Warning…

- Don’t over think this stuff.
- You can talk yourself into backwards answers.
- Focus on the fact that there are only a set number of trends to learn.
- Practice explaining each trend until you can do it in your sleep!
- There will ALWAYS be exceptions. Don’t worry about that – focus on the pattern and answer questions based on the patterns.

Warning…

- There is about to be a lot of notes because it takes a lot of words to explain
- You don't need EVERY word written down to understand it.
- Focus on listening and understanding.
- You can add to your notes at home.
- Capture enough to pay attention, leave space to come back and add/annotate.

Warning…

Make sure you capture:

What

How

Why

Make sure you can tell me:

What

How

Why

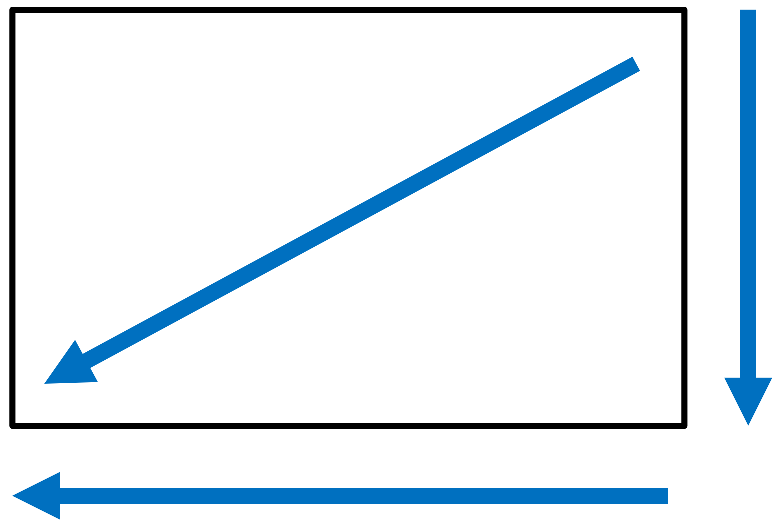
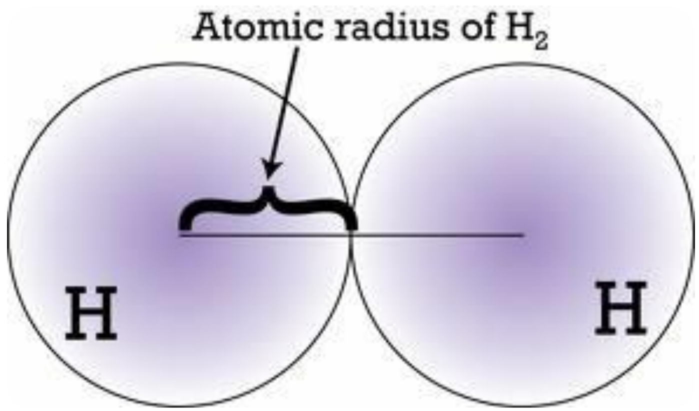
Periodic Trends

hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 **	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

Atomic Radius

ATOMIC RADIUS

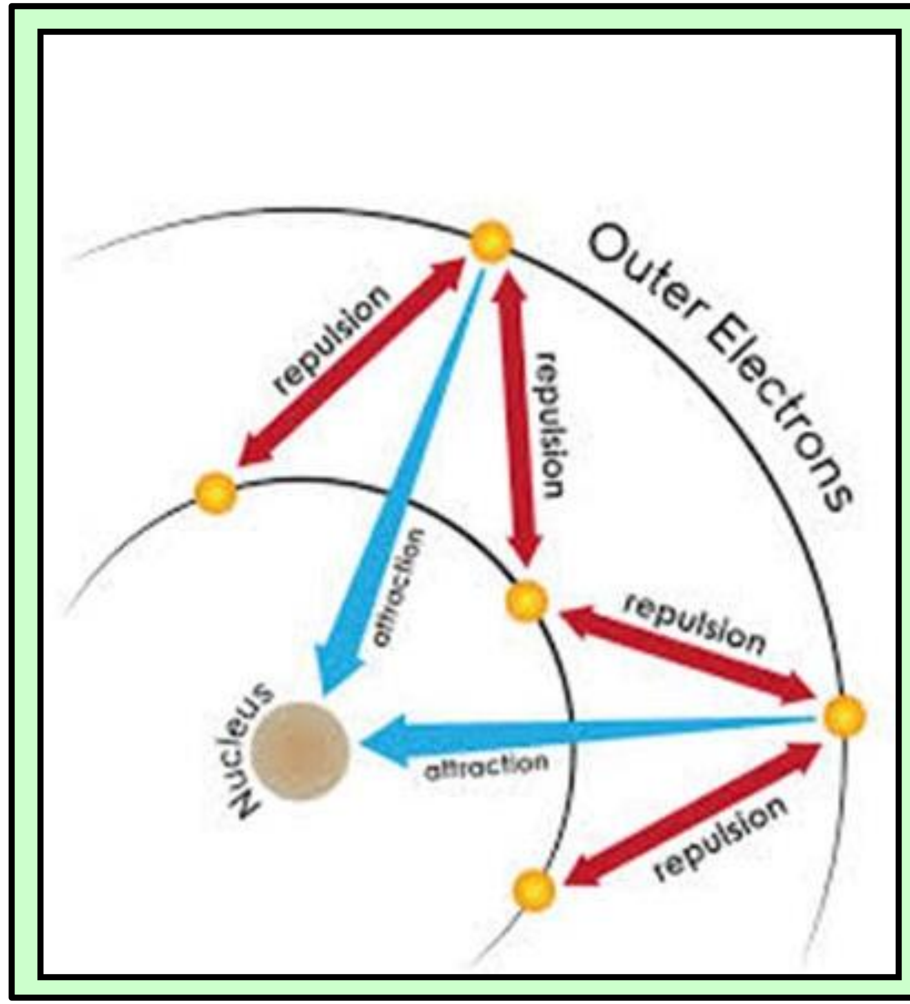
What	How
• ½ the distance between two bonded nuclei	
• Cant measure to the edge b/c orbitals aren't tangible!	
 	

ATOMIC RADIUS

Why	
INCREASES DOWN	**DECREASES TO RIGHT**
	• Adding a proton = bigger change than adding an e-
• Adding energy levels further from the nucleus resulting in larger radius.	• More protons pull the valence electrons in closer - “Greater Effective Nuclear Charge”
• Inner e- keep valence e- from “feeling” the nucleus • Outer e^-s are not as pulled in by the protons in the nucleus – there is more “shielding” by the inner electrons	• No increase in shielding b/c no new energy levels

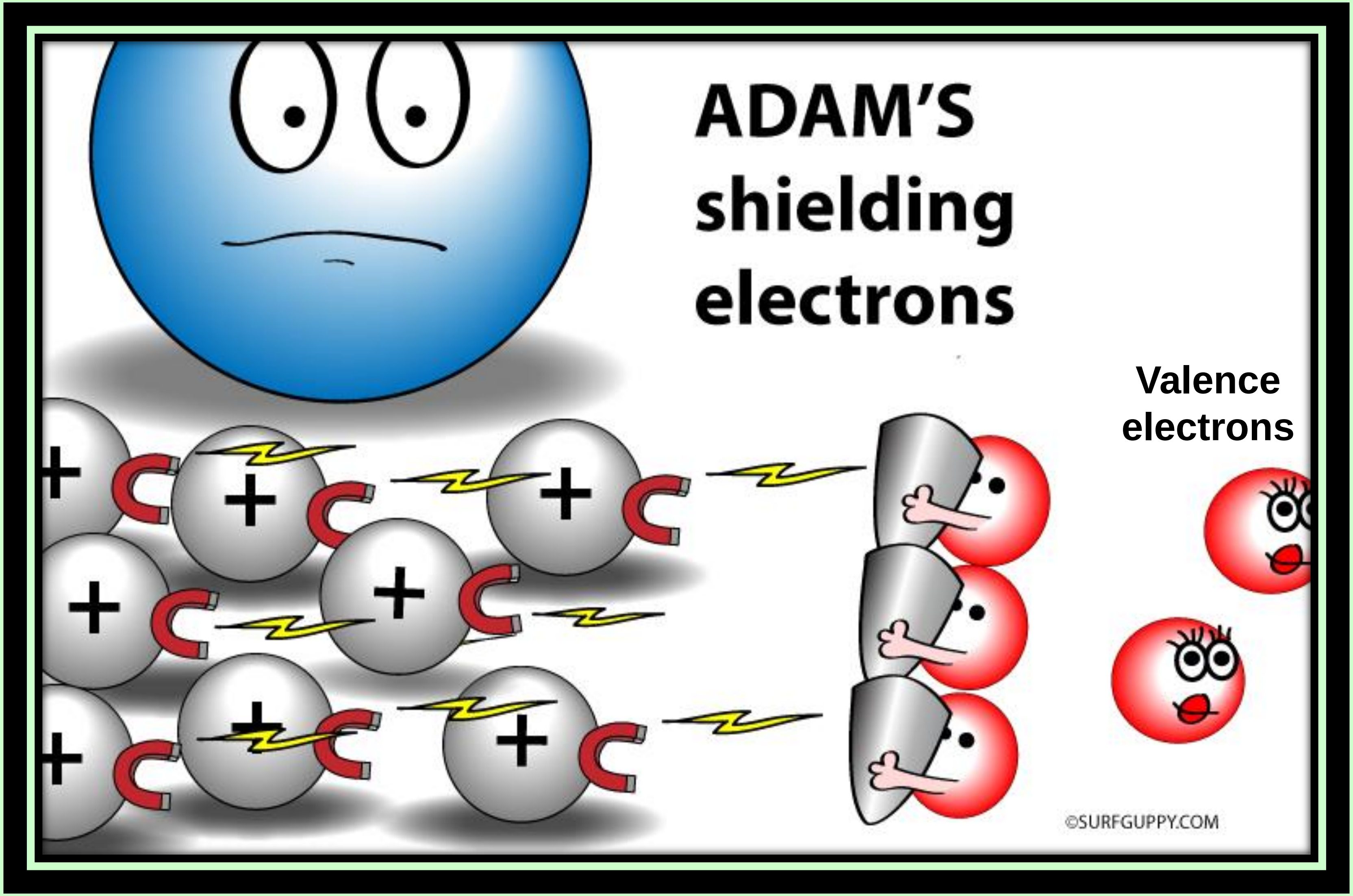
Effective Nuclear Charge (Z_{eff})

The relative attraction the valence electrons have for the protons in the nucleus



Shielding Effect

The inner shell electrons repel the outer valence electrons – keeps the valence e- from “feeling” the nucleus. More repulsion results in less attraction between nucleus and valence e-.


ADAM'S
shielding
electrons
Valence
electrons
©SURFGUPPY.COM

Calculating Effective Nuclear Charge

The relative attraction the valence electrons have for the protons in the nucleus

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

Z = nuclear attraction = # protons

S = the core/inner e- shielding the valence e-’s

= the total number of e- minus the e- in the highest occupied s and p energy levels

= *(# of e- in previous noble gas + any d or f e-’s past the noble gas in the element)*

Calculating Effective Nuclear Charge

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

Magnesium

Z = 12 protons

S = Previous noble gas

= Neon = 10 electrons

Zeff = 12 - 10 = 2

Aluminum

Z = 13 protons

S = Previous noble gas

= Neon = 10 electrons

Zeff = 13 – 10 = 3

Aluminum is smaller – valence electrons are pulled in harder by the nucleus

IONIC RADIUS

What	How
The radius of an ion	Cation – always smaller Anion – always bigger
Cation – lost electrons Anion – gained electrons	

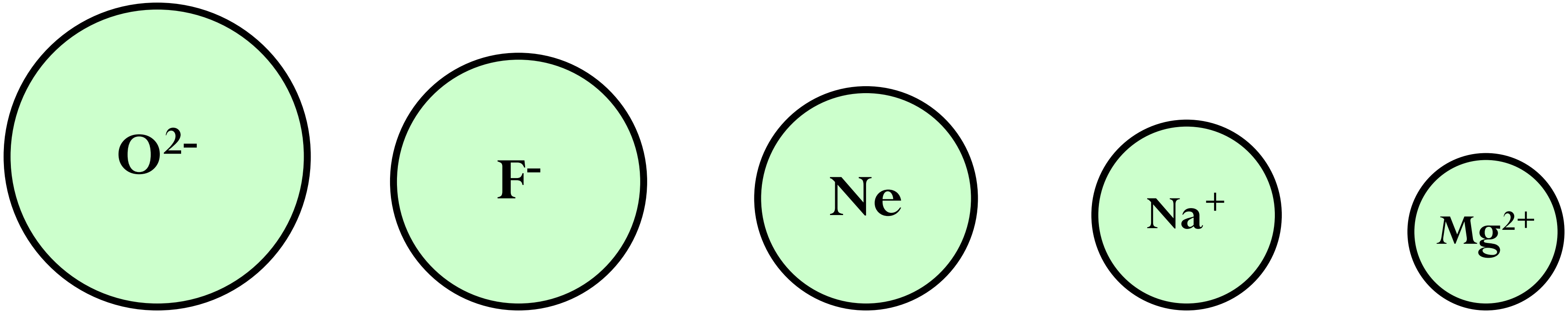
IONIC RADIUS

Why	
CATION SMALLER • Reduced repulsion between electrons • If you lose enough electrons you even drop down an energy level! Much smaller!	**ANION LARGER** • Extra valence electrons repel each other a bit more so it gets larger.

Isoelectric Species

Atoms/Ions that have the same number of e-

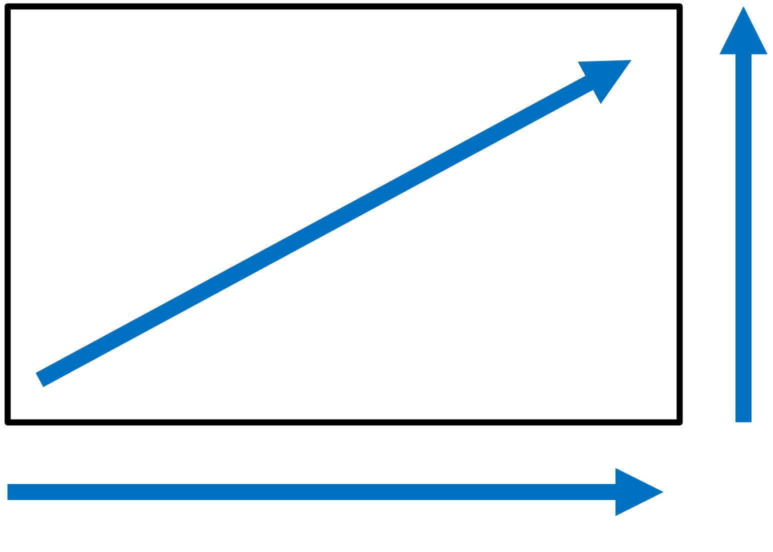
All these examples are $1s^2 2s^2 2p^6$

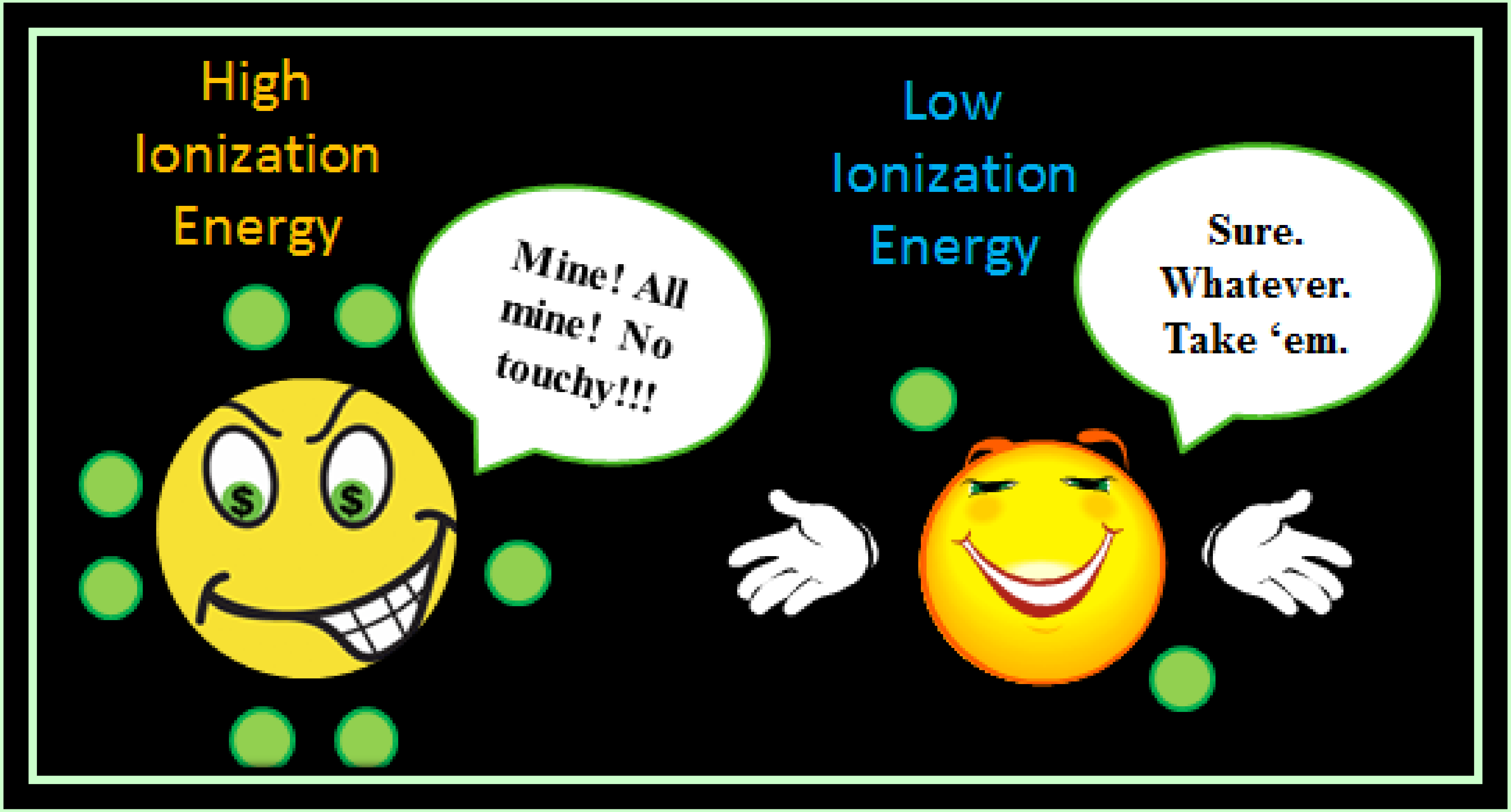


Increased protons can pull harder on the valence electrons – greater effective nuclear charge – so the radius is smaller even though they have the same number of electrons and energy levels

Ionization Energy

IONIZATION ENERGY

What	How
The energy required to remove on electron from a neutral atom of an element	 Noble Gases are HIGHEST! They REALLY don't want to let go of an e-


High Ionization Energy
Mine! All mine! No touchy!!!
Low Ionization Energy
Sure. Whatever. Take 'em.

IONIZATION ENERGY

Why	
DECREASES DOWN	**INCREASES TO RIGHT**
• Electrons are further from nucleus in higher energy levels	• Closer to having a full stable valence shell
• Increased shielding from core e- causes nucleus to not pull as hard on valence e-	• Increased effective nuclear charge means nucleus is pulling harder on the valence e- so they are harder to remove

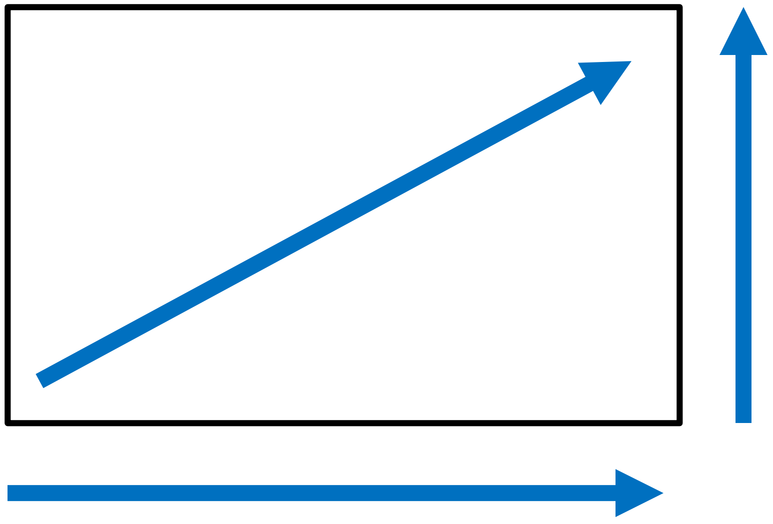
Subsequent Ionizations

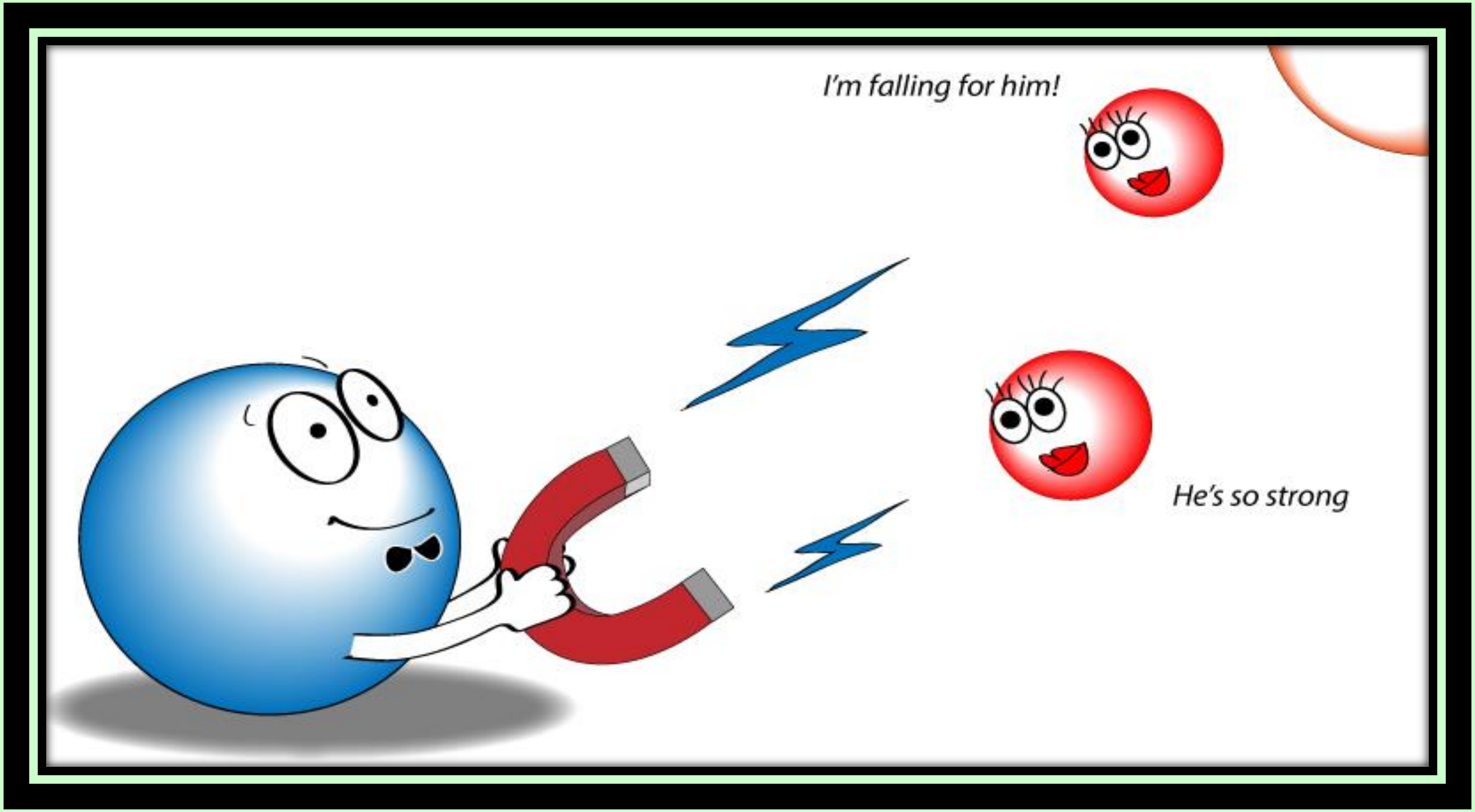
Every time you take an e- away it gets harder to take the next one. Radius is getting smaller, so nucleus can pull harder on the valence - harder to remove the next one. HUGE LEAP in I.E. once it's achieved noble gas configuration – why would it want to lose another one?!

Element	IE_1	IE_2	IE_3	IE_4
Na	496	4560		
Mg	738	1450	7730	
Al	578	1820	2750	11,600

Electronegatvity

ELECTRONEGATIVITY

What	How
A measure of the ability of an atom in a chemical compound to attract electrons from another atom in the compound	
How strongly can one atom pull on the electrons being shared in a bond.	Noble Gases are LOWEST! They DON'T CARE about attracting electrons!

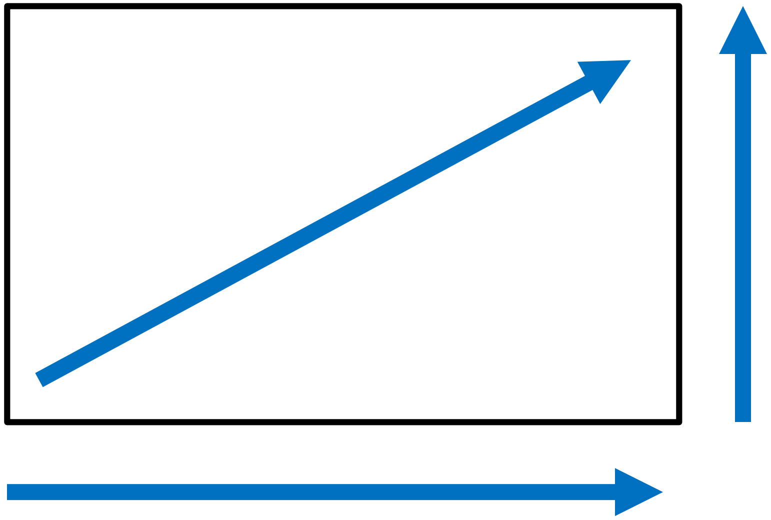

I'm falling for him!
He's so strong

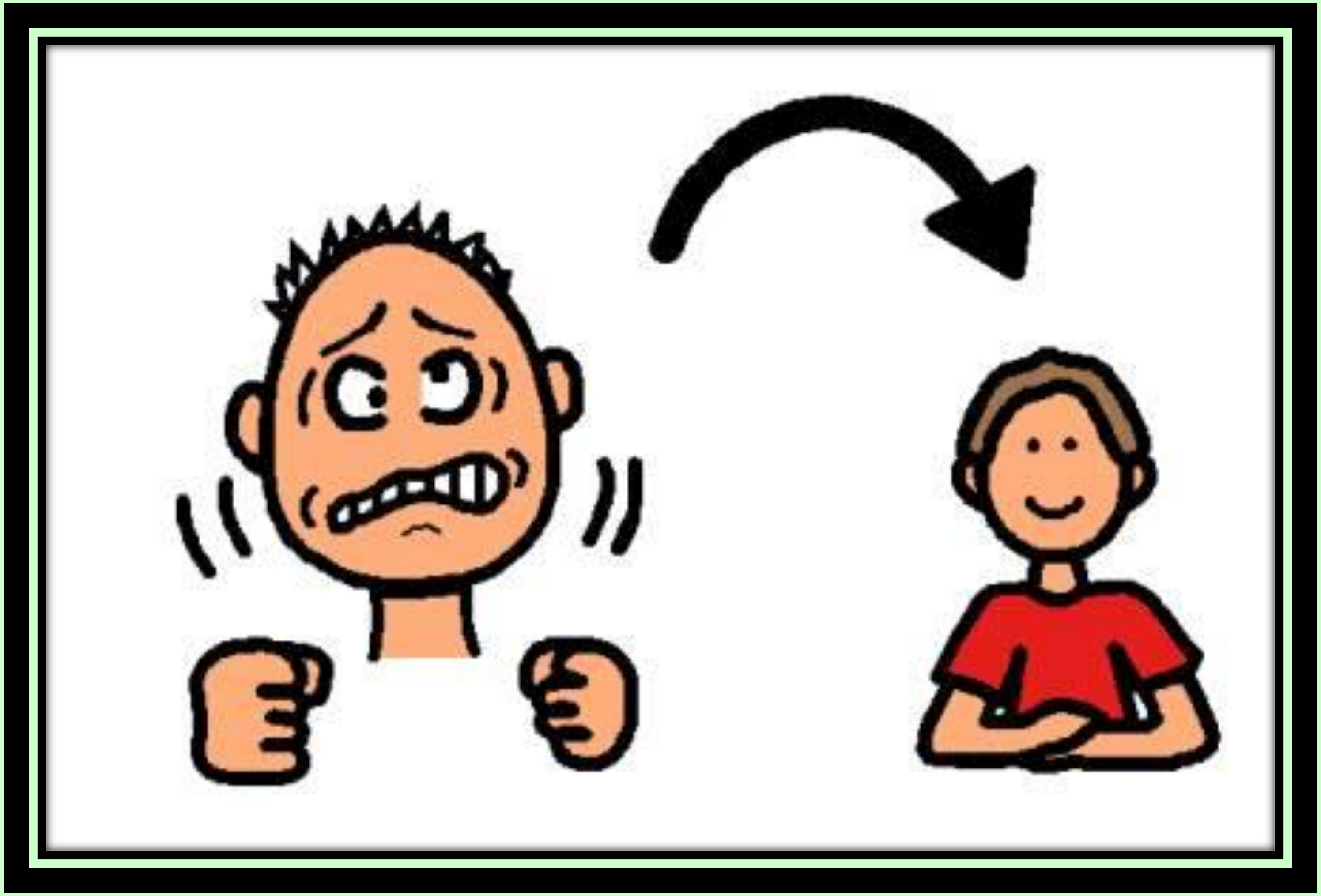
ELECTRONEGATIVITY

Why	
DECREASES DOWN	**INCREASES TO RIGHT**
• e- are further from nucleus in higher energy levels	• Smaller radius, increased effective nuclear charge
• Increased shielding from core e- causes nucleus to not pull as hard on valence e-	• Nucleus is pulling harder on the valence electrons – which is where the bonding is occurring.
• So nucleus doesn't pull as hard on the bonding e-'s from another atom	

Electron Affinity

ELECTRON AFFINITY

What	How
How much energy is released when the atom gains an electron to make a negative ion. *How much stability does it gain once it is an anion. More energy released – more stable.*	 Noble Gases are LOWEST! They DON'T CARE about attracting electrons!

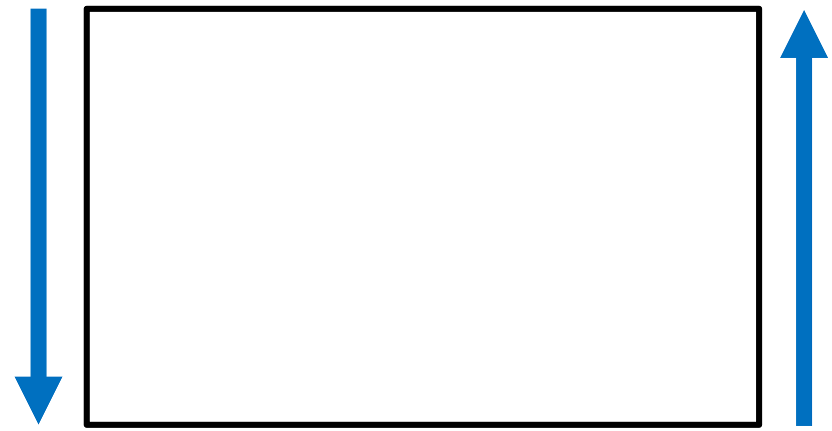


ELECTRON AFFINITY

Why	
DECREASES DOWN • Electrons are further from nucleus in higher energy levels • Increased shielding from core e-'s causes the nucleus to not pull as hard on valence e-'s • So atom doesn't notice as much if it gains an electron – doesn't gain much stability	**INCREASES TO RIGHT** • Closer to filling valence shell – noble gas configuration is most stable

Reactivity

REACTIVITY

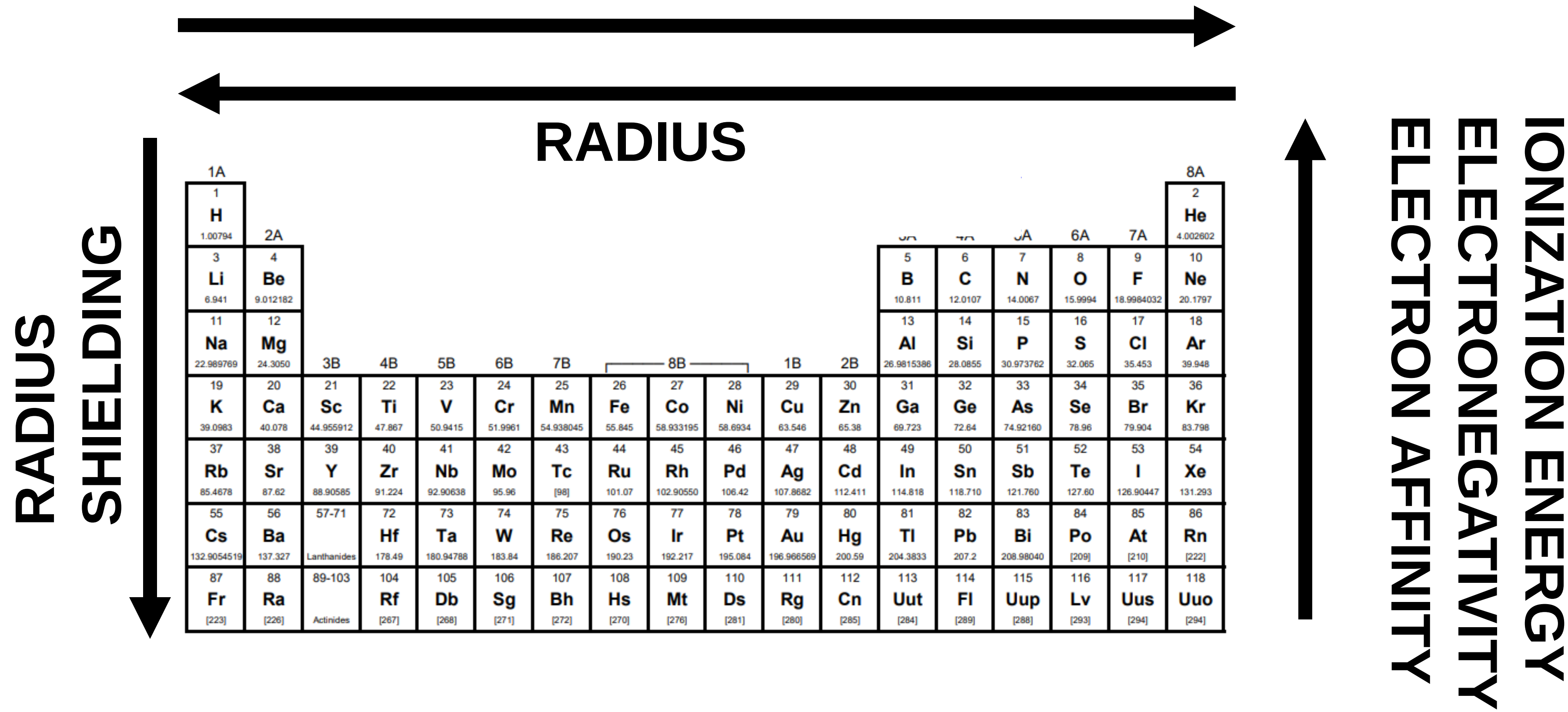
What	How
Elements in the same group have similar types of behaviors <u>because they have the same number of valence e-</u> BUT The MAGNITUDE of their reactions changes!	 Metals and Non-metals are opposite trends! Noble gases are "INERT" or non-reactive

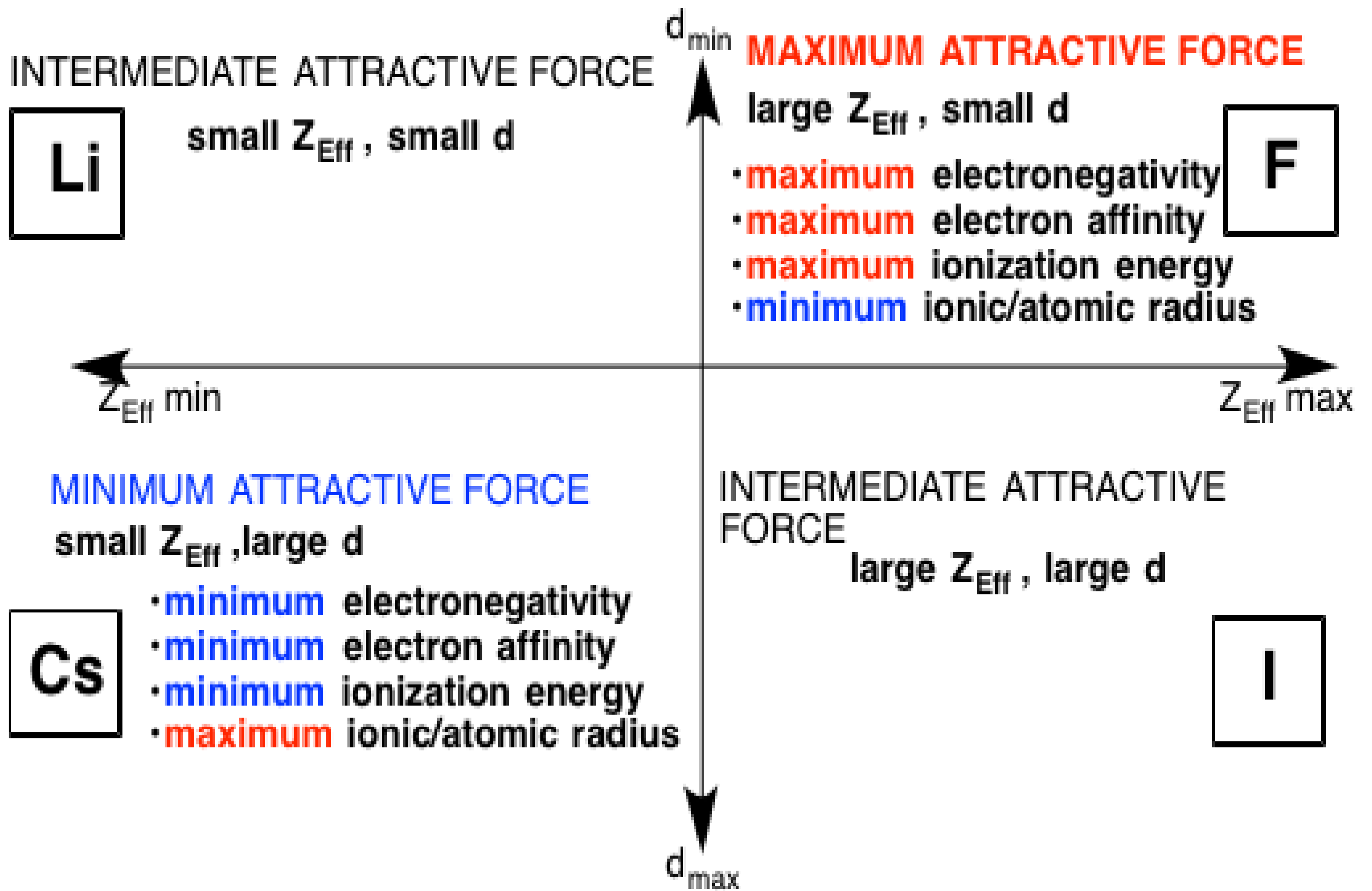
REACTIVITY

Why	
METALS INCREASE DOWN	**NON-METALS INCREASE UP**
• Larger radius and increased shielding means lower ionization energy so it is easier to remove electrons	• Smaller radius and greater effective nuclear charge means higher electronegativity and electron affinity so it can attract an electron easier

Summary

IONIZATION ENERGY
ELECTRONEGATIVITY
ELECTRON AFFINITY
EFFECTIVE NUCLEAR CHARGE - Z_{EFF}





INTERMEDIATE ATTRACTIVE FORCE
Li
small Z_{Eff} , small d
d_{min}
MAXIMUM ATTRACTIVE FORCE
large Z_{Eff} , small d
F
• maximum electronegativity
• maximum electron affinity
• maximum ionization energy
• minimum ionic/atomic radius
Z_{Eff} min
Z_{Eff} max
MINIMUM ATTRACTIVE FORCE
small Z_{Eff} ,large d
• minimum electronegativity
• minimum electron affinity
• minimum ionization energy
• maximum ionic/atomic radius
Cs
INTERMEDIATE ATTRACTIVE FORCE
large Z_{Eff} , large d
I
d_{max}

Brainiac Video – *note: they augmented the reactions, but it is such a fun, silly, memorable video I think it is still worth watching* ☺

Disposal of Sodium – *old footage from WWII. Neat to see such old footage and how they actually disposed of the sodium after the war!*

Quick summary. Also has a quick but good explanation of some exceptions to the trends

https://www.youtube.com/watch?v=hePb00CqvP0

YouTube Link to this Presentation