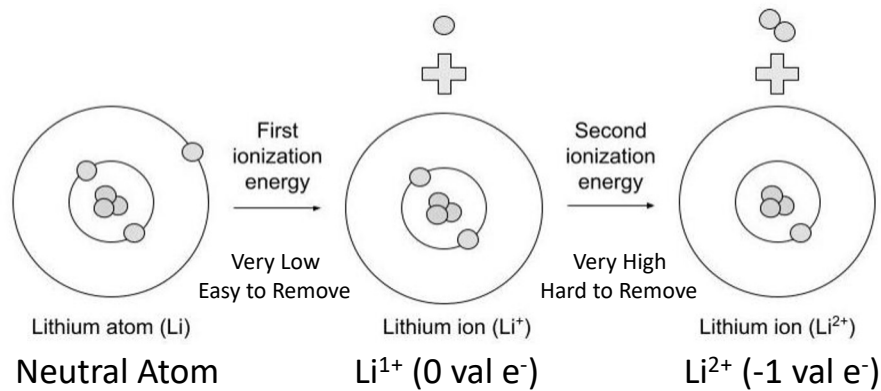


Formation of Ions

Ionization Energy

Energy required to remove an electron from atom to form an ion



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Formation of Ions

Ionization Energy Trends

INCREASING IONIZATION ENERGY

1																		2																	
H																		He																	
3	4																	5	6	7	8	9	10												
Li	Be																	B	C	N	O	F	Ne												
6.941	9.0122																	10.811	12.0107	14.00643	15.9994	16.99943	20.1797												
11	12																	13	14	15	16	17	18												
Na	Mg																	Al	Si	P	S	Cl	Ar												
22.989769	24.3040																	26.981538	28.0855	30.973761	32.06	35.453	39.948												
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																		
39.0983	40.078	44.955912	47.867	50.9415	51.9961	54.938044	55.845	58.933195	58.6934	63.546	65.38	69.723	72.630	74.921595	78.96	79.904	83.80																		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54																		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																		
85.4678	87.62	88.90584	91.224	92.90638	95.94	98	101.07	102.90550	106.42	107.8682	112.411	114.818	118.710	121.757	127.60	126.90447	131.29																		
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86																		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																		
132.90545	137.327	138.90547	178.49	180.94788	183.84	186.207	190.23	192.222	195.083	196.96655	200.59	204.3833	207.2	208.98039	209	(210)	(222)																		
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104																		
Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																			
223	226	227	232	231	238	237	244	243	247	247	251	252	257	258	259	262																			

Not every element always falls the IE trend,
for example noble gases (8A/18) don't form
ions (*full octet*)

Ionization Energy

Group Trend (*left to right*)

Increases Across Table

More val e^- make it harder
to remove val e^- from atom

Period Trend (*up and down*)

Decreases Down Table

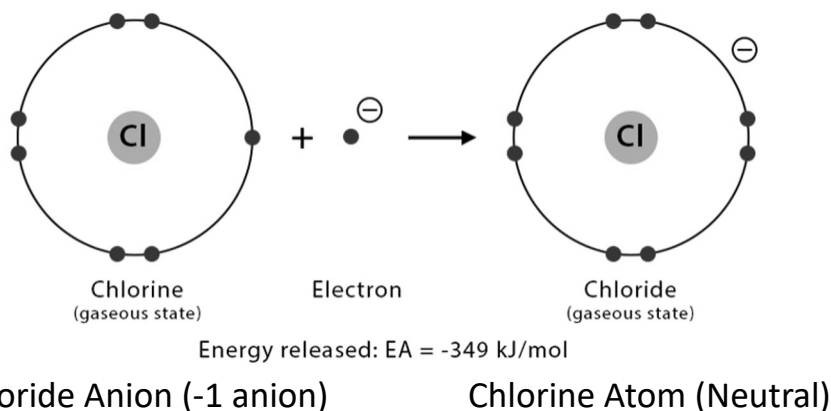
Electrons in higher Energy
Levels are pushed away
from nucleus by inner e^-

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Formation of Ions

Electron Affinity

Energy lost or gained when an atom gains an electron



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Formation of Ions

Electron Affinity Trends

INCREASING ELECTRON AFFINITY

1 H Hydrogen 1.312	2 He Helium 4.481																				
3 Li Lithium 0.60	4 Be Beryllium 0.48															5 B Boron 0.68	6 C Carbon 1.26	7 N Nitrogen 0.07	8 O Oxygen 1.40	9 F Fluorine 3.33	10 Ne Neon 4.05
11 Na Sodium 0.48	12 Mg Magnesium 0.74															13 Al Aluminum 0.44	14 Si Silicon 0.11	15 P Phosphorus 0.22	16 S Sulfur 2.00	17 Cl Chlorine 3.16	18 Ar Argon 3.24
19 K Potassium 0.42	20 Ca Calcium 0.90	21 Sc Scandium 1.57	22 Ti Titanium 1.09	23 V Vanadium 1.53	24 Cr Chromium 1.69	25 Mn Manganese 1.51	26 Fe Iron 1.12	27 Co Cobalt 1.16	28 Ni Nickel 1.13	29 Cu Copper 1.10	30 Zn Zinc 1.10	31 Ga Gallium 0.34	32 Ge Germanium 0.61	33 As Arsenic 0.78	34 Se Selenium 2.00	35 Br Bromine 2.96	36 Kr Krypton 3.49				
37 Rb Rubidium 0.40	38 Sr Strontium 0.95	39 Y Yttrium 1.03	40 Zr Zirconium 1.04	41 Nb Niobium 1.61	42 Mo Molybdenum 1.82	43 Tc Technetium 1.70	44 Ru Ruthenium 1.11	45 Rh Rhodium 1.10	46 Pd Palladium 1.05	47 Ag Silver 1.13	48 Cd Cadmium 1.04	49 In Indium 0.58	50 Sn Tin 1.06	51 Sb Antimony 1.05	52 Te Tellurium 1.90	53 I Iodine 2.48	54 Xe Xenon 2.24				
55 Cs Cesium 0.39	56 Ba Barium 0.90	57 La Lanthanum 1.04	58 Ce Cerium 1.10	59 Pr Praseodymium 1.04	60 Nd Neodymium 1.12	61 Pm Promethium 1.04	62 Sm Samarium 1.13	63 Eu Europium 1.14	64 Gd Gadolinium 1.19	65 Tb Terbium 1.20	66 Dy Dysprosium 1.21	67 Ho Holmium 1.22	68 Er Erbium 1.23	69 Tm Thulium 1.24	70 Yb Ytterbium 1.25	71 Lu Lutetium 1.26	72 Hf Hafnium 1.27				
73 Ta Tantalum 1.28	74 W Tungsten 1.29	75 Re Rhenium 1.30	76 Os Osmium 1.31	77 Ir Iridium 1.32	78 Pt Platinum 1.33	79 Au Gold 1.34	80 Hg Mercury 1.35	81 Tl Thallium 1.36	82 Pb Lead 1.37	83 Bi Bismuth 1.38	84 Po Polonium 1.39	85 At Astatine 1.40	86 Rn Radon 1.41	87 Fr Francium 1.42	88 Ra Radium 1.43	89 Ac Actinium 1.44	90 Th Thorium 1.45				
91 Pa Protactinium 1.46	92 U Uranium 1.47	93 Np Neptunium 1.48	94 Pu Plutonium 1.49	95 Am Americium 1.50	96 Cm Curium 1.51	97 Bk Berkelium 1.52	98 Cf Californium 1.53	99 Es Einsteinium 1.54	100 Fm Fermium 1.55	101 Md Mendelevium 1.56	102 No Nobelium 1.57	103 Lr Lawrencium 1.58	104 Rf Rutherfordium 1.59	105 Db Dubnium 1.60	106 Sg Seaborgium 1.61	107 Bh Bohrium 1.62	108 Hs Hassium 1.63				
109 Mt Meitnerium 1.64	110 Ds Darmstadtium 1.65	111 Rg Roentgenium 1.66	112 Cn Copernicium 1.67	113 Nh Nihonium 1.68	114 Fl Flerovium 1.69	115 Mc Moscovium 1.70	116 Lv Livermorium 1.71	117 Ts Tennessine 1.72	118 Og Oganesson 1.73												

INCREASING ELECTRON AFFINITY

Metals (groups 1A – 3A + transition elements) do not lose electrons, so the electron affinity values are much higher than expected

Electron Affinity

Group Trend (*left to right*)
Increases Across Table

Atoms closer to an octet of e^- lose more energy when forming ions

Period Trend (*up and down*)
Decreases Down Table

Lower atoms are pulled less by p^+ and lose less energy

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Formation of Ions

Comparing Ionization Energy and Electron Affinity

Energy required to remove an electron from atom to form an ion

Element Type	Ionization Energy	Electron Affinity
Metals (0 – 4 Valence Electrons)	Low IE (<i>easy to lose e^-</i>) Atoms want to lose e^-	Low EA (<i>Low desire to gain e^-</i>) Atoms don't want e^-
Non-Metals (5 – 8 Valence Electrons)	High IE (<i>hard to lose e^-</i>) Atoms don't want to lose e^-	High EA (<i>High desire to gain e^-</i>) Atoms want to gain e^-

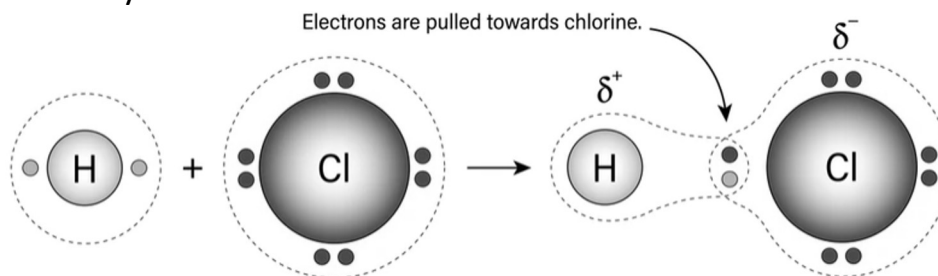
In general: Atoms always want to lose heat (q), - to become more stable

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Formation of Ions

Electronegativity

Atoms ability to attract electrons towards itself



Metals/Hydrogen – Low Electroneg. Non-Metals – High Electroneg.

Higher Electronegativity = More pull on electrons towards itself in bond

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Formation of Ions

Electronegativity Trends

INCREASING ELECTRONEGATIVITY

1																	2						
H Hydrogen 1.00794																	He Helium 4.00260						
3	4																	5	6	7	8	9	10
Li Lithium 0.977735	Be Beryllium 1.571																	B Boron 2.041	C Carbon 2.556	N Nitrogen 3.046	O Oxygen 3.44	F Fluorine 3.98	Ne Neon 4.79
11	12																	13	14	15	16	17	18
Na Sodium 0.933971	Mg Magnesium 1.312																	Al Aluminum 1.61	Si Silicon 1.90	P Phosphorus 2.19	S Sulfur 2.58	Cl Chlorine 3.16	Ar Argon 3.24
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36						
K Potassium 0.8219	Ca Calcium 0.90	Sc Scandium 1.36	Ti Titanium 1.54	V Vanadium 1.63	Cr Chromium 1.66	Mn Manganese 1.55	Fe Iron 1.83	Co Cobalt 1.88	Ni Nickel 1.91	Cu Copper 1.90	Zn Zinc 1.65	Ga Gallium 1.82	Ge Germanium 2.01	As Arsenic 2.18	Se Selenium 2.55	Br Bromine 2.96	Kr Krypton 3.00						
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54						
Rb Rubidium 0.821	Sr Strontium 0.95	Y Yttrium 1.22	Zr Zirconium 1.39	Nb Niobium 1.46	Mo Molybdenum 1.68	Tc Technetium 1.70	Ru Ruthenium 1.86	Rh Rhodium 1.88	Pd Palladium 1.95	Ag Silver 1.93	Cd Cadmium 1.69	In Indium 1.78	Sn Tin 1.96	Sb Antimony 2.05	Te Tellurium 2.1	I Iodine 2.66	Xe Xenon 2.6						
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86						
Cs Cesium 0.79	Ba Barium 0.89	La Lanthanum 1.10	Hf Hafnium 1.37	Ta Tantalum 1.40	W Tungsten 1.88	Re Rhenium 1.86	Os Osmium 1.89	Ir Iridium 1.92	Pt Platinum 1.96	Au Gold 2.48	Hg Mercury 2.00	Tl Thallium 1.88	Pb Lead 2.33	Bi Bismuth 2.02	Po Polonium 2.0	At Astatine 2.2	Rn Radon 2.2						
87	88	89	104	105	106	107	108	109	110	111	112	113	114										
Fr Francium 0.7	Ra Radium 0.9	Ac Actinium 1.1	Rf Rutherfordium 1.3	Db Dubnium 1.3	Sg Seaborgium 1.38	Bh Bohrium 1.36	Hs Hassium 1.28	Mt Meitnerium 1.22															

Metals (groups 1A – 3A + transition elements) want to lose electrons, so they generally have a low attraction to their own valence electrons

Electronegativity

Group Trend (*left to right*)

Increases Across Table

Atoms have a stronger attraction to e^- the closer they are to an octet of e^-

Period Trend (*up and down*)

Decreases Down Table

Lower atoms have more inner e^- to the val. e^-