MODERN PERIODIC TABLE

Lecture 8.

TREND FOR EFFECTIVE NUCLEAR CHARGE

- Across a period, nuclear charge increases by +1, however the valence shell remains the same i.e. the incoming electron is accommodated to the same shell.
- Thus, the EFFECTIVE NUCLEAR CHARGE Z_{eff} increases across a period.

- Down the group, nuclear charge increases, however a new valence shell is added i.e. the incoming electron is accommodated in the next shell.
- Shielding effect exhibited by inner electrons increases as a result.
- Thus, the EFFECTIVE NUCLEAR CHARGE Z_{eff} decreases down the group.

TREND FOR ATOMIC RADIUS:

- Across a period, nuclear charge increases by +1, however the valence shell remains the same i.e. the incoming electron is accommodated in the same shell.
- Hence, the EFFECTIVE NUCLEAR CHARGE Z_{eff} increases across a period.
- Due to poor shielding of electrons, Atomic Radius across a period decreases.

- Down the group, nuclear charge increases, however a new valence shell is added i.e. the incoming electron is accommodated in the next shell.
- Hence, the EFFECTIVE NUCLEAR CHARGE Z_{eff} decreases down the group.
- Shielding effect of these inner electrons increases and so does the ATOMIC RADIUS down the group.

REMEMBER!!

- Ionic Radius for:
  - i. Cations are always smaller than its atomic radius.
  - ii. Anions are always larger than its atomic radius.

IONISATION ENTHALPY

- If an electron is pulled toward another atom with enough energy to overcome the effective nuclear attraction of the parent atom holding the electron in the cloud, it can leave the atom completely.
- Once an electron has been removed from one atom and added to another, both atoms change into ions i.e. they have been “ionized”.
- The number of protons and electrons is no longer equal.
- The atom that lost an electron becomes POSITIVELY charged (more P+ than e-) while the atom that gained an electron becomes NEGATIVELY charged (more e- than P+).

IONISATION ENTHALPY

- Ionisation Enthalpy = Amount of energy required to remove a valence electron from an atom in gas phase.

- 1st Ionisation Enthalpy = Energy required to remove the most loosely held valence electron (e^- farthest from nucleus).
- So, 1st I.E. is the energy required to remove first valence electron.

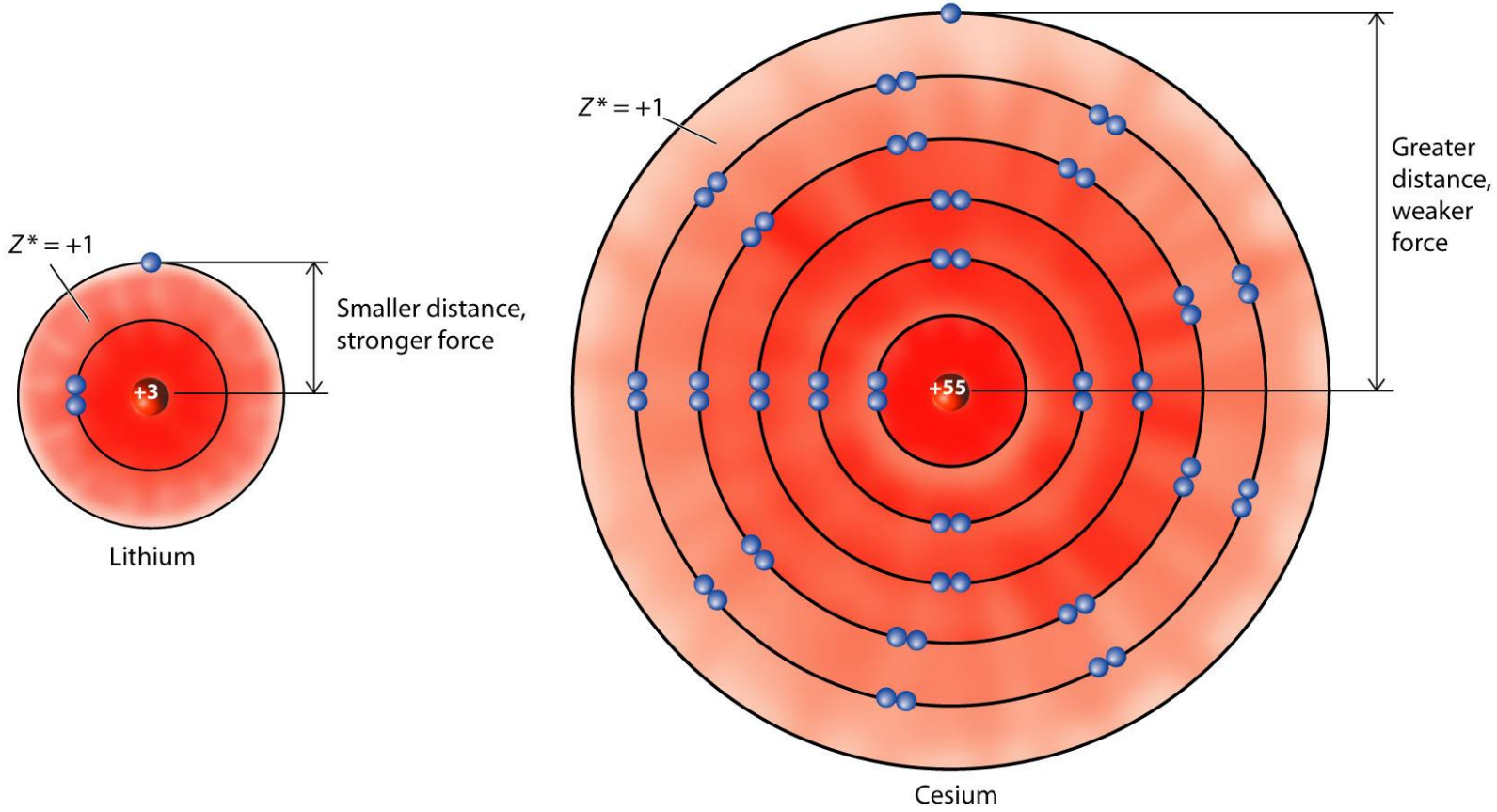
$$Na \rightarrow Na^+ + e^-$$

- So, 2nd I.E. is the energy required to remove second valence electron.

$$Ca \rightarrow Ca^+ + e^-$$

$$Ca^+ \rightarrow Ca^{2+} + e^-$$

$$Ca \rightarrow Ca^{2+} + 2e^-$$



- Cs valence electron is farther away from nucleus than Li.
- Thus, electrostatic force of attraction is much weaker in Cs than Li.
- So it is easier to remove electron from Cs.
- THEREFORE, Li has a higher Ionization enthalpy than Cs.

TREND FOR IONISATION ENTHALPY:

- Across a period, nuclear charge increases by +1, however the valence shell remains the same i.e. the incoming electron is accommodated in the same shell.
- Hence, the EFFECTIVE NUCLEAR CHARGE Z_{eff} increases across a period.
- Due to poor shielding of electrons, Atomic Radius across a period decreases.
- Thus, due to increased effective nuclear charge & decreased atomic radius, IONISATION ENTHALPY, across a period, increases.

- Down the group, nuclear charge increases, however a new valence shell is added i.e. the incoming electron is accommodated in the next shell.
- Hence, the EFFECTIVE NUCLEAR CHARGE Z_{eff} decreases down the group.
- Shielding effect of these inner electrons increases and so does the ATOMIC RADIUS down the group.
- Thus, due to decrease in effective nuclear charge & increasing atomic radius, IONISATION ENTHALPY, down the group, decreases.

Increased Ionization Energy (harder to remove an electron)

Decreasing Atomic Radius



Decreased Ionization Energy

(easier to remove an electron)

IONISATION ENTHALPY:

- It requires more energy to remove each successive electron.
- When all valence electrons have been removed, the ionization energy takes a quantum leap.

Element	I_1	I_2	I_3	I_4	I_5	I_6	I_7
Na	495	4562			(inner-shell electrons)		
Mg	738	1451	7733				
Al	578	1817	2745	11,577			
Si	786	1577	3232	4356	16,091		
P	1012	1907	2914	4964	6274	21,267	
S	1000	2252	3357	4556	7004	8496	27,107
Cl	1251	2298	3822	5159	6542	9362	11,018
Ar	1521	2666	3931	5771	7238	8781	11,995

REMEMBER!!

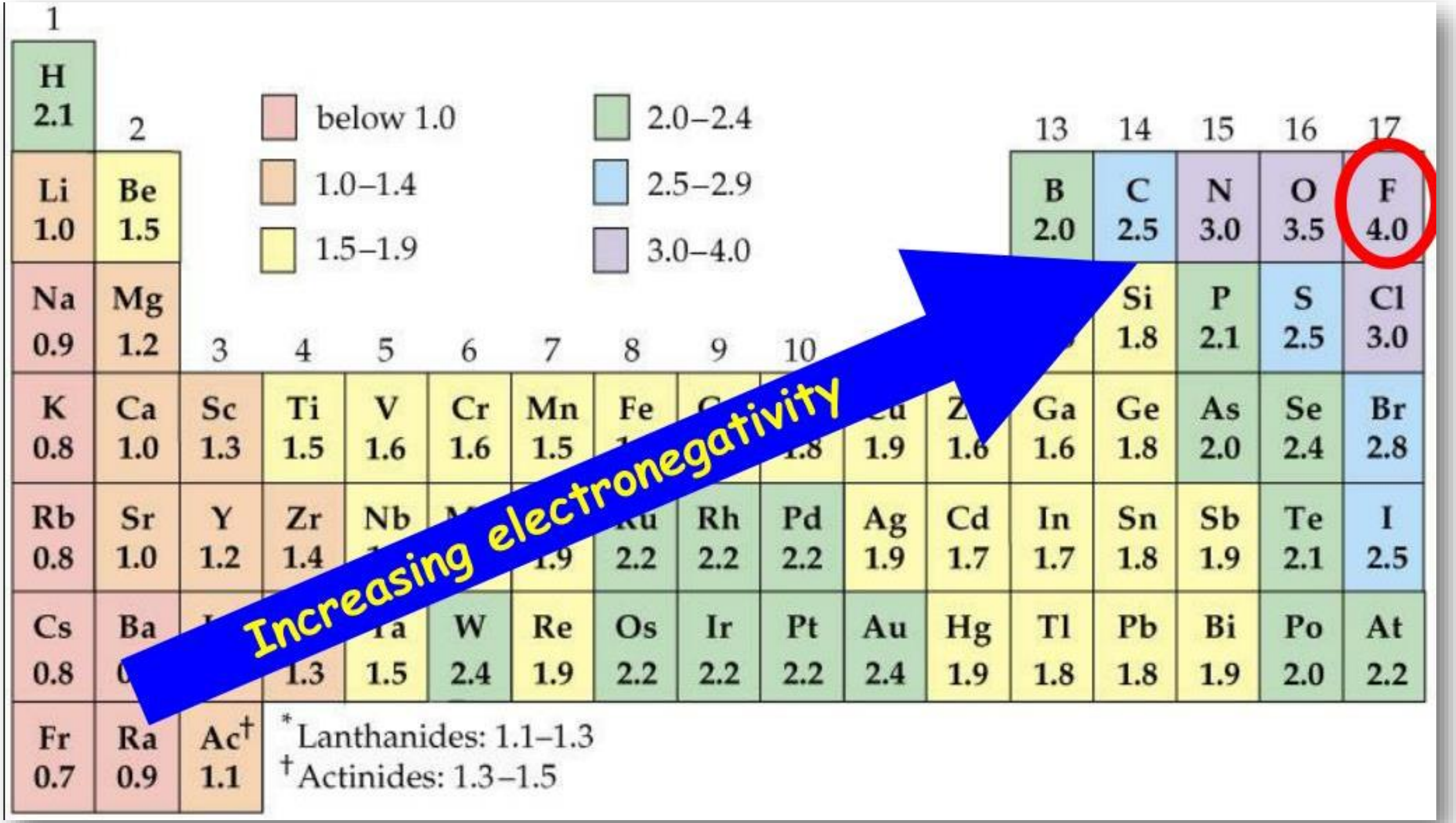
- The energy required to remove a valence electron(s) from an atom is ionization enthalpy.
- Larger the size of the atom, easier it is to remove valence electron(s).
- Ionization Enthalpy and Atomic Radius are inversely proportional.
- Ionization enthalpy is always endothermic, that is energy is added to the atom to remove the valence electron(s).

ELECTRONEGATIVITY

- The ability of a covalently bonded atom to attract the shared pair of electrons toward itself.

- Ability of an atom to attract electron(s).
- Depends on the effective nuclear charge experienced by the electron involved in the formation of covalent bond.

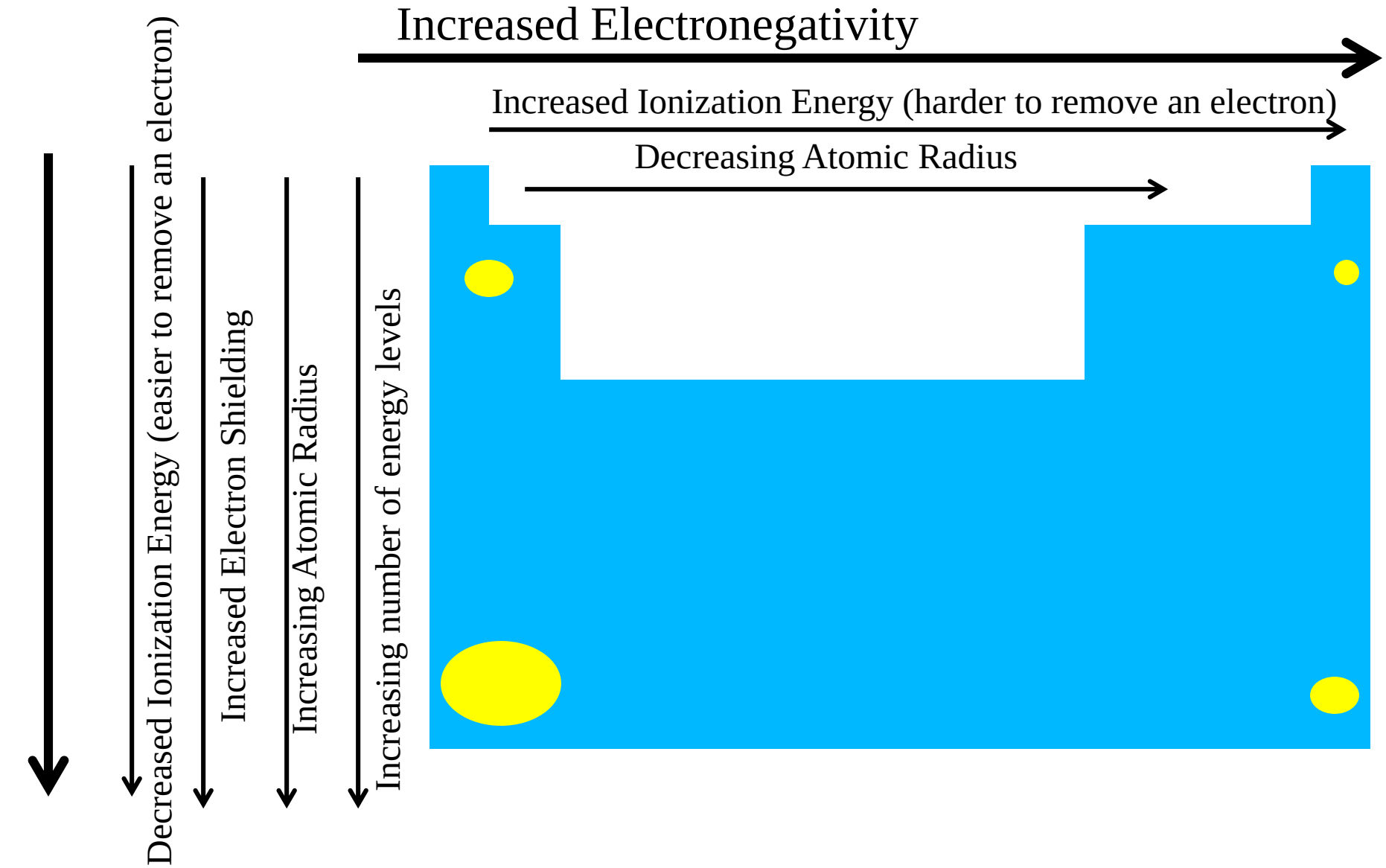
- Fluorine: most electronegative element = 4.0 (on Pauling Scale)


1
2
13
14
15
16
17
below 1.0
1.0–1.4
1.5–1.9
2.0–2.4
2.5–2.9
3.0–4.0
H 2.1
Li 1.0
Be 1.5
B 2.0
C 2.5
N 3.0
O 3.5
F 4.0
Na 0.9
Mg 1.2
Si 1.8
P 2.1
S 2.5
Cl 3.0
3
4
5
6
7
8
9
10
K 0.8
Ca 1.0
Sc 1.3
Ti 1.5
V 1.6
Cr 1.6
Mn 1.5
Ga 1.6
Ge 1.8
As 2.0
Se 2.4
Br 2.8
Rb 0.8
Sr 1.0
Y 1.2
Zr 1.4
Rh 2.2
Pd 2.2
Ag 1.9
Cd 1.7
In 1.7
Sn 1.8
Sb 1.9
Te 2.1
I 2.5
Cs 0.8
Ba
W 2.4
Re 1.9
Os 2.2
Ir 2.2
Pt 2.2
Au 2.4
Hg 1.9
Tl 1.8
Pb 1.8
Bi 1.9
Po 2.0
At 2.2
Fr 0.7
Ra 0.9
Ac† 1.1
Increasing electronegativity
*Lanthanides: 1.1–1.3
†Actinides: 1.3–1.5

TREND FOR ELECTRONEGATIVITY:

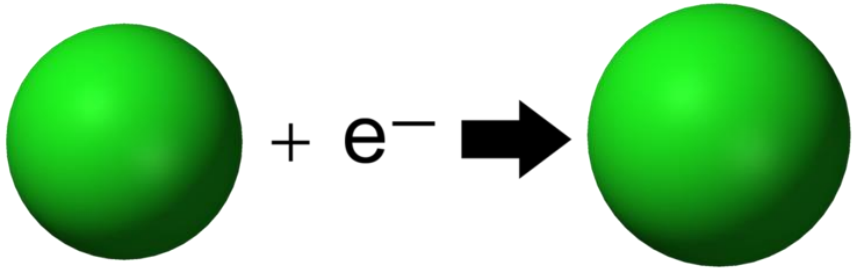
- Across a period, nuclear charge increases by +1, however the valence shell remains the same i.e. the incoming electron is accommodated in the same shell.
- Hence, the EFFECTIVE NUCLEAR CHARGE Z_{eff} increases across a period.
- Due to poor shielding of electrons, Atomic Radius across a period decreases.
- Due to increasing effective nuclear charge, decreasing atomic radii & increasing IONISATION ENTHALPY, across a period, Electronegativity also increases.

- Down the group, nuclear charge increases, however a new valence shell is added i.e. the incoming electron is accommodated in the next shell.
- Hence, the EFFECTIVE NUCLEAR CHARGE Z_{eff} decreases down the group.
- Shielding effect of these inner electrons increases and so does the ATOMIC RADIUS down the group.
- Due to decreasing effective nuclear charge, increasing atomic radii & decreasing IONISATION ENTHALPY, down the group, Electronegativity also decreases.


Increased Electronegativity
Increased Ionization Energy (harder to remove an electron)
Decreasing Atomic Radius
Decreased Ionization Energy (easier to remove an electron)
Increased Electron Shielding
Increasing Atomic Radius
Increasing number of energy levels
Decreased Electronegativity

ELECTRON GAIN ENTHALPY

- Electron Gain Enthalpy is the energy change that accompanies an electron addition to an isolated gaseous atom in its ground state.



  - Generally, the energy that results from this process is negative or positive close to zero.
  - The more negative this energy the more this process is favored (exothermic).
  - The less negative this energy less favorable is the process (endothermic).

ELECTRON GAIN ENTHALPY

- Energy change accompanying addition of an electron to gaseous atom.

$$Cl + e^- \longrightarrow Cl^-$$

- It is a measure of the ease with which an atom adds an electron thereby forming an anion.

ELECTRON GAIN ENTHALPY

1A	2A	3A	4A	5A	6A	7A	8A
H −73							He > 0
Li −60	Be > 0	B −27	C −122	N > 0	O −141	F −328	Ne > 0
Na −53	Mg > 0	Al −43	Si −134	P −72	S −200	Cl −349	Ar > 0
K −48	Ca −2	Ga −30	Ge −119	As −78	Se −195	Br −325	Kr > 0
Rb −47	Sr −5	In −30	Sn −107	Sb −103	Te −190	I −295	Xe > 0

In general, electron gain enthalpy becomes more exothermic, left to right, across a row.

ELECTRON GAIN ENTHALPY

1A	2A	3A	4A	5A	6A	7A	8A
H −73							He > 0
Li −60	Be > 0	B −27	C −122	N > 0	O −141	F −328	Ne > 0
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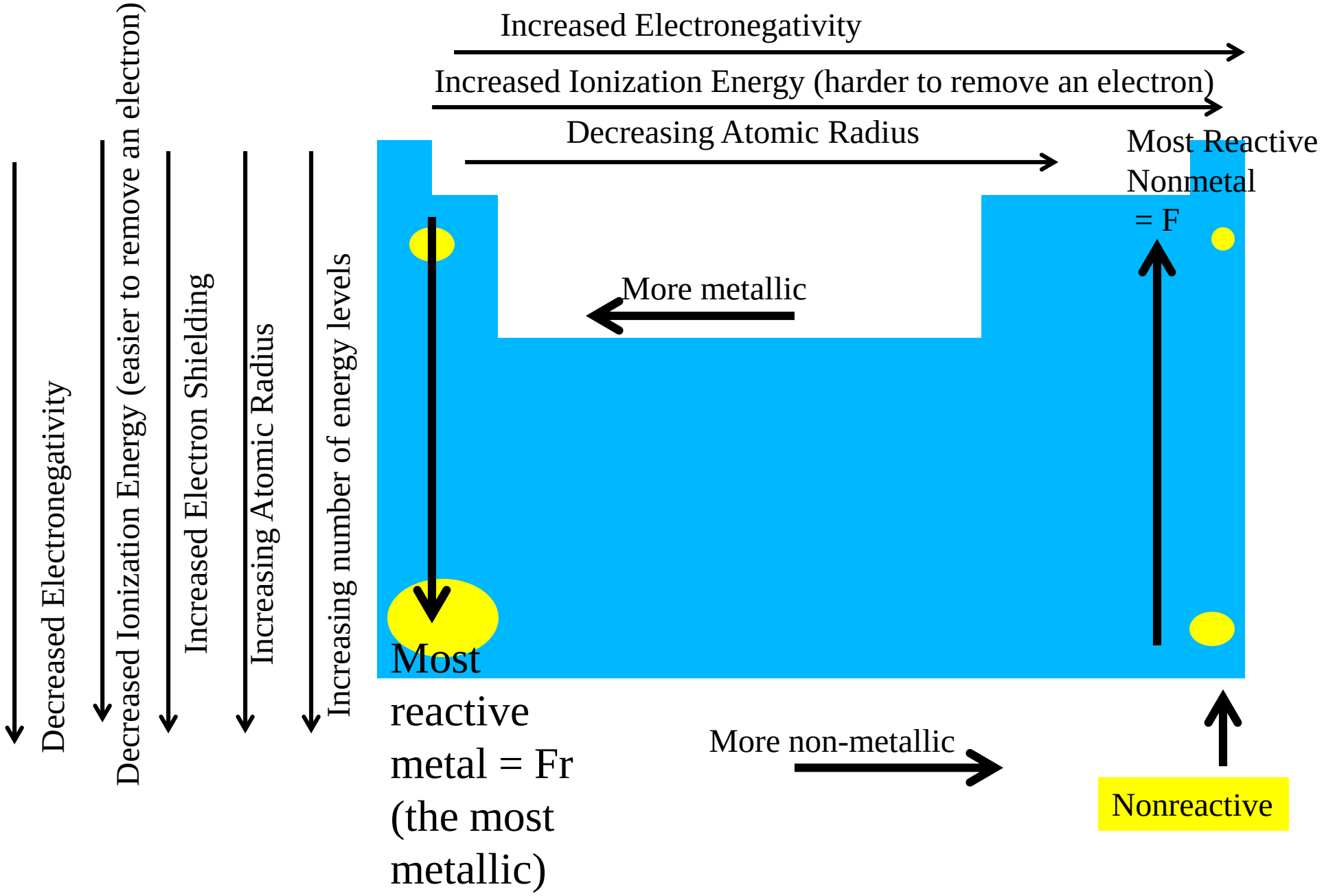
- There are two discontinuities in this trend.

TREND FOR ELECTRON GAIN ENTHALPY:

- The trends for electron gain enthalpy values are less regular, unlike I.E. or E.N.
- Across a period, up to the second last element, EGE becomes more negative (more favorable) with increasing atomic number.
- Down the group, EGE value becomes less negative (less favorable) as the incoming electron is accommodated in the farthest shell.


Increased Electronegativity
Increased Ionization Energy (harder to remove an electron)
Decreasing Atomic Radius
Most Reactive Nonmetal = F
More metallic
Decreased Electronegativity
Decreased Ionization Energy (easier to remove an electron)
Increased Electron Shielding
Increasing Atomic Radius
Increasing number of energy levels
Most reactive metal = Fr (the most metallic)
More non-metallic
Nonreactive

Next Lecture:

1. Periodic trends in Valency.
2. Periodic trends in Metallic-Non-Metallic Character.

Any Question



“It is not the answer that enlightens, but the question.”

- Eugene Ionesco