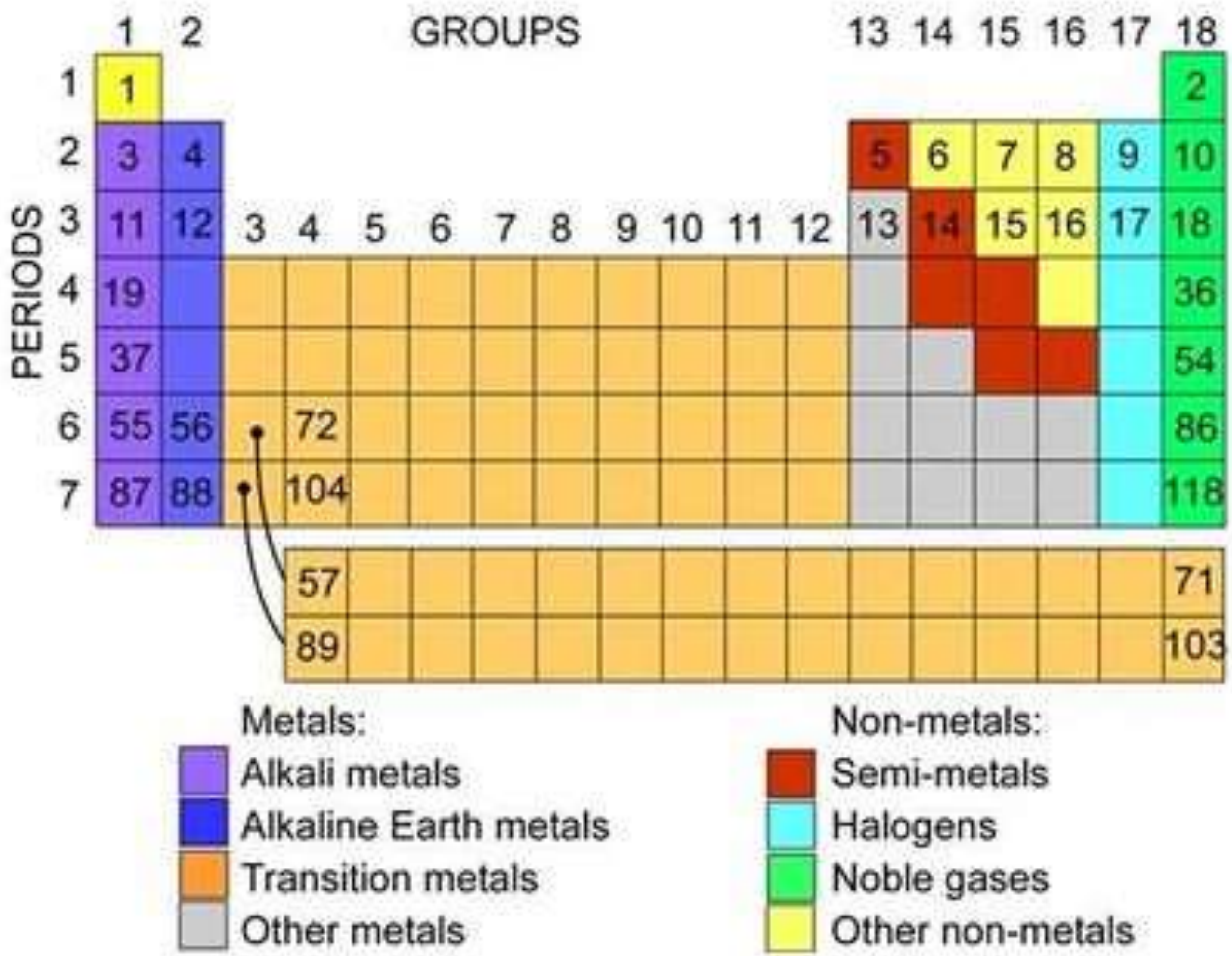
PERIODIC TRENDS

PERIODIC TRENDS

Recall: Periodic Law

- Elements are arranged in order of increasing atomic number
- Elements with similar properties occur at regular intervals

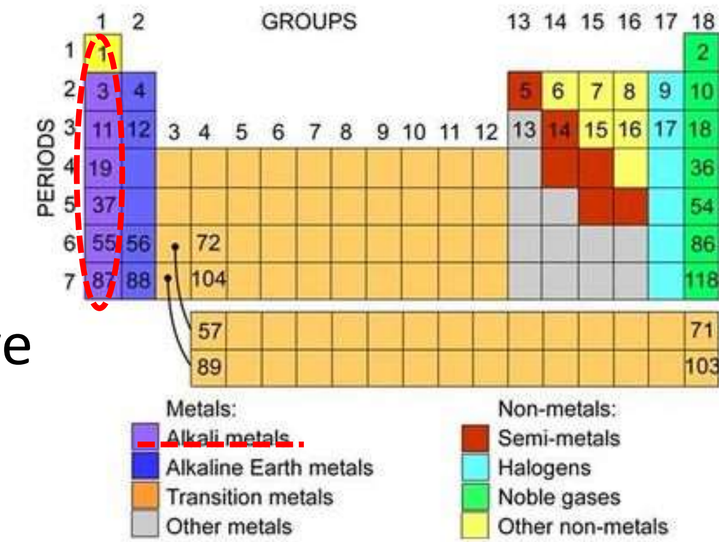


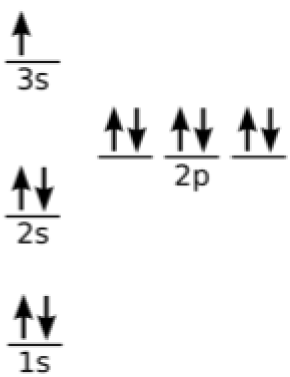
PERIODIC TRENDS

Recall: Groups in the periodic table

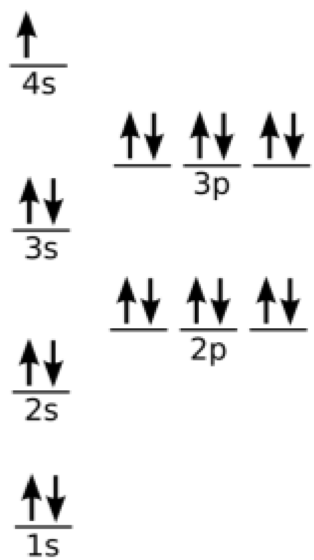
i.e. **Alkali metals**

-Alkali metals have one half-filled **s** orbital
-Hence they readily lose an electron to achieve stability





Na



K

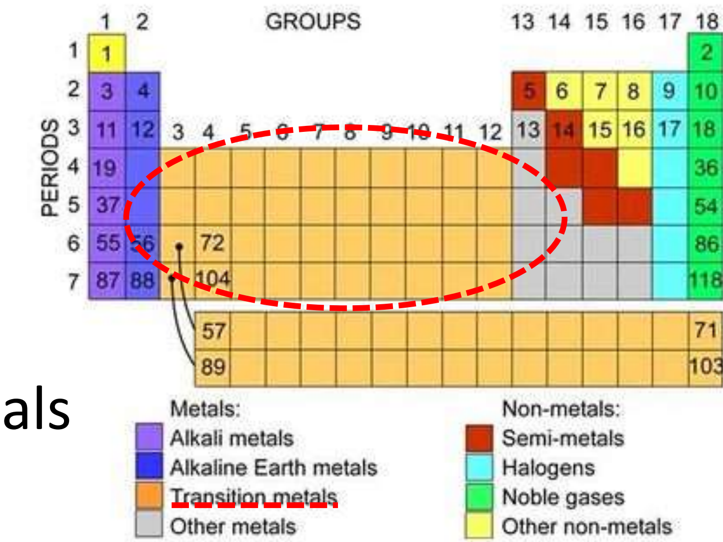
PERIODIC TRENDS

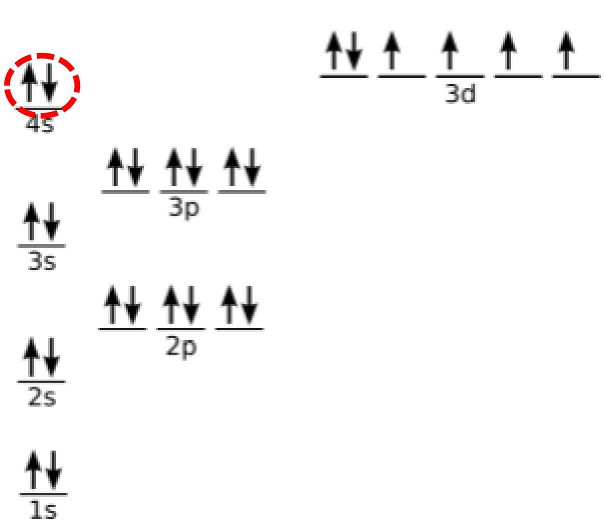
Recall: Groups in the periodic table

i.e. **Transition metals**

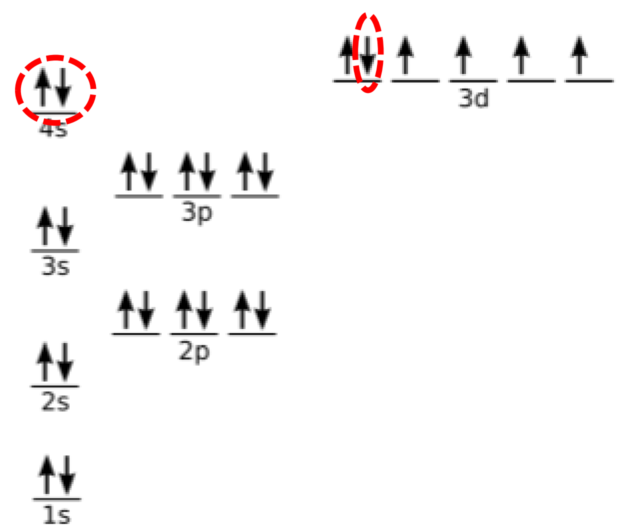
-Transition metals are elements where the highest-energy electrons are in **d** orbitals

-They may lose electrons in their **d** and **s** orbitals when forming ions to achieve stability





Fe^{2+}



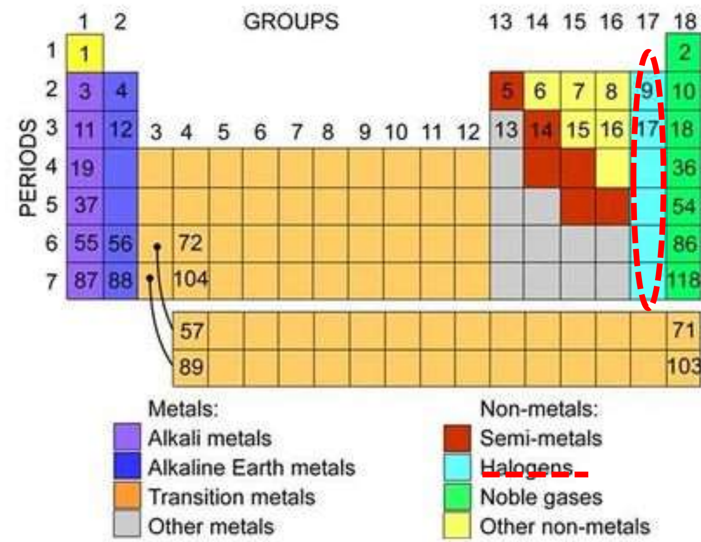
Fe^{3+}

PERIODIC TRENDS

Recall: Groups in the periodic table

i.e. **Halogens**

-Halogens are missing one electron to achieve a stable **p** sub-shell



F: .... $2s^2 2p^5$

Cl: .... $3s^2 3p^5$

Br: ....$4s^2 4p^5$

I: .... $5s^2 5p^5$

At: ....$6s^2 6p^5$

PERIODIC TRENDS

Recall: Valence electrons

-electrons in the outermost principal quantum level of an atom

How many valence electrons are there in each group?

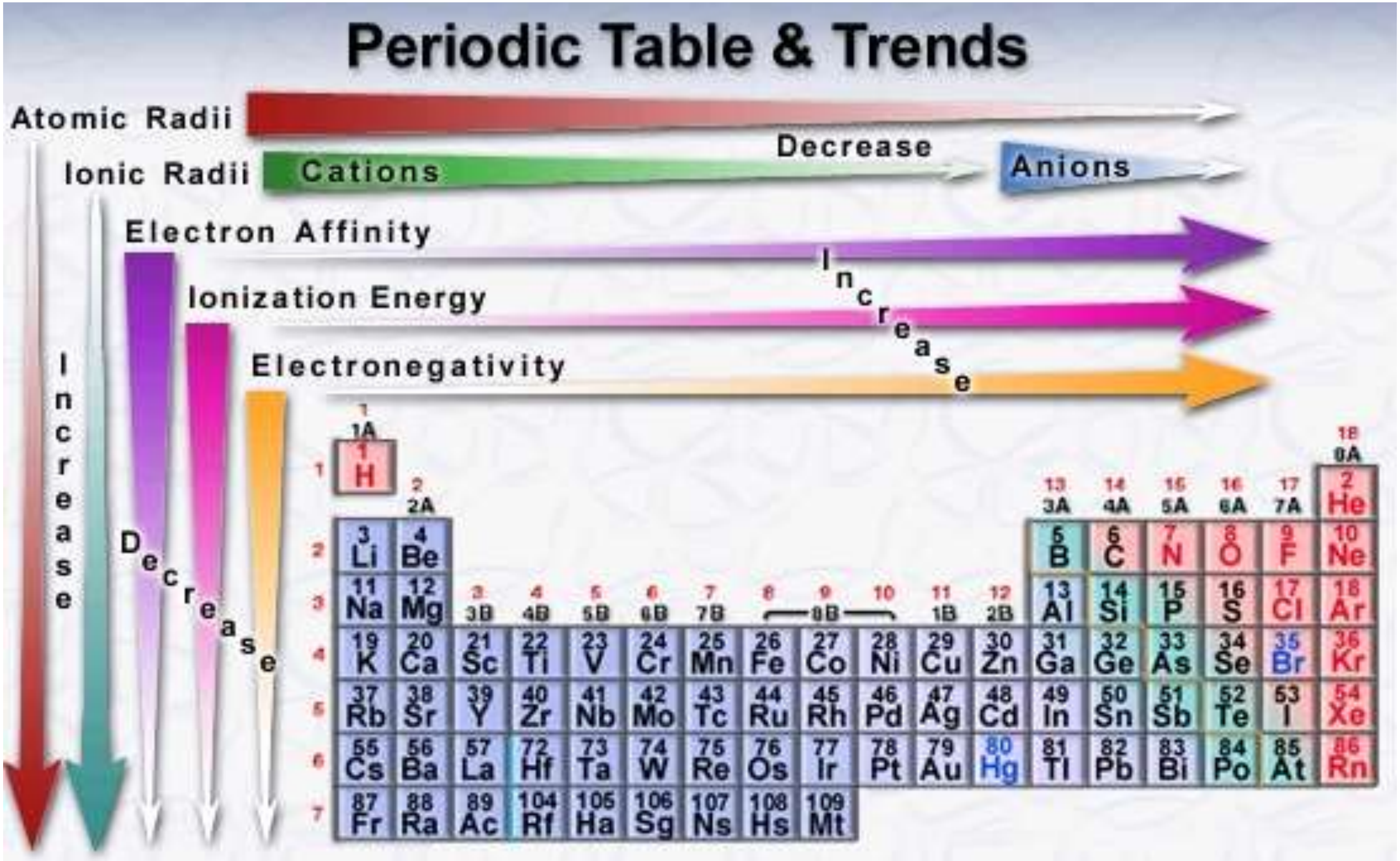
Abridged Periodic Table of the Elements

4/17/96 ghw

1A	2A		1B	2B	3A	4A	5A	6A	7A	noble
H 1 $1s^1$										He 2 $1s^2$
Li 3 $1s^2 2s^1$	Be 4 $1s^2 2s^2$			$1s^2$	B 5 $2s^2 2p^1$	C 6 $2s^2 2p^2$	N 7 $2s^2 2p^3$	O 8 $2s^2 2p^4$	F 9 $2s^2 2p^5$	Ne 10 $2s^2 2p^6$
Na 11 $[Ne] 3s^1$	Mg 12 $[Ne] 3s^2$			[Ne]	Al 13 $3s^2 3p^1$	Si 14 $3s^2 3p^2$	P 15 $3s^2 3p^3$	S 16 $3s^2 3p^4$	Cl 17 $3s^2 3p^5$	Ar 18 $3s^2 3p^6$
K 19 $[Ar]\ 4s^1$		$[Ar] 3d^{10}$	Cu 29 $4s^1$	Zn 30 $4s^2$	Ga 31 $4s^2 4p^1$	Ge 32 $4s^2 4p^2$	As 33 $4s^2 4p^3$	Se 34 $4s^2 4p^4$	Br 35 $4s^2 4p^5$	Kr 36 $4s^2 4p^6$
Rb 37 $[Kr]\ 5s^1$		$[Kr] 4d^{10}$	Ag 47 $5s^1$	Cd 48 $5s^2$	In 49 $5s^2 5p^1$	Sn 50 $5s^2 5p^2$	Sb 51 $5s^2 5p^3$	Te 52 $5s^2 5p^4$	I 53 $5s^2 5p^5$	Xe 54 $5s^2 5p^6$
Cs 55 $[Xe]\ 6s^1$		$[Xe]\ 4f^{14} 5d^{10}$	Au 79 $6s^1$	Hg 80 $6s^2$	Tl 81 $6s^2 6p^1$	Pb 82 $6s^2 6p^2$	Bi 83 $6s^2 6p^3$	Po 84 $6s^2 6p^4$	At 85 $6s^2 6p^5$	Rn 86 $6s^2 6p^6$
1	2				3	4	5	6	7	8

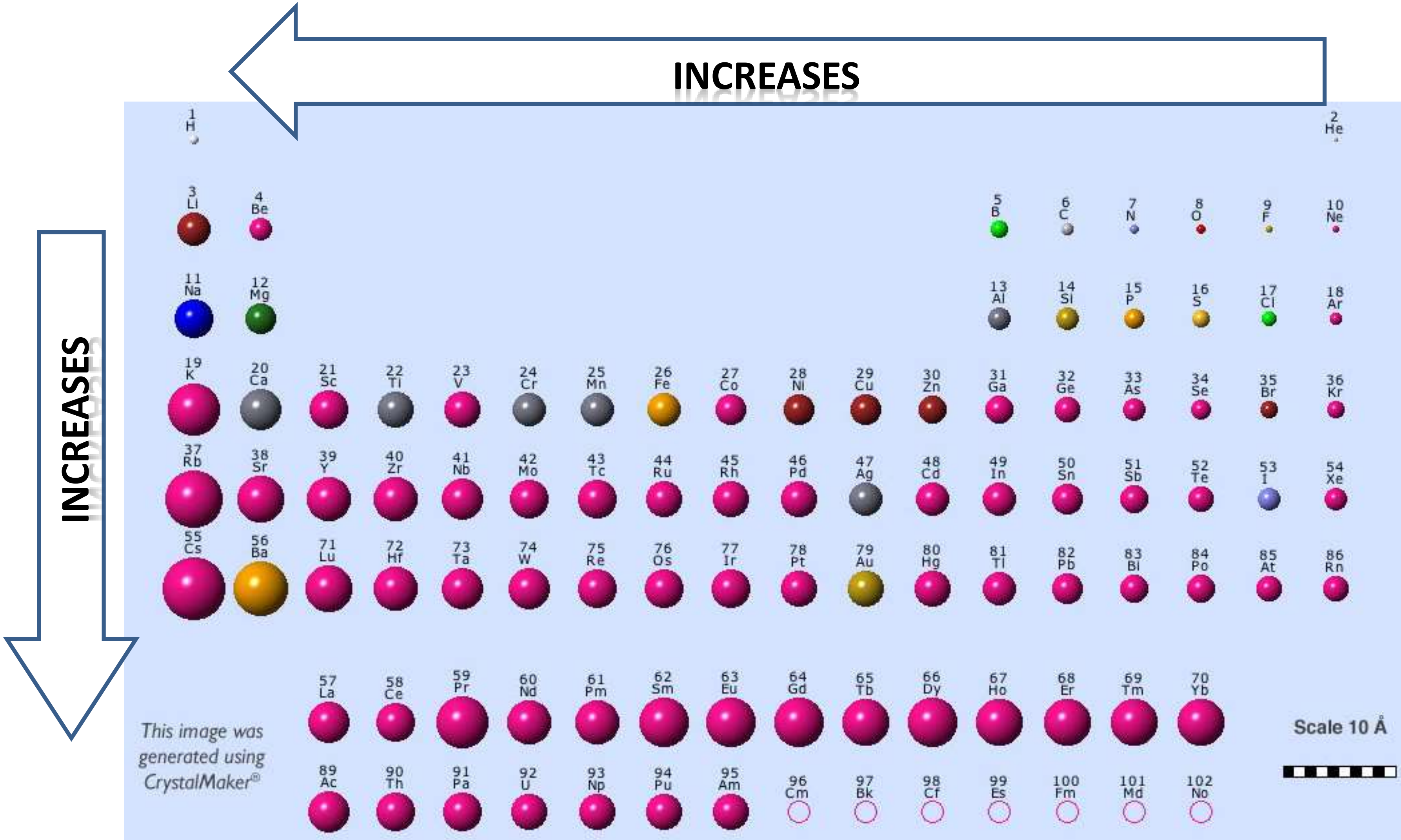
PERIODIC TRENDS

Recall: Trends



PERIODIC TRENDS

Trend: Atomic Radius



Why?

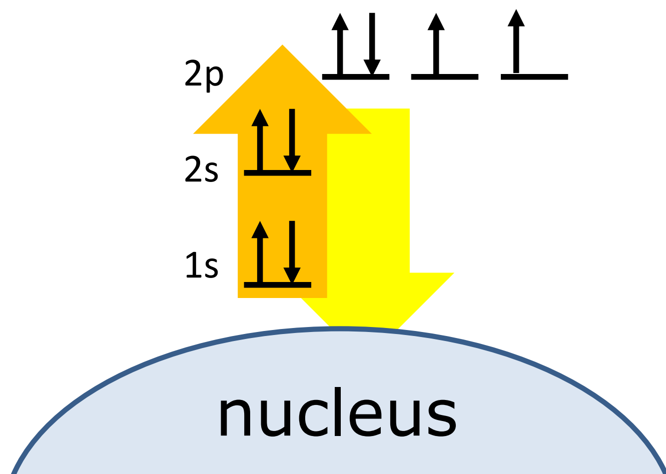
ATOMIC RADIUS

Trend: Atomic Radius – **Down a group**

Electrons are attracted by the nucleus (+), but repelled by other electrons (-).

Thus electrons 'shield' other electrons from the attraction of the nucleus.

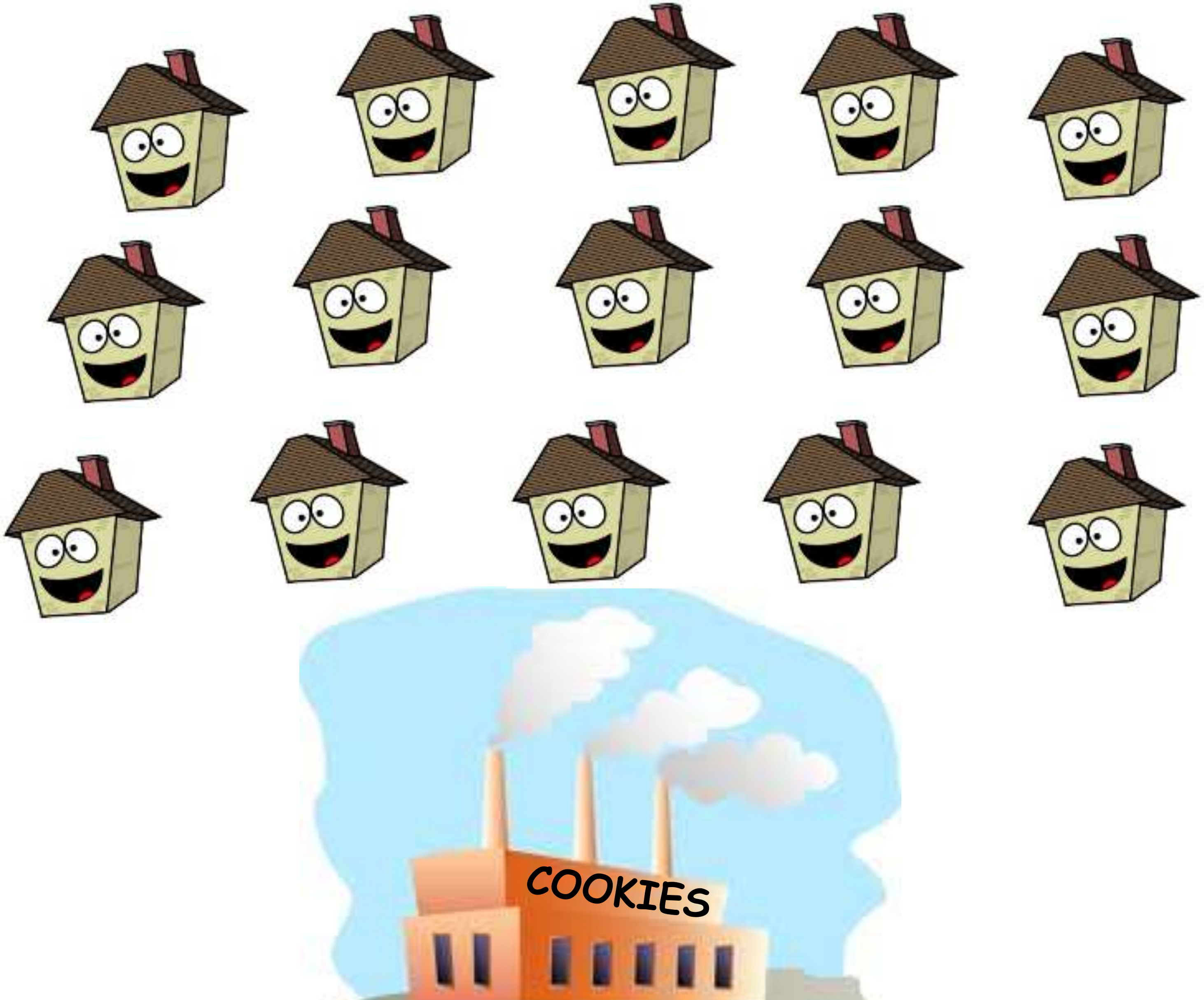
This shielding reduces the full nuclear charge to an **effective nuclear charge** (Z_{eff}), *the nuclear charge an electron actually experiences*.



Forces of attraction are reduced by repulsion

ATOMIC RADIUS

ANALOGY: The aromas from a cookie factory

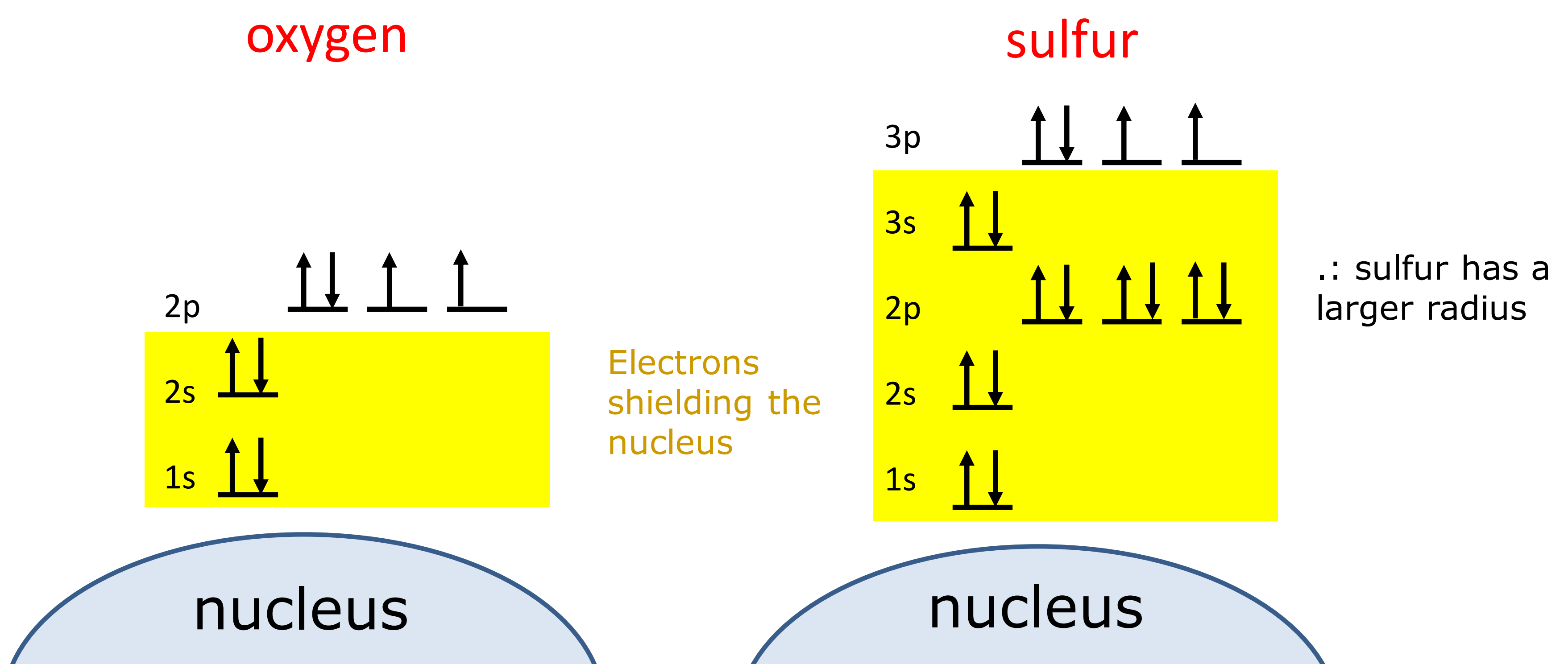


ATOMIC RADIUS

Trend: Atomic Radius – **Down a group**

-The more energy levels there are, the more the nucleus is shielded from the outermost electrons

-Force of attraction between nucleus and outermost electrons becomes weaker, making the atomic radius bigger

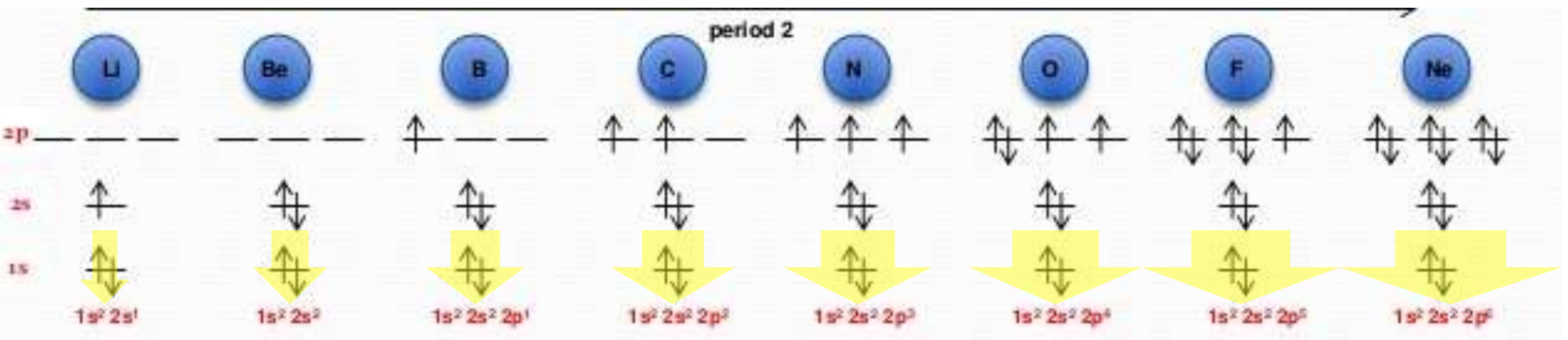


ATOMIC RADIUS

Trend: Atomic Radius – **Across a period**

-Electrons within the same valence level contribute minimally to shielding each other from the nuclear charge

-Thus the more protons there are, the greater the attraction between the nucleus and the outermost electrons

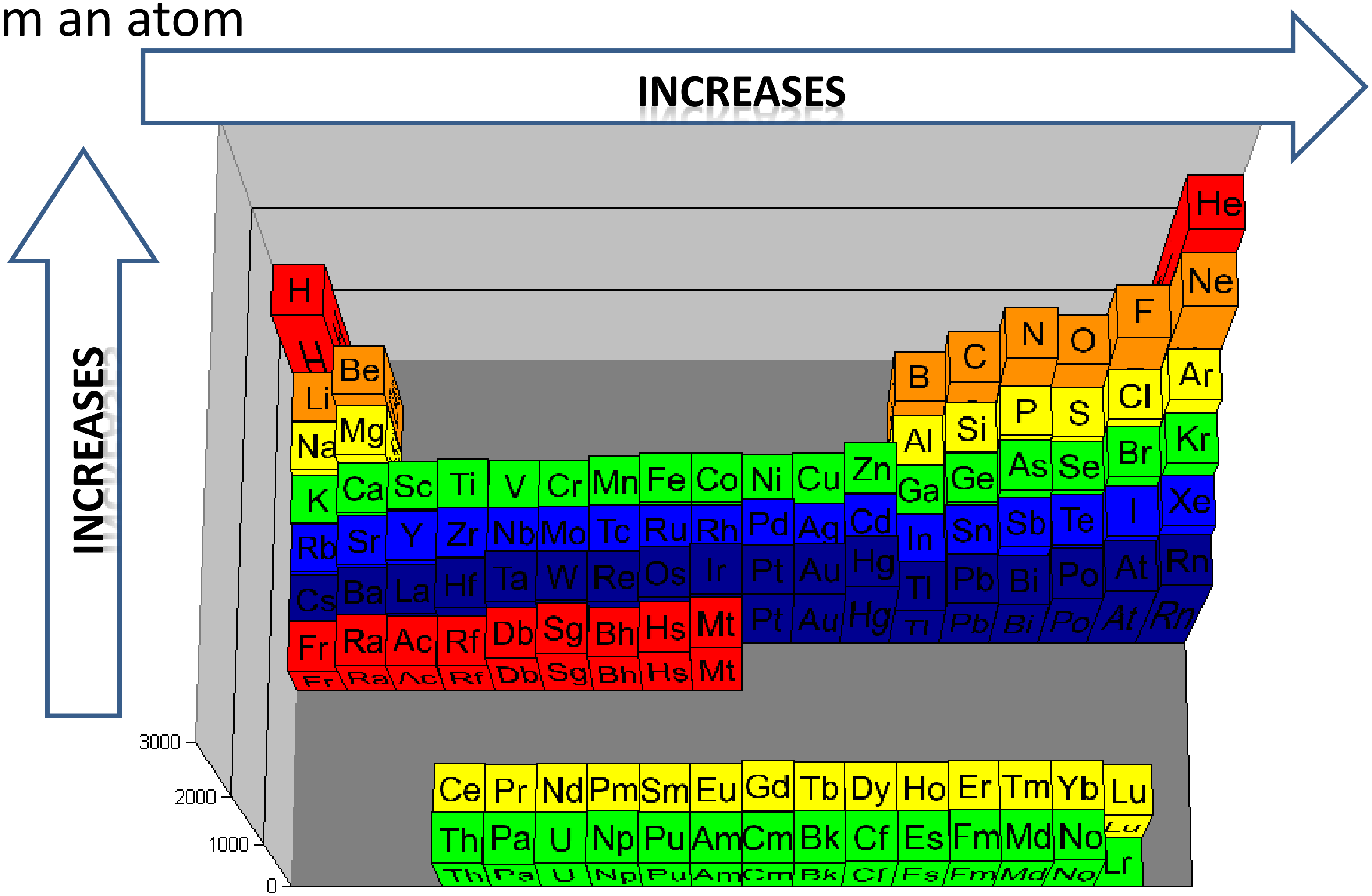


3 protons **4 protons** **5 protons** **6 protons** **7 protons** **8 protons** **9 protons** **10 protons**

IONIZATION ENERGY

Trend: Ionization energy

Energy required to remove the most weakly held (outermost) electron from an atom

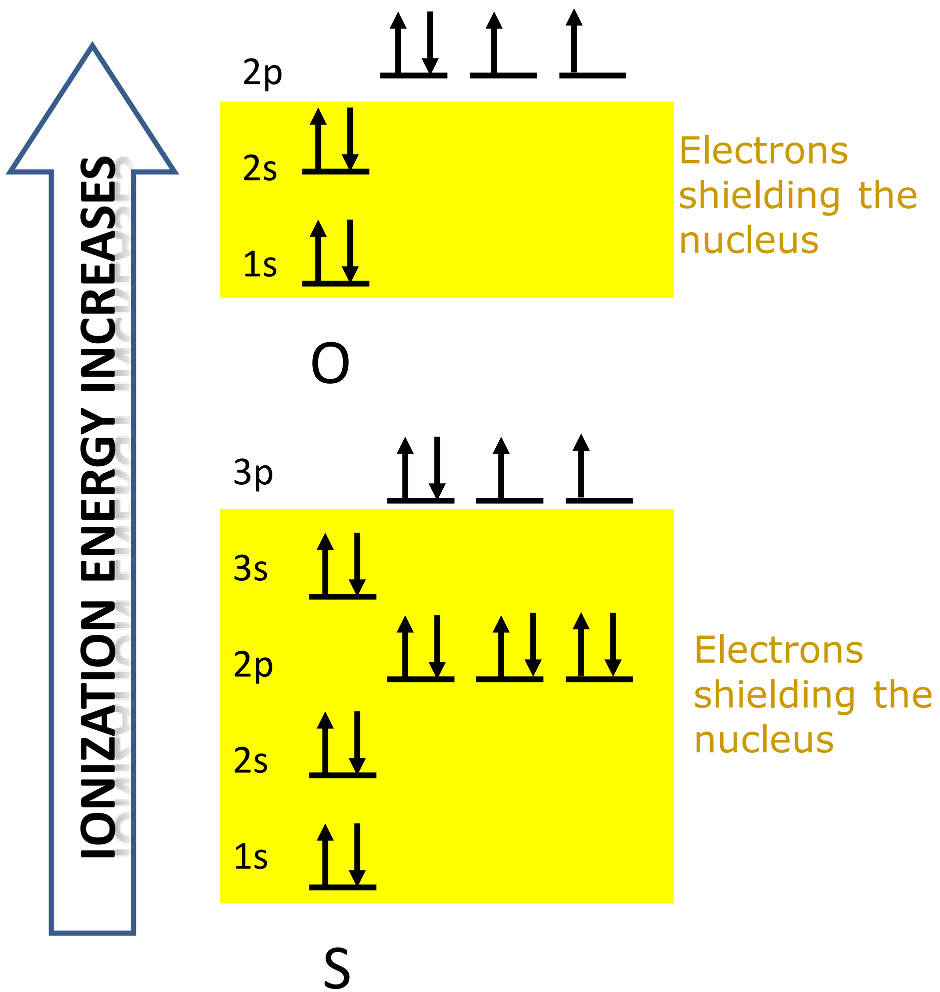


Why?

IONIZATION ENERGY

Trend: Ionization energy – **Down a group**

-The less shielding between the nucleus and outermost electrons, the greater the force of attraction (.: greater ionization energy)

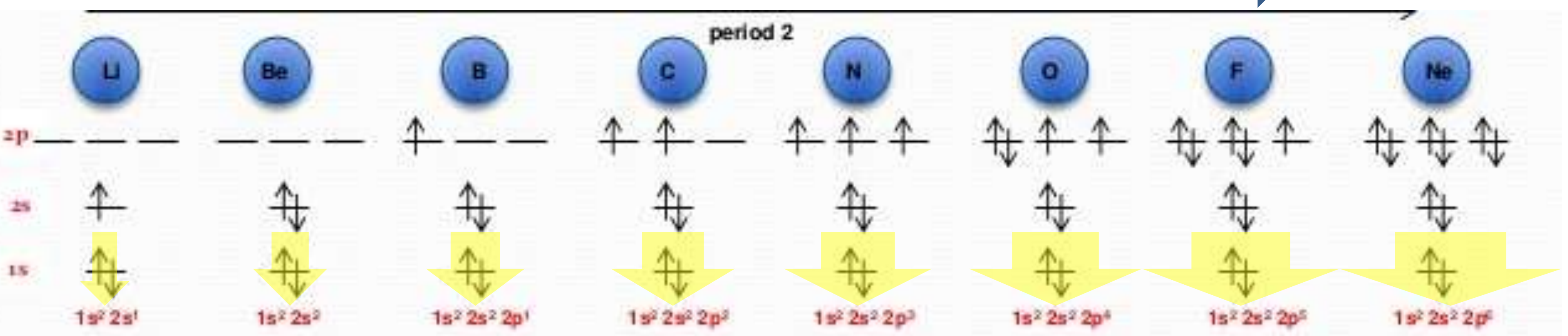


IONIZATION ENERGY

Trend: Ionization energy – **Across a period**

-The greater the force of attraction between the nucleus and the outermost electron, the more energy it requires to remove it

INCREASING IONIZATION ENERGY

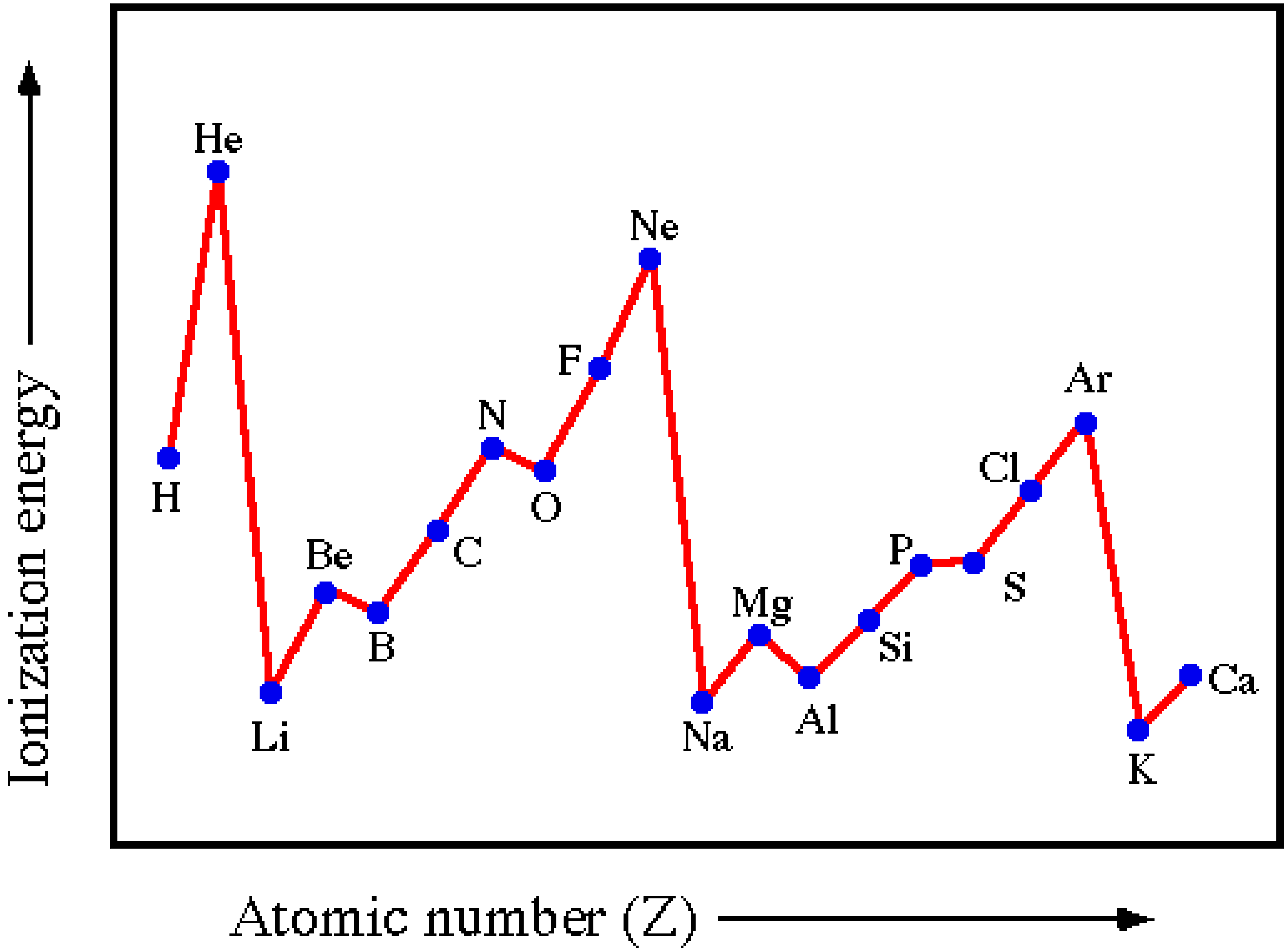


3 protons 4 protons 5 protons 6 protons 7 protons 8 protons 9 protons 10 protons

IONIZATION ENERGY

Trend: Ionization energy

Graphing the first ionization energy reveals exceptions

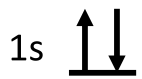


Why?

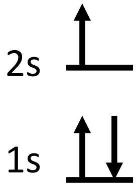
IONIZATION ENERGY

Trend: Ionization energy - **Exceptions**

It requires much more energy to remove the outermost electron of helium than lithium



He



Li

This will destabilize a full orbital

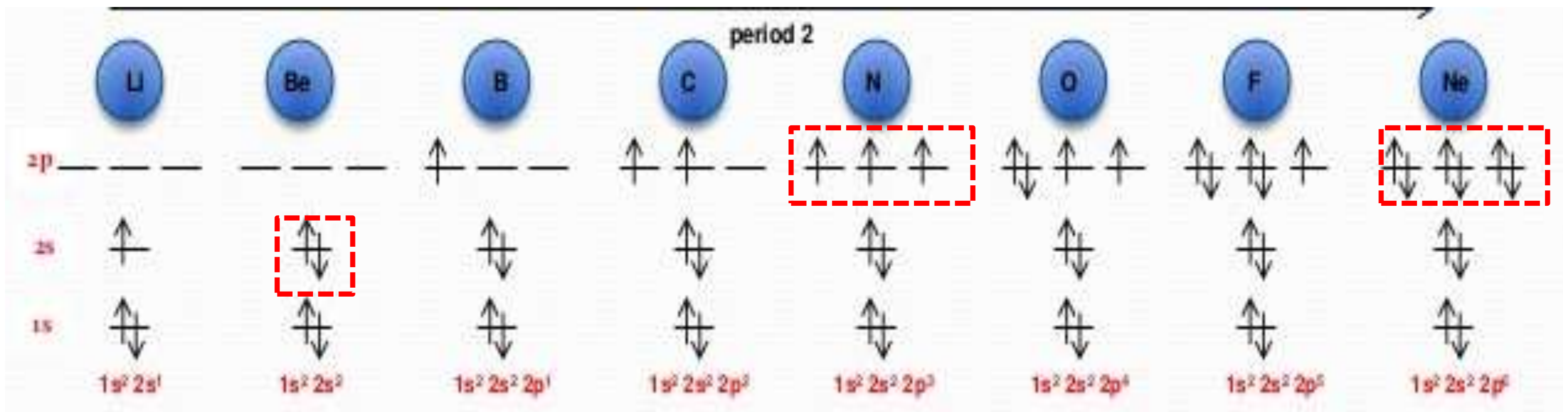
.: greater ionization energy is required

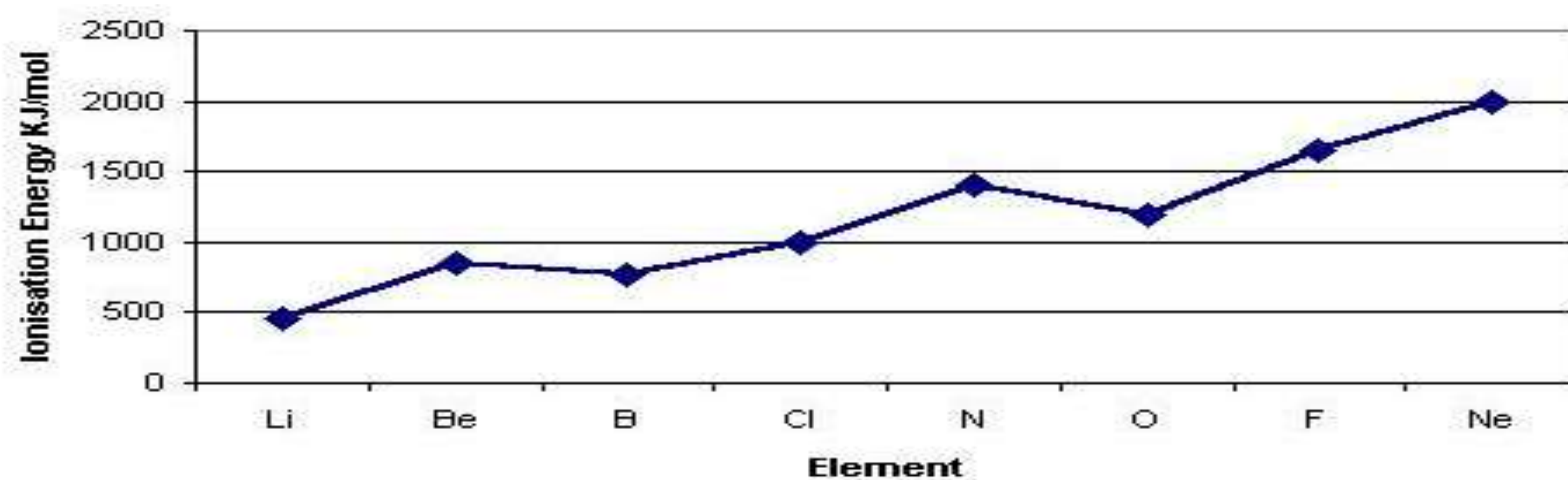
This will not destabilize a full orbital

.: less ionization energy is required

IONIZATION ENERGY

Trend: Ionization energy - **Exceptions**



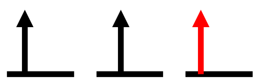


If removing the outermost electron destabilizes a sub-shell, then the ionization energy is abnormally higher

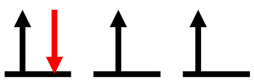
IONIZATION ENERGY

Trend: Ionization energy - **Exceptions**

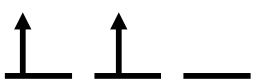
The third electron in the p subshell requires more energy to remove than the fourth electron



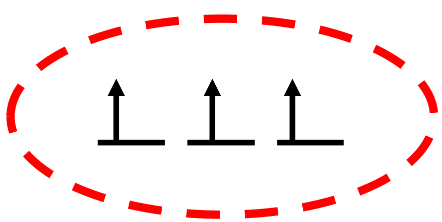
vs



Removing the third electron produces this:

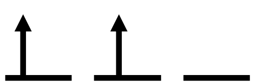


Having all three half-full orbitals is more stable than having one orbital completely empty



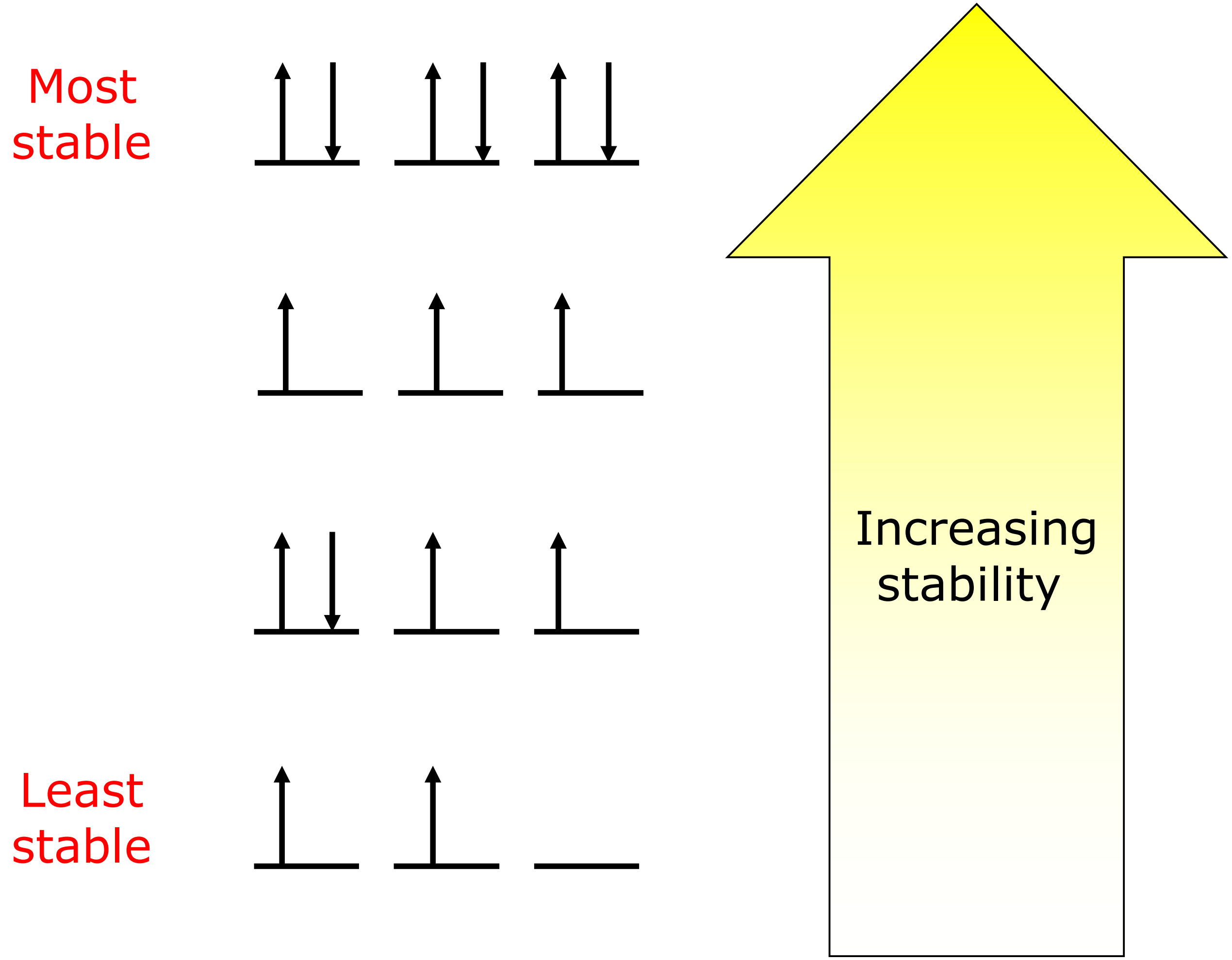
More stable

vs



IONIZATION ENERGY

Stability: **Rank the following from most to least stable**

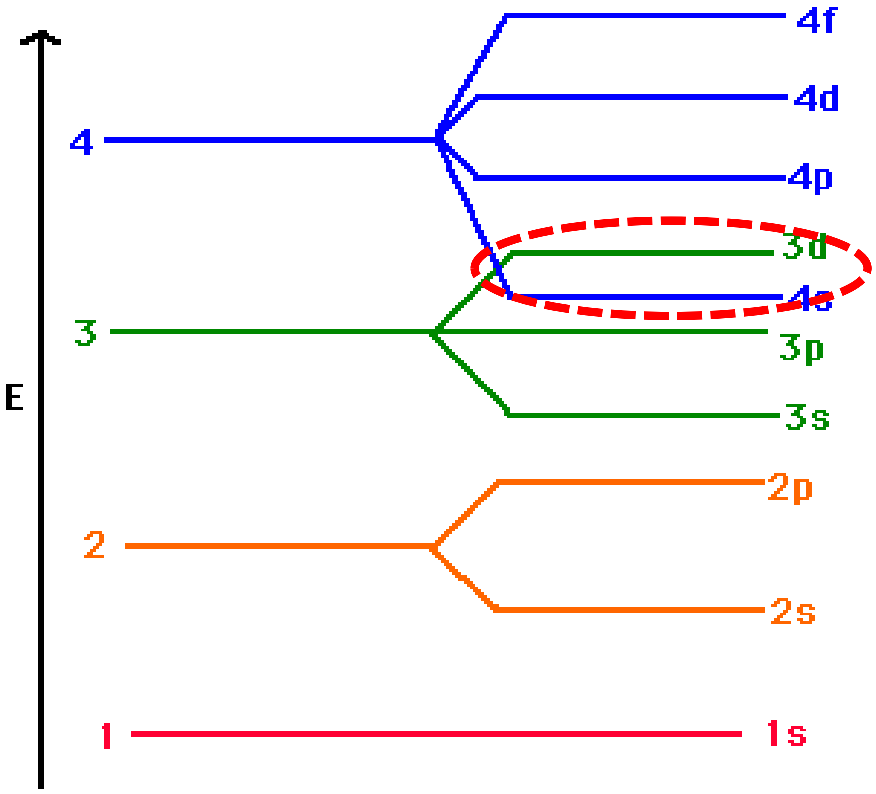


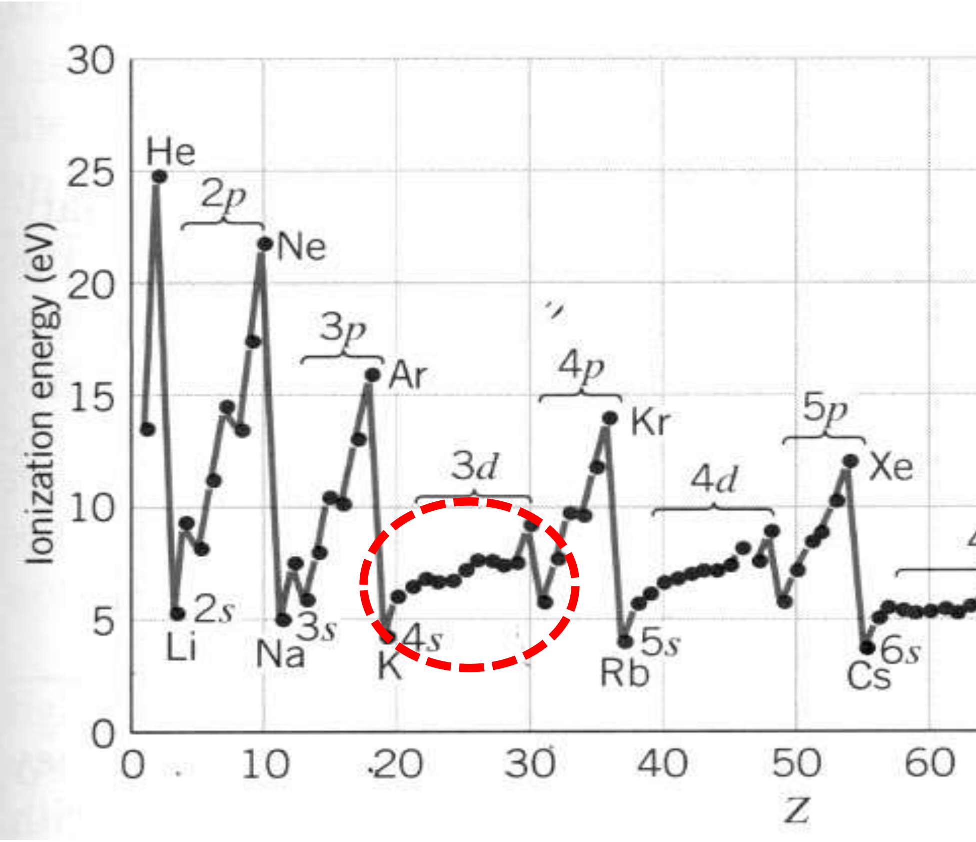
IONIZATION ENERGY

Trend: Ionization energy - **Exceptions**

4s and 3d are close in energy, so there is no great change in ionization energy in between.

RECALL:

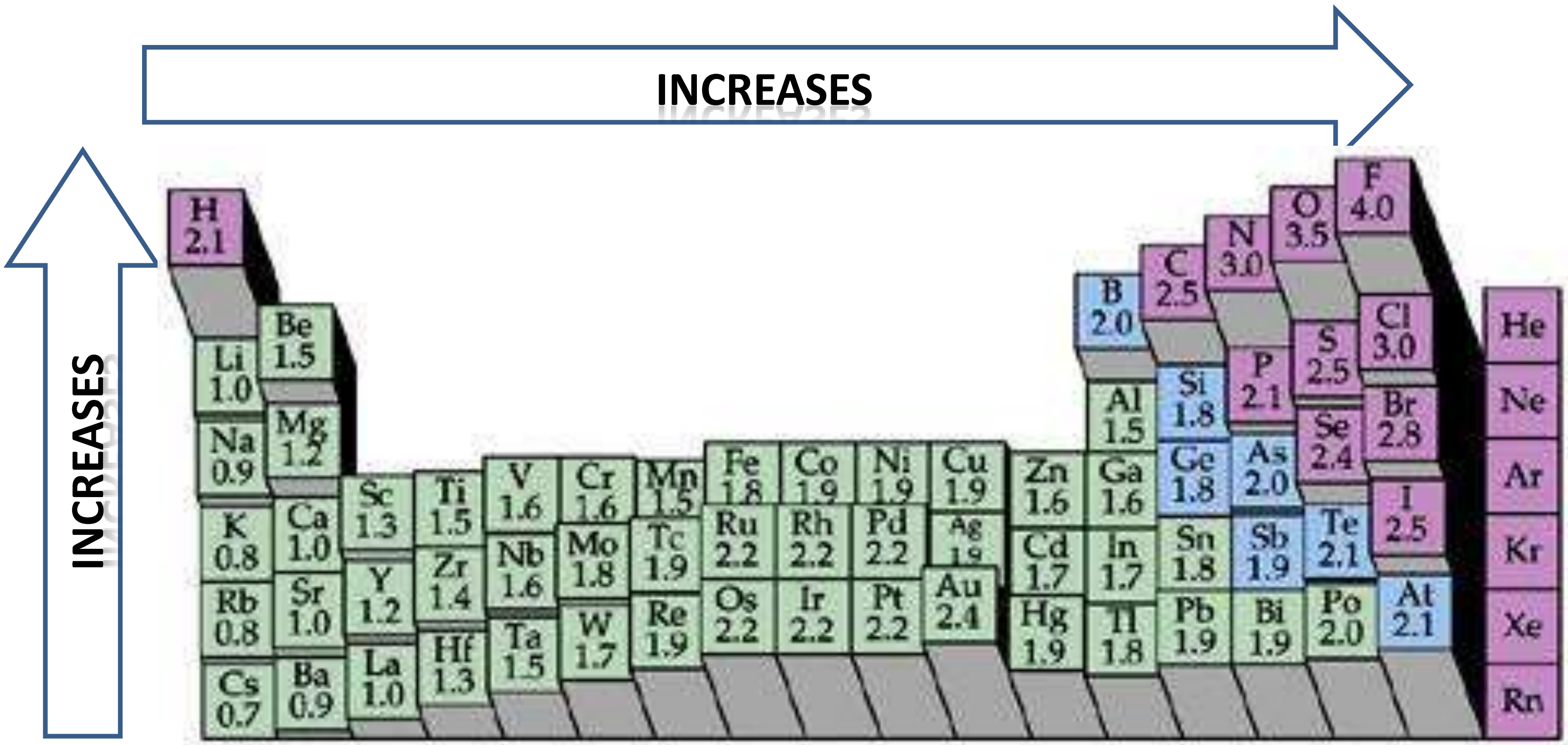




ELECTRONEGATIVITY

Trend: Electronegativity

Ability of an atom to attract electrons in a chemical bond



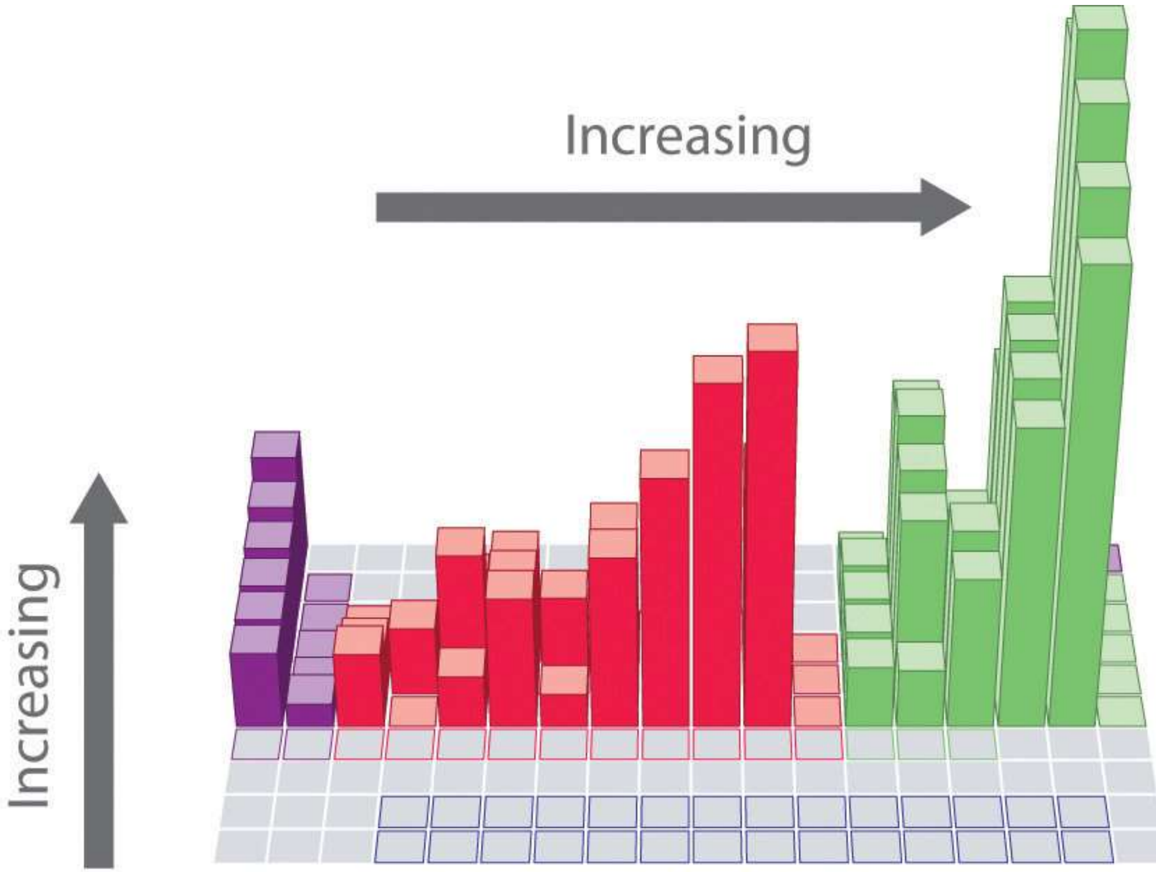
The trend may be explained by the effect of shielding of the nucleus, which makes its effective nuclear charge weaker when there are more energy levels or fewer protons.

ELECTRON AFFINITY

Trend: Electron Affinity

Amount of energy released when an atom gains an electron.

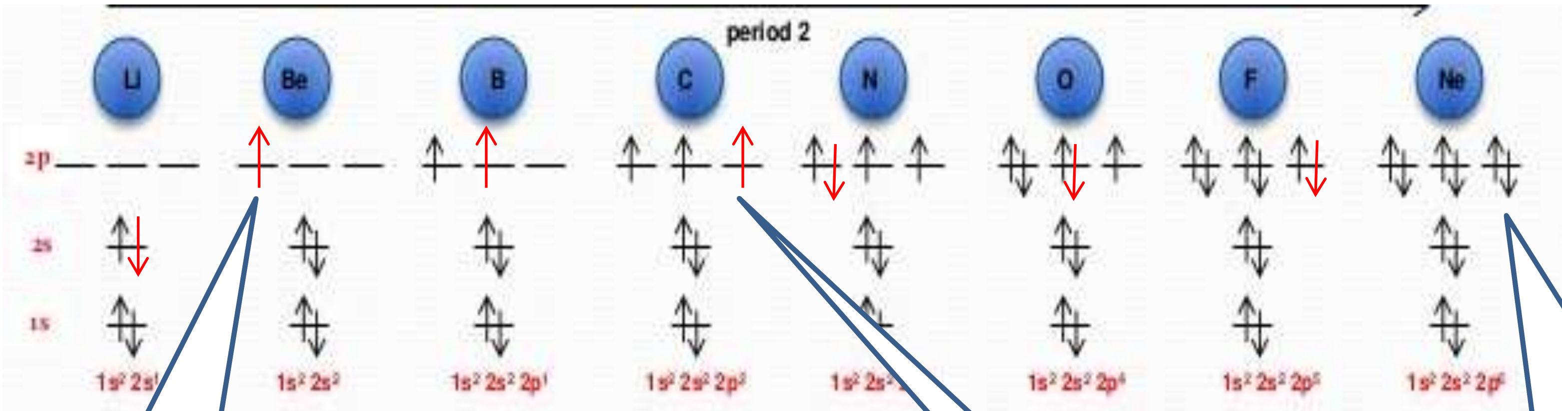
Atoms that gain stability when an electron is added will release more energy



This trend has several exceptions. Why?

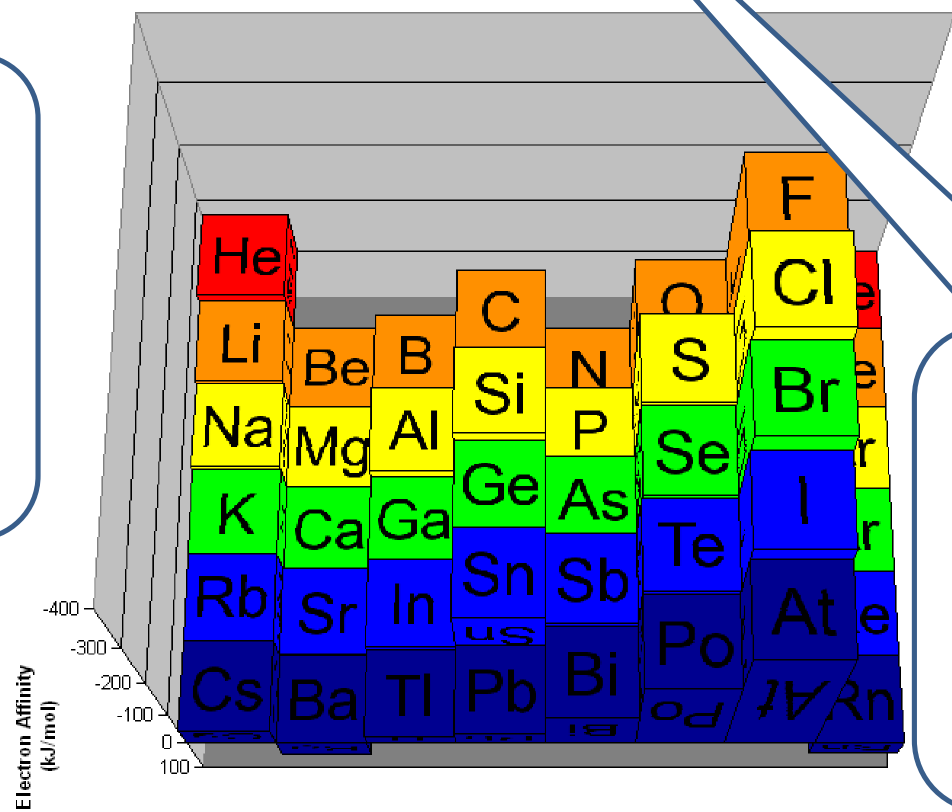
ELECTRON AFFINITY

Trend: Electron Affinity



Decrease in stability means that Group 2 elements won't release a lot of energy if an electron is added

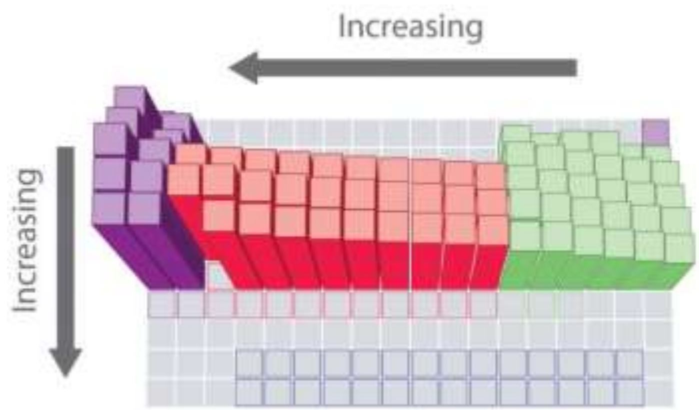
Noble gases already have a stable sub-shell.



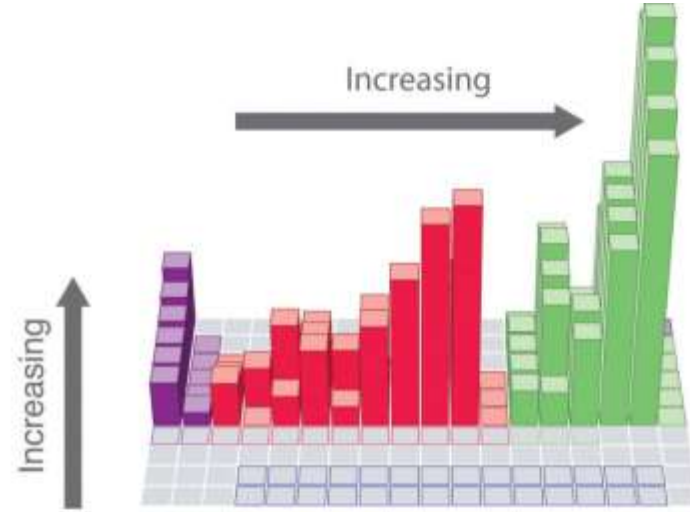
Half-full sub-shell is more stable, thus group 4 elements release more energy when electron is added

SUMMARY

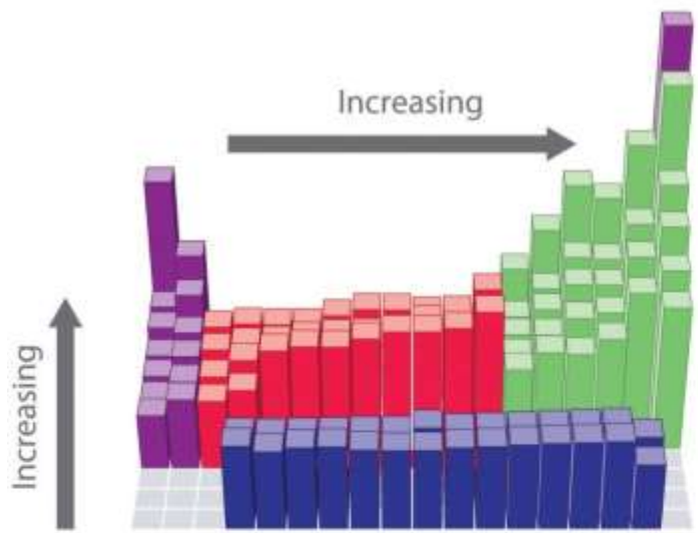
Trends:



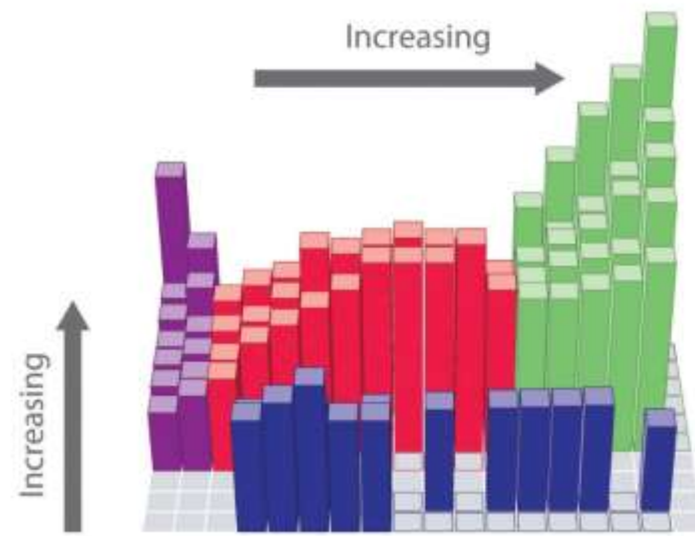
Calculated atomic radius (pm)



Magnitude of electron affinity (kJ/mol)



First ionization energy (kJ/mol)



Electronegativity, χ

s block *p* block *d* block *f* block