N17 – Atomic Structure and Periodicity

Shielding and Such

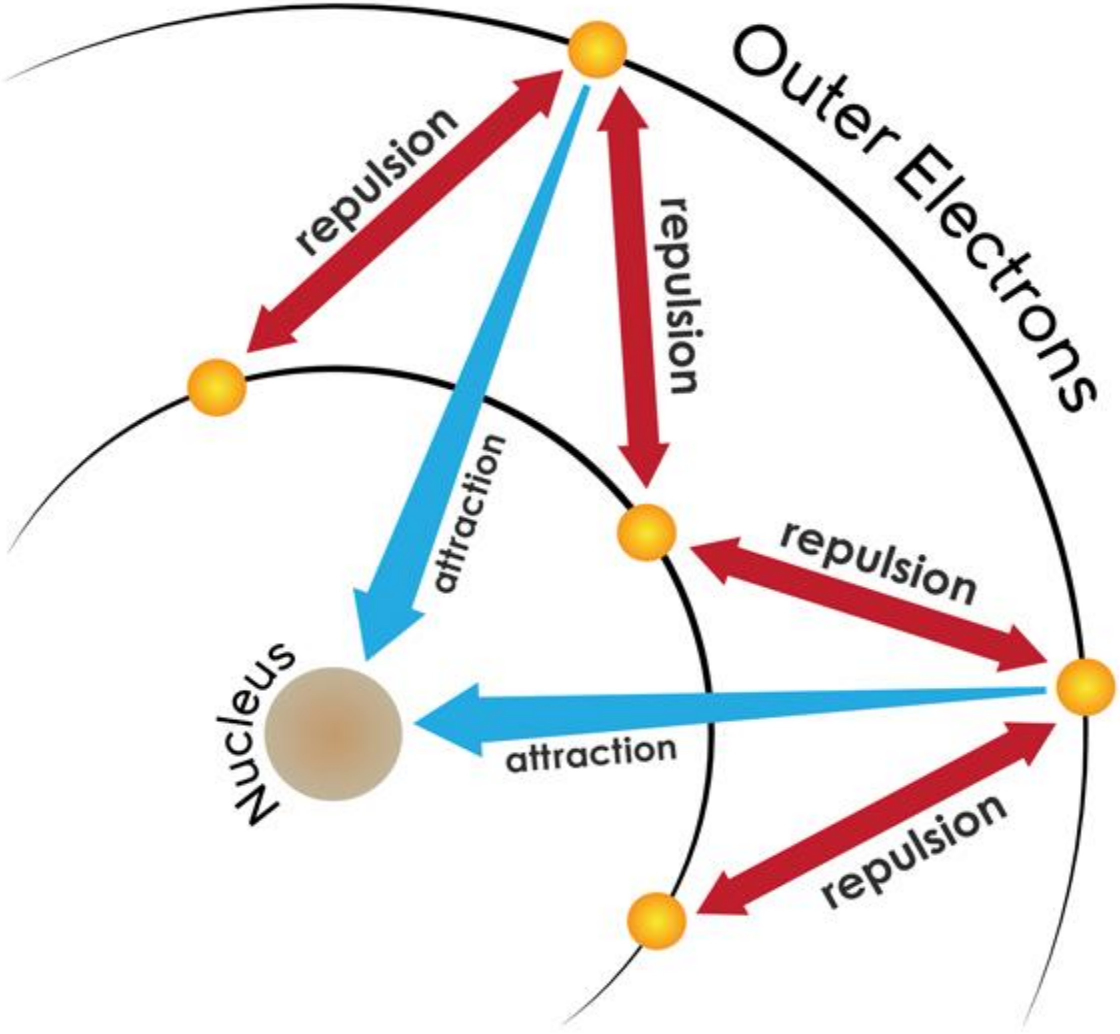
Link to YouTube Presentation: https://youtu.be/paSLdnz8rE0

N17 – Atomic Structure and Periodicity

Shielding and Such

Target: I can keep nuclear attractions and electron repulsions in mind when explaining periodic trends.

EVERYTHING is about…



ATTRACTIONS

- Electrons attracted to protons in the nucleus

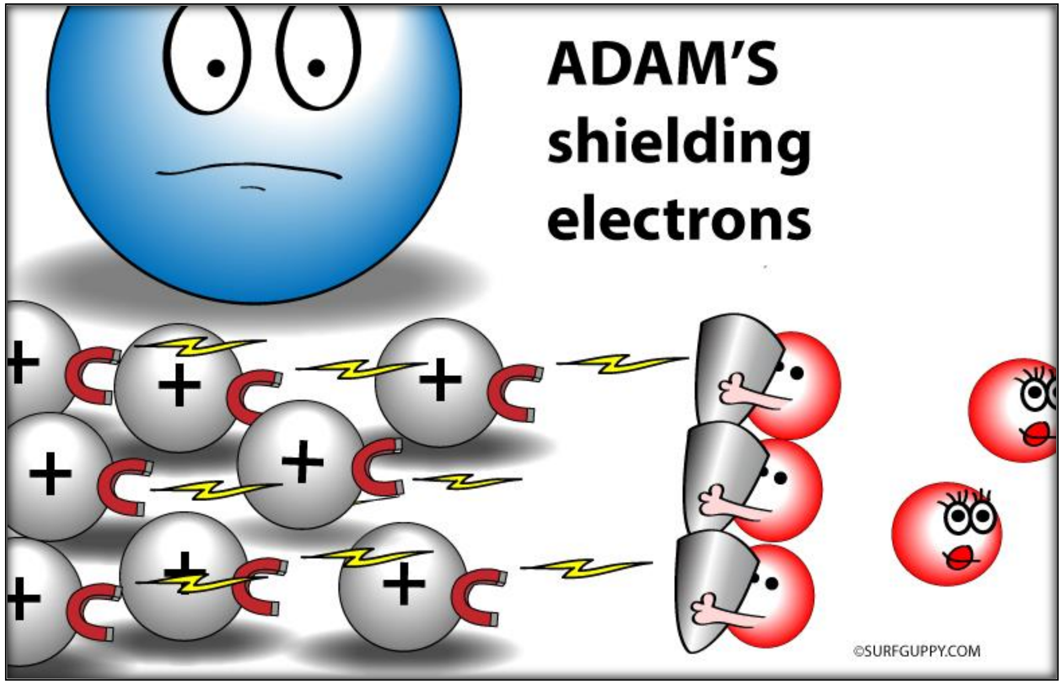
REPULSIONS

- Electrons repelled by each other

Shielding

Outer electrons are shielded from nucleus by the core electrons.

- Shielding effect
- Outer electrons do *not* effectively screen for *each other*.



Shielding causes outer electrons to not experience the full strength of the nuclear charge.

- The electrons would be more attracted to the nucleus if the core electrons were not there!

Effective Nuclear Charge

The effective nuclear charge is a net positive charge that is attracting a particular electron.

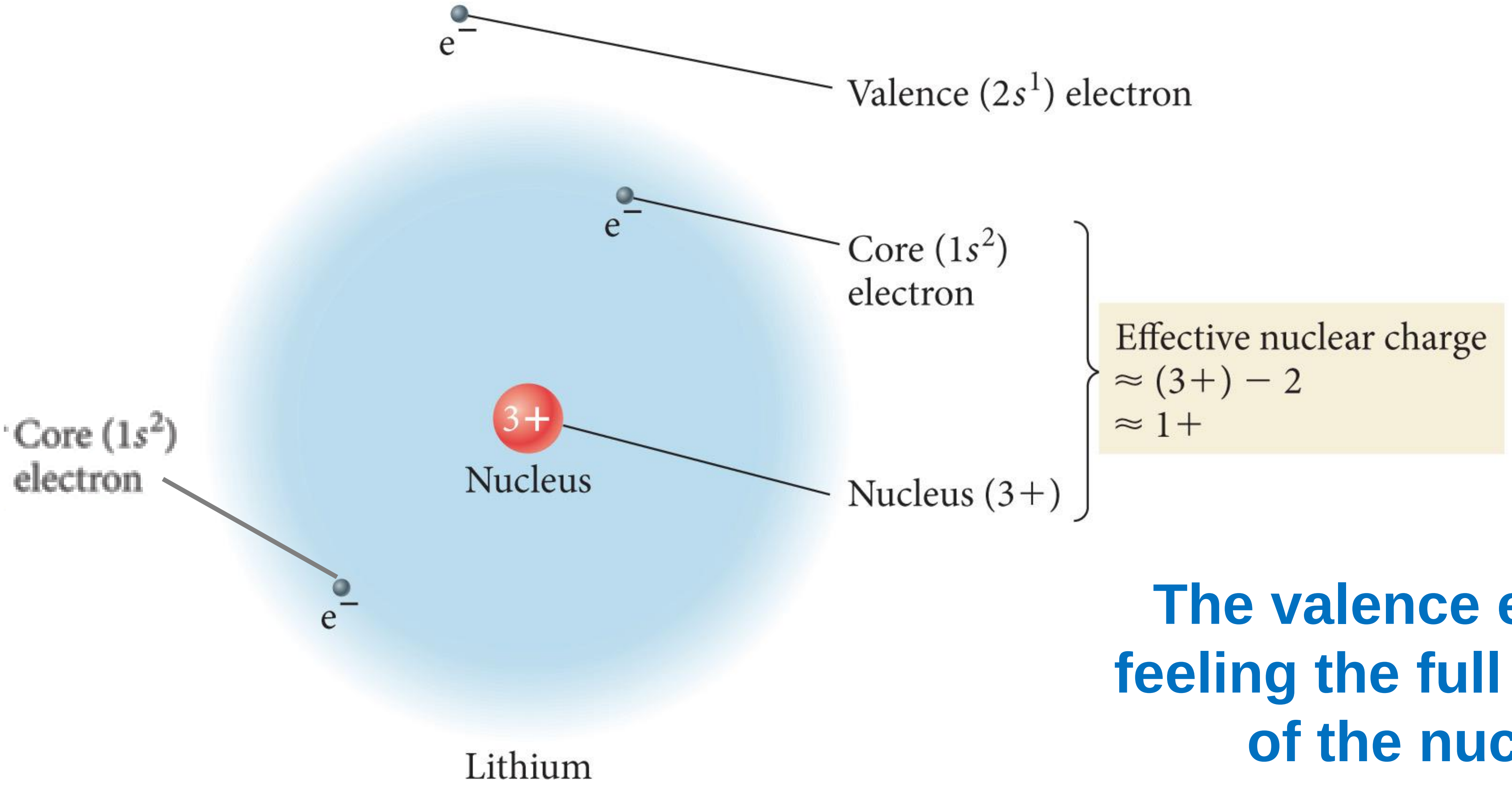
$$Z_{effective} = Z - S$$

Z = nuclear charge
S = number of electrons in lower energy levels.

Electrons in the same energy level contribute to screening but their contribution is so small they are not part of the calculation.

Trend in Shielding strength: *s > p > d > f.*

Effective Nuclear Charge

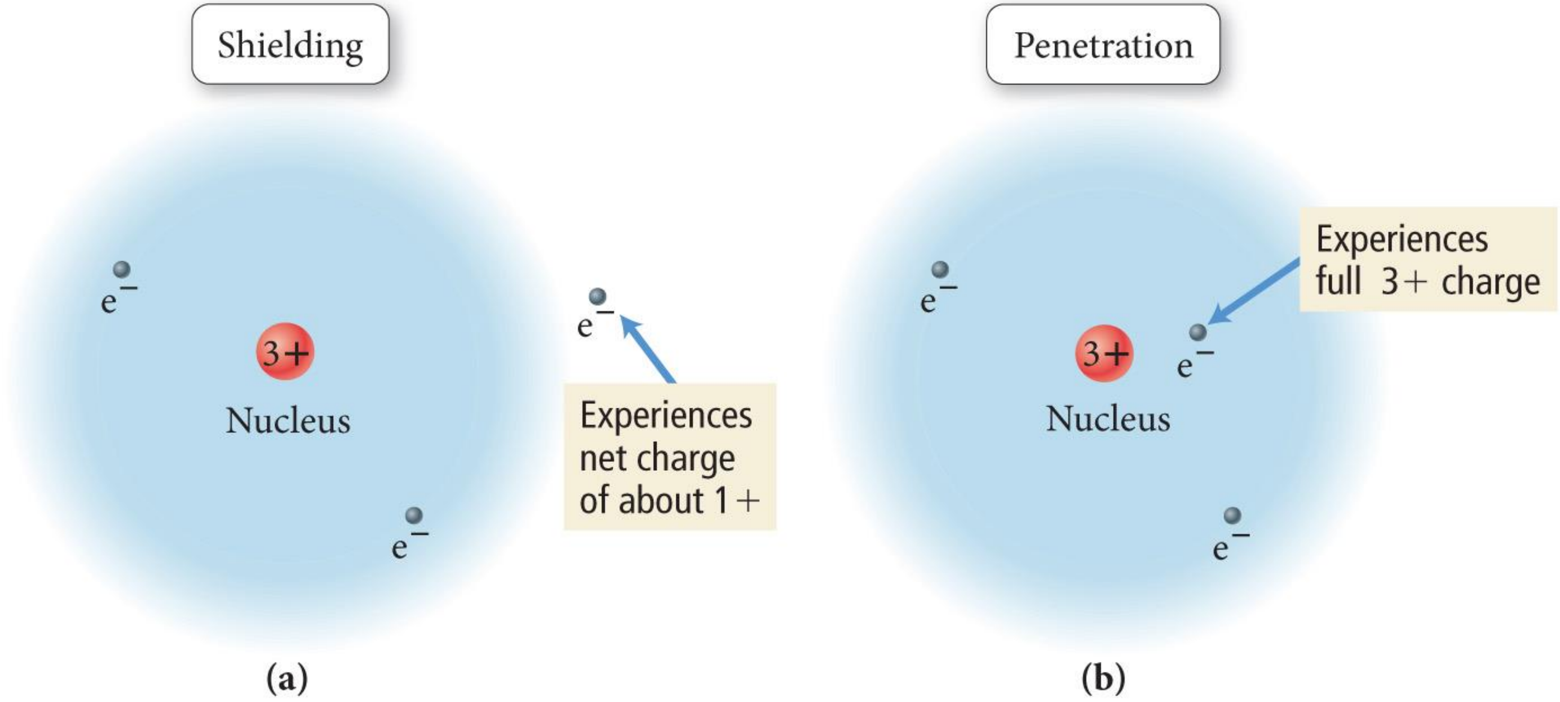


The valence e- is NOT feeling the full +3 charge of the nucleus!

Penetration

Penetration is when an electron spends time closer to the nucleus than it's outer boundary distance.

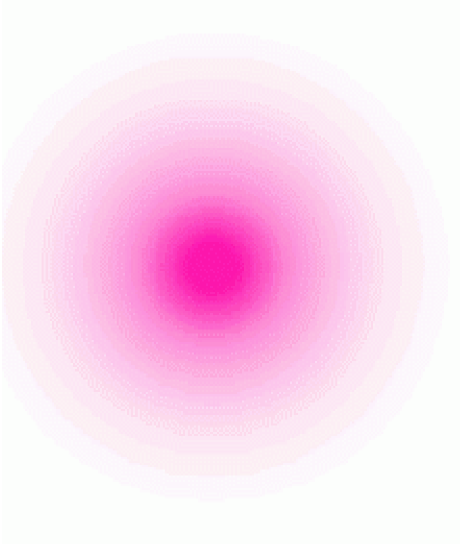
- Remember - there are different orbital shapes
- Some will have some electron density in closer to the nucleus than others

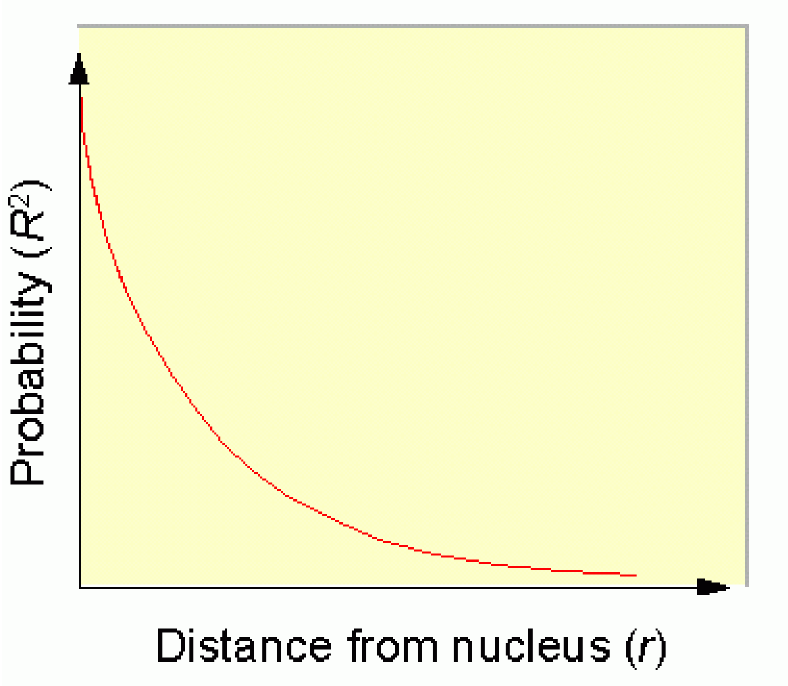


Remember…

An orbital **is a region within an atom where there is a *probability* of finding an electron. Orbital shapes are defined as the surface that contains 90% of the total electron probability.**

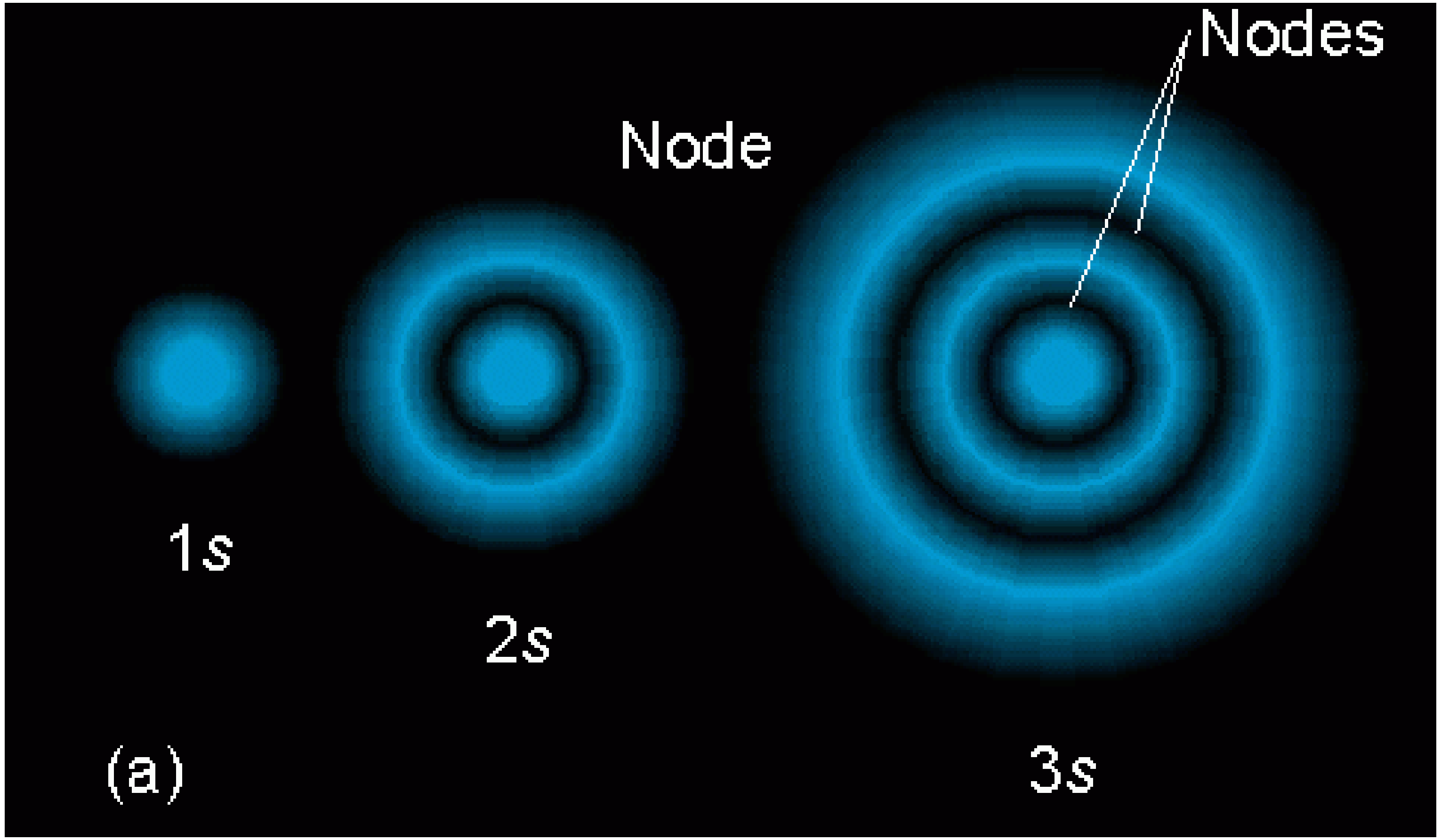
This is a probability diagram for the s orbital in the the first energy level…





s Orbitals – not just a solid sphere!

s orbitals have areas of low probability inside them called nodes.



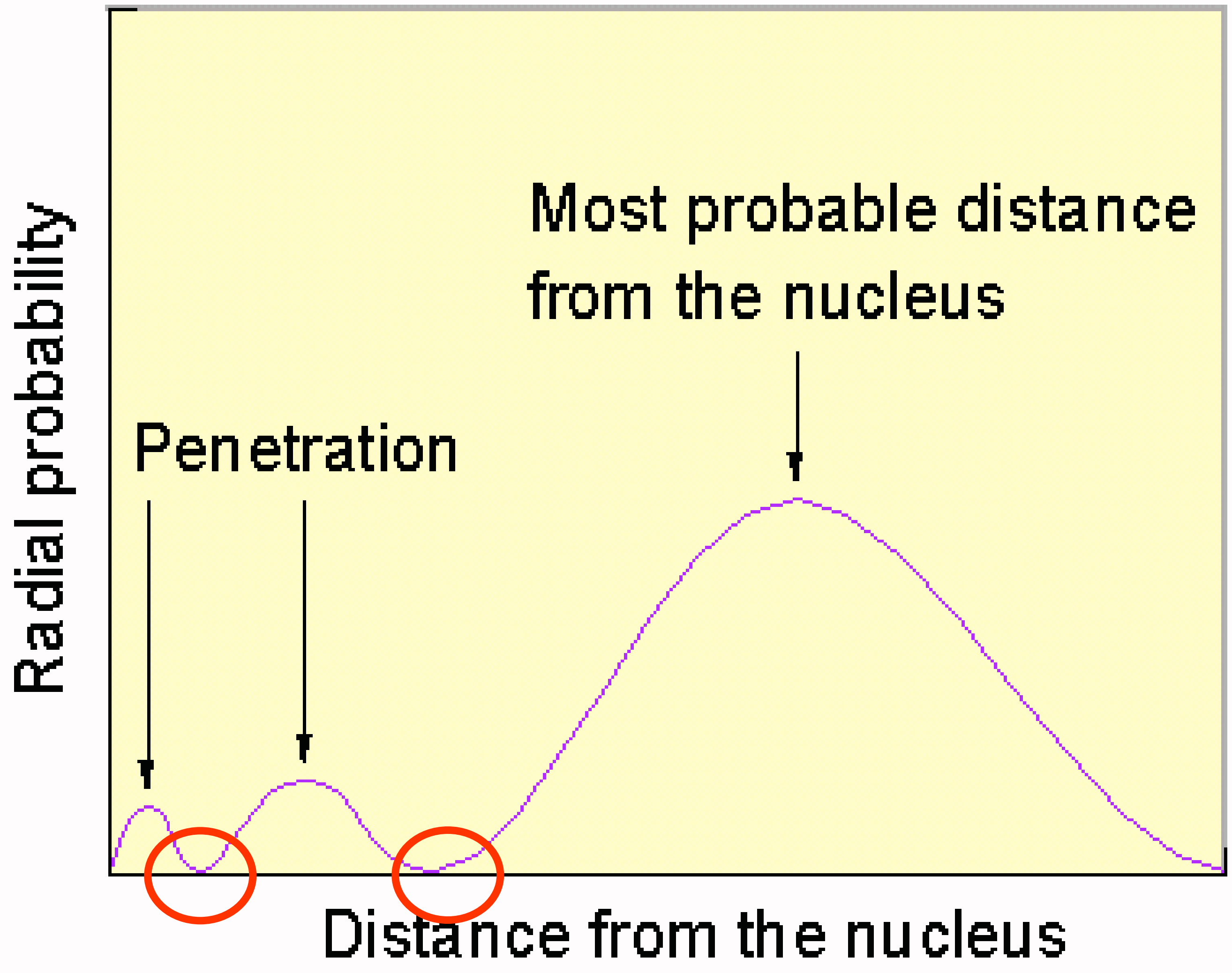
Penetration

Even larger s orbitals have some electron density near the nucleus!

Which s orbital is this?

3s orbital

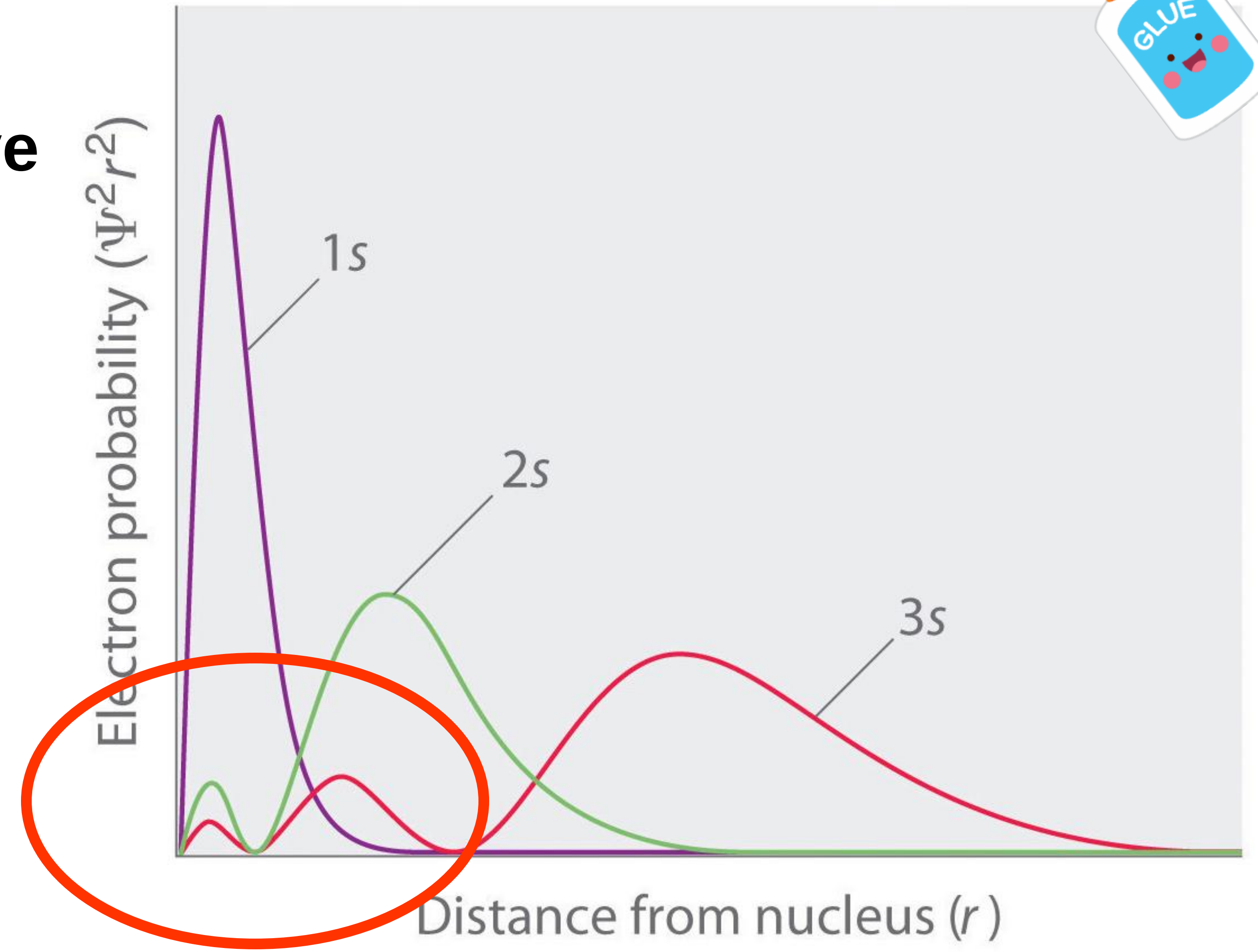
What parts correspond to the "nodes" – areas with zero probability?



Penetration

Even larger s orbitals have some electron density near the nucleus!

Penetration of the 2s electrons and the 3s electrons!



(c) Radial probability

Penetration

The closer an electron is to the nucleus, the more attraction it experiences.

The better an outer electron is at penetrating through the electron cloud of inner electrons, the more attraction it will have for the nucleus.

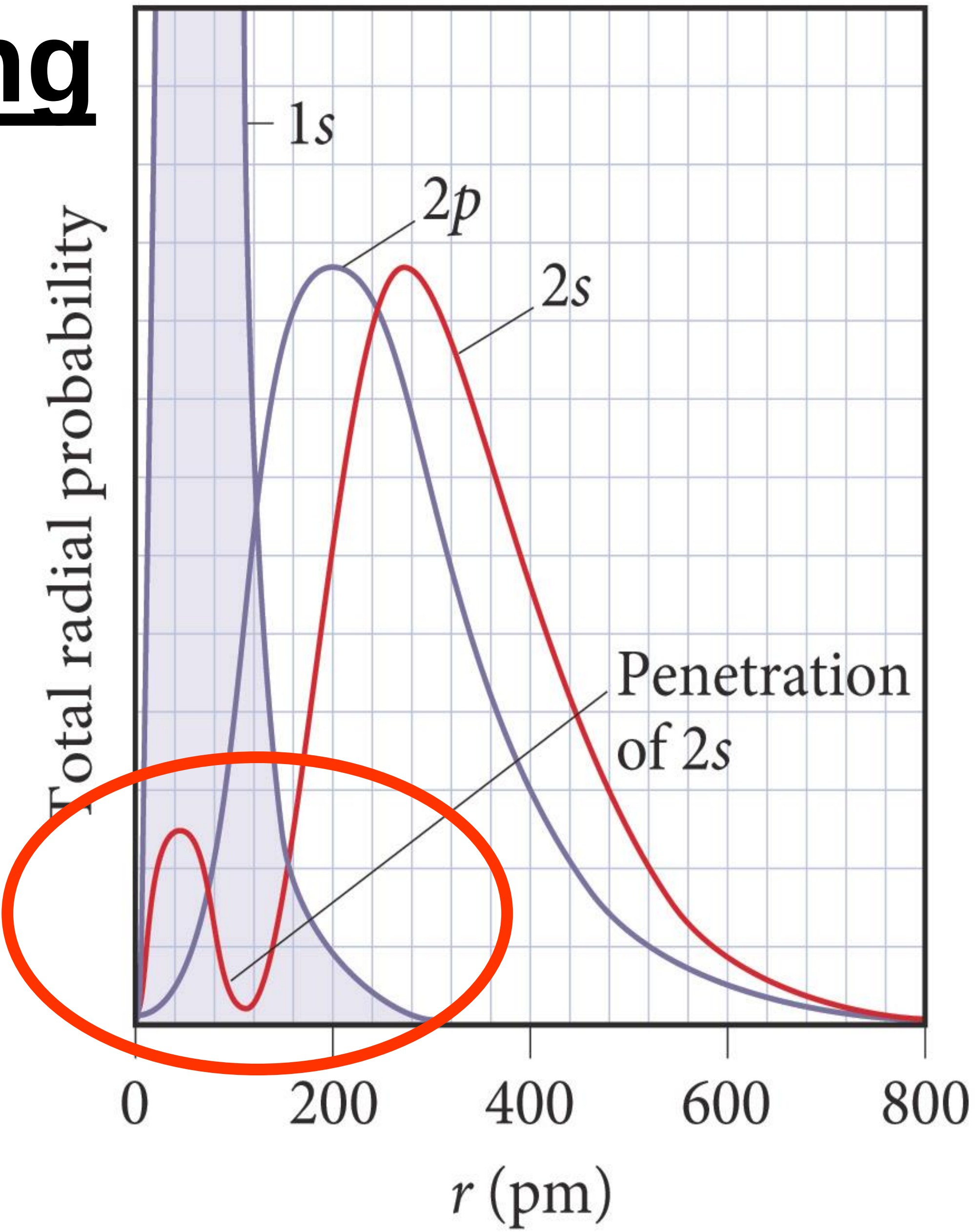
The degree of penetration is related to the orbital's "radial distribution function" – tells us the probability of finding the electron at certain distances.

Penetration and Shielding

- **2s orbital – penetrates more deeply into the 1s orbital, towards the nucleus than the 2p orbital does**

- **The weaker penetration of the 2p orbital means the 2p electrons experience LESS attractive force from the nucleus. They are more shielded from the nucleus.**

- **The greater penetration of the 2s means electrons in the 2s orbital experience MORE attractive force from the nucleus. They are less shielded from the nucleus.**



Penetration, Attraction, Shielding

Penetration towards the nucleus:

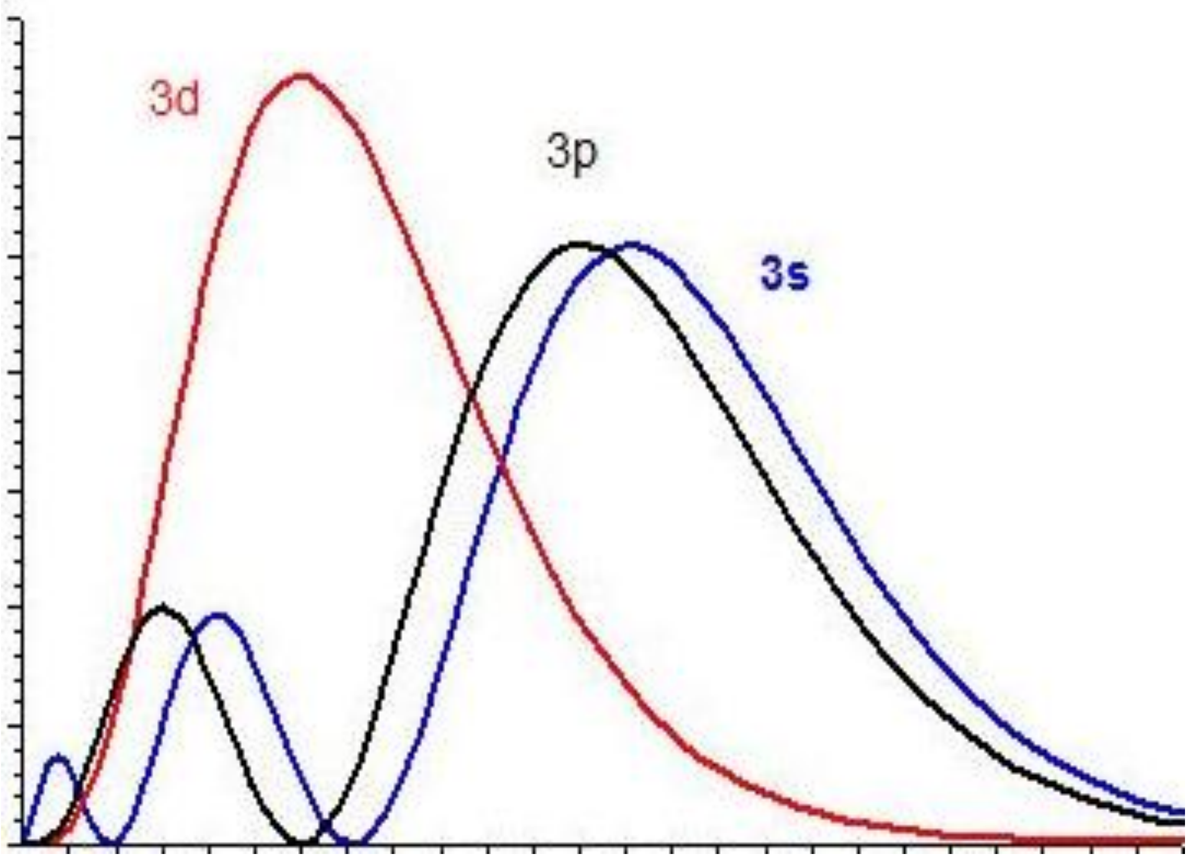
s > p > d > f

Attraction for nucleus:

s > p > d > f

Shielding they contribute for valence electrons:

s > p > d > f



Careful…

You need to be VERY careful with your phrasing!

Do not use generic or nonspecific terms – be specific.

BAD: It is shielded more

BETTER: Calcium's valence electrons experience more shielding

You MUST reference BOTH atoms being compared.

BAD: Calcium's valence electrons experience more shielding

BETTER: Calcium's valence electrons experience more shielding than Sodium's valence electrons

Careful…

You need to be VERY careful with your phrasing!

You MUST give REASONS.

BAD: Calcium's valence electrons experience more shielding than Sodium's valence electrons

BEST! Calcium's valence electrons experience more shielding than Sodium's valence electrons, because Calcium's valence electrons are in energy level 4, while Sodium's are in energy level 3. Therefore, Calcium's valence electrons are shielded from 3 levels of core electrons, while sodium's are shielded from only 2 levels of core electrons.

Last few suggestions…

- **Be succinct!**
- **Do not ramble!**
- **Bullet points are your friend!**
- **Keep the grading rubric in mind – what key things are we looking to check off that you addressed????**
  - **Attraction to the nucleus**
  - **Repulsions between the electrons**
- **Do not vocab drop!**
  - **Can't just say "shielding" or "effective nuclear charge"**
- **Read as many AP Chem rubrics as possible for this topic! Internalize their phrasing (not necessarily "memorize")**

Why care about shielding & penetration?

Helps explain periodic trends!

- Z_{eff}
- **Radius, Ionization energy, Electronegativity**
- **A lot of "exceptions" to the periodic trends patterns that we glossed over in Honors Chem**

Link to YouTube Presentations

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