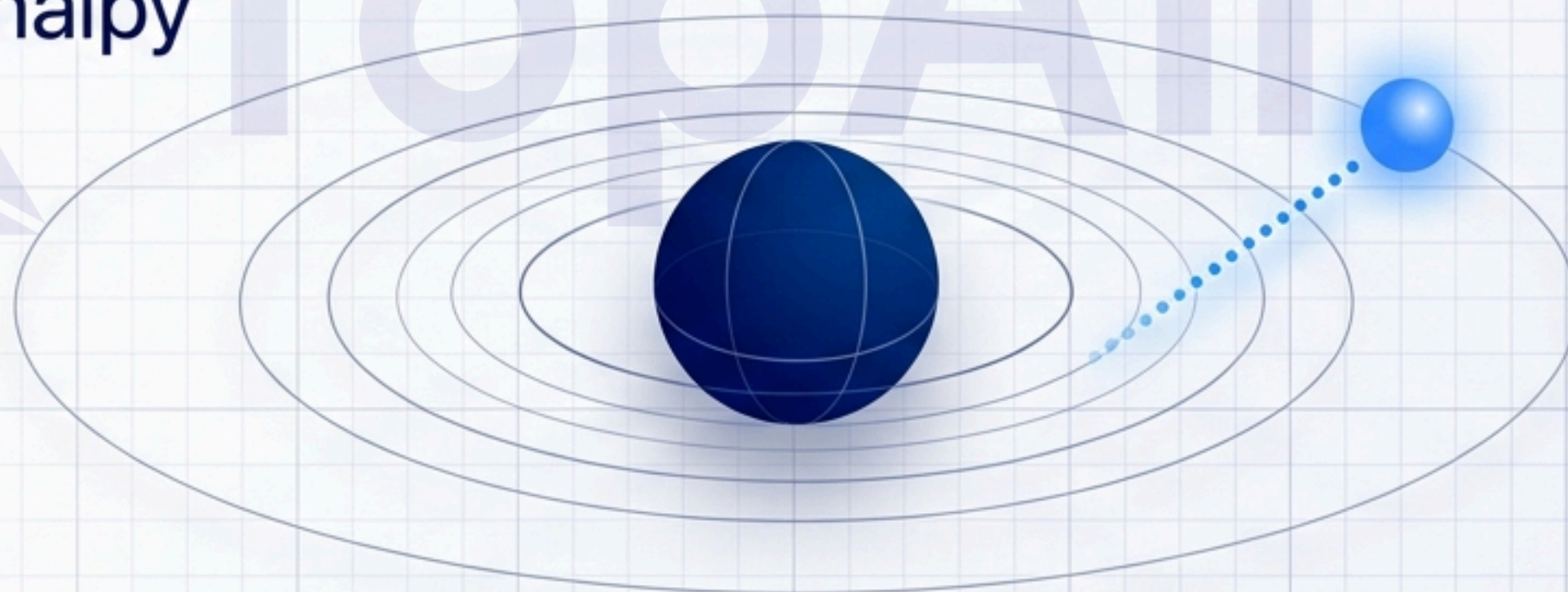


The Energy Needed to Remove an Electron

Concept 15: Ionization Enthalpy
($\Delta_i H$)



Defining Ionization Enthalpy

The precise conditions required to measure electron removal.

Ionization Enthalpy is the minimum energy required to remove the most loosely bound electron from an **isolated gaseous atom** in its **ground state**.

1. Isolated

No bonding interactions with other atoms.

2. Gaseous Atom

Measured in the standard gaseous state to negate intermolecular forces.

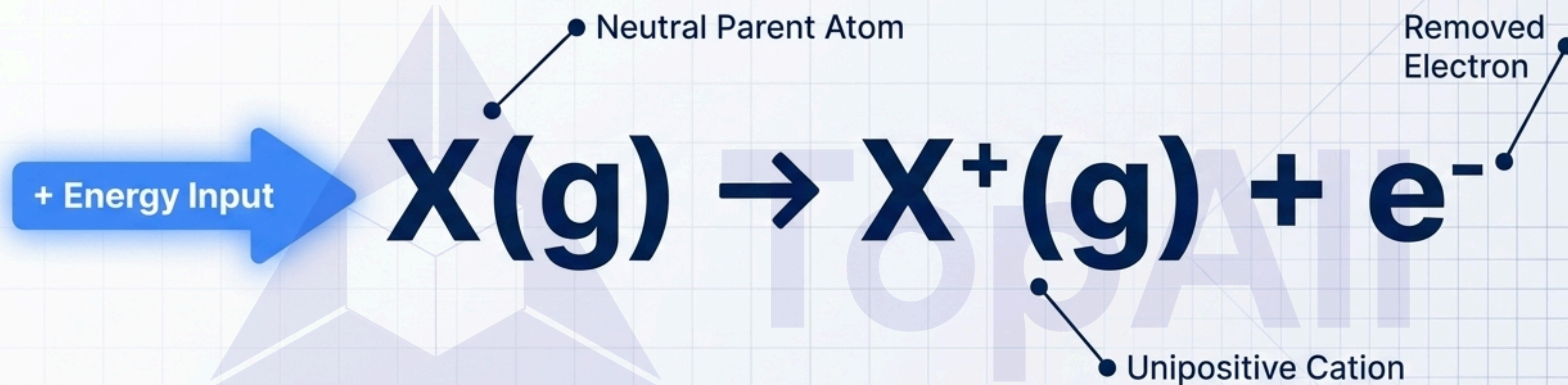
3. Ground State

The atom must be in its lowest energy, unexcited state.

Unit of Measurement: Expressed in kJ mol^{-1}

The Chemical Equation

First Ionization Enthalpy ($\Delta_i H_1$)



Key Thermodynamic Rule: Energy is ALWAYS required to remove electrons. Therefore, $\Delta_i H$ is ALWAYS POSITIVE (Endothermic).



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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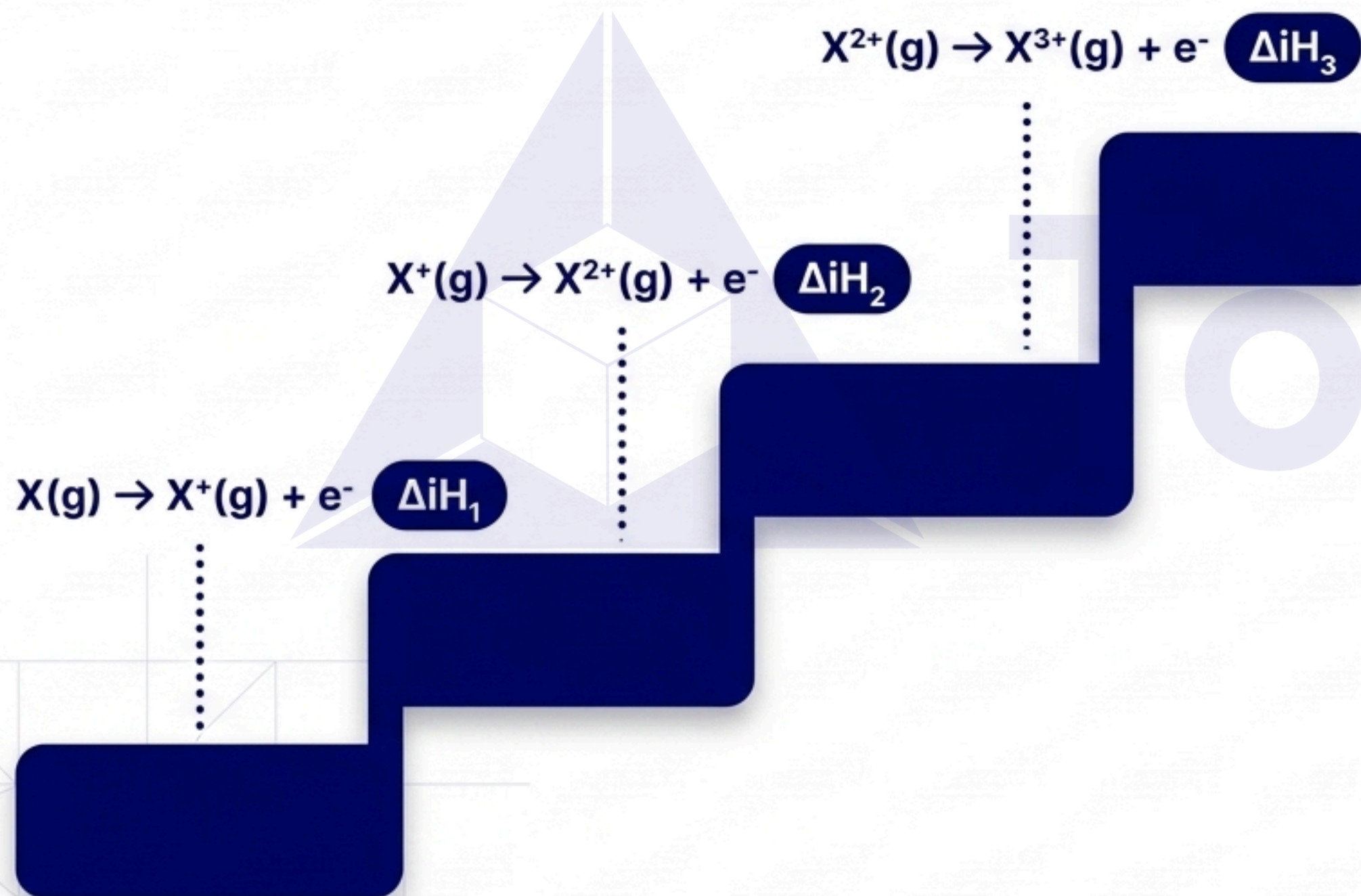
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Successive Ionizations

Removing the second and third electrons.

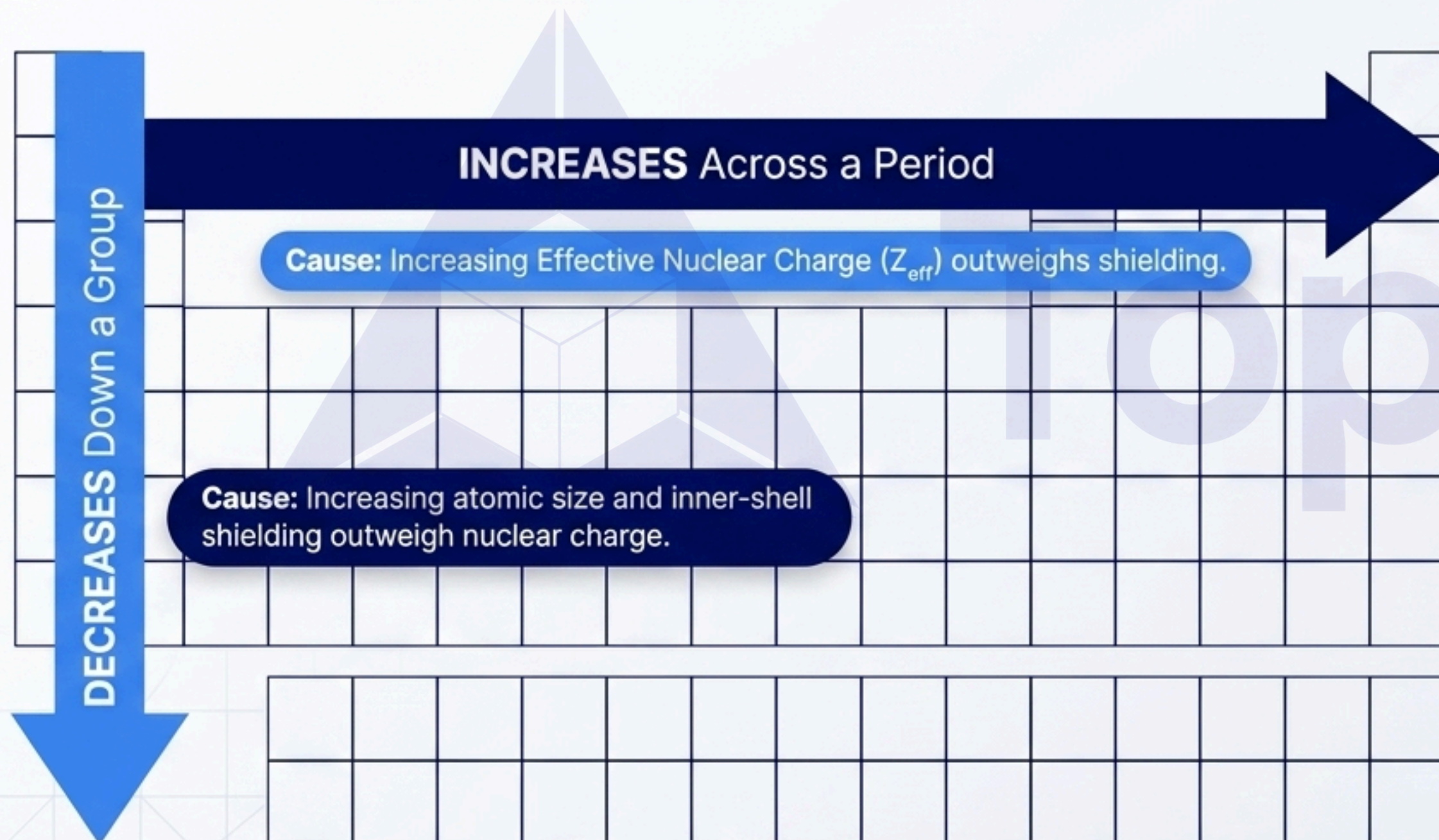


The Universal Rule:
 $\Delta iH_1 < \Delta iH_2 < \Delta iH_3$

Why? It is increasingly difficult to remove a negative electron from an increasingly positive ion due to greater electrostatic attraction.

Macro Trends in the Periodic Table

How Ionization Enthalpy changes across periods and groups.



Absolute Highest:
Noble Gases
 (Highly stable closed shells).

Absolute Lowest:
Alkali Metals
 (Highly reactive, eager to lose $1 e^-$).

Exception 1: Beryllium (Be) vs. Boron (B)

The Penetration Effect (Group 2 vs. Group 13)

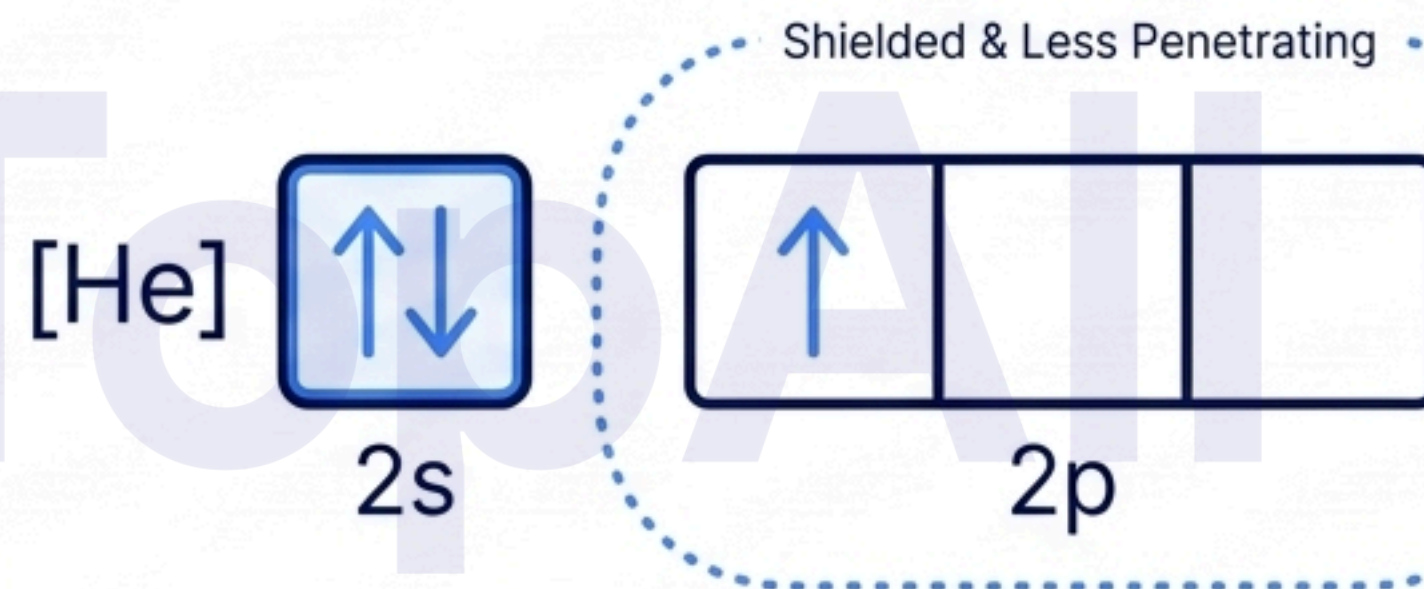
JEE EXCEPTION ALERT



Beryllium ($Z=4$)



Boron ($Z=5$)



Result: $\text{Be} > \text{B}$. An s-electron is more penetrating and tightly bound to the nucleus than a p-electron. It is therefore easier to remove the shielded 2p electron from Boron.

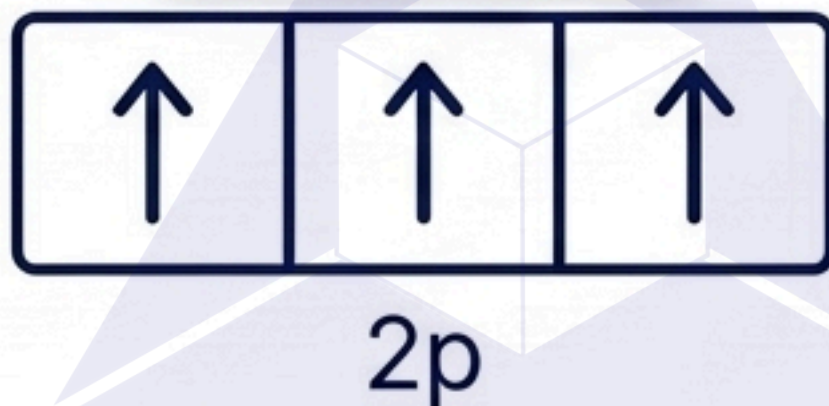
Exception 2: Nitrogen (N) vs. Oxygen (O)

JEE EXCEPTION ALERT

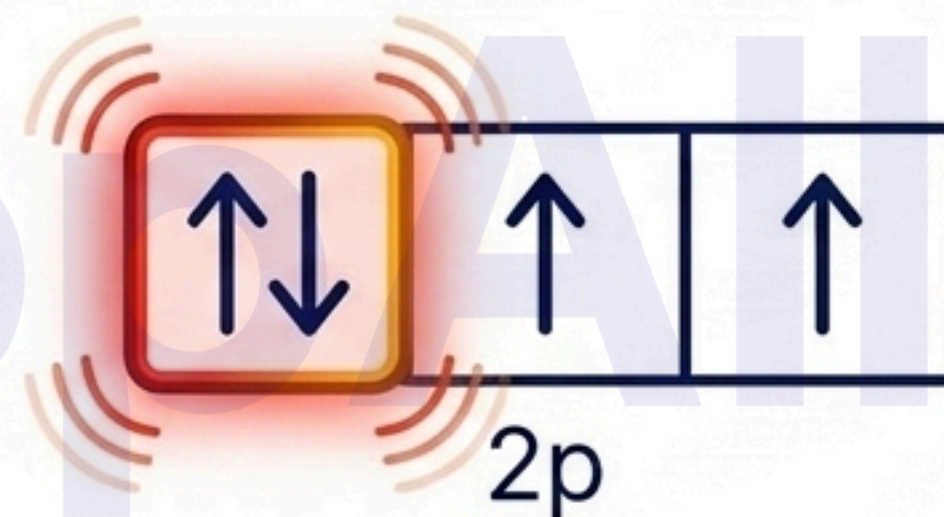
The Repulsion Effect (Group 15 vs. Group 16)

Nitrogen ($Z=7$)

Half-filled Stability



Oxygen ($Z=8$)



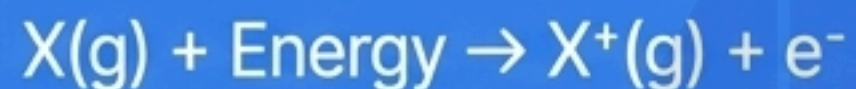
Result: $N > O$. Oxygen has paired electrons in a 2p orbital causing e^-e^- repulsion, making it easier to remove the 4th electron compared to Nitrogen's perfectly symmetric half-filled orbitals.

JEE Revision Card: Ionization Enthalpy

Snapshot Summary



The Core Formula



Constraint: Always endothermic (positive value).
Units: kJ/mol.

Successive IE Rule

$$IE_1 < IE_2 < IE_3$$

Note: It is strictly harder to remove negative electrons from increasingly positive cations.

Macro Trends

Across period: $\uparrow$ Increases (Driven by Z_{eff}).

Down group: $\downarrow$ Decreases (Driven by size & shielding).

The Famous Exceptions

Period 2 True Sequence:





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