

How Hard Is It to Remove an Electron?

A visual guide to **Ionization Enthalpy**, periodic trends, and quantum anomalies.

Defining First Ionization Enthalpy ($\Delta_i H$)

The energy required to remove an electron from an isolated gaseous atom in its ground state.



Isolated Gaseous Atom

Prevents inter-atomic forces from affecting the energy measurement.



Ground State

The lowest, most stable energy level of the atom.



Energy Required

Always an endothermic process (Positive $\Delta_i H$).
Measured in kJ mol^{-1} .

The First Ionization Equation



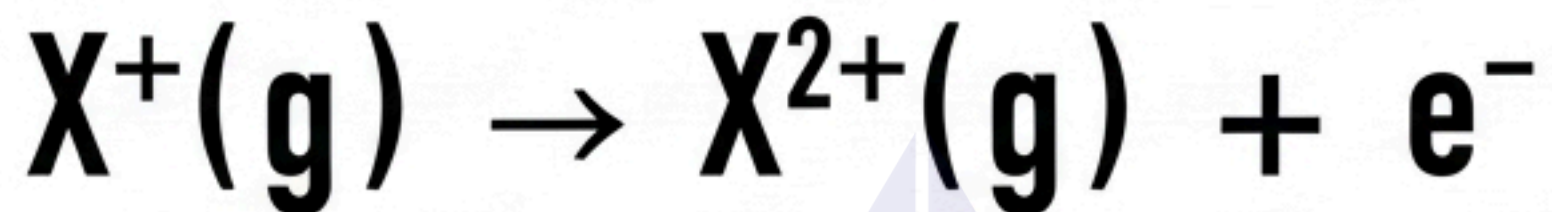
Neutral atom strictly
in the gas phase.

Formation of a
positive cation.

The most loosely
bound valence
electron is ejected.

Core Principle: This process always requires an input of energy to overcome the attractive force of the positive nucleus.

Removing the Second Electron



Why is $\Delta_i H_2 > \Delta_i H_1$?

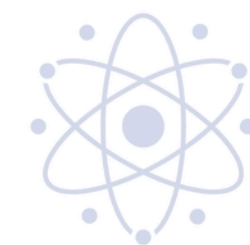
- ✓ The second electron is being removed from a positively charged ion, not a neutral atom.
- ✓ The remaining electrons face less electron-electron repulsion.
- ✓ The effective nuclear charge pulls the remaining electrons closer and tighter.

Result: It is significantly harder (requires more energy) to remove the second electron than the first.



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

$$E=mc^2$$



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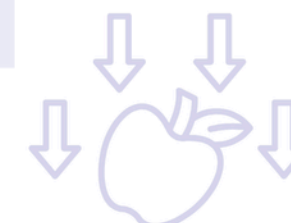
Practice Now



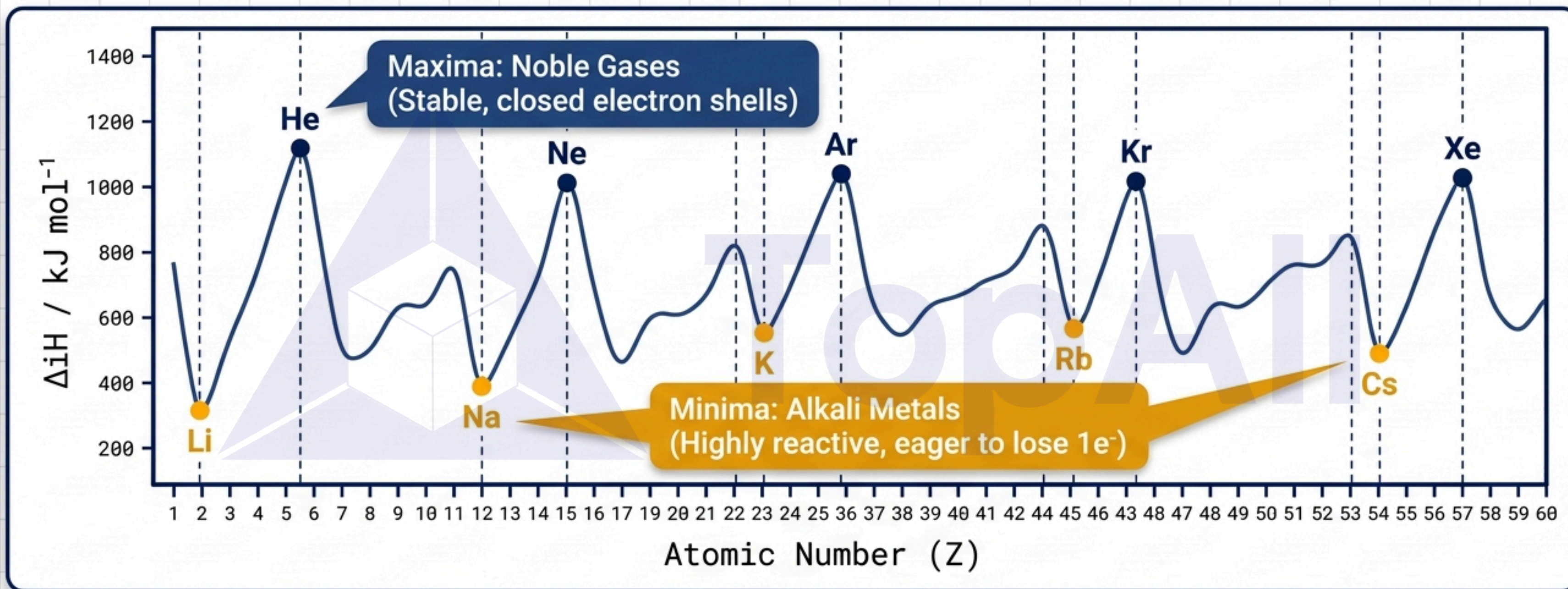
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Key Highlights

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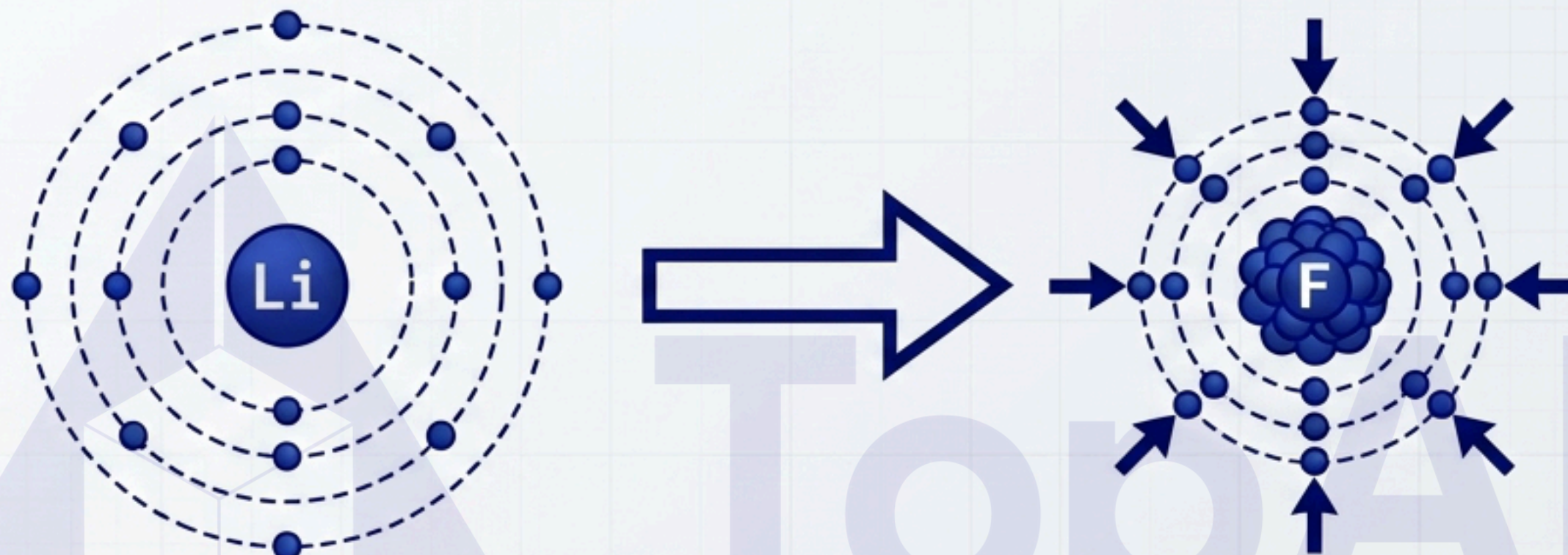


The Periodic Rhythm of Elements



A striking periodic pattern reveals that electron configuration dictates chemical stability and reactivity.

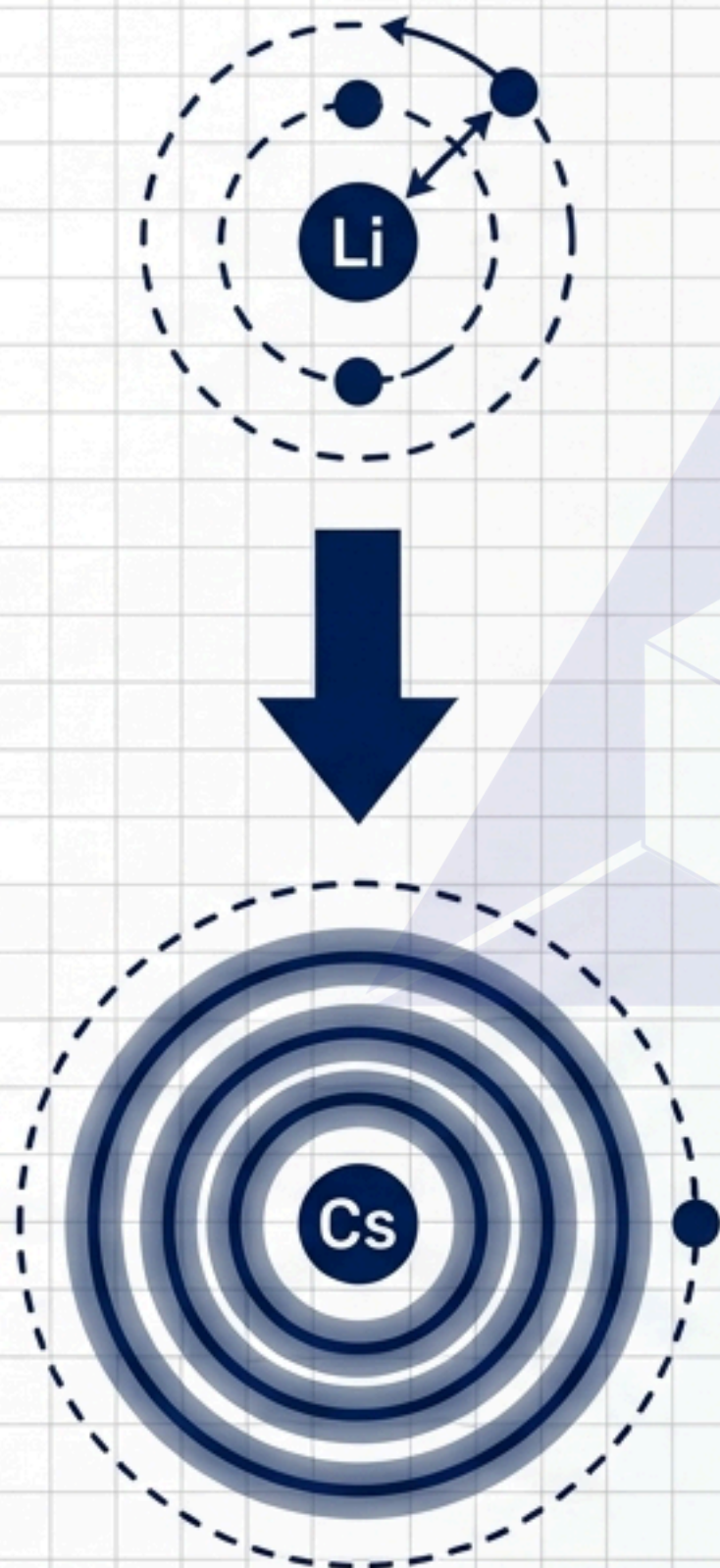
Across a Period: Ionization Enthalpy **INCREASES**



1. **Nuclear Charge Increases:** More protons are added to the nucleus, increasing the positive pull.
2. **Shielding Remains Constant:** Electrons are added to the same principal valence shell (n). Inner core electrons do not increase, offering no extra shielding.

Outermost electrons are held more tightly → Atomic radius shrinks → Harder to remove an electron.

Down a Group: Ionization Enthalpy **DECREASES**



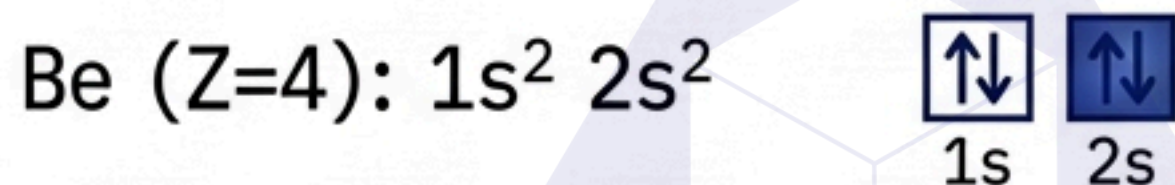
- 1. Distance Increases:** The outermost electron enters a new, higher principal quantum level (n_n). It is physically further from the nucleus.
- 2. Increased Shielding:** Inner energy levels are filled with core electrons that **shield the valence electron** from the nuclear pull.

Increased distance and shielding completely outweigh the increased nuclear charge → Easier to remove an electron

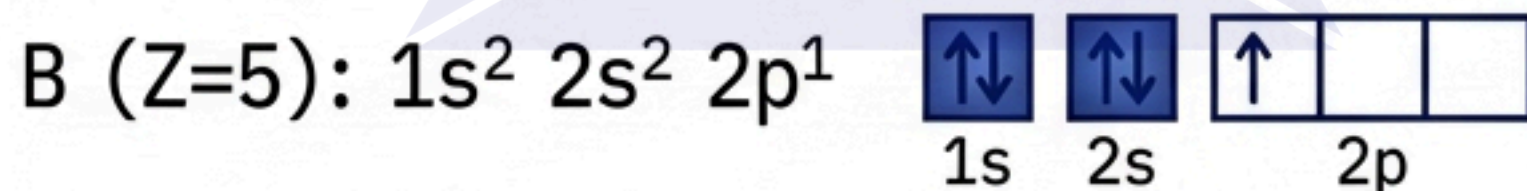
The Rule-Breakers (Period 2 Anomalies)

Sometimes, increasing Z across a period results in a drop in $\Delta_i H$.
Why? Quantum stability.

Beryllium vs. Boron



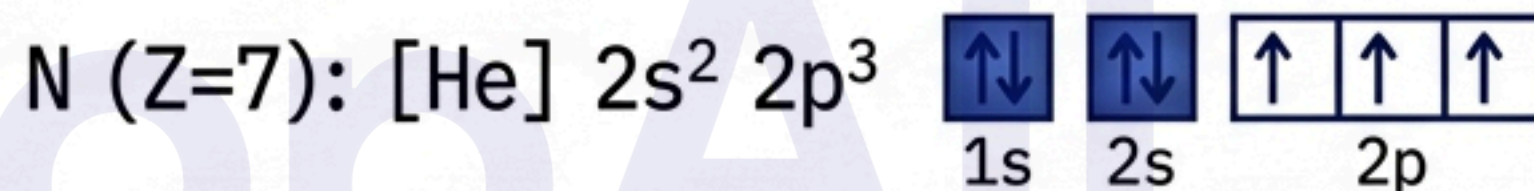
Stable, harder to remove.



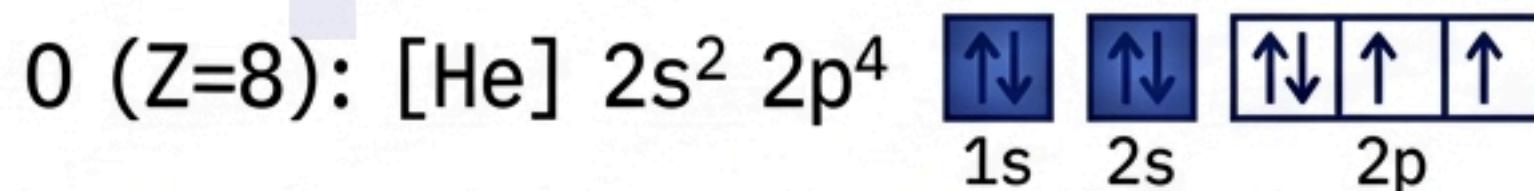
2p is less penetrating and more shielded than 2s. Easier to remove.

$$\Delta_i H(B) < \Delta_i H(Be)$$

Nitrogen vs. Oxygen



Exactly half-filled 2p is highly stable.



Increased electron-electron repulsion makes it easier to eject the 4th electron.

$$\Delta_i H(O) < \Delta_i H(N)$$

Summary & Key Takeaways

Definitions

- ✓ **Ionization Enthalpy (ΔiH):** Energy to remove an electron from a neutral, isolated gas atom. The process is **endothermic**.
- ✓ **Always Positive:** Removing electrons is **endothermic**.
- ✓ **Successive Energy:** ΔiH_2 is always greater than ΔiH_1 .

Macro Trends

- ✓ **Across a Period:** ΔiH Increases. Driven by higher **effective nuclear charge** with constant shielding.
- ✓ **Down a Group:** ΔiH Decreases. Driven by higher **n levels**, increased atomic distance, and core shielding.

Quantum Exceptions

- ✓ **Be > B:** A single 2p electron in Boron is **easier to remove** than the stable 2s pair in Beryllium.
- ✓ **N > O:** Electron repulsion in Oxygen's 2p⁴ makes it **easier to remove** than Nitrogen's stable, **half-filled** 2p³.



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