PHYSICAL PERIODICITY

- predicting physical properties of atoms

impacts

NUCLEAR ATTRACTION

Nuclear attraction: net electrostatic forces of attraction between nucleus and electrons

1. Nuclear charge: total charge of all the protons in the nucleus

Nuclear charge ↑, nuclear attraction ↑

Increase in protons = increase in nuclear charge
- ↑ across period
- ↑ down a group

1. Shielding effect: reduction in the nuclear attraction due to the offset of nuclear charge by the inner-shell/inner principal quantum shell

Shielding effect ↑, nuclear attraction ↓

Shell with more electrons = greater shielding effect
- Constant Across period (same shell)
- ↑ Down a group

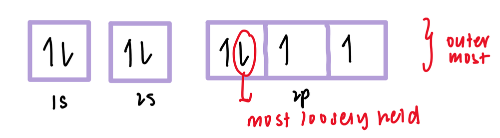
3. Distance of electrons from nucleus

Distance from nucleus ↑, nuclear attraction ↓

- Distance of outermost electrons from nucleus depends on the number of occupied principal quantum shells
  - same across a period
  - ↑ down a group

TYPES OF e^-

Outermost electrons -> atomic radius
Most loosely held electrons -> ionization energy
Bonding electrons -> electronegativity



ATOMIC RADIUS

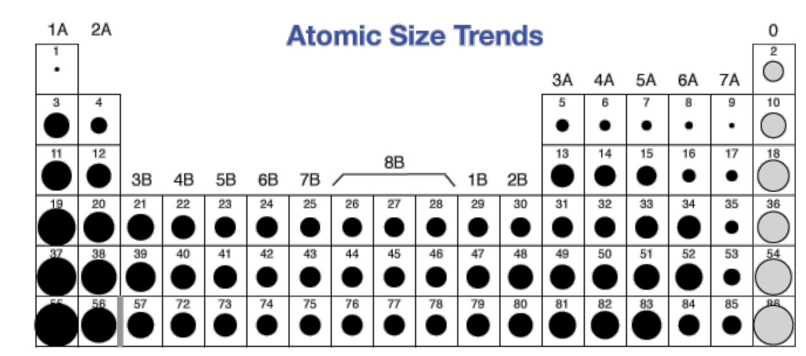
○ weak nuclear attraction

○ strong nuclear attraction

How far the outermost electrons are found from the nucleus of an atom

→
nuclear charge ↑
shielding effect & distance —
nuclear att ↑

↓
nuclear charge ↑
shielding effect ↑
distance ↑
nuclear attraction ↓



IONIC RADIUS

ionic size (Na^+) (P^-)

atomic size (Na) (P)

cations / anions across a period
nuclear attraction ↑
shielding effect —
distance —
nuclear attraction ↑

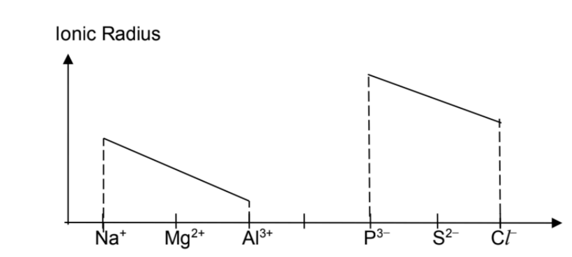
ionic radius ↓

anions > cations in the same period
nuclear attraction:
anions < cations

distance / shielding effect:
cations < anions

ionic radii
anions > cations

** ionic radius focuses on amount of protons if isoelectric



_ have the same electric configuration of _. There is an increase in nuclear charge from _ to _. Shielding effect is relatively constant for these cations/anions with the same number of inner-shell electrons. Nuclear attraction increases across the isoelectronic series, resulting in outermost electrons being increasingly more tightly held by the nucleus, hence the smaller ionic radius.

IONISATION ENERGY

Higher nuclear attraction = higher IE (more energy required to lose an electron)

Ionisation: process that involves the addition or removal of an electron to form an ion
Ionisation energy: amount of energy needed to overcome the electrostatic forces of attraction between electron and the nucleus

Across a period ↑, nuclear attraction ↓

1st I.E: amount of energy required to remove 1 mole of the most loosely held electrons from one mole of gaseous atoms to form one mole of gaseous single-charged cations
- Atoms must be in gaseous state as atoms have minimal interactions with one another. The energy input would contribute only to removing the electron and overcoming other bonds.
- All atoms have first ionisation energies (if anion then more is needed)
- Each new inner quantum shell you extract an electron from requires a HUGE jump in energy

have to write
↳ 1st ionisation $Ca(g) \rightarrow Ca^+(g) + e^-$
2nd ionisation $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$

There is a big jump in energy seen between the ath and bth IE, implying that the bth electron to be removed belongs to an inner quantum shell. As there are a electrons in the outermost principal quantum shell, element X belongs to group _.

Successive IE trend

General increase in successive as it becomes increasingly difficult to remove an electron from an increasingly positively charged species
- Remove more electrons = total number of electrons decreases (nuclear charge remains the same)
- Stronger nuclear attraction for electrons

- Large jumps are due to electrons being removed from an inner principal quantum shell

Each IE graph shifts right by 1 unit.

ELECTRONEGATIVITY

The tendency of an atom of that element to attract the bonding electrons into a covalent bond

- Nuclear charge increases
  - More protons
  - Increase in inner-shell electrons, found further from the

Decreases down a group

- Nuclear charge increases
  - More protons
  - Increase in inner-shell electrons, found further from the nucleus and experience a greater shielding effect
  - Outweighs nuclear charge

Increases across a period

- Nuclear charge increases
  - More protons
  - Similar distance away and experience similar shielding effect

Electrons closer to the nucleus:
- more strongly attached
- Lower energy = Greater stability

ANOMALIES

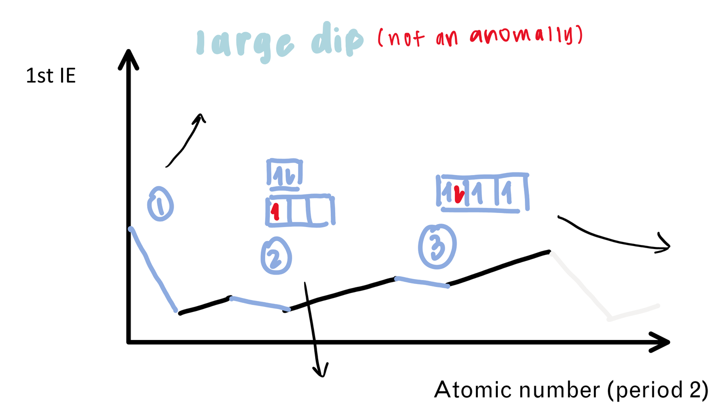
- Works for any IE
- Works for any period

The most loosely held electron are removed from principal quantum shell 2 for Na+ but principal quantum shell 3 for Mg+.

A lower amount of energy is required to remove the most loosely held electrons from an outermost principal quantum shell (drop from 3 to 2)

$Na^+(g) \rightarrow Na^{2+}(g) + e^-$
$1s^2 2s^2 2p^6$ $1s^2 2s^2 2p^5$
$Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$
$1s^2 2s^2 2p^6 3s^1$ $1s^2 2s^2 2p^6$

large dip (not an anomally)



$S^+(g) \rightarrow S^{2+}(g) + e^-$
$1s^2 2s^2 2p^6 3s^2 3p^3$ $1s^2 2s^2 2p^6 3s^2 3p^2$
$Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$
$1s^2 2s^2 2p^6 3s^2 3p^4$ $1s^2 2s^2 2p^6 3s^2 3p^3$

1) Electrons from where? The most loosely held electrons to be removed from singly filled 3p orbital and paired 3p orbital.
2) Outweigh? The inter-electron repulsion between the paired electrons in the same orbital out weights the effect of increasing nuclear charge, resulting in weaker nuclear attraction for the most loosely held e-, lower amount of energy is thus needed, giving chlorine a lower 2nd ionisation energy that that of sulfur.

Between elements 13 and 14, the most loosely held electrons to be removed from Al+ to Si+ are from 3s and 3p subshells respectively.

A lower amount of energy is needed to remove an electron from higher energy state 3p subshell as compared to 3s subshell (it is further). Hence, 2nd ionization energy of Si is lower than that of Al.

easier to remove as there is repulsion between ↿⇂

$Al^+(g) \rightarrow Al^{2+}(g) + e^-$
$1s^2 2s^2 2p^6 3s^2$ $1s^2 2s^2 2p^6 3s^1$
$Si^+(g) \rightarrow Si^{2+}(g) + e^-$
$1s^2 2s^2 2p^6 3s^2 3p^1$ $1s^2 2s^2 2p^6 3s^2$

Transition metals

- Nuclear charge increases due to the increase in the number of protons.
- The number of occupied principal quantum shells remains constant across a period.
- The most loosely held electrons are occupying orbitals from the same principal quantum shell. There is an increase in number of inner-shell electrons as electrons fill up the 3d subshell.
- Even though they are of similar distance away from the nucleus, they experience increasing shielding effect.
- As a result, nuclear attraction remain approximately constant and similar amount of energy is required to remove the most loosely held electrons.
- Hence, the first ionization energies remain generally constant from scandium to copper.