. <https://www.doubtnut.com/qna/74449596>



118. <https://byjus.com/physics/faraday-constant/>
119. <https://www.vedantu.com/jee-main/the-relation-between-faraday-constant-f-chemical-chemistry-question-answer>
120. [https://en.wikipedia.org/wiki/Faraday's\\_laws\\_of\\_electrolysis](https://en.wikipedia.org/wiki/Faraday's_laws_of_electrolysis)
121. <https://www.doubtnut.com/qna/13156711>
122. <https://tardigrade.in/question/a-relation-between-faraday-s-constant-f-chemical-equivalent-xhmkqwk2>
123. [https://en.wikipedia.org/wiki/Faraday\\_constant](https://en.wikipedia.org/wiki/Faraday_constant)
124. [https://www.simply.science/images/content/chemistry/chemical\\_reactions/electrochemistry/conceptmap/Faraday\\_Laws\\_Chem.html](https://www.simply.science/images/content/chemistry/chemical_reactions/electrochemistry/conceptmap/Faraday_Laws_Chem.html)
125. <https://www.youtube.com/watch?v=2jhBD9Xuy2E>
126. <https://testbook.com/blog/faradays-second-law/>
127. <https://www.chemistrylearner.com/faradays-laws-of-electrolysis.html>
128. <https://www.doubtnut.com/qna/96607377>
129. [https://en.wikipedia.org/wiki/Faraday's\\_laws\\_of\\_electrolysis](https://en.wikipedia.org/wiki/Faraday's_laws_of_electrolysis)
130. <https://allen.in/dn/qna/646936418>
131. <https://www.khanacademy.org/science/class-12-chemistry-india/x6a5fb67b43bb54b9:electrochemistry/x6a5fb67b43bb54b9:quantitative-aspects-of-electrolysis/v/faraday-s-second-law-of-electrolysis>
132. <https://byjus.com/chemistry/laws-of-electrolysis/>
133. [https://www.youtube.com/watch?v=w9o1VP7m\\_Nc](https://www.youtube.com/watch?v=w9o1VP7m_Nc)
134. [https://www.youtube.com/watch?v=4DK0go1\\_u4Y](https://www.youtube.com/watch?v=4DK0go1_u4Y)
135. [https://www.shaalaa.com/question-bank-solutions/explain-faraday-s-second-law-electrolysis\\_14392](https://www.shaalaa.com/question-bank-solutions/explain-faraday-s-second-law-electrolysis_14392)
136. <https://www.doubtnut.com/qna/309497236>
137. [https://en.wikipedia.org/wiki/Faraday's\\_law\\_of\\_electrolysis](https://en.wikipedia.org/wiki/Faraday's_law_of_electrolysis)
138. <https://askfilo.com/user-question-answers-smart-solutions/2-phairaadde-kaa-dvitiy-niyam-faradays-second-law-jb-ek-hii-3132333239343930>
139. [https://www.youtube.com/watch?v=w9o1VP7m\\_Nc](https://www.youtube.com/watch?v=w9o1VP7m_Nc)
140. <https://www.youtube.com/watch?v=uLtiH MJ5ytk>
141. [https://hi.wikipedia.org/wiki/फैराडे\\_का\\_विद्युत\\_अपघटन\\_का\\_नियम](https://hi.wikipedia.org/wiki/फैराडे_का_विद्युत_अपघटन_का_नियम)
142. [https://hiwiki.iit.ac.in/index.php/फैराडे\\_का\\_विद्युत\\_अपघटन\\_का\\_नियम](https://hiwiki.iit.ac.in/index.php/फैराडे_का_विद्युत_अपघटन_का_नियम)
143. <https://askfilo.com/user-question-answers-smart-solutions/q-phairaadde-ke-vidyut-apghatn-ke-niyam-ko-likhe-faradays-law-3132393039323733>
144. <https://testbook.com/question-answer/hn/faradays-law-of-electrolysis-is-related-to--60cc2ea881e372841a957b54>
145. [https://en.wikipedia.org/wiki/Faraday's\\_laws\\_of\\_electrolysis](https://en.wikipedia.org/wiki/Faraday's_laws_of_electrolysis)
146. <https://www.doubtnut.com/qna/309497236>
147. <https://www.doubtnut.com/qna/460504725>
148. <https://arvindsirpatna.com/faraday-ka-niyam-pratham-or-dvitiy-niyam/>
149. [https://hi.wikipedia.org/wiki/फैराडे\\_का\\_विद्युत\\_चुम्बकीय\\_प्रेरण\\_का\\_नियम](https://hi.wikipedia.org/wiki/फैराडे_का_विद्युत_चुम्बकीय_प्रेरण_का_नियम)

150. <https://askfilo.com/user-question-answers-smart-solutions/phairaadde-kaa-dvitiy-niyam-kyaa-hai-smjh-aaie-athvaa-3132353134333034>
151. <https://testbook.com/articles-in-hindi/faradays-law-in-hindi>
152. <https://www.youtube.com/watch?v=4MWhszbLtX8>
153. <https://testbook.com/question-answer/hn/choose-the-expression-for-faradays-second-law--5f7afecd0d84d9b71007e96b>
154. <https://askfilo.com/user-question-answers-smart-solutions/1-phairaadde-ke-vidyut-vicchedn-kaa-dvitiy-niyam-kaa-vrnnn-3135383630393637>
155. <https://www.youtube.com/watch?v=ixiL6R3W0vM>
156. <https://testbook.com/blog/faradays-second-law/>
157. <https://www.jagranjosh.com/articles/faradays-second-law-of-electrolysis-1698217521-1>
158. [https://en.wikipedia.org/wiki/Faraday's\\_laws\\_of\\_electrolysis](https://en.wikipedia.org/wiki/Faraday's_laws_of_electrolysis)
159. <https://www.pw.live/chemistry-doubts/faradays-laws-of-electrolysis>
160. <https://www.khanacademy.org/science/class-12-chemistry-india/x6a5fb67b43bb54b9:electrochemistry/x6a5fb67b43bb54b9:quantitative-aspects-of-electrolysis/v/faraday-s-second-law-of-electrolysis>
161. [https://www.youtube.com/watch?v=w9o1VP7m\\_Nc](https://www.youtube.com/watch?v=w9o1VP7m_Nc)
162. <https://byjus.com/chemistry/laws-of-electrolysis/>
163. <https://www.doubtnut.com/qna/96607377>
164. [https://www.youtube.com/watch?v=4DK0go1\\_u4Y](https://www.youtube.com/watch?v=4DK0go1_u4Y)
165. [https://www.shaalaa.com/question-bank-solutions/explain-faraday-s-second-law-electrolysis\\_14392](https://www.shaalaa.com/question-bank-solutions/explain-faraday-s-second-law-electrolysis_14392)
166. [https://chem.libretexts.org/Bookshelves/Physical\\_and\\_Theoretical\\_Chemistry\\_Textbook\\_Maps/Supplemental\\_Modules\\_\(Physical\\_and\\_Theoretical\\_Chemistry\)/Thermodynamics/Energies\\_and\\_Potentials/Free\\_Energy/Gibbs\\_\(Free\)\\_Energy](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Thermodynamics/Energies_and_Potentials/Free_Energy/Gibbs_(Free)_Energy)
167. <https://www.vedantu.com/physics/gibbs-free-energy>
168. <https://chemistrytalk.org/what-is-gibbs-free-energy/>
169. <https://www.sciencedirect.com/topics/chemistry/gibbs-free-energy>
170. [https://en.wikipedia.org/wiki/Gibbs\\_free\\_energy](https://en.wikipedia.org/wiki/Gibbs_free_energy)
171. <https://byjus.com/jee/gibbs-free-energy/>
172. <https://study.com/academy/lesson/gibbs-free-energy-definition-significance.html>
173. [https://chem.libretexts.org/Bookshelves/General\\_Chemistry/Chem1\\_\(Lower\)/15:\\_Thermodynamics\\_of\\_Chemical\\_Equilibria/15.04:\\_Free\\_Energy\\_and\\_the\\_Gibbs\\_Function](https://chem.libretexts.org/Bookshelves/General_Chemistry/Chem1_(Lower)/15:_Thermodynamics_of_Chemical_Equilibria/15.04:_Free_Energy_and_the_Gibbs_Function)
174. <https://www.sciencedirect.com/topics/engineering/gibbs-free-energy>
175. [https://www.reddit.com/r/chemistry/comments/1b3wna0/what\\_exactly\\_is\\_gibbs\\_free\\_energy/](https://www.reddit.com/r/chemistry/comments/1b3wna0/what_exactly_is_gibbs_free_energy/)
176. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ](https://www.youtube.com/watch?v=nPQ-mvll_bQ)
177. [https://www.youtube.com/watch?v=nPQ-mvll\\_bQ&t=2017s](https://www.youtube.com/watch?v=nPQ-mvll_bQ&t=2017s)
178. [https://chem.libretexts.org/Bookshelves/Physical\\_and\\_Theoretical\\_Chemistry\\_Textbook\\_Maps/Supplemental\\_Modules\\_\(Physical\\_and\\_Theoretical\\_Chemistry\)/Thermodynamics/Energies\\_and\\_Potentials/Free\\_Energy/Gibbs\\_\(Free\)\\_Energy](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Thermodynamics/Energies_and_Potentials/Free_Energy/Gibbs_(Free)_Energy)
179. <https://www.vedantu.com/physics/gibbs-free-energy>
180. <https://chemistrytalk.org/what-is-gibbs-free-energy/>

