N15 - Periodic Trends

Target:

I can describe periodic trends and the reasons behind them.

Links to YouTube Presentations:

Part 1: *https://youtu.be/jmy5tlVlFTs*

Part 2: *https://youtu.be/lTGOnu_WJ5I*

(based on an old version of this lecture – same info just not laid out the same)

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.

Periodic Trends

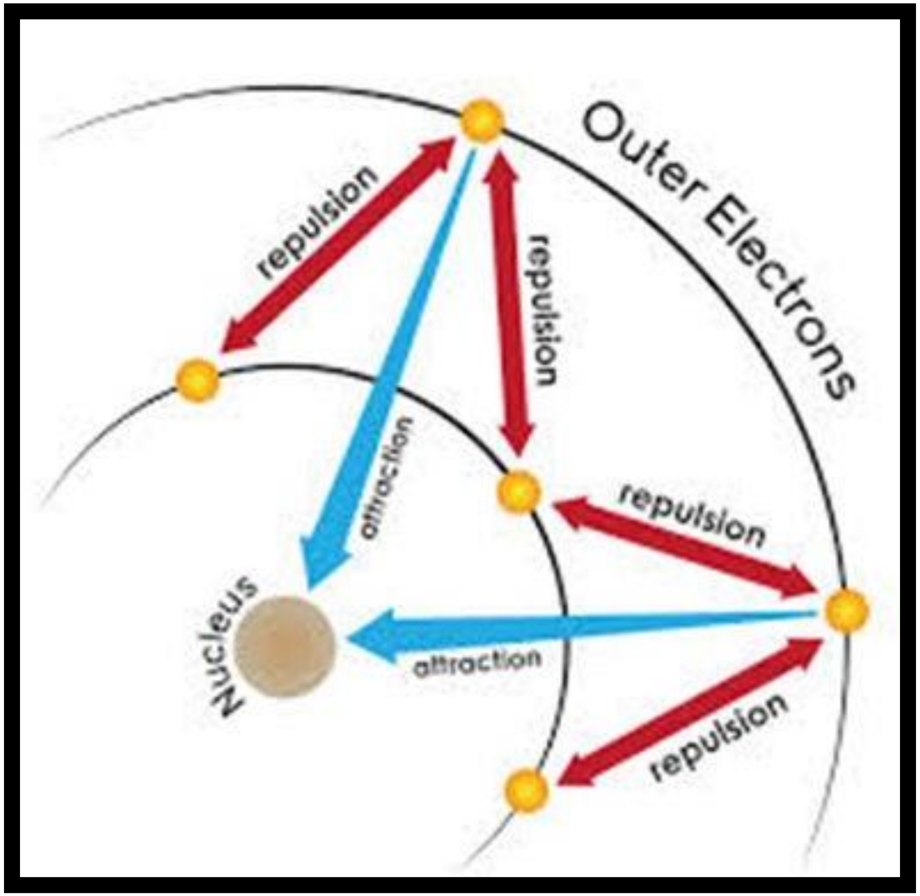
hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 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]

Factors that contribute to trends we see on the periodic table

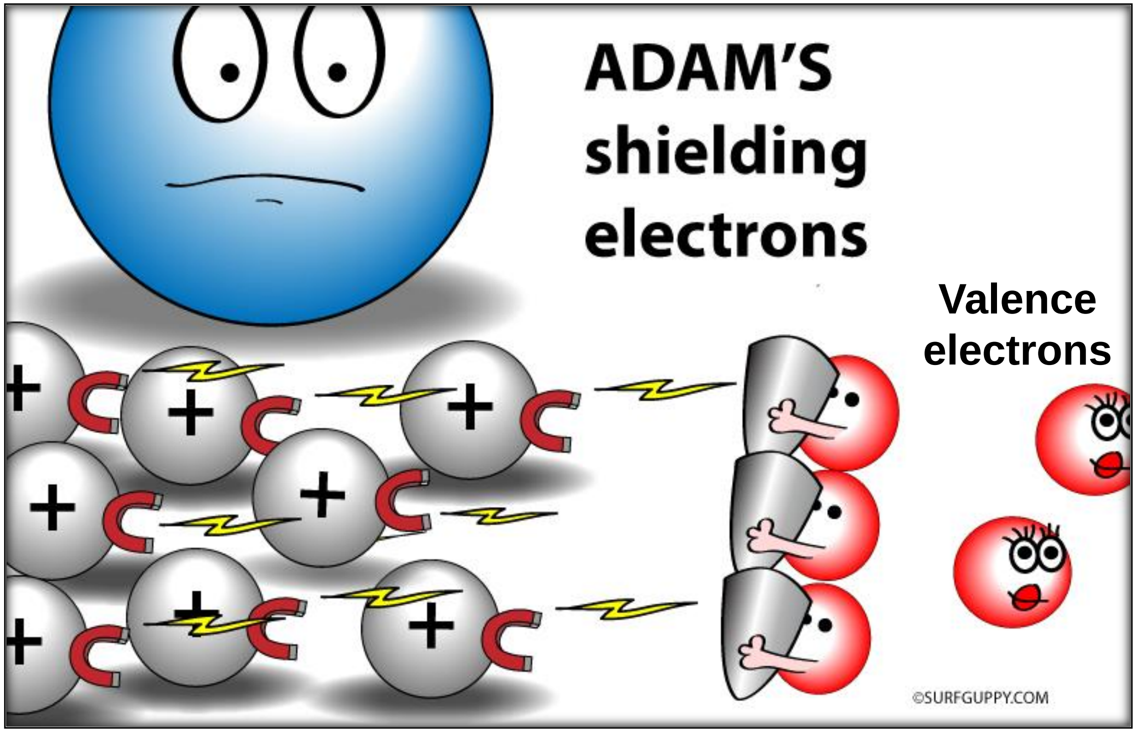
EVERYTHING is about...

- Attractions
- Repulsions



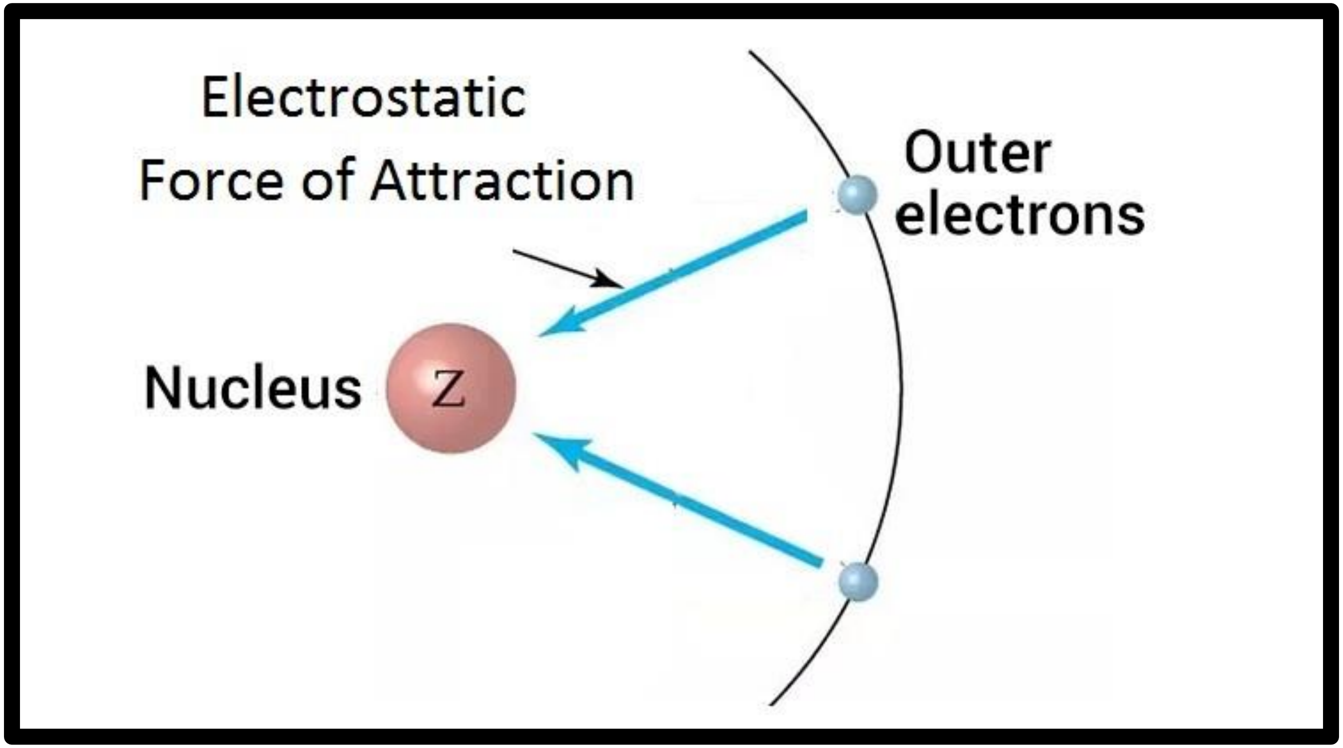
Shielding Effect

- Inner shell electrons repel the outer valence electrons
- Keeps valence e^- from feeling the full attractive force of the nucleus.



Effective Nuclear Charge (Z_{eff})

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



Effective Nuclear Charge (Z_{eff})

Adding a proton has a larger effect than adding an electron

p^+

e^-

p^+

e^-

Effective Nuclear Charge (Z_{eff})

- 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

Calculating Effective Nuclear Charge

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

Magnesium

Z = 12 protons

S = (12 total e^-) – (2 valence e^-) = 10 core e^-

Z_{eff} = 12 - 10 = 2

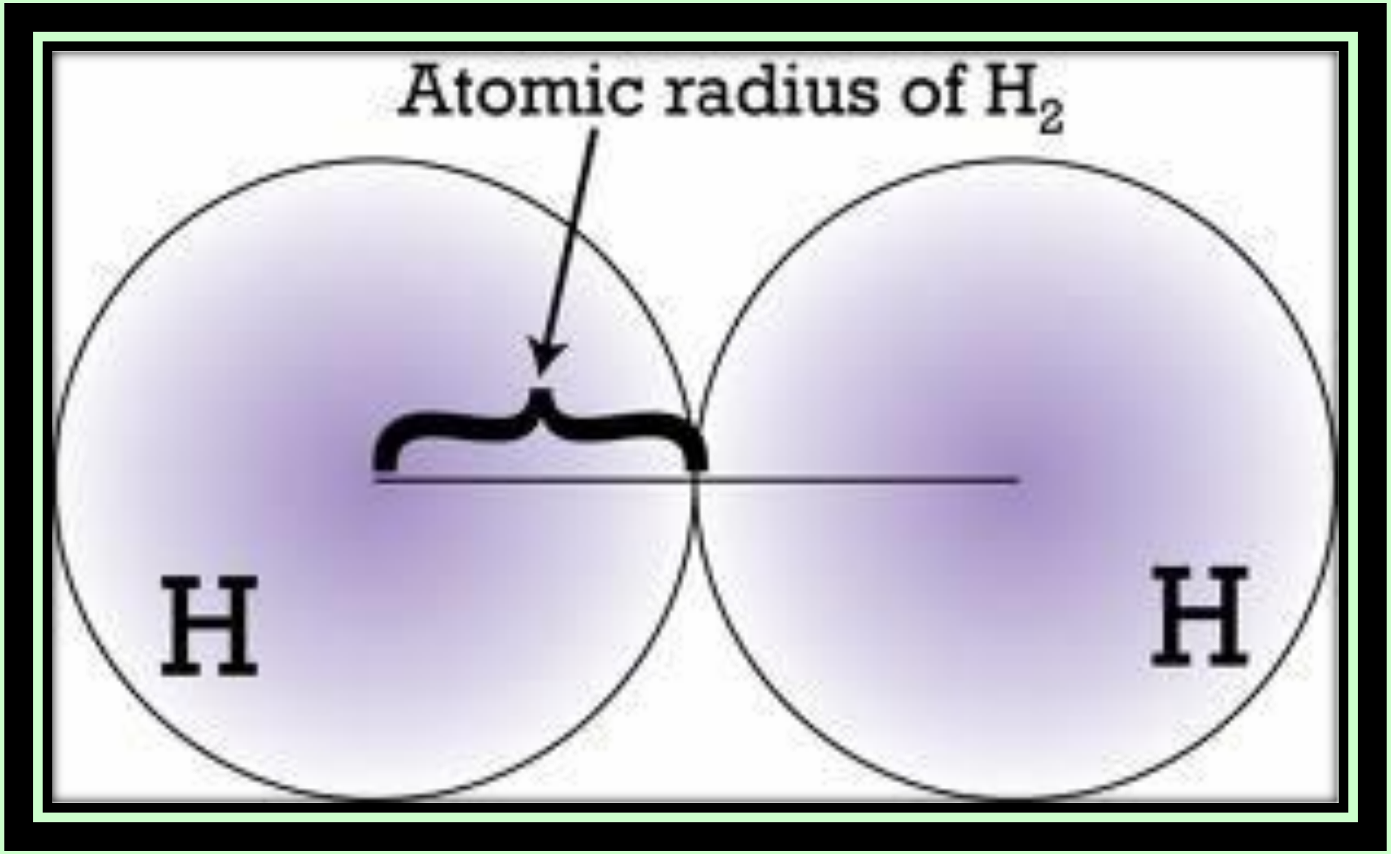
Aluminum

Z = 13 protons

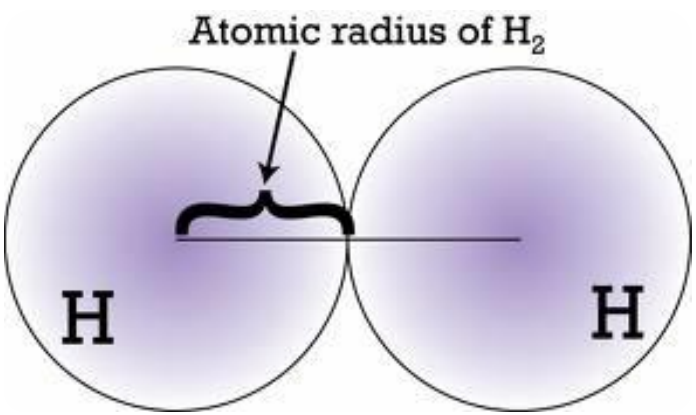
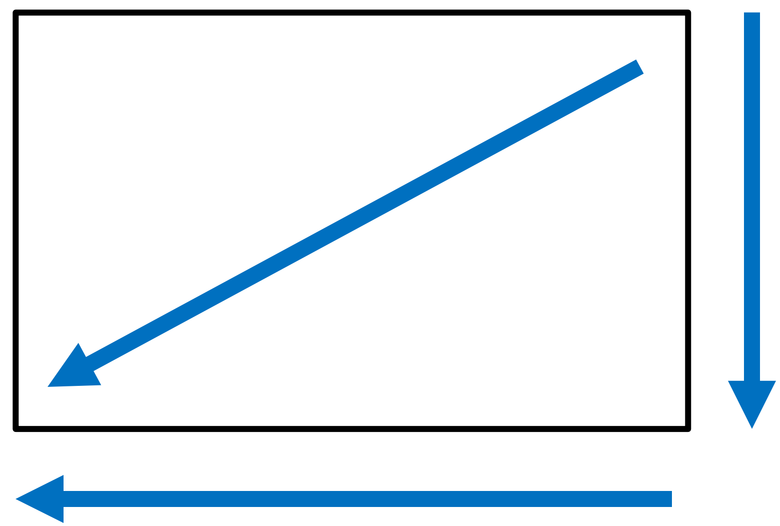
S = = (13 total e^-) – (3 valence e^-) = 10 core e^- Zeff = 13 – 10 = 3

Aluminum is smaller in radius! Valence electrons are pulled in harder by the nucleus

Radius



ATOMIC RADIUS

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

ATOMIC RADIUS

Why

<u>INCREASES DOWN because...</u>

Circle one:

Increased Shielding or Increased Nuclear Charge

- More energy levels
- v.e$^-$ Further from nucleus
- More shielding
- Less attraction → **Larger Radius**

ATOMIC RADIUS

Why

DECREASES TO RIGHT because...

Circle one:

Increased Shielding

or

Increased Nuclear Charge

- More protons
- Same # of energy levels so no increase in shielding
- Stronger nuclear attraction → **Smaller Radius**

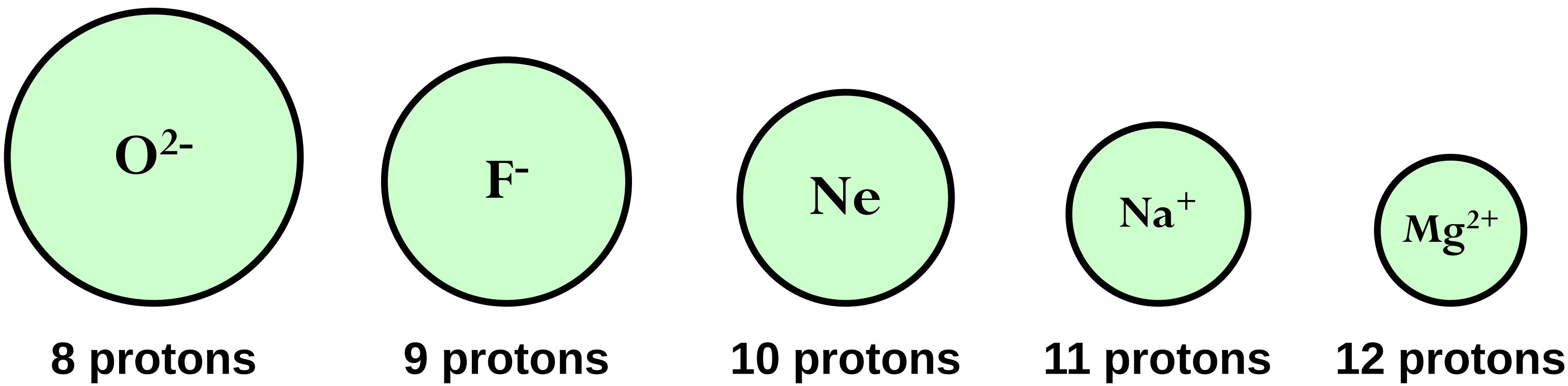
IONIC RADIUS

Cation	*Anion*
• Lost electrons • Always smaller than their neutral atom	• Gained electrons • Always bigger than their neutral atom
• Reduced e- repulsions • Nucleus pulling on fewer e^- • May even drop down an energy level!	• Extra valence e- = more repulsions = bigger

Isoelectric Species

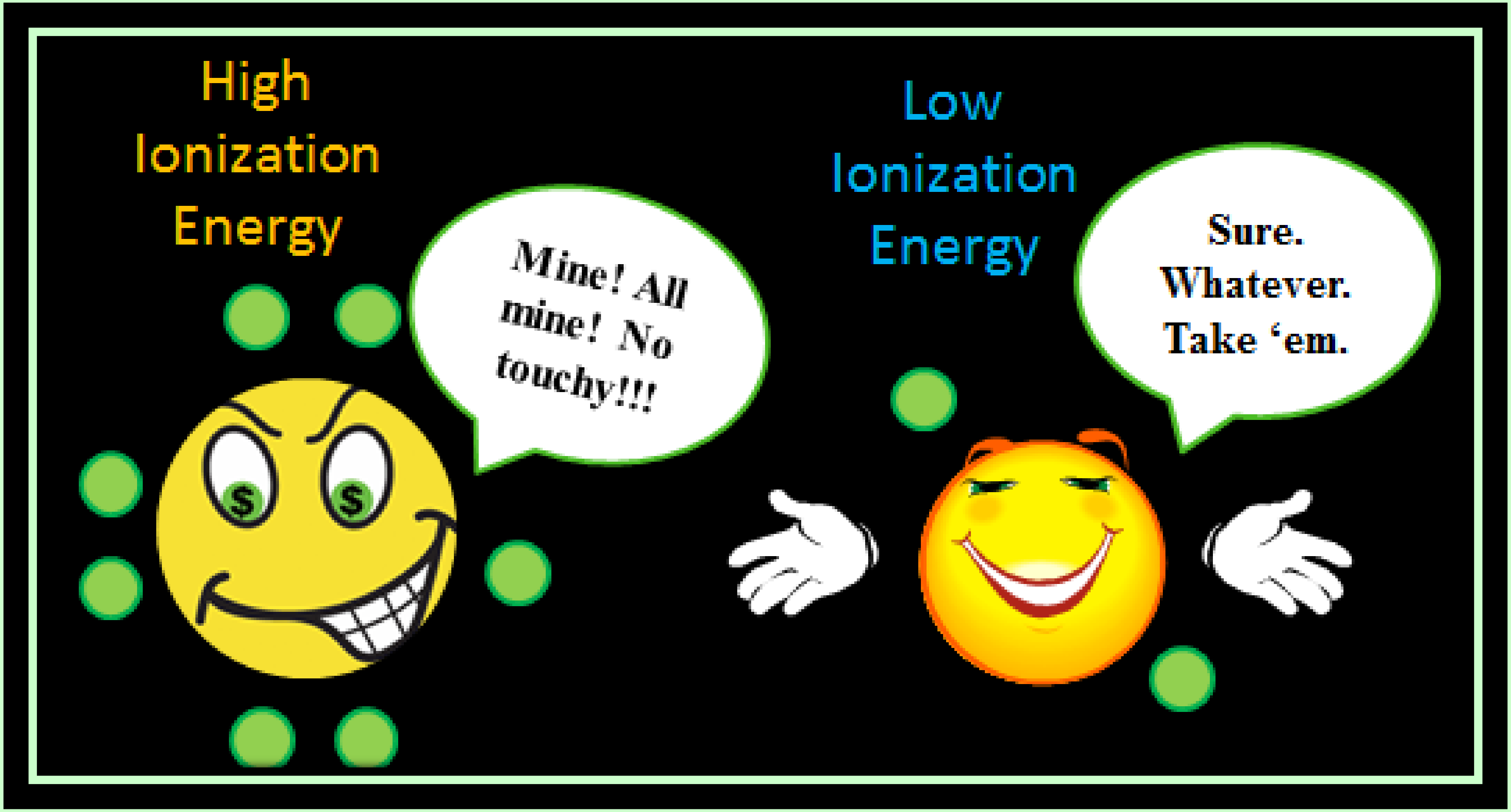
Atoms/Ions that have the same number of e-

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



- Increased protons pull harder on valence electrons - *"Greater effective nuclear charge"*
- Radius ends up smaller

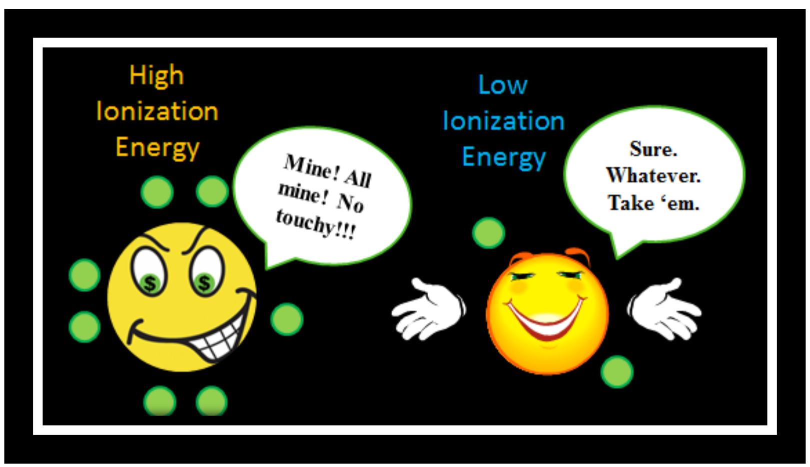
Ionization Energy



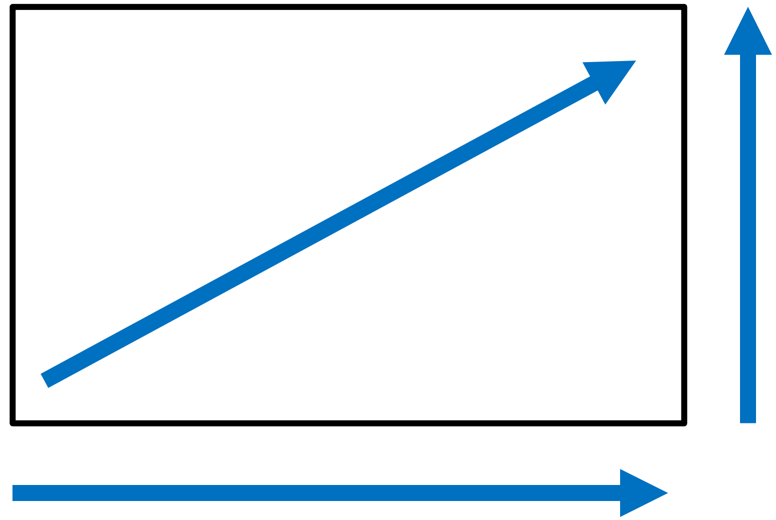
IONIZATION ENERGY

What

The energy required to remove one electron from a neutral atom of an element



How



Noble Gases are HIGHEST!

They REALLY don't want to let go of an e-

IONIZATION ENERGY

Why

DECREASES DOWN because...

Circle one:

Increased Shielding or Increased Nuclear Charge

- More energy levels
- v.e^- Further from nucleus
- More shielding
- Less attraction → **easier to take electron away!**

IONIZATION ENERGY

Why

INCREASES TO RIGHT because...

Circle one:

Increased Shielding | or | Increased Nuclear Charge

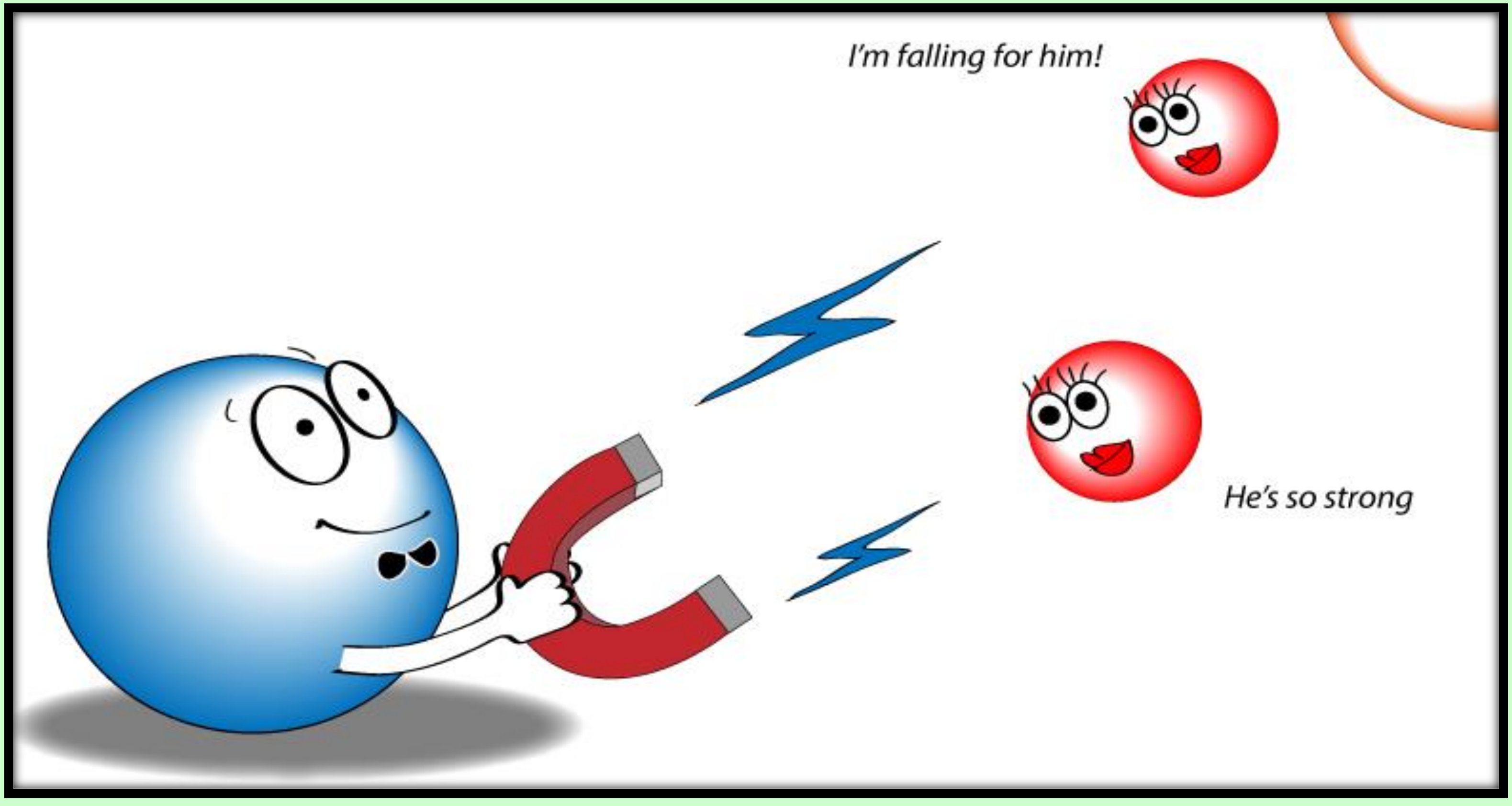
- More protons
- Same # of energy levels so no increase in shielding
- Stronger nuclear attraction → **Harder to take e- away!**

Subsequent Ionizations

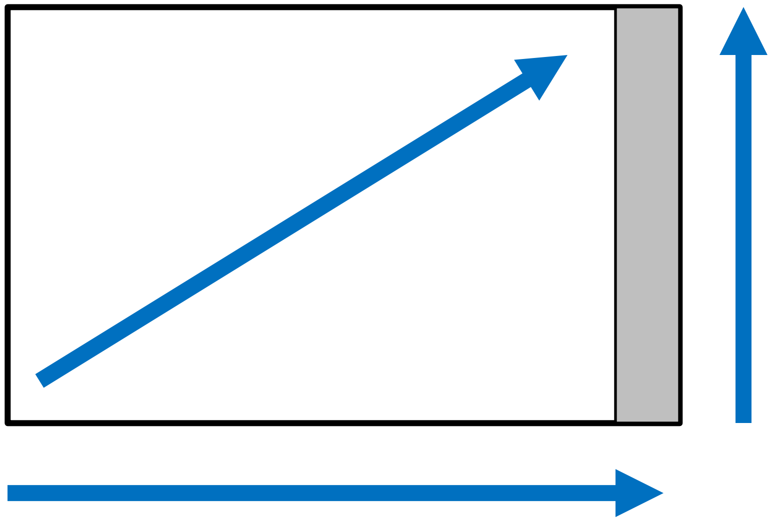
- Each time e- removed →harder to take next one.
- **Radius is getting smaller → increased attraction**
- HUGE LEAP in I.E. once it's achieved noble gas configuration
  – why would it want to lose another one?!

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!**

ELECTRONEGATIVITY

Why

DECREASES DOWN because...

Circle one:

Increased Shielding	or	Increased Nuclear Charge

- More energy levels
- v.e^- Further from nucleus
- More shielding
- **Less attraction**

ELECTRONEGATIVITY

Why

INCREASE TO RIGHT because...

Circle one:

Increased Shielding or Increased Nuclear Charge

- More protons
- Same # of energy levels so no increase in shielding
- **Stronger attraction**

Reactivity

REACTIVITY

What	How
Elements in the same group have *similar* types of behaviors **because they have the same # of valence e- !** 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 because...

Circle one:

Remember – metals want to LOSE electrons

Increased Shielding   or   Increased Nuclear Charge

- More energy levels
- v.e^- Further from nucleus
- More shielding
- Less attraction → **easier to LOSE an electron!**

REACTIVITY

Why

NON-METALS INCREASE UP because...

Circle one:

Remember – nonmetals want to GAIN electrons

Decreased ~~Increased~~ Shielding or Increased Nuclear Charge

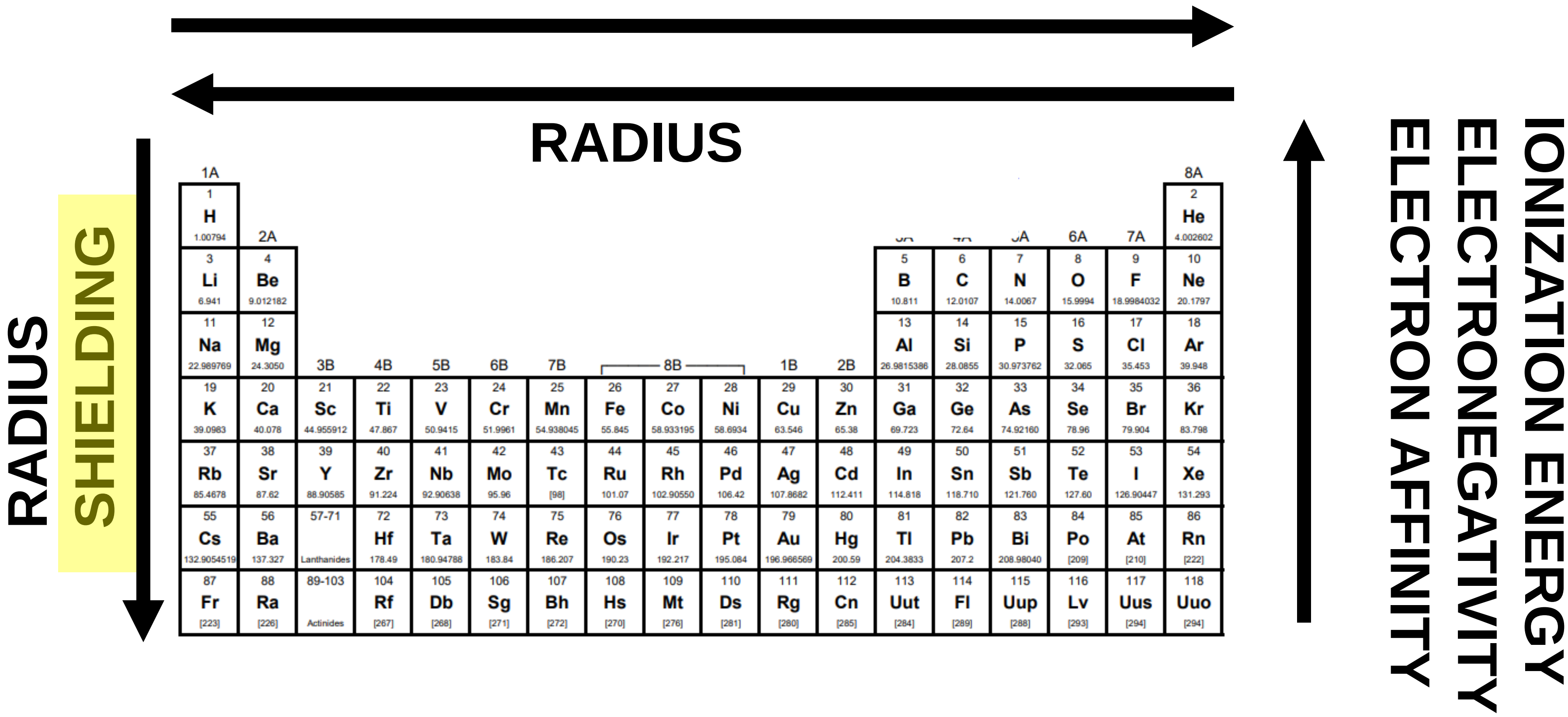
Ha! TRICKY!!!!!!

- FEWER energy levels
- v.e$^-$ CLOSER to nucleus
- LESS shielding
- MORE attraction → **easier to GAIN an electron!**

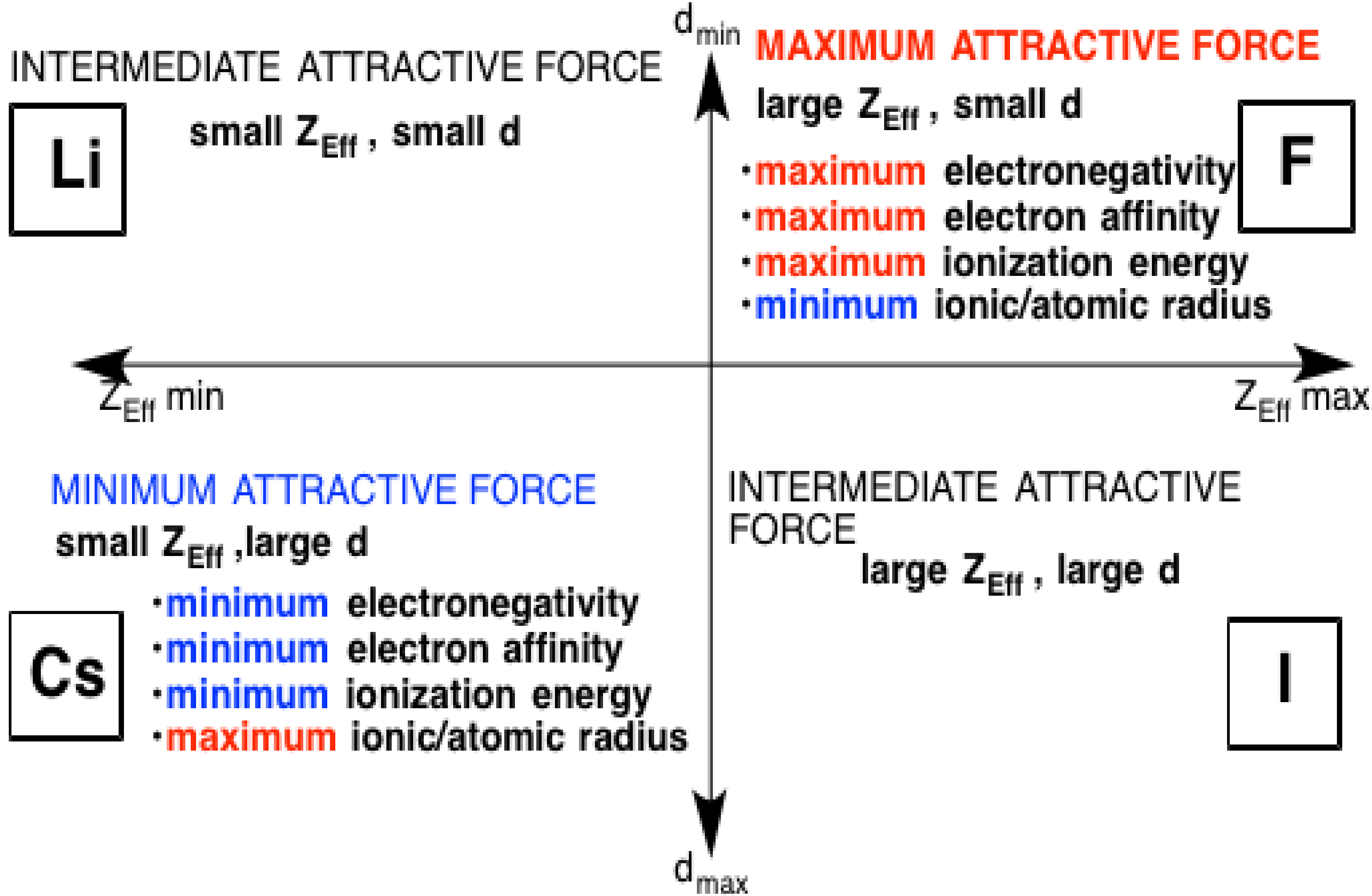
Summary

IONIZATION ENERGY
ELECTRONEGATIVITY
ELECTRON AFFINITY*

EFFECTIVE NUCLEAR CHARGE - Z_{EFF}



1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B				6A	7A	8A
1 **H** 1.00794																	2 **He** 4.002602
3 **Li** 6.941	4 **Be** 9.012182											5 **B** 10.811	6 **C** 12.0107	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984032	10 **Ne** 20.1797
11 **Na** 22.989769	12 **Mg** 24.3050											13 **Al** 26.9815386	14 **Si** 28.0855	15 **P** 30.973762	16 **S** 32.065	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.955912	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.938045	26 **Fe** 55.845	27 **Co** 58.933195	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.64	33 **As** 74.92160	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.90585	40 **Zr** 91.224	41 **Nb** 92.90638	42 **Mo** 95.96	43 **Tc** [98]	44 **Ru** 101.07	45 **Rh** 102.90550	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.90447	54 **Xe** 131.293
55 **Cs** 132.9054519	56 **Ba** 137.327	57-71 Lanthanides	72 **Hf** 178.49	73 **Ta** 180.94788	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.084	79 **Au** 196.966569	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.98040	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** [226]	89-103 Actinides	104 **Rf** [267]	105 **Db** [268]	106 **Sg** [271]	107 **Bh** [272]	108 **Hs** [270]	109 **Mt** [276]	110 **Ds** [281]	111 **Rg** [280]	112 **Cn** [285]	113 **Uut** [284]	114 **Fl** [289]	115 **Uup** [288]	116 **Lv** [293]	117 **Uus** [294]	118 **Uuo** [294]


d min
INTERMEDIATE ATTRACTIVE FORCE
Li
small Z Eff , small d
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
Cs
•minimum electronegativity
•minimum electron affinity
•minimum ionization energy
•maximum ionic/atomic radius
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!*

Crash Course – *Periodic Table episode*

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

(these are based on an old version of this lecture – same info just not laid out the same way we did in class)

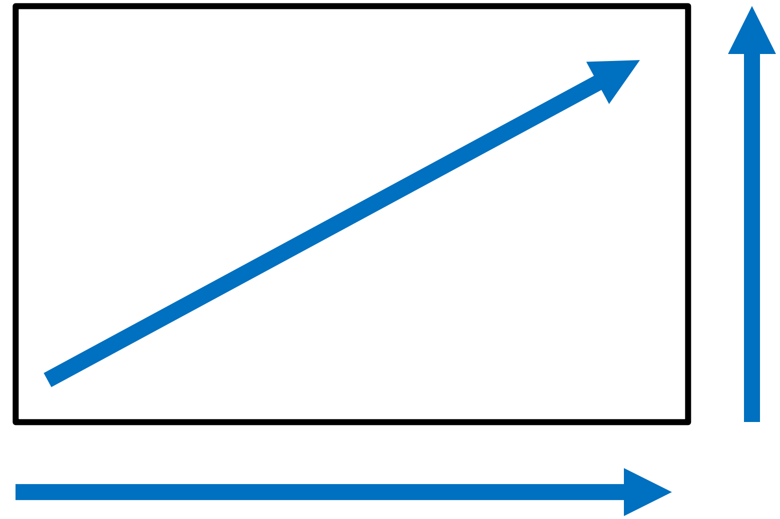
Part 1: *https://youtu.be/jmy5t1VlFTs*

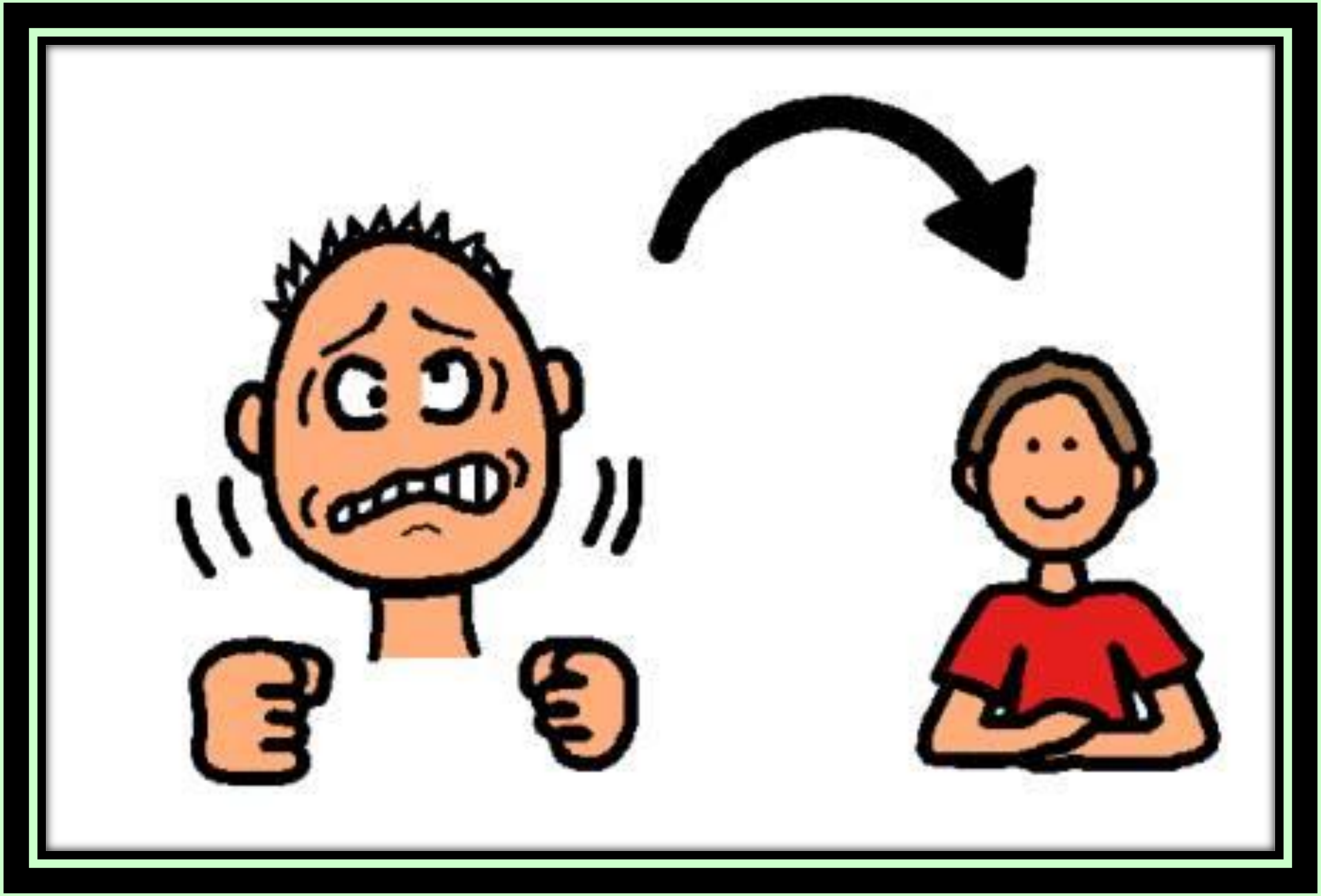
Part 2: *https://youtu.be/1TGOnu_WJ5I*

Things past this slide are not being taught this year

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