

Searching For an Organizing Principle

- Chlorine, bromine, and iodine have very similar chemical properties.



Chlorine
35.453 amu

Bromine
79.904 amu

Iodine
126.90 amu

The Periodic Law



- In the modern periodic table, elements are arranged in order of increasing atomic number.

1	1	H	2	He
2	3	Li	4	Be
3	11	Na	12	Mg
4	19	K	20	Ca
5	37	Rb	38	Sr
6	55	Cs	56	Ba
7	87	Fr	88	Ra
	56	La	57	Ce
	59	Pr	60	Nd
	61	Pm	62	Sm
	63	Eu	64	Gd
	65	Tb	66	Dy
	67	Ho	68	Er
	69	Tm	70	Yb
	71	Lu	72	Hf
	73	Ta	74	W
	75	Re	76	Os
	77	Ir	78	Pt
	79	Au	80	Hg
	81	Tl	82	Pb
	83	Bi	84	Po
	85	At	86	Rn
	90	Th	91	Pa
	92	U	93	Np
	94	Pu	95	Am
	96	Cm	97	Bk
	98	Cf	99	Es
	100	Fm	101	Md
	102	No	103	Lr
	104	Rf	105	Db
	106	Sg	107	Bh
	108	Hs	109	Mt
	110	Ds	111	Rg
	112	Uub	114	Uuo

The Periodic Law

- The **periodic law**: When elements are arranged in order of increasing atomic number, there is a periodic repetition of their physical and chemical properties.
 - The properties of the elements within a period change as you move across a period from left to right.
 - The pattern of properties within a period repeats as you move from one period to the next.

Metals, Nonmetals, and Metalloids

- Three broad classes of elements are metals, nonmetals, and metalloids.
- Across a period, the properties of elements become less metallic and more nonmetallic.

Metals, Nonmetals, and Metalloids

- Metals, Metalloids, and Nonmetals in the Periodic Table

1 IA 1A	2 IIA 2A	Metals						Metalloids			Nonmetals						18 VIIIB 8A
H		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	He
Li	Be	3B	4B	5B	6B	7B	8	9	10	11B	12B	13	14	15	16	17	Ne
Na	Mg	3B	4B	5B	6B	7B	8	9	10	11B	12B	Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uuq	114				
		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		
		89	90	91	92	93	94	95	96	97	98	99	100	101	102	No	
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md			

Metals, Nonmetals, and Metalloids

1 IA 1A																	18 VIIIB 8A	
3 IA 1A	4 IIA 2A															2 He		
Li	Be																	
11 Na	12 Mg																	
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	13 B	14 Al	7 N	8 O	9 F	10 Ne
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	33 Se	34 Br	35 Cl	36 Ar	
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 Xe	86 Rn	
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	114 Uuq						
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb			
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No			

Metals, Nonmetals, and Metalloids

1 IA																		18 VIIA							
1 H	2 IA	3 IIA	4 Be	5 VA	6 VIA	7 VIIA	8 VIIIA	9 VIIIA	10 VIIIA	11 IB	12 IIB	13 IIIB	14 IVB	15 VIB	16 VIB	17 VIB	18 VIIA								
												3 E	6 C	7 N	8 O	9 F	10 Ne								
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar										
11 Na	12 Mg	13 B	14 C	15 N	16 O	17 F	18 Ne	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr								
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe								
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn								
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	114 Uuq													
		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb										
		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No										

Metals, Nonmetals, and Metalloids

- Metals, Metalloids, and Nonmetals in the Periodic Table

1 IA 1A	2 IIA 2A	Metals										5 B	14 IVB 4A	15 VB 5A	16 IVB 6A	17 VIB 7A	18 VIIIB 8A	2 He	
H																			
Li	Be	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 9B	10 10B	11 11B	12 12B	B	14 14B Si	15 15B Ge	16 16B As	17 17B Sb	18 18B Te	19 19B At	
Na	Mg	11 11B	12 12B	38 38B	48 48B	58 58B	68 68B	78 78B		18 18B	28 28B	Al	32 32B Ga	33 33B In	30 30B Sn	31 31B Tl	35 35B Br	36 36B Kr	
K	Ca	19 19B	20 20B	21 21B	22 22B	23 23B	24 24B	25 25B	26 26B	27 27B	28 28B	29 29B	30 30B	31 31B Ge	32 32B As	33 33B Sb	35 35B Te	36 36B Xe	
Rb	Sr	37 37B	38 38B	39 39B	40 40B	41 41B	42 42B	43 43B	44 44B	45 45B	46 46B	47 47B	48 48B	49 49B	50 50B Tl	51 51B Pb	52 52B Te	54 54B Rn	
Cs	Ba	55 55B	56 56B	71 71B	72 72B	73 73B	74 74B	75 75B	76 76B	77 77B	78 78B	79 79B	80 80B	81 81B Hg	82 82B Pb	83 83B Te	84 84B At		
Fr	Ra	87 87B	88 88B	103 103B	104 104B	105 105B	106 106B	107 107B	108 108B	109 109B	110 110B	111 111B	112 112B	113 113B Uuu	114 114B Uuq				
		57 57B	58 58B	59 59B	60 60B	61 61B	62 62B	63 63B	64 64B	65 65B	66 66B	67 67B	68 68B	69 69B	70 70B				
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb				
		89 89B	90 90B	91 91B	92 92B	93 93B	94 94B	95 95B	96 96B	97 97B	98 98B	99 99B	100 100B	101 101B	102 102B				
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No				

Metals, Nonmetals, and Metalloids

- Metals
 - **Metals** are good conductors of heat and electric current.
 - 80% of elements are metals.
 - Metals have a high luster, are ductile, and are malleable.

Metals, Nonmetals, and Metalloids



Metals, Nonmetals, and Metalloids

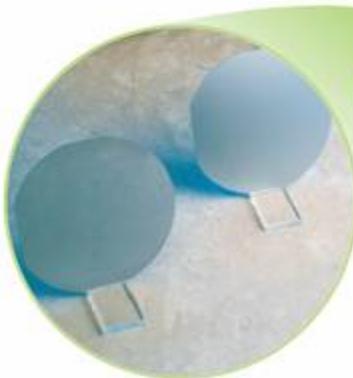
- Nonmetals
 - In general, **nonmetals** are poor conductors of heat and electric current.
 - Most nonmetals are gases at room temperature.
 - A few nonmetals are solids, such as sulfur and phosphorus.
 - One nonmetal, bromine, is a dark-red liquid.

Metals, Nonmetals, and Metalloids

- Metalloids
 - A **metalloid** generally has properties that are similar to those of metals and nonmetals.
 - The behavior of a metalloid can be controlled by changing conditions.

Metals, Nonmetals, and Metalloids

- If a small amount of boron is mixed with silicon, the mixture is a good conductor of electric current. Silicon can be cut into wafers, and used to make computer chips.



Write labels on your blank periodic table

- The Group 1A metals are called **alkali metals.** (not hydrogen)
- The Group 2A elements are called **alkaline earth metals.**
- The nonmetals of Group 7A are called **halogens.**

Representative Elements																		Transition Elements																	
Alkali Metals									Transition Metals									Alkaline Earth Metals									Inner transition metals								
Other Metals									Metalloids									Nonmetals									Noble Gases								
1 1A 1 H Hydrogen 1.0079	2 2A 2 Be Beryllium 9.0122	3 3A 1 Li Lithium 6.941	4 4A 2 Be Beryllium 9.0122	5 5A 3 B Boron 10.81	6 6A 4 C Carbon 12.011	7 7A 5 N Nitrogen 14.007	8 8A 6 O Oxygen 15.999	9 9A 7 F Fluorine 18.998	10 10A 8 Ne Neon 28.179	11 11A 9 Na Sodium 22.990	12 12A 10 Mg Magnesium 24.305	13 13A 11 Al Aluminum 26.982	14 14A 12 Si Silicon 28.086	15 15A 13 P Phosphorus 30.974	16 16A 14 S Sulfur 32.06	17 17A 15 Cl Chlorine 35.453	18 18A 16 Ar Argon 39.949																		
19 19A 1 K Potassium 39.099	20 20A 2 Ca Calcium 40.08	21 21A 3 Sc Scandium 44.956	22 22A 4 Ti Titanium 47.90	23 23A 5 V Vanadium 50.941	24 24A 6 Cr Chromium 51.996	25 25A 7 Mn Manganese 54.939	26 26A 8 Fe Iron 55.847	27 27A 9 Co Cobalt 58.933	28 28A 10 Ni Nickel 58.71	29 29A 11 Cu Copper 63.546	30 30A 12 Zn Zinc 65.38	31 31A 13 Ga Gallium 69.72	32 32A 14 Ge Germanium 72.59	33 33A 15 As Arsenic 74.922	34 34A 16 Se Selenium 78.96	35 35A 17 Br Bromine 79.904	36 36A 18 Kr Krypton 83.80																		
37 37A 1 Rb Rubidium 85.468	38 38A 2 Sr Strontium 87.62	39 39A 3 Y Yttrium 88.906	40 40A 4 Zr Zirconium 91.22	41 41A 5 Nb Niobium 92.906	42 42A 6 Mo Molybdenum 95.94	43 43A 7 Tc Technetium (98)	44 44A 8 Ru Ruthenium 101.07	45 45A 9 Rh Rhodium 102.91	46 46A 10 Pd Palladium 106.4	47 47A 11 Ag Silver 107.87	48 48A 12 Cd Cadmium 112.41	49 49A 13 In Indium 114.82	50 50A 14 Sn Tin 119.69	51 51A 15 Sb Antimony 121.75	52 52A 16 Te Tellurium 127.60	53 53A 17 I Iodine 126.90	54 54A 18 Xe Xenon 131.30																		
55 55A 1 Cs Cesium 132.91	56 56A 2 Ba Barium 137.33	57 57A 3 Lu Lutetium 174.97	58 58A 4 Hf Hafnium 178.49	59 59A 5 Ta Tantalum 180.95	60 60A 6 W Tungsten 183.95	61 61A 7 Re Rhenium 186.21	62 62A 8 Os Osmium 190.2	63 63A 9 Ir Iridium 192.22	64 64A 10 Pt Platinum 195.09	65 65A 11 Au Gold 196.97	66 66A 12 Hg Mercury 200.59	67 67A 13 Tl Thallium 204.97	68 68A 14 Pb Lead 207.2	69 69A 15 Bi Bismuth 209.98	70 70A 16 Po Polonium (209)	71 71A 17 At Astatine (210)	72 72A 18 Rn Radon (222)																		
87 87A 1 Fr Francium (223)	88 88A 2 Ra Radium (226)	89 89A 3 Lr Lawrencium (261)	90 90A 4 Rf Rutherfordium (262)	91 91A 5 Db Dubnium (262)	92 92A 6 Sg Seaborgium (263)	93 93A 7 Bh Bohrium (264)	94 94A 8 Hs Hassium (265)	95 95A 9 Mt Meitnerium (265)	96 96A 10 Ds Darmstadtium (266)	97 97A 11 Rg Roentgenium (267)	98 98A 12 Uub Ununquadium (272)	99 99A 13 *Uuo Ununoctetium (277)	100 100A 14 Fm Fermium (257)	101 101A 15 Md Mendelevium (258)	102 102A 16 No Nobelium (259)																				
57 57A 1 La Lanthanum 138.91	58 58A 2 Ce Cerium 140.12	59 59A 3 Pr Praseodymium 140.91	60 60A 4 Nd Neodymium 144.24	61 61A 5 Pm Promethium (145)	62 62A 6 Sm Samarium 150.4	63 63A 7 Eu Europium 151.96	64 64A 8 Gd Gadolinium 157.25	65 65A 9 Tb Terbium 158.93	66 66A 10 Dy Dysprosium 162.50	67 67A 11 Ho Holmium 164.93	68 68A 12 Er Erbium 167.26	69 69A 13 Tm Thulium 169.93	70 70A 14 Yb Ytterbium 173.04																						
89 89A 1 Ac Actinium (227)	90 90A 2 Th Thorium 232.04	91 91A 3 Pa Protactinium 231.04	92 92A 4 U Uranium 238.03	93 93A 5 Np Neptunium (237)	94 94A 6 Pu Plutonium (244)	95 95A 7 Am Americium (243)	96 96A 8 Cm Curium (247)	97 97A 9 Bk Berkelium (247)	98 98A 10 Cf Californium (251)	99 99A 11 Es Einsteinium (252)	100 100A 12 Fm Fermium (257)	101 101A 13 Md Mendelevium (258)	102 102A 14 No Nobelium (259)																						
<p>Elements 104–114 are the transactinide elements.</p> <p>Lanthanide Series</p>																		<p>*Name not officially assigned.</p>																	

Electron Configurations in Groups

- Elements can be sorted groups based on their electron configurations.
- Elements within a group end with the same suborbital configuration. For representative elements, the principle energy level is the same number as the period.

Electron Configurations in Groups

- The Representative Elements
 - Elements in groups 1A through 7A are often referred to as **representative elements** because they display a wide range of physical and chemical properties.
 - The *s* and *p* sublevels of the highest occupied energy level are not filled.
 - The group number equals the number of electrons in the highest occupied energy level.

Electron Configurations in Groups

- The Noble Gases

- The **noble gases** are the elements in Group 8A of the periodic table. The electron configurations for the first four noble gases in Group 8A are listed below.

Helium (He)	$1s^2$
Neon (Ne)	$1s^2 2s^2 2p^6$
Argon (Ar)	$1s^2 2s^2 2p^6 3s^2 3p^6$
Krypton (Kr)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

Electron Configurations in Groups

- In atoms of the Group 1A elements below, there is only one electron in the highest occupied energy level.

Lithium (Li)	$1s^2 2s^1$
Sodium (Na)	$1s^2 2s^2 2p^6 3s^1$
Potassium (K)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Alkali Metals have similar properties

- Alkali metals and water

Electron Configurations in Groups

- In atoms of the Group 4A elements below, there are four electrons in the highest occupied energy level.

Carbon (C)	$1s^2 2s^2 2p^2$
Silicon (Si)	$1s^2 2s^2 2p^6 3s^2 3p^2$
Germanium (Ge)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^2$

Transition Elements

- In atoms of a **transition metal**, the highest occupied *s* sublevel and a nearby *d* sublevel contain electrons.
- In atoms of an **inner transition metal**, the highest occupied *s* sublevel and a nearby *f* sublevel generally contain electrons.

Transition Elements

- Blocks of Elements

