

# Periodic Trends

*Flash Review*

CHEM 371

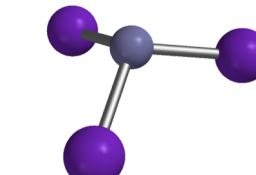
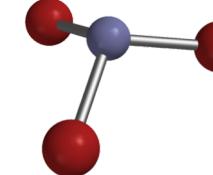
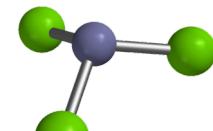
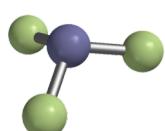
Dr. Christopher B. Durr



# Atomic Radius

Atomic Radius *Increases*

hydrogen	1	1.0079
H		
lithium	3	6.941
Li		
sodium	11	22.990
Na		
potassium	19	39.098
K		
rubidium	37	85.468
Rb		
caesium	55	132.91
Cs		
francium	87	[223]
Fr		



beryllium	4	9.0122
Li		
magnesium	12	24.305
Mg		
calcium	20	40.078
Ca		
yttrium	39	88.906
Y		
zirconium	40	91.224
Zr		
niobium	41	92.906
Nb		
molybdenum	42	95.94
Mo		
technetium	43	[98]
Tc		
ruthenium	44	101.07
Ru		
rhodium	45	102.91
Rh		
palladium	46	106.42
Pd		
silver	47	107.87
Ag		
cadmium	48	112.41
Cd		
indium	49	114.82
In		
germanium	32	118.71
Ge		
arsenic	33	121.76
As		
selenium	34	127.60
Se		
bromine	35	126.90
Br		
krypton	36	131.29
Kr		
tin	50	131.29
Tl		
antimony	51	131.29
Sb		
tellurium	52	131.29
Te		
iodine	53	131.29
I		
xenon	54	131.29
Xe		

Atomic Radius *Increases*

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

\* Lanthanide series

\*\* Actinide series

s – Block

p – Block

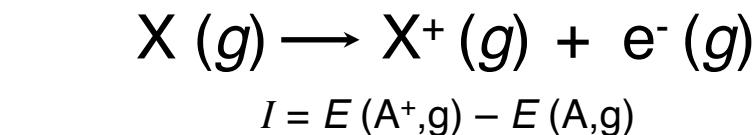
d – Block

f – Block

# Ionization Energy ( $I$ )

First Ionization Energy *Increases*

hydrogen 1 <b>H</b> 1.0079	beryllium 4 <b>Be</b> 9.0122
lithium 3 <b>Li</b> 6.941	magnesium 12 <b>Mg</b> 24.305
sodium 11 <b>Na</b> 22.990	calcium 20 <b>Ca</b> 40.078
potassium 19 <b>K</b> 39.098	
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62
caesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]
	57-70 * <b>Lu</b> 174.97
	89-102 * * <b>Lr</b> [262]



scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	helium 2 <b>He</b> 4.0026
yttrium 39 <b>Y</b> 88.906	zirconium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	ruthenium 44 <b>Ru</b> 101.07	rhodium 45 <b>Rh</b> 102.91	palladium 46 <b>Pd</b> 106.42	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	neon 10 <b>Ne</b> 20.180
ytterbium 71 <b>Lu</b> 174.97	hafnium 72 <b>Hf</b> 178.49	tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhenum 75 <b>Re</b> 186.21	osmium 76 <b>Os</b> 190.23	iridium 77 <b>Ir</b> 192.22	platinum 78 <b>Pt</b> 195.08	gold 79 <b>Au</b> 196.97	mercury 80 <b>Hg</b> 200.59	thallium 81 <b>Tl</b> 204.38	lead 82 <b>Pb</b> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	radon 86 <b>Rn</b> [222]
lawrencium 103 <b>Lr</b> [262]	rutherfordium 104 <b>Rf</b> [261]	dubnium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [266]	bohrium 107 <b>Bh</b> [264]	hassium 108 <b>Hs</b> [269]	meitnerium 109 <b>Mt</b> [268]	ununnilium 110 <b>Uun</b> [271]	ununnilium 111 <b>Uuu</b> [272]	ununnilium 112 <b>Uub</b> [277]	nihonium 113 <b>Nh</b> [284]	flerovium 114 <b>Fl</b> [289]	moscovium 115 <b>Mc</b> [288]	livemorium 116 <b>Lv</b> [293]	tennessine 117 <b>Ts</b> [294]	oganesson 118 <b>Og</b> [294]

\* Lanthanide series

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

\*\* Actinide series

s – Block

p – Block

d – Block

f – Block

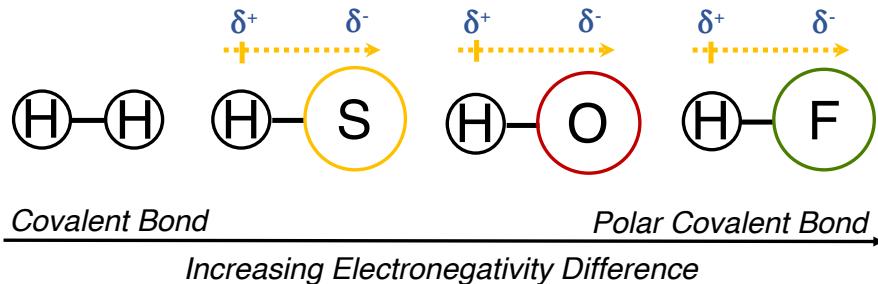
First Ionization Energy Increases

First Ionization Energy Increases

# Electronegativity

Electronegativity *Increases*

hydrogen 1 <b>H</b> 1.0079	beryllium 4 <b>Be</b> 9.0122
lithium 3 <b>Li</b> 6.941	magnesium 12 <b>Mg</b> 24.305
sodium 11 <b>Na</b> 22.990	
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62
caesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]



helium 2 <b>He</b> 4.0026	neon 10 <b>Ne</b> 20.180
boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011
aluminium 13 <b>Al</b> 26.982	nitrogen 7 <b>N</b> 14.007
silicon 14 <b>Si</b> 28.086	oxygen 8 <b>O</b> 15.999
phosphorus 15 <b>P</b> 30.974	fluorine 9 <b>F</b> 18.998
sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453
chlorine 18 <b>Ar</b> 39.948	argon 18 <b>Ar</b> 39.948
krypton 36 <b>Kr</b> 83.80	
bromine 35 <b>Br</b> 79.904	
iodine 53 <b>I</b> 131.29	xenon 54 <b>Xe</b> 131.29
astatine 85 <b>At</b> [222]	radon 86 <b>Rn</b> [222]
polonium 84 <b>Po</b> [209]	
lead 82 <b>Pb</b> [208.98]	
bismuth 83 <b>Bi</b> [210]	
thallium 81 <b>Tl</b> [204.38]	
moscovium 115 <b>Mc</b> [288]	
livermorium 116 <b>Lv</b> [293]	
tennessine 117 <b>Ts</b> [294]	
oganesson 118 <b>Og</b> [294]	

\* Lanthanide series

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

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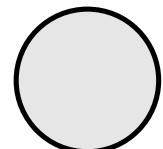
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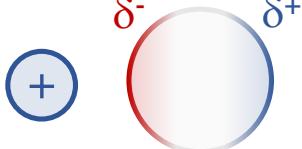
Electronegativity *Increases*

# Polarizability

hydrogen 1 <b>H</b> 1.0079	beryllium 4 <b>Be</b> 9.0122
lithium 3 <b>Li</b> 6.941	magnesium 12 <b>Mg</b> 24.305
sodium 11 <b>Na</b> 22.990	calcium 20 <b>Ca</b> 40.078
potassium 19 <b>K</b> 39.098	strontium 38 <b>Sr</b> 87.62
rubidium 37 <b>Rb</b> 85.468	barium 56 <b>Ba</b> 137.33
caesium 55 <b>Cs</b> 132.91	lanthanum 57 <b>La</b> 138.91
francium 87 <b>Fr</b> [223]	cerium 58 <b>Ce</b> 140.12
radium 88 <b>Ra</b> [226]	praseodymium 59 <b>Pr</b> 140.91
*	neodymium 60 <b>Nd</b> 144.24
*	promethium 61 <b>Pm</b> [145]
*	samarium 62 <b>Sm</b> 150.36
*	europerium 63 <b>Eu</b> 151.96
*	gadolinium 64 <b>Gd</b> 157.25
*	terbium 65 <b>Tb</b> 158.93
*	dysprosium 66 <b>Dy</b> 162.50
*	holmium 67 <b>Ho</b> 164.93
*	erbium 68 <b>Er</b> 167.26
*	thulium 69 <b>Tm</b> 168.93
*	ytterbium 70 <b>Yb</b> 173.04



Atom Not Polarized



Atom Polarized

boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	neon 10 <b>Ne</b> 20.180
aluminum 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	krypton 18 <b>Ar</b> 39.948
gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	xenon 36 <b>Xe</b> 83.80
indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	radon 86 <b>Rn</b> 131.29
thallium 81 <b>Tl</b> 204.38	lead 82 <b>Pb</b> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	oganesson 86 <b>Og</b> [222]
hafnium 72 <b>Hf</b> 178.49	rhenium 75 <b>Re</b> 186.21	osmium 76 <b>Os</b> 190.23	iridium 77 <b>Ir</b> 192.22	platinum 78 <b>Pt</b> 195.08	rhodium 45 <b>Rh</b> 102.91
tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhodium 44 <b>Ru</b> 101.07	ruthenium 45 <b>Ru</b> 106.42	silver 46 <b>Ag</b> 107.87	cobalt 27 <b>Co</b> 55.845
zirconium 40 <b>Zr</b> 88.906	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	rhodium 45 <b>Rh</b> 58.933	nickel 28 <b>Ni</b> 58.693
yttrium 39 <b>Y</b> 88.906	cerium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	iron 26 <b>Fe</b> 54.938
scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845

Polarizability Increases

\* Lanthanide series

\*\* Actinide series

lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europerium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04
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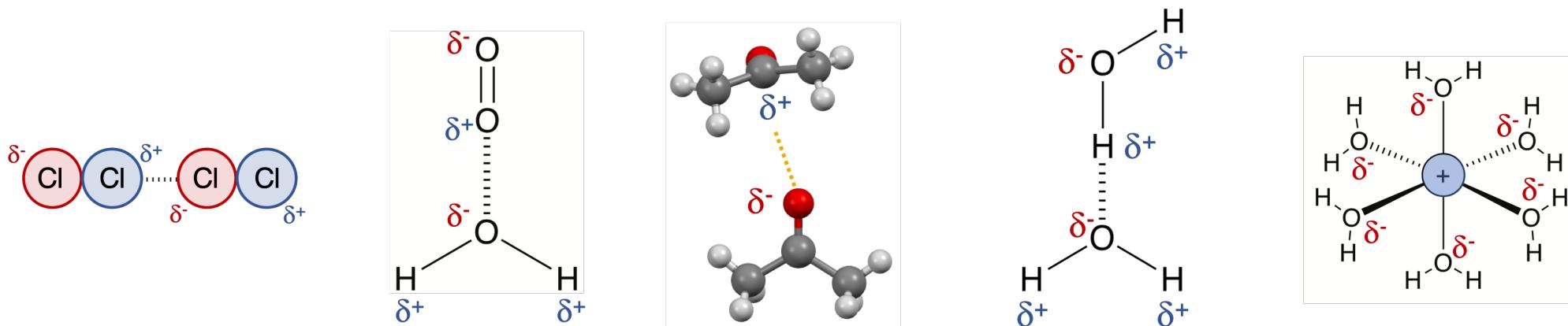
s – Block

p – Block

d – Block

f – Block

# Basic Intermolecular Interactions



**London  
Dispersion  
Forces**

**Dipole Induced  
Dipole**

**Dipole-Dipole**

**Hydrogen  
Bonding**

**Relative Strength**

**London Dispersion  
Forces**

