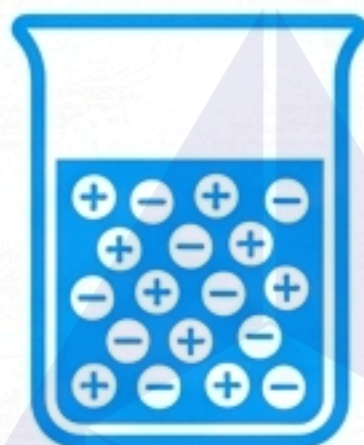


16. Strong and Weak Electrolytes

Complete vs Partial Ionisation

The **Electrolyte Dichotomy** (Michael Faraday's Classification)



Strong Electrolytes

- **Dissociation:** ~100% (Complete)
- **Reaction Arrow:** Single directional ($\rightarrow$)
- **Conductivity:** Very High
- **Species in Solution:** Constituent ions only
- **Examples:** NaCl, HCl, NaOH, HNO₃



Weak Electrolytes

- **Dissociation:** < 5% (Partial)
- **Reaction Arrow:** Equilibrium ($\rightleftharpoons$)
- **Conductivity:** Low
- **Species in Solution:** Mostly unionised molecules + few ions
- **Examples:** CH₃COOH, NH₄OH, HF

Strong Electrolytes: Complete Ionisation

When dissolved, the solvent's physics take over. Water possesses a very high dielectric constant (80), which reduces electrostatic interactions between solid solute ions by a factor of 80. The solute splits completely into freely moving, hydrated ions. There are no unionised molecules left to form an equilibrium.

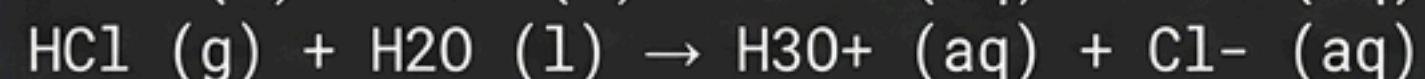
The One-Way Street

The reaction proceeds essentially to completion. The final concentration of the resulting ions is directly determined by the exact initial concentration of the electrolyte.

Before vs. After Ionisation



[Formula Bank]



Initial: c 0 0

Final: 0 c c



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$$E=mc^2$$



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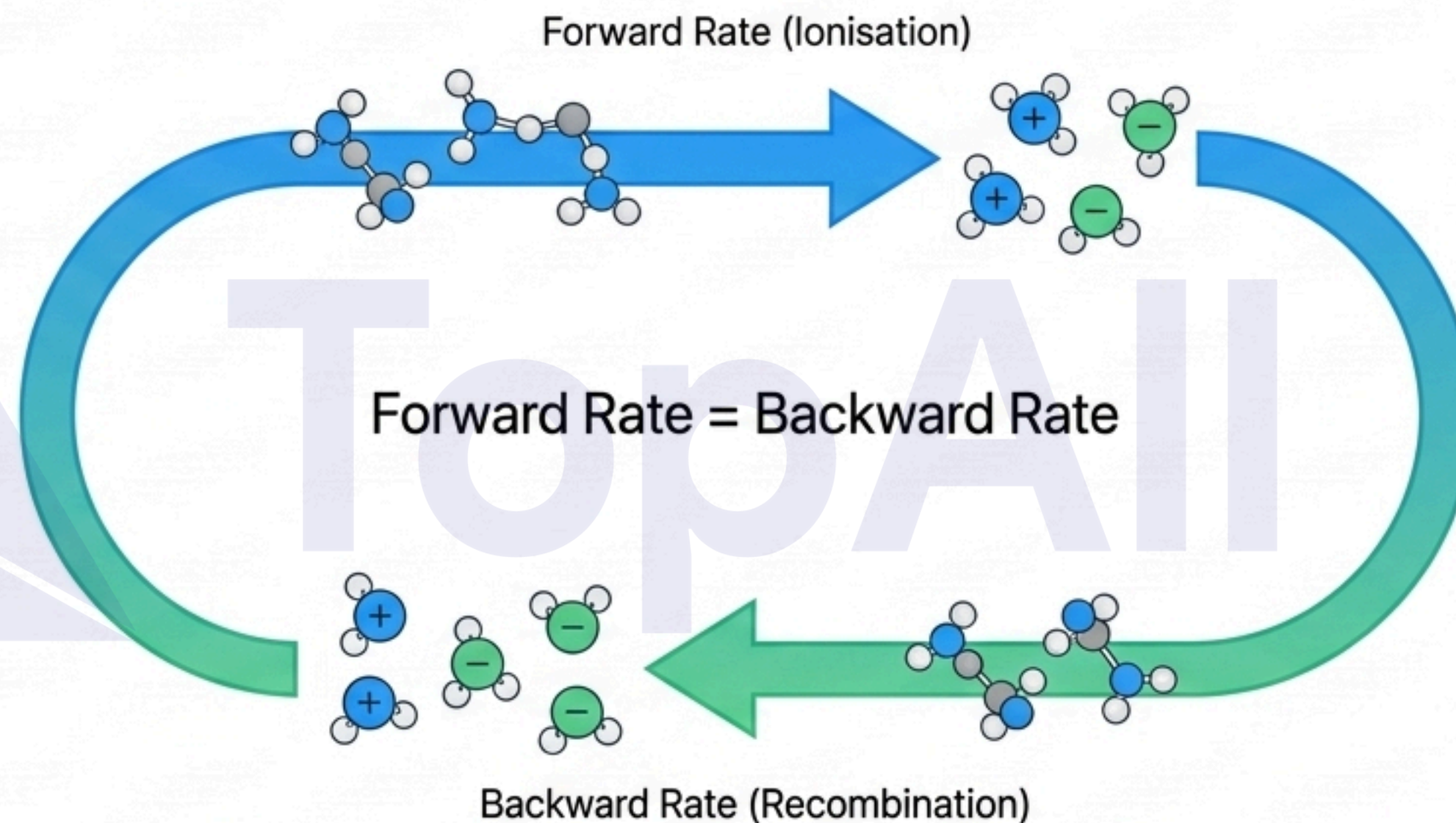
Weak Electrolytes: The Dynamic Equilibrium

Weak electrolytes only partially ionize (typically < 5%). The un-dissociated molecules and the newly formed ions exist together in a state of continuous dynamic equilibrium.

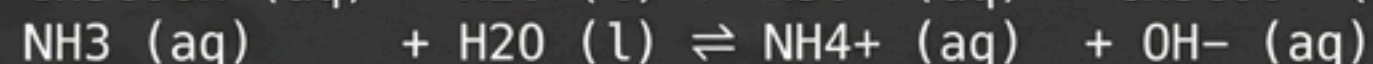
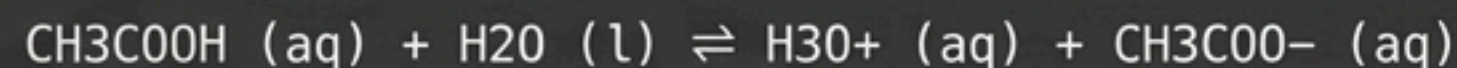
Why Partial?

The extent of ionization depends on chemical bond strength and ion solvation.

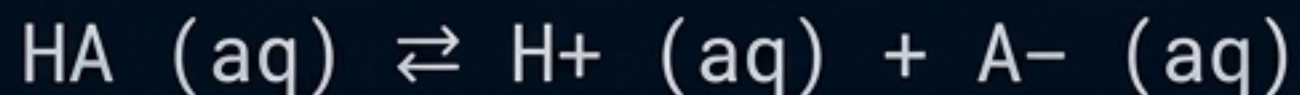
For weak acids/bases, the ion-solvent interactions are not strong enough to completely overcome the lattice/bond enthalpy.



[Formula Bank]

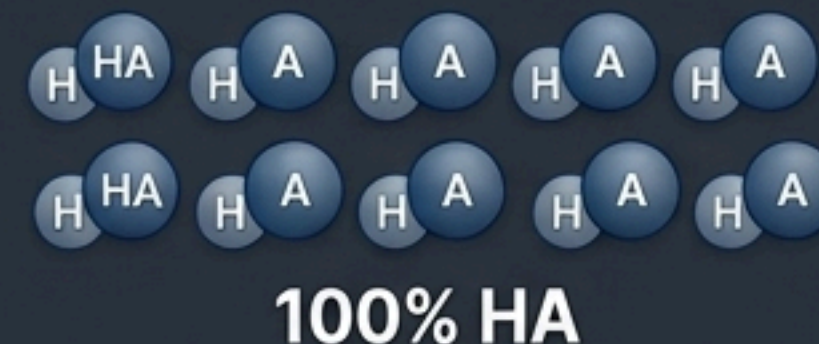


Molecular Dynamics of a Weak Acid



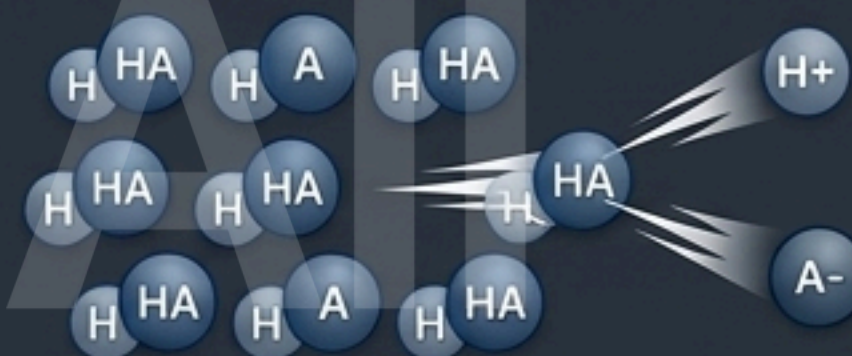
Initial State (t=0)

Pure weak acid added to water. Zero dissociation has occurred yet.



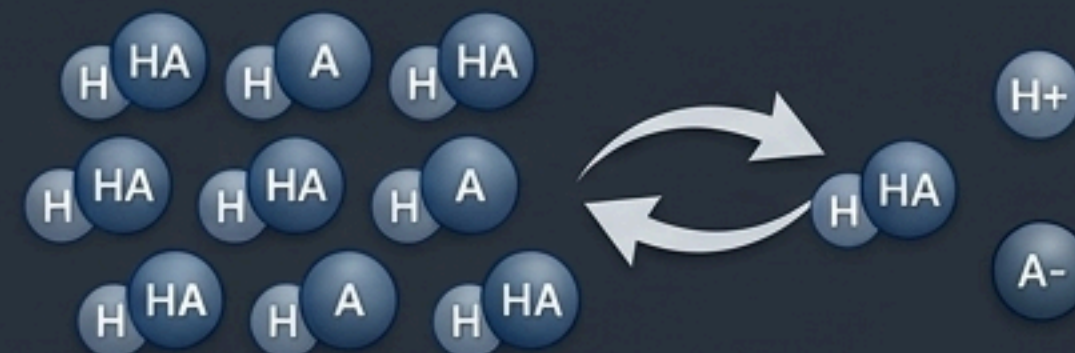
The Forward Shift (t > 0)

Water molecules pull apart a small fraction of the HA bonds, generating H⁺ and A⁻ ions.



Dynamic Equilibrium (t = t_{eq})

The rate of HA splitting exactly matches the rate of H⁺ and A⁻ recombining. Macroscopic concentrations are locked, but microscopic swapping continues endlessly.



Quantifying the Split: Degree of Ionisation (α)

To solve equilibrium numericals, we must quantify exactly how much of the weak electrolyte has dissociated. This fraction is represented by α .

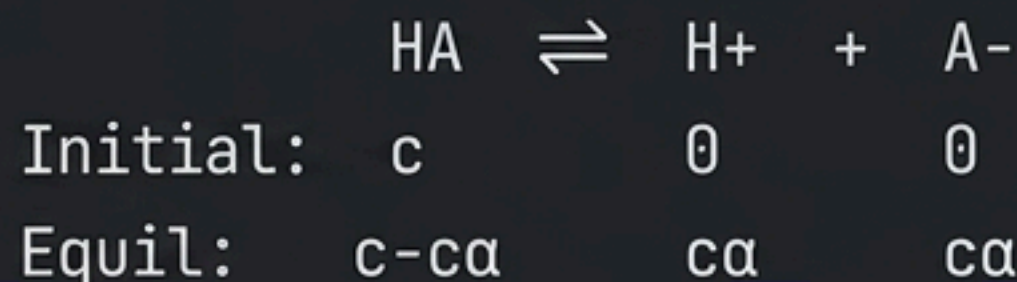
For weak electrolytes, α is typically very small ($\alpha \ll 1$).

$$\alpha = \frac{\text{(Number of moles dissociated)}}{\text{(Total number of moles taken initially)}}$$

(Note: Multiply by 100 for Percent Dissociation)

[Ostwald's Dilution Law Application]

General weak acid dissociation:



Equilibrium Constant (K_a):

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

$$K_a = \frac{(c\alpha)(c\alpha)}{c(1-\alpha)}$$

$$K_a = \frac{c\alpha^2}{(1-\alpha)}$$

If α is very small ($\alpha < 0.05$):

$$(1-\alpha) \approx 1 \Rightarrow K_a \approx c\alpha^2 \Rightarrow \alpha = \sqrt{(K_a/c)}$$

Exam Strategy & Common Pitfalls

⚠ JEE Trap Alert: STRENGTH $\neq$ CONCENTRATION

Examiners will trick you by mixing these terms. Do not confuse a **dilute strong acid** for a weak acid!

- | | |
|--|--|
| • Concentration (Molarity): How much solute is dissolved (e.g., 10 M vs 0.001 M). | • Strength (α): How much the solute ionises once dissolved. |
|--|--|

The Trap: A highly concentrated solution of Acetic Acid (**10 M**) is still a **weak acid**. A highly dilute solution of HCl (**0.0001 M**) is still a **strong acid**.

✓ Exam Snapshot: Rapid Revision Matrix

Property	Strong Electrolyte	Weak Electrolyte
Reaction Type	Irreversible ($\rightarrow$)	Reversible ($\rightleftharpoons$)
Calculations	Stoichiometry (100% yield)	Equilibrium Constants (K_a , K_b)
Vant Hoff Factor (i)	$i = n$ (total constituent ions)	$i = 1 + \alpha(n-1)$
Examples	Mineral acids, Strong bases	Organic acids, Weak bases



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