

CHAPTER 5

Elements and the Periodic Table

The Periodic Table

A field of stars with the text "Are you made of star dust?" overlaid. The background is a dense field of stars of various sizes and brightnesses, set against a black sky. The text is in a bold, yellow, sans-serif font, centered horizontally and slightly above the vertical center. The top and bottom of the image have light blue horizontal bars.

Are you made of star dust?



Are you made of star dust?

**The Big Bang produced
hydrogen and helium
and a tiny bit of lithium**



Are you made of star dust?

**Other elements were
created in the cores of
exploding stars**



Element	% by mole
Hydrogen	63.0
Oxygen	26.0
Carbon	9.0
Nitrogen	1.25
Calcium	0.25
Phosphorus	0.19
Potassium	0.06
Sulfur	0.06
Sodium	0.04
Chlorine	0.025
Magnesium	0.013
Iron	0.00004
Iodine	0.000002

99% of atoms in a human body come from only 4 elements

Essential elements

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											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	Uut	Uuq	Uup	Uuh		Uuo

Chemistry terms

macronutrients: elements needed in large quantities by your body.

trace elements: elements that are needed in very small quantities to maintain optimum health.

Metals, nonmetals and metalloids

group 1										group 18									
1 H 1.0079 hydrogen																		2 He 4.0028 helium	
3 Li 6.941 lithium	4 Be 9.0122 beryllium																		
11 Na 22.990 sodium	12 Mg 24.305 magnesium																		
19 K 39.090 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton		
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon		
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon		
87 Fr (223) francium	88 Ra (226) radium	103 Lr (262) lawrencium	104 Rf (267) rutherfordium	105 Db (268) dubnium	106 Sg (271) seaborgium	107 Bh (272) bohrium	108 Hs (270) hassium	109 Mt (276) meitnerium	110 Ds (281) darmstadtium	111 Rg (280) roentgenium	112 Uub (285) ununbium	113 Uut (284) ununtrium	114 Uuq (289) ununquadium	115 Uup (288) ununpentium	116 Uuh (293) ununhexium	118 Uuo (294) ununoctium			
57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium						
89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium						

Atomic Number → 6

Atomic Mass → 12.011

C
12.011
carbon

metal
metalloid
nonmetal

ionic compound:

one non-metal atom
bonded with one metal
atom

molecular compound:

two non-metal atoms
bonded with each other

Metals, nonmetals and metalloids

Atomic Number → 6

Atomic Mass → 12.011

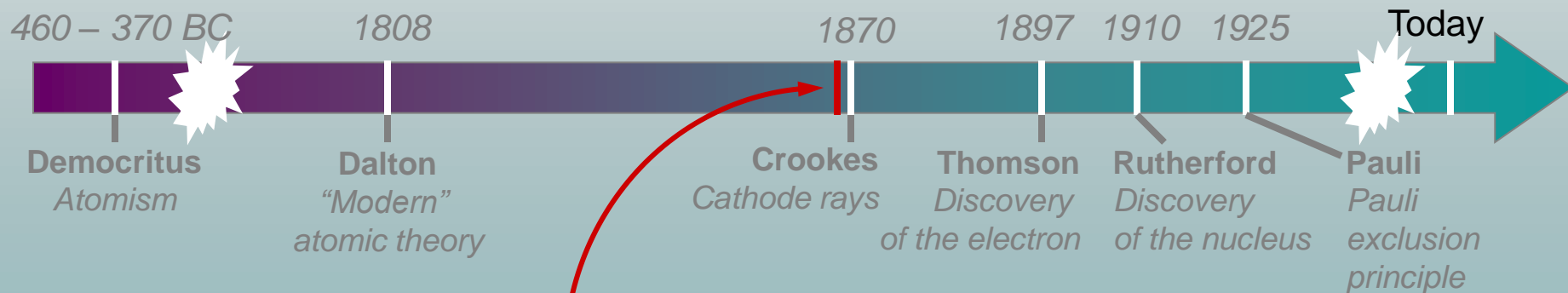
Carbon (C) is a nonmetal.

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ionic compound:
one non-metal atom bonded with one metal atom

molecular compound:
two non-metal atoms bonded with each other

What does “periodic” in “periodic table” mean?

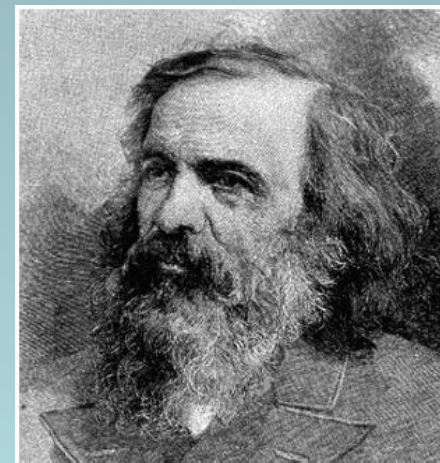


1869

Mendeleev looks for a logical way to organize the elements known at the time.

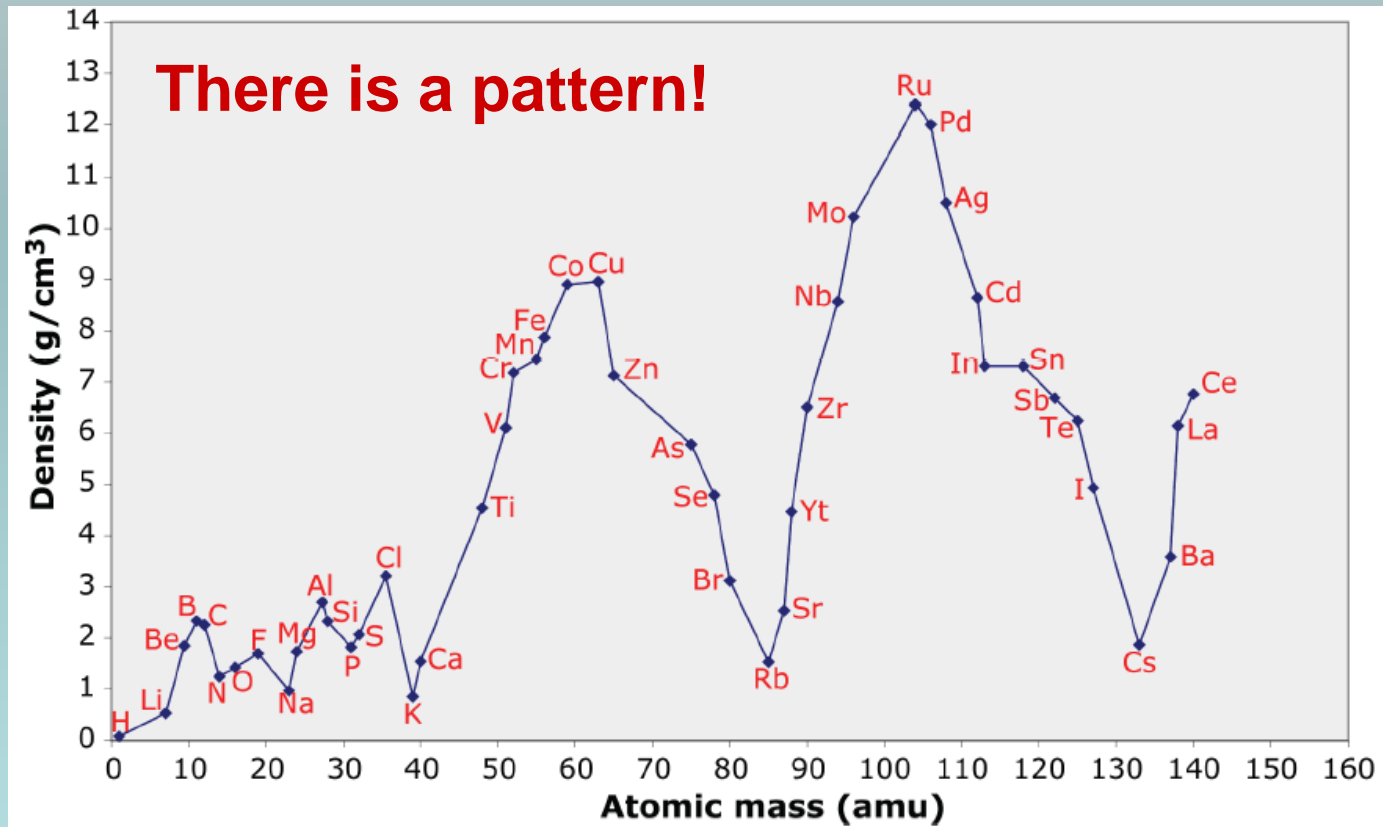
Note that at this time, very little is known about atoms.

Protons and atomic numbers were **not discovered yet**.

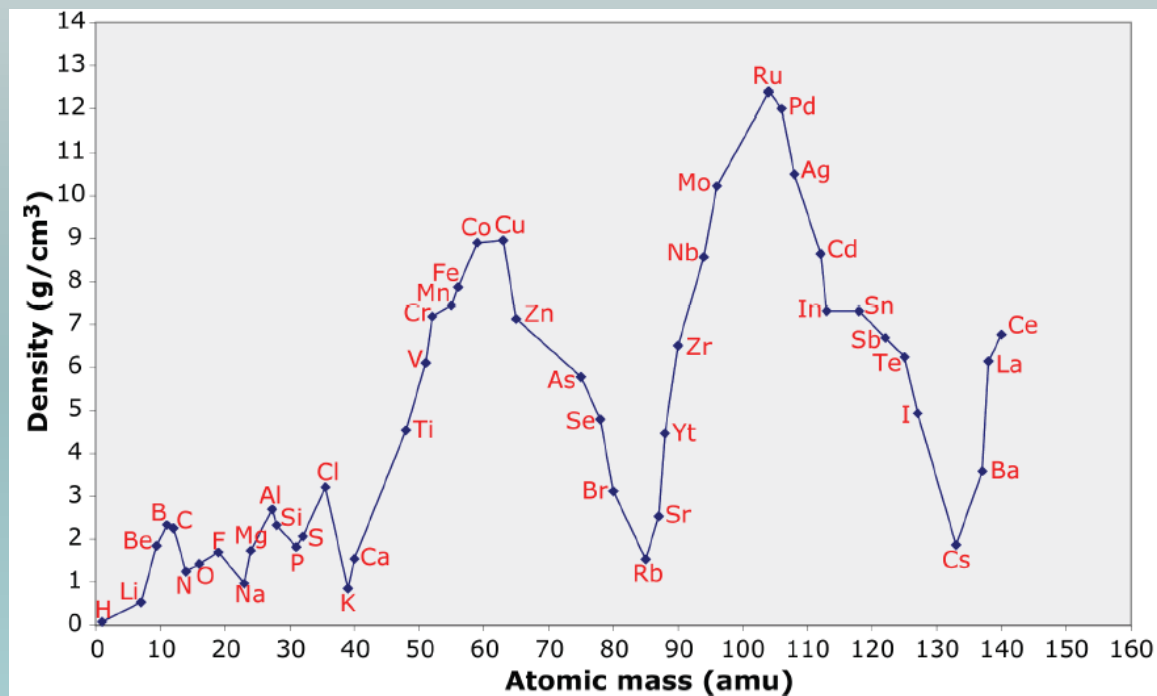


Dimitri Mendeleev

Mendeleev uses density (a physical property) of atoms, and organizes them in order of increasing atomic mass.



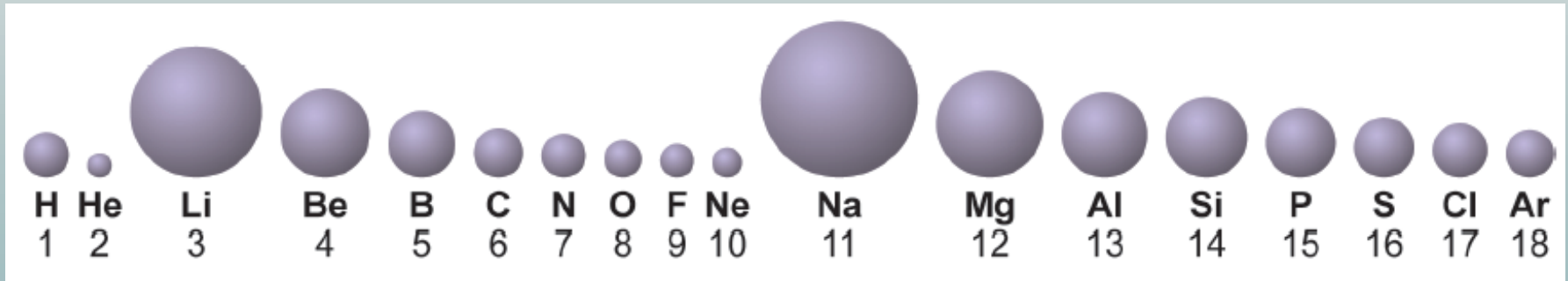
The **periodic table** contains patterns that repeat at regular intervals



Chemistry terms

periodic: repeating at regular intervals.

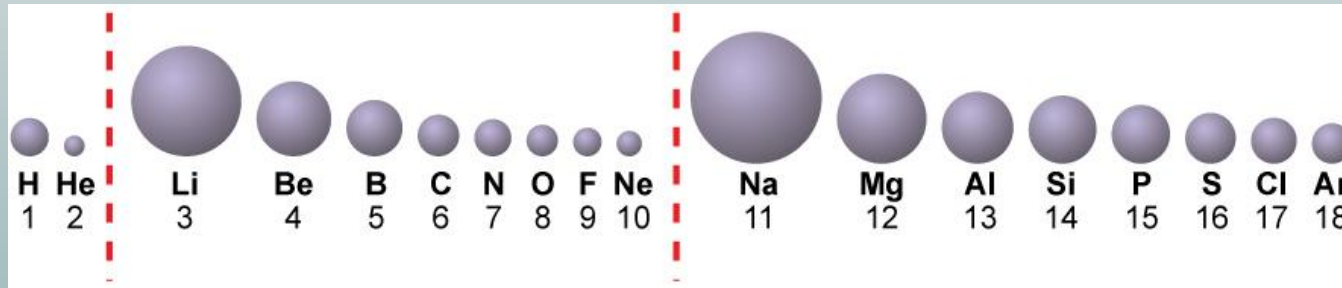
Atomic radius



Increasing atomic number

Like for density, there is a **repeating pattern** in atomic radii.

Atomic radius



Relative atom size arranged
in a periodic table view

A new period

A new period

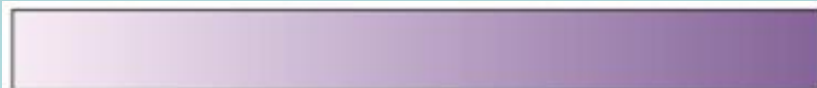
1 H	Relative atom size arranged in a periodic table view						2 He
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar

Atomic radius

atomic radius: the distance from the center of an atom to its “outer edge.”

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											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	Uut	Uuq	Uup	Uuh		Uuo

small



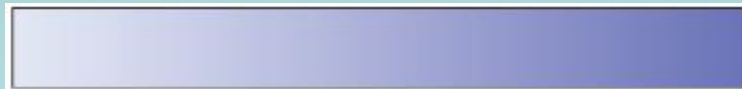
large

Electronegativity

electronegativity: the ability of an atom to attract another atom's electrons when bound to that other atom.

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											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	Uut	Uuq	Uup	Uuh		Uuo

low



high

Ionization energy

ionization energy: the energy required to remove an electron from an atom.

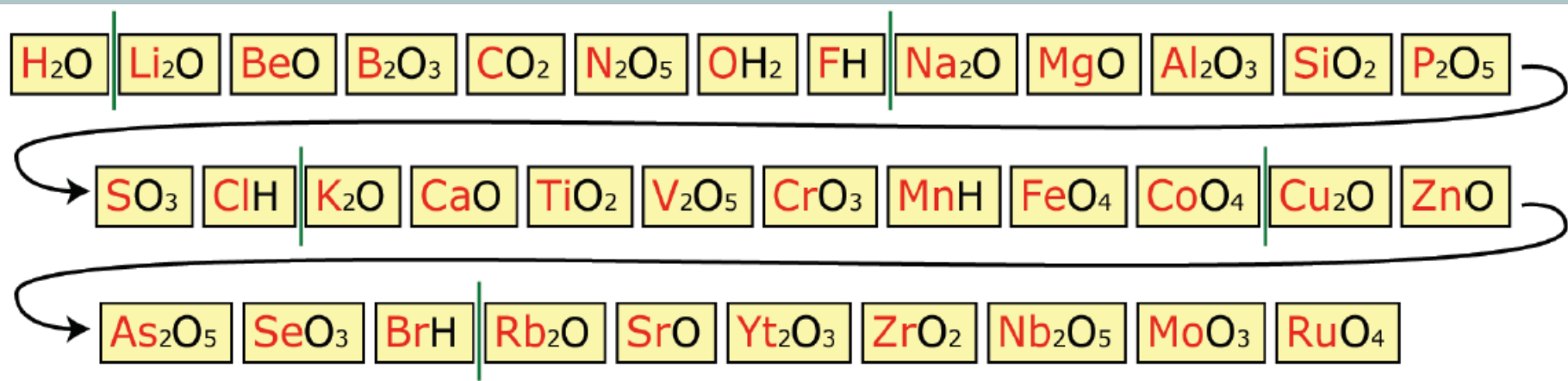
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
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Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh		Uuo

low



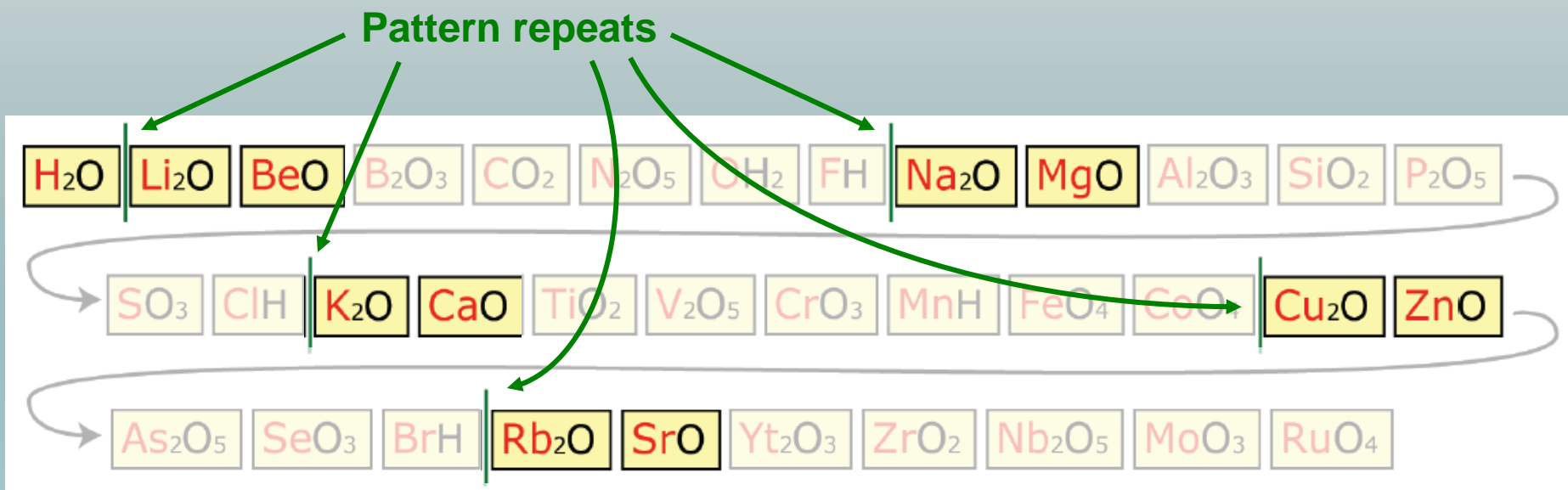
high

The first periodic table



Mendeleev placed the elements in order of increasing atomic mass and then noticed a repeating pattern in the oxide and hydride formula.

The first periodic table



Mendeleev placed the elements in order of increasing atomic mass and then noticed a repeating pattern in the oxide and hydride formula.

A new pattern was discovered!

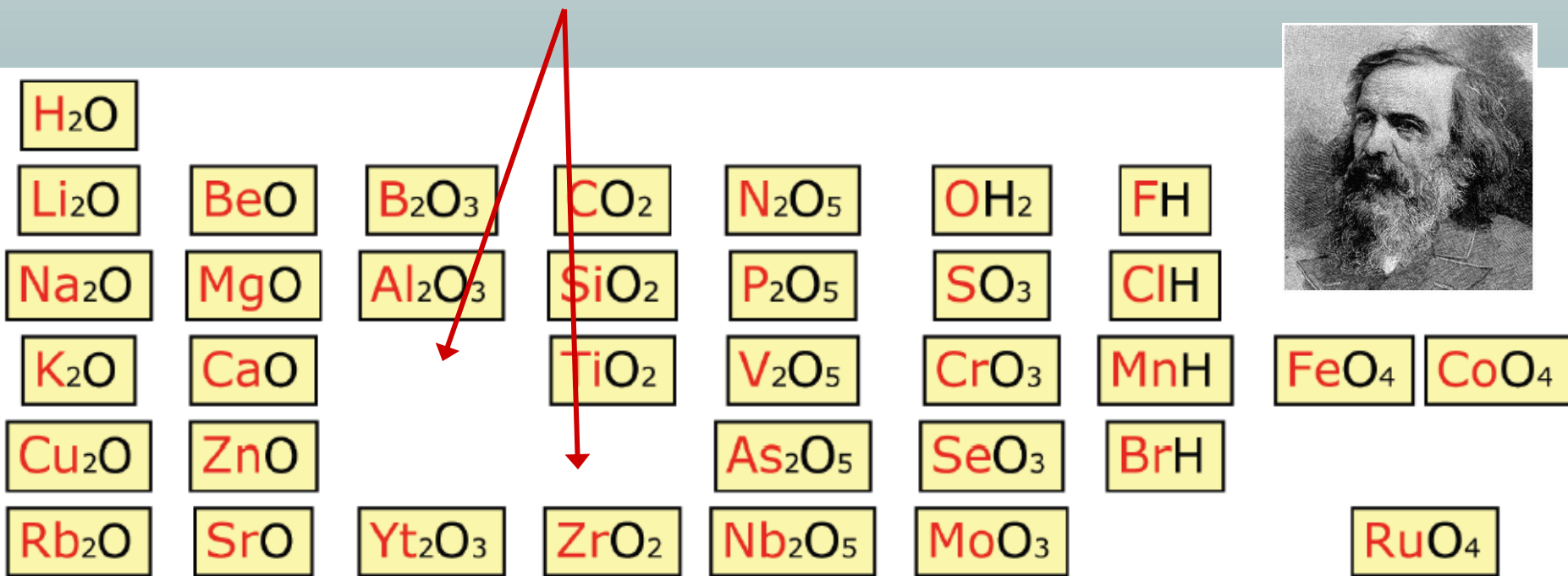
The first periodic table

Oxides and hydrides sorted into rows:

H_2O																				
Li_2O	BeO	B_2O_3	CO_2	N_2O_5	OH_2	FH														
Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	ClH														
K_2O	CaO		TiO_2	V_2O_5	CrO_3	MnH	FeO_4	CoO_4												
Cu_2O	ZnO			As_2O_5	SeO_3	BrH														
Rb_2O	SrO	Yt_2O_3	ZrO_2	Nb_2O_5	MoO_3					RuO_4										

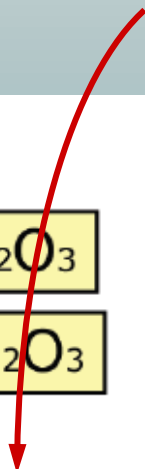
The first periodic table as suggested by Mendeleev in 1869

Mendeleev left empty spaces for **elements not yet discovered**



The first periodic table as suggested by Mendeleev in 1869

Gallium was discovered 6 years later!



H_2O										
Li_2O	BeO	B_2O_3	CO_2	N_2O_5	OH_2	FH				
Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	ClH				
K_2O	CaO		TiO_2	V_2O_5	CrO_3	MnH	FeO_4	CoO_4		
Cu_2O	ZnO			As_2O_5	SeO_3	BrH				
Rb_2O	SrO	Yt_2O_3	ZrO_2	Nb_2O_5	MoO_3				RuO_4	

The first periodic table as suggested by Mendeleev in 1869

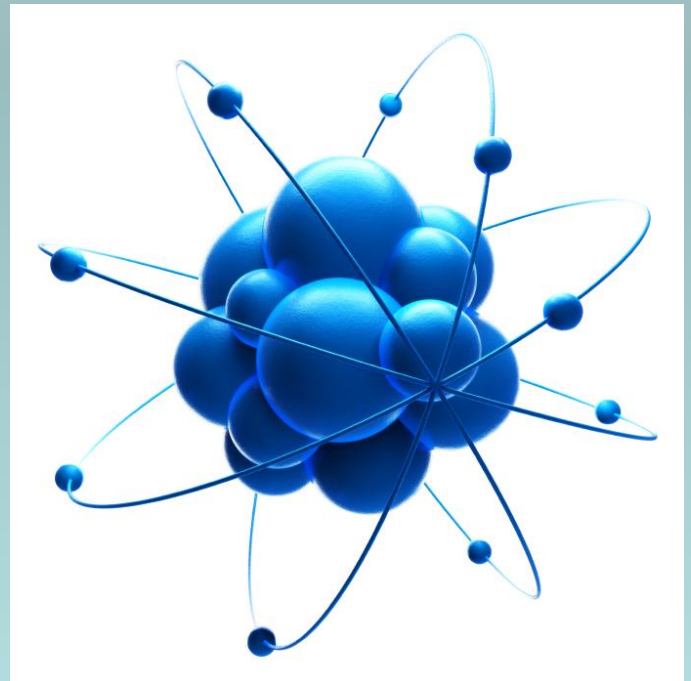
The modern periodic table

The modern periodic table arranges elements in order of **increasing atomic number**, not atomic mass.

Scientists have been adding elements to the periodic table, as more are discovered or created.

The last naturally occurring element to be discovered is Francium (Fr) in **1939**.

70 years after Mendeleev,
who had called it
eka-caesium



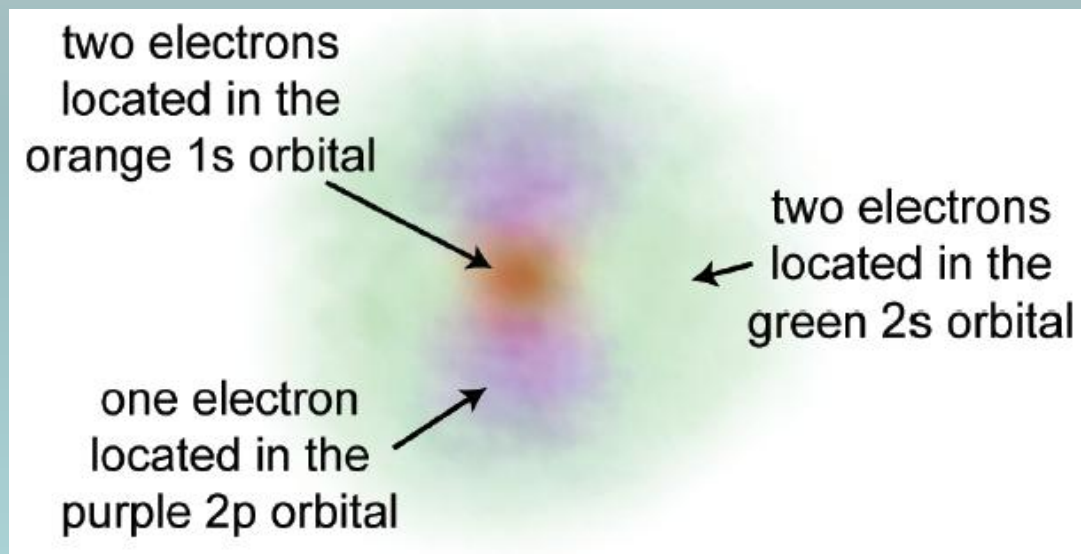
The modern periodic table

group 1		metals										nonmetals						group 18													
		alkali metals					alkaline earth metals					transition metals		rare earth metals		other metals		halogens						noble gases		other nonmetals					
		metalloids										metalloids																			
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3 Li 6.941 lithium	4 Be 9.0122 beryllium																	5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon								
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Electron structure was discovered after the periodic table was developed...

5
B
10.811
boron

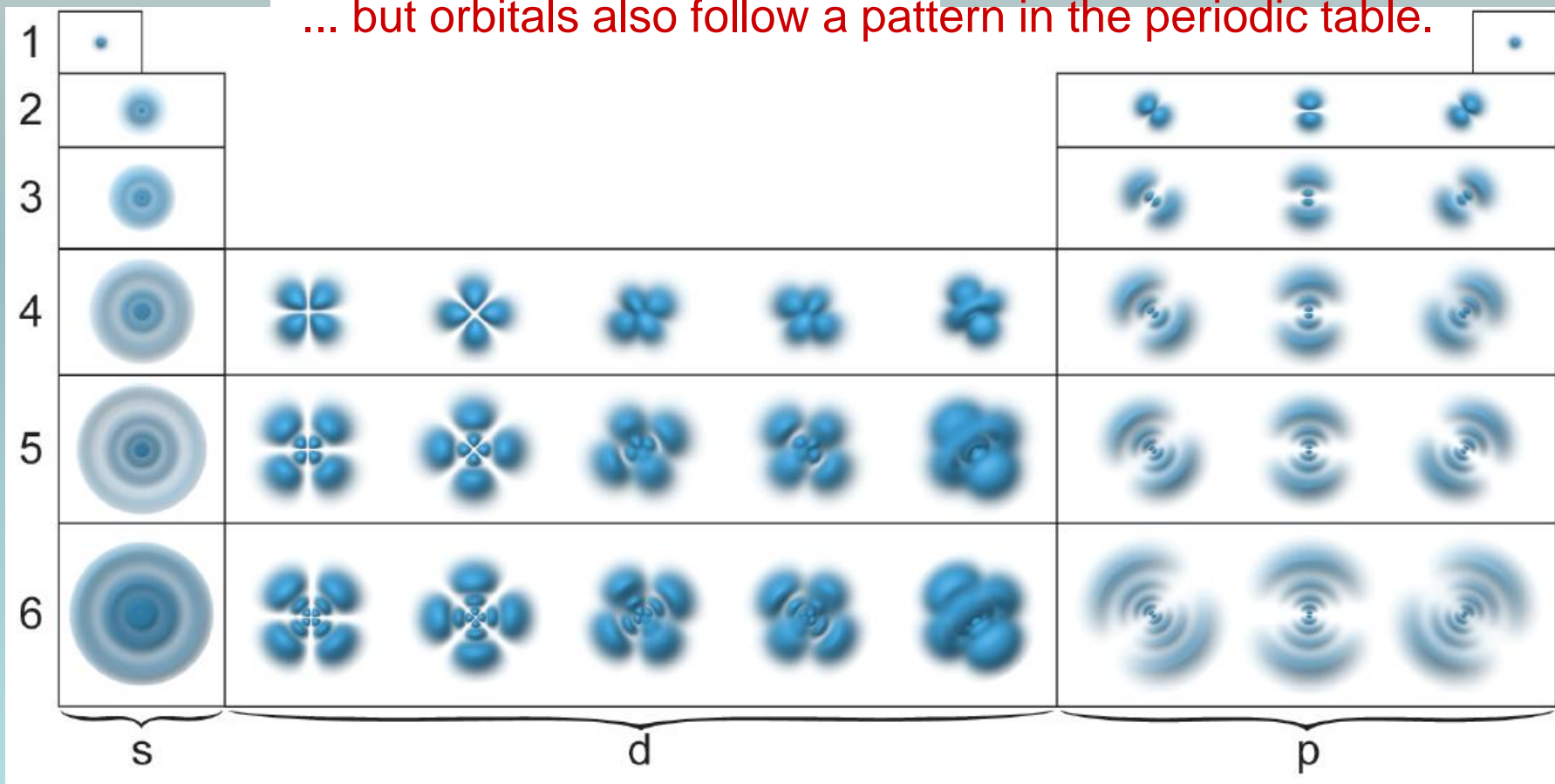
Electron configuration: $1s^2 2s^2 2p^1$



Overlapping orbitals of boron

Electron structure was discovered after the periodic table was developed...

... but orbitals also follow a pattern in the periodic table.

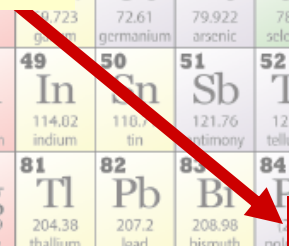


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- alkali metals
- alkaline earth metals
- transition metals
- rare earth metals
- other metals

- halogens
- noble gases

Element # 117 missing here



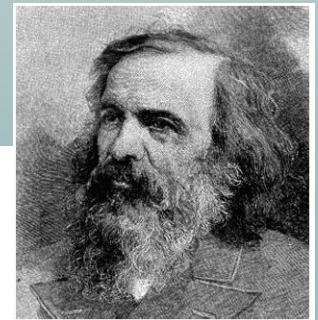
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2009-2010

Element #117 was discovered through a Russian-US collaboration.
The discovery still needs to be confirmed.
It is temporarily named ununseptium (Uus).

Discoveries are made all the time!

Elements in **the first periodic table** were arranged in order of increasing **atomic mass**

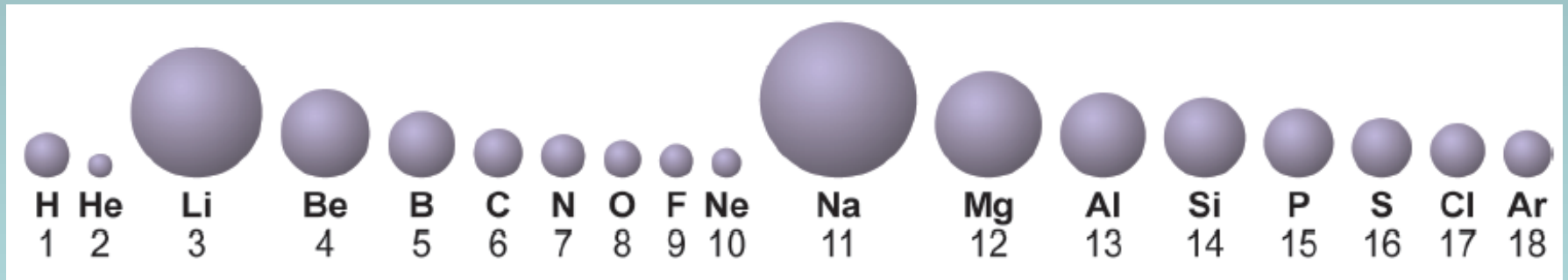


H_2O									
Li_2O	BeO	B_2O_3	CO_2	N_2O_5	OH_2	FH			
Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	ClH			
K_2O	CaO		TiO_2	V_2O_5	CrO_3	MnH	FeO_4	CoO_4	
Cu_2O	ZnO			As_2O_5	SeO_3	BrH			
Rb_2O	SrO	Yt_2O_3	ZrO_2	Nb_2O_5	MoO_3			RuO_4	

The first periodic table as suggested by Mendeleev in 1869

Elements in **the modern periodic table** are arranged in order of increasing **atomic number**

The modern periodic table shows trends or repeating patterns in atomic radii, electronegativity and ionization energy



Increasing atomic number

Elements and the Periodic Table

Properties of Groups
of Elements

There are millions and millions of different kinds of matter (compounds) composed of the same 92 elements.

These elements are organized in a periodic table.

It is called “periodic” because there is a repeating pattern.

Periodic table of the elements

Legend:
Nonmetals (orange)
Metals (grey)

1 H 1.0079 hydrogen	Periodic table of the elements																2 He 4.0028 helium
3 Li 6.941 lithium	4 Be 9.0122 beryllium	5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon	11 Na 22.990 sodium	12 Mg 24.305 magnesium	13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon		
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon
87 Fr (223) francium	88 Ra (226) radium	103 Lr (262) lawrencium	104 Rf (267) rutherfordium	105 Db (268) dubnium	106 Sg (271) seaborgium	107 Bh (272) bohrium	108 Hs (270) hassium	109 Mt (276) meitnerium	110 Ds (281) darmstadtium	111 Rg (280) roentgenium	112 Uub (285) ununbium	113 Uut (284) ununtrium	114 Uuq (289) ununquadium	115 Uup (288) ununpentium	116 Uuh (293) ununhexium	118 Og (294) oganessonium	
57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium				
89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium				

There are millions and millions of different kinds of matter (compounds) composed of the same 92 elements.

These elements are organized in a periodic table.

It is called “periodic” because there is a repeating pattern.

Elements that belong to the same column have similar chemical properties.

Here, we are going to go over these groups of elements

Periodic table of the elements

Nonmetals
 Metals

1 H 1.0079 hydrogen																	2 He 4.0028 helium	
3 Li 6.941 lithium	4 Be 9.0122 beryllium											5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon	
11 Na 22.990 sodium	12 Mg 24.305 magnesium											13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon	
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon	
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	
87 Fr (223) francium	88 Ra (226) radium	103 Lr (262) lawrencium	104 Rf (267) rutherfordium	105 Db (268) dubnium	106 Sg (271) seaborgium	107 Bh (272) bohrium	108 Hs (270) hassium	109 Mt (276) meitnerium	110 Ds (281) darmstadtium	111 Rg (280) roentgenium	112 Uub (285) ununbium	113 Uut (284) ununtrium	114 Uuq (289) ununquadium	115 Uup (288) ununpentium	116 Uuh (293) ununhexium			118 Uuo (294) ununoctium
57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium					
89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium					

Periodic table of the elements

Alkali metals

Nonmetals

Metals

1 H 1.0079 hydrogen																	2 He 4.0028 helium	
3 Li 6.941 lithium	4 Be 9.0122 beryllium	Nonmetals																10 Ne 20.180 neon
11 Na 22.990 sodium	12 Mg 24.305 magnesium	Metals																18 Ar 39.948 argon
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon	
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	
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		57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium			
		89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium			

Periodic table of the elements

Alkaline earth metals

1 H 1.0079 hydrogen																	2 He 4.0028 helium	
3 Li 6.941 lithium	4 Be 9.0122 beryllium											6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon		
11 Na 22.990 sodium	12 Mg 24.305 magnesium											13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon	
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon	
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	
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Periodic table of the elements

Nonmetals

Transition metals

1 H 1.0079 hydrogen																	2 He 4.0028 helium
3 Li 6.941 lithium	4 Be 9.0122 beryllium																
11 Na 22.990 sodium	12 Mg 24.305 magnesium																
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon
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89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium

Periodic table of the elements

1 H 1.0079 hydrogen																	2 He 4.0028 helium						
3 Li 6.941 lithium	4 Be 9.0122 beryllium																	5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
11 Na 22.990 sodium	12 Mg 24.305 magnesium																	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar 39.948 argon
19 K 39.098 potassium	20 Ca 40.078 calcium	44.956 scandium	47.867 titanium	50.942 vanadium	51.996 chromium	54.938 manganese	55.845 iron	58.933 cobalt	58.693 nickel	63.546 copper	65.38 zinc	69.723 gallium	72.61 germanium	79.922 arsenic	78.96 selenium	79.904 bromine	36 Kr 83.80 krypton						
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon						
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Nonmetals
 Metals



Carbon, nitrogen, and oxygen

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium
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Periodic table of the elements

Halogens

1 H 1.0079 hydrogen																	He 4.0026 helium	
3 Li 6.941 lithium	4 Be 9.0122 beryllium																	10 Ne 20.180 neon
11 Na 22.990 sodium	12 Mg 24.305 magnesium																	18 Ar 39.948 argon
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	
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 Nonmetals
 Metals

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Periodic table of the elements



Nonmetals



Metals

Noble gases

1 H 1.0079 hydrogen																	2 He 4.0028 helium	
3 Li 6.941 lithium	4 Be 9.0122 beryllium																	10 Ne 20.180 neon
11 Na 22.990 sodium	12 Mg 24.305 magnesium																	18 Ar 39.948 argon
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon	
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	
87 Fr (223) francium	88 Ra (226) radium	103 Lr (262) lawrencium	104 Rf (267) rutherfordium	105 Db (268) dubnium	106 Sg (271) seaborgium	107 Bh (272) bohrium	108 Hs (270) hassium	109 Mt (276) meitnerium	110 Ds (281) darmstadtium	111 Rg (280) roentgenium	112 Uub (285) ununbium	113 Uut (284) ununtrium	114 Uuq (289) ununquadium	115 Uup (288) ununpentium	116 Uuh (293) ununhexium	118 Uuo (294) ununoctium		

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium
89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium

Alkali metals

Periodic table of the elements

Legend:
Nonmetals (orange)
Metals (green)

Why do elements in Group 1 have the tendency to form +1 ions?

1 H 1.0079 hydrogen																
3 Li 6.941 lithium	4 Be 9.0122 beryllium															
11 Na 22.990 sodium	12 Mg 24.305 magnesium															
19 K 39.098 potassium	20 Ca 40.078 calcium															
37 Rb 85.468 rubidium	38 Sr 87.62 strontium															
55 Cs 132.91 cesium	56 Ba 137.33 barium															
87 Fr (223) francium	88 Ra (226) radium	103 Lr (262) lawrencium														

57 La 138.91 lanthanum
58 Ce 140.12 cerium
59 Pr 140.91 praseodymium
60 Nd 144.24 neodymium
61 Pm (145) promethium
62 Sm 150.36 samarium
63 Eu 151.96 europium
64 Gd 157.25 gadolinium
65 Tb 158.93 terbium
66 Dy 162.50 dysprosium
67 Ho 164.93 holmium
68 Er 167.26 erbium
69 Tm 168.93 thulium
70 Yb 173.05 ytterbium

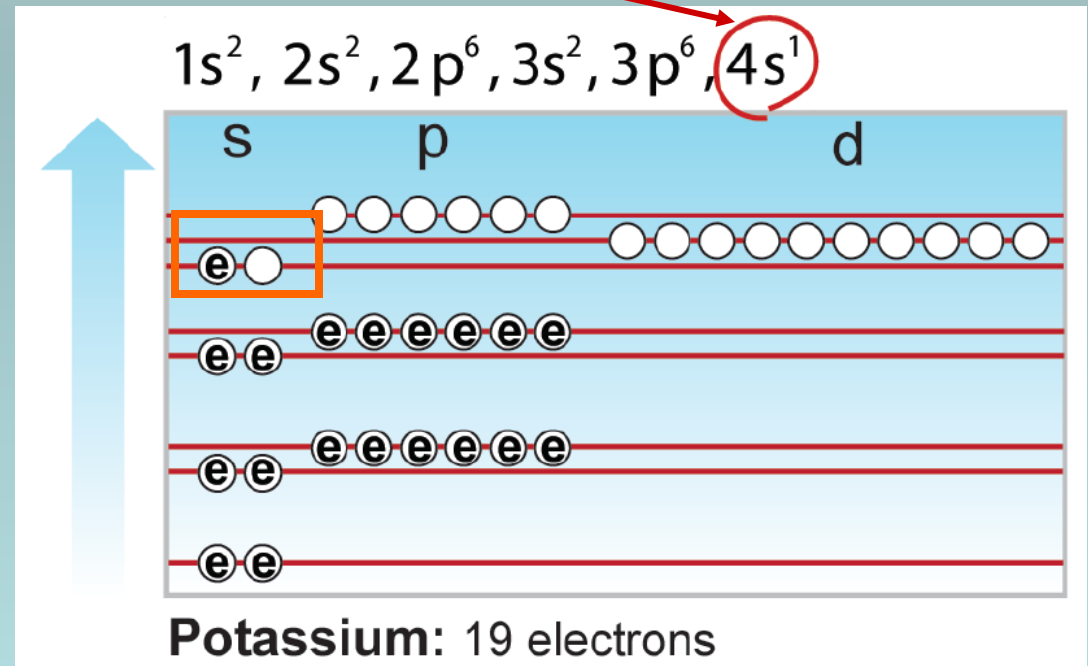
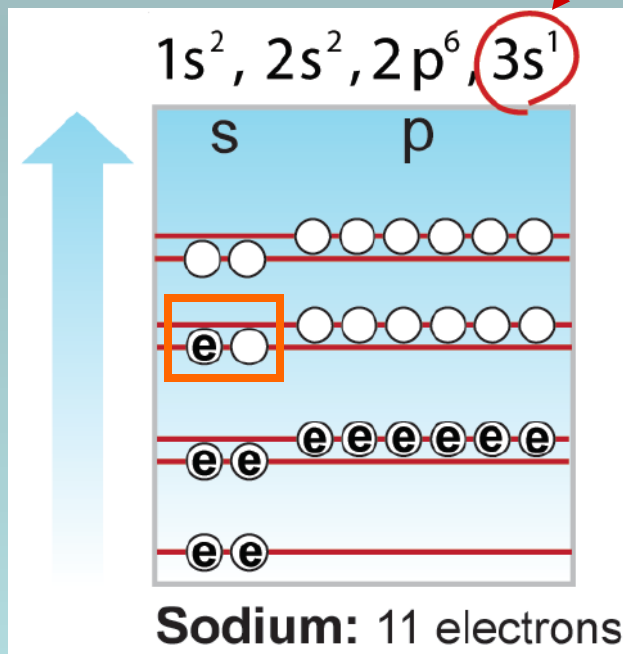
89 Ac (227) actinium
90 Th 232.04 thorium
91 Pa 231.04 protactinium
92 U 238.03 uranium
93 Np (237) neptunium
94 Pu (244) plutonium
95 Am (243) americium
96 Cm (247) curium
97 Bk (247) berkelium
98 Cf (251) californium
99 Es (252) einsteinium
100 Fm (257) fermium
101 Md (258) mendelevium
102 No (259) nobelium

25 Mn 54.938 manganese
26 Fe 55.845 iron
27 Co 58.933 cobalt
28 Ni 58.693 nickel
29 Cu 63.546 copper
30 Zn 65.38 zinc
31 Ga 69.723 gallium
32 Ge 72.61 germanium
33 As 74.921 arsenic
34 Se 78.96 selenium
35 Br 79.904 bromine
36 Kr 83.80 krypton
43 Tc (98) technetium
44 Ru 101.07 ruthenium
45 Rh 102.91 rhodium
46 Pd 106.42 palladium
47 Ag 107.87 silver
48 Cd 112.41 cadmium
49 In 114.82 indium
50 Sn 118.710 tin
51 Sb 121.76 antimony
52 Te 127.60 tellurium
53 I 126.905 iodine
54 Xe 131.29 xenon
75 Re 186.21 rhenium
76 Os 190.23 osmium
77 Ir 192.22 iridium
78 Pt 195.08 platinum
79 Au 196.97 gold
80 Hg 200.59 mercury
81 Tl 204.38 thallium
82 Pb 207.2 lead
83 Bi 208.980 bismuth
84 Po (209) polonium
85 At (210) astatine
107 Bh (272) bohrium
108 Hs (270) hassium
109 Mt (276) meitnerium
110 Ds (281) darmstadtium
111 Rg (280) roentgenium
112 Uub (285) ununbium
113 Uut (284) ununtrium
114 Uuq (289) ununquadium
115 Uup (288) ununpentium
116 Uuh (286) ununhexium

Alkali metals

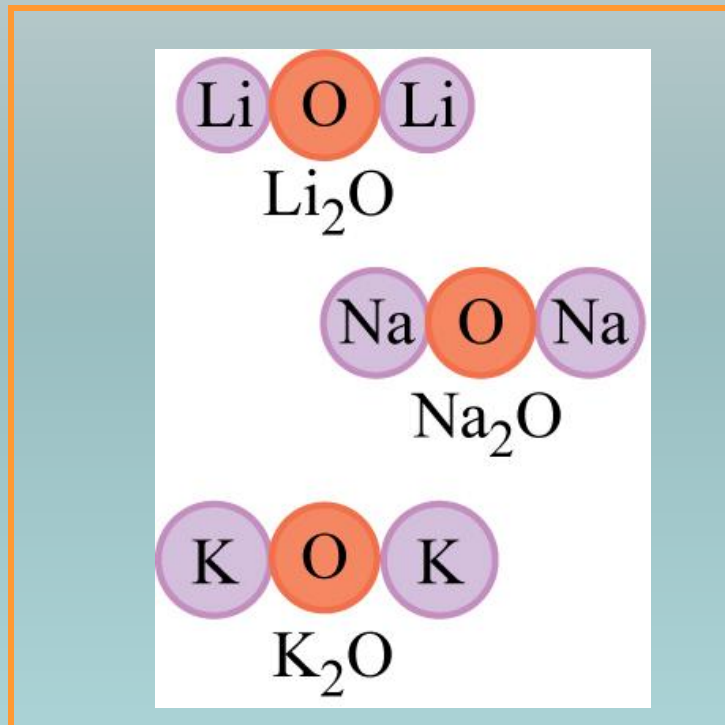
Electron configuration

Alkali metals have a single electron in the highest unfilled energy level.

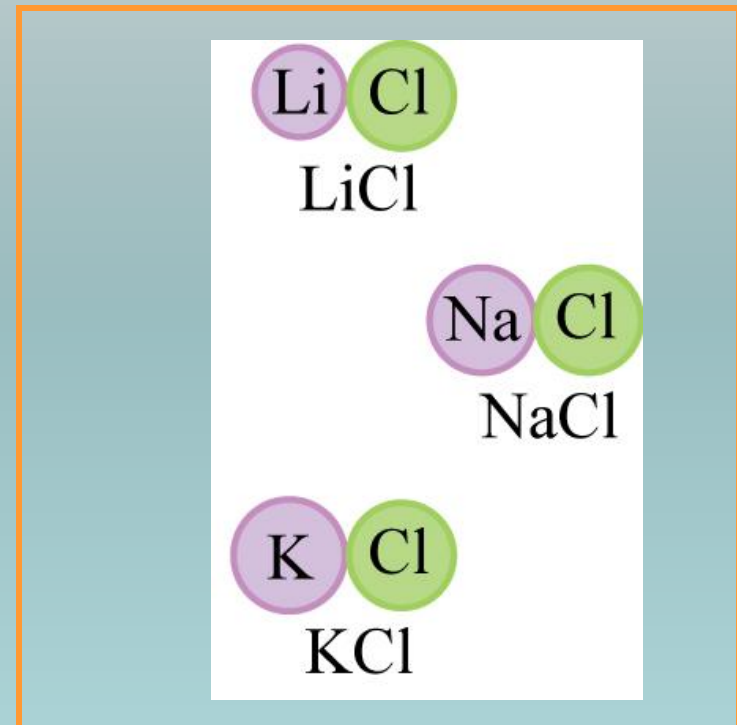


Alkali metals

2:1 ratio with oxygen



1:1 ratio with chlorine



We will see why this happens after we discuss oxygen and chlorine.

Alkaline earth metals

1 H 1.0079 hydrogen	4 Be 9.0122 beryllium
3 Li 6.941 lithium	12 Mg 24.305 magnesium
11 Na 22.990 sodium	20 Ca 40.078 calcium
37 Rb 85.468 rubidium	38 Sr 87.62 strontium
55 Cs 132.91 cesium	56 Ba 137.33 barium
87 Fr (223) francium	88 Ra (226) radium

Periodic table of the elements

Be²⁺

Mg²⁺

Ca²⁺

Sr²⁺

Ba²⁺

Ra²⁺

5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen
13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.07 sulfur
27 Co 58.93 cobalt	28 Ni 58.69 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc
45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium
77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury
109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Uub (285)

Nonmetals
Metals

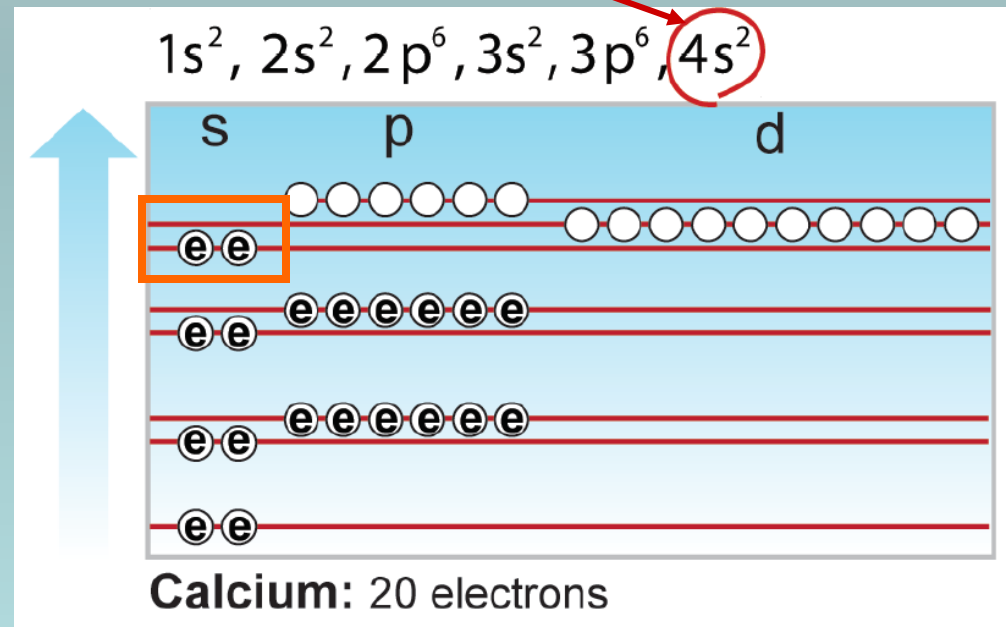
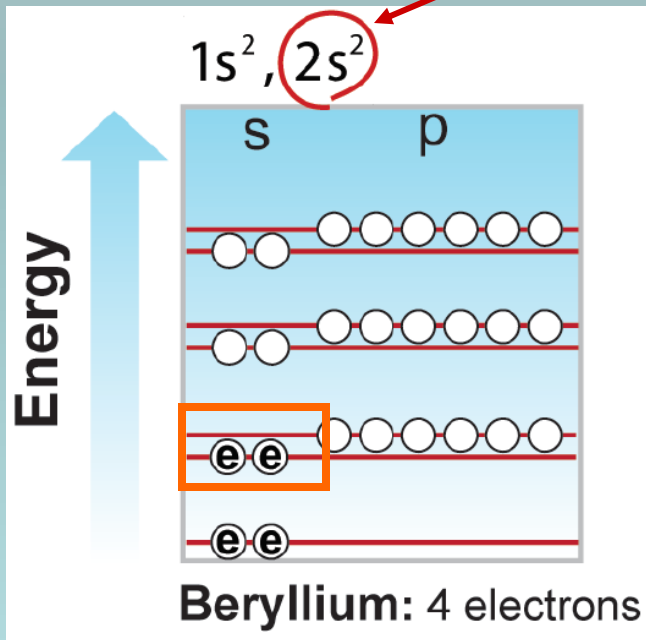
Why do elements in Group 2 have the tendency to form +2 ions?

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.05 ytterbium
89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium

Alkaline earth metals

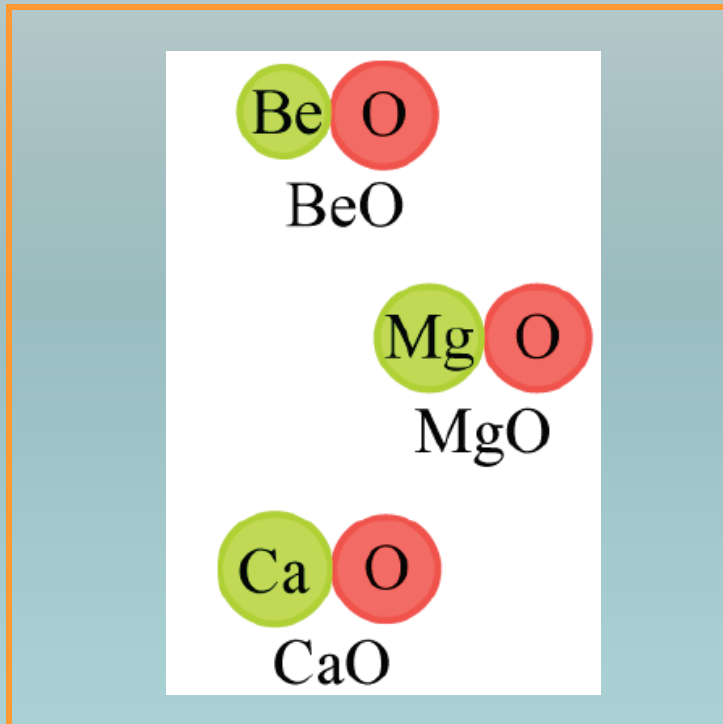
Electron configuration

Alkaline earth metals have two electrons in the highest unfilled energy level.

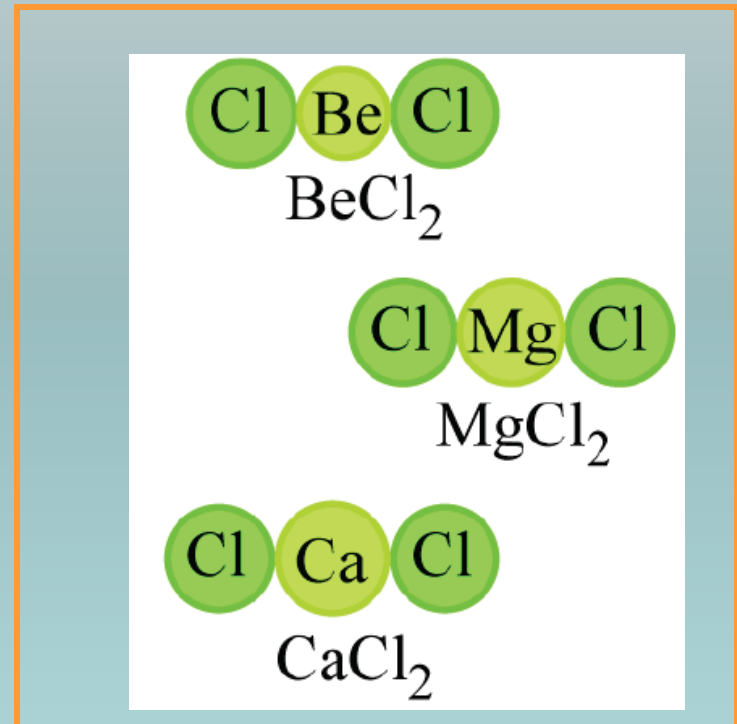


Alkaline earth metals

1:1 ratio with oxygen



1:2 ratio with chlorine



We will see why this happens after we discuss oxygen and chlorine.

Transition metals

Periodic table of the elements

1 H 1.0079 hydrogen																	2 He 4.0028 helium						
3 Li 6.941 lithium	4 Be 9.0122 beryllium																	5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
11 Na 22.990 sodium	12 Mg 24.305 magnesium																	13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton						
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon						
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon						
87 Fr (223) francium	88 Ra (226) radium	103 Lr (262) lawrencium	104 Rf (267) rutherfordium	105 Db (268) dubnium	106 Sg (271) seaborgium	107 Bh (272) bohrium	108 Hs (270) hassium	109 Mt (276) meitnerium	110 Ds (281) darmstadtium	111 Rg (280) roentgenium	112 Uub (285) ununbium	113 Uut (284) ununtrium	114 Uuq (289) ununquadium	115 Uup (288) ununpentium	116 Uuh (293) ununhexium			118 Uuo (294) ununoctium					

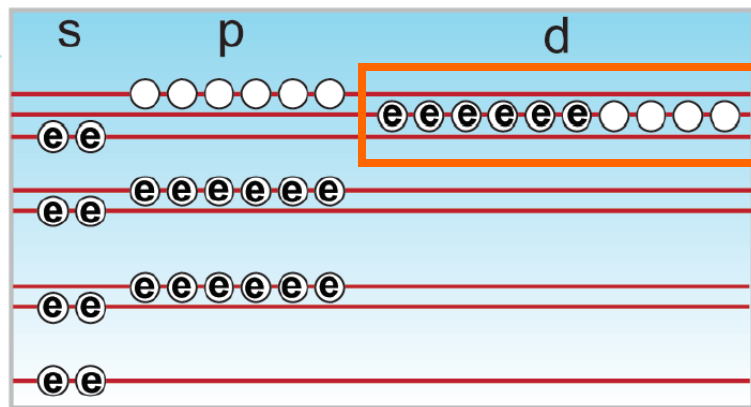
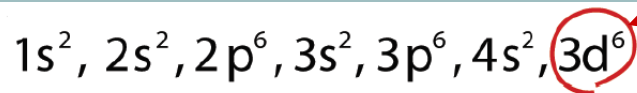
Nonmetals
 Metals

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium
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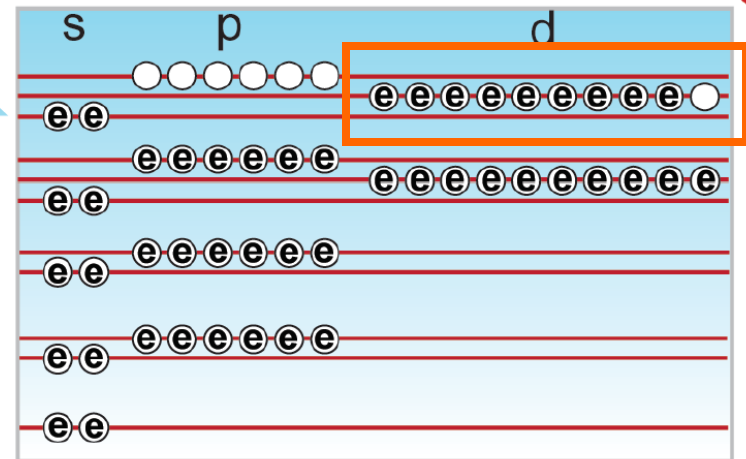
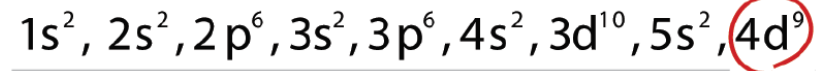
Transition metals

Electron configuration

Transition metals all have electrons in partly filled *d* orbitals.



Iron: 26 electrons



Silver: 47 electrons

Transition metals

Bonding properties are complicated. For bonding with oxygen:

1:1, 2:3, 3:4 ratios for iron



Rust (Fe_2O_3)

2:1 ratio for silver



Silver
tarnish
(Ag_2O)

Carbon, nitrogen, oxygen

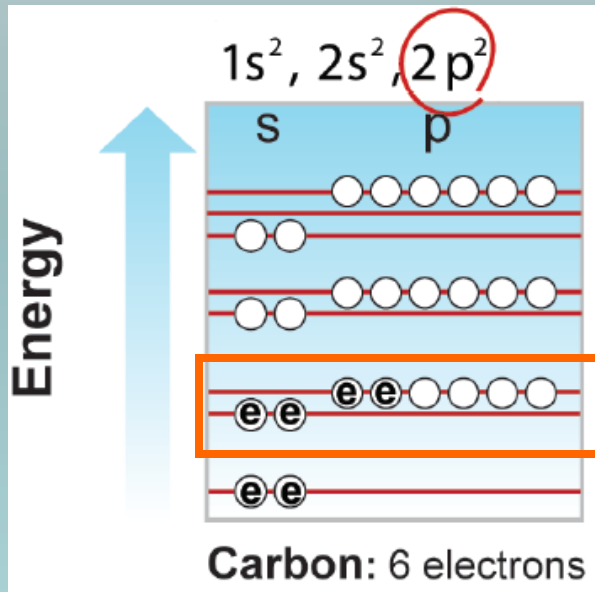
Extremely important elements
to be discussed separately

Periodic table of the elements

																2	He																
																5	B	6	C	7	N	8	O	9	F	10	Ne						
																10.811	12.011	14.007	15.999	18.998	20.180												
																boron	carbon	nitrogen	oxygen	fluorine	neon												
																13	Al	14	Si	15	P	16	S	17	Cl	18	Ar						
																26.982	28.086	30.974	32.065	35.453	39.948												
																aluminum	silicon	phosphorus	sulfur	chlorine	argon												
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
40.078	44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.38	69.723	72.61	79.922	78.96	79.904	83.80																	
calcium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton																	
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
87.62	88.906	91.224	92.906	95.96	(98)	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.60	126.90	131.29																	
strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon																	
88	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
137.33	174.967	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.599	204.38	207.2	208.98	(209)	(210)	(222)																	
barium	lutetium	hafnium	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon																	
88	Ra	103	Lr	104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Uub	113	Uut	114	Uuq	115	Uup	116	Uuh	118	Uuo		
226	(262)	(267)	(268)	(271)	(272)	(270)	(276)	(281)	(280)	(285)	(284)	(289)	(288)	(293)	(294)																		
radium	lawrencium	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	darmstadtium	roentgenium	ununbium	ununtrium	ununquadium	ununpentium	ununhexium	ununoctium																		
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						
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	173.06																				
lanthanum	cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium																				
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						
(227)	232.04	231.04	238.03	(237)	(244)	(243)	(247)	(251)	(252)	(257)	(258)	(259)																					
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium																				

Carbon, nitrogen, oxygen

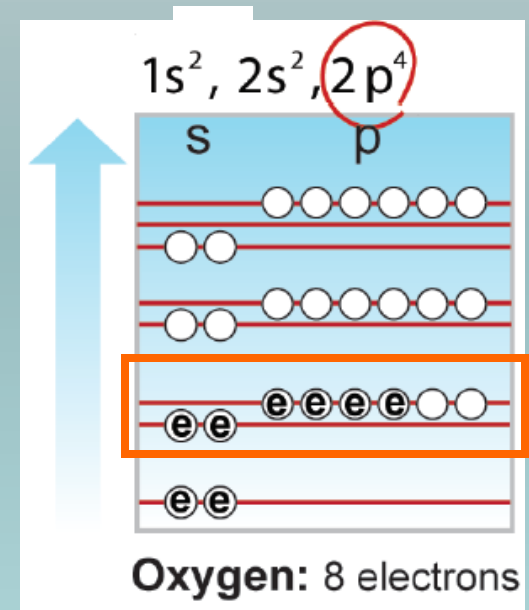
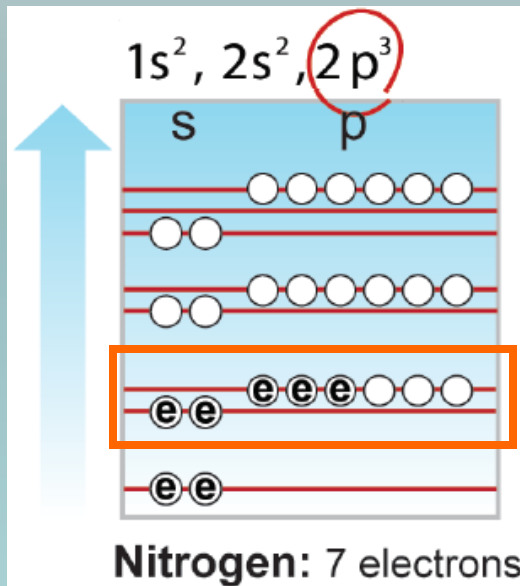
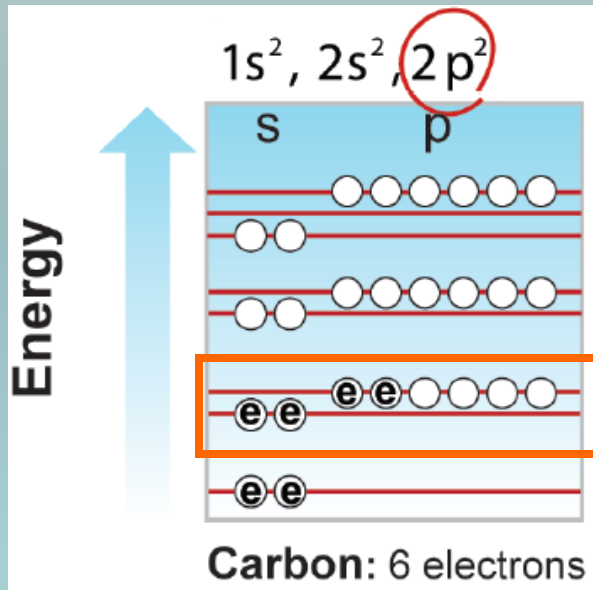
The electron structures makes these elements **very flexible** in their chemistry.



Carbon can accept or donate electrons

Carbon, nitrogen, oxygen

The electron structures makes these elements **very flexible** in their chemistry.



Carbon can accept or donate electrons

Nitrogen and oxygen tend to accept electrons

Halogens

Periodic table of the elements

Why do elements in Group 17 have the tendency to form **-1 ions**?

Nonmetals
Metals

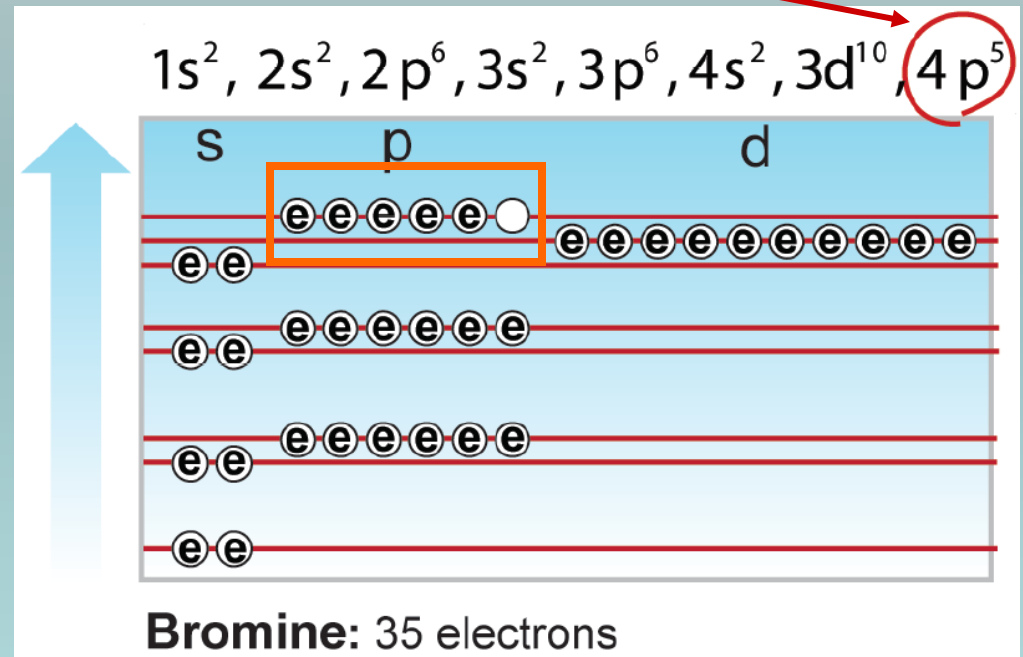
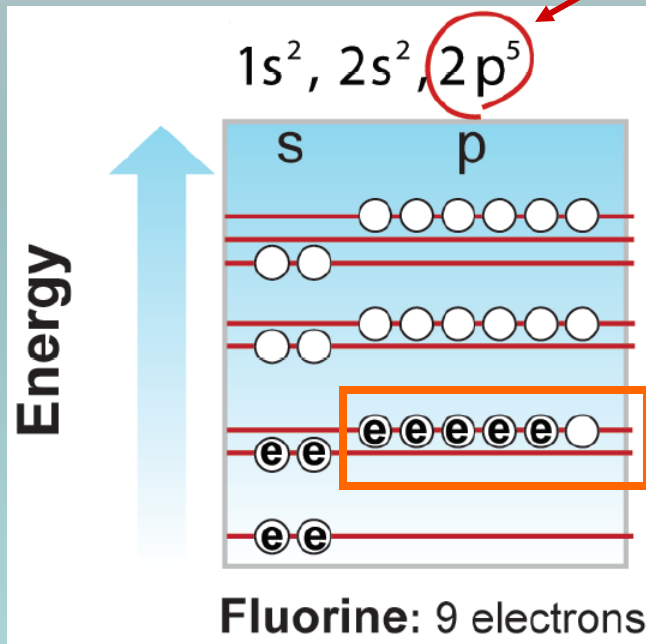
F-
Cl-
Br-
I-
At-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
H	He							F	Ne							Cl	Ar		
								Br	Kr										
								I	Xe										
								At	Rn										

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)	(173.06)
lanthanum	cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium
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)
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendeleevium	nobelium

Halogens

Halogens have a single open quantum state in the highest energy *p* orbital.



Halogens

In their pure forms:

Halogens form diatomic molecules (Cl_2 , F_2)

They are highly reactive, and toxic to many organisms.



When combined with a metal:

The resulting compound is generally an ionic salt.



Noble gases

Periodic table of the elements

Elements in group 18 are called “noble gases” because they do not chemically bond with any of the other elements.

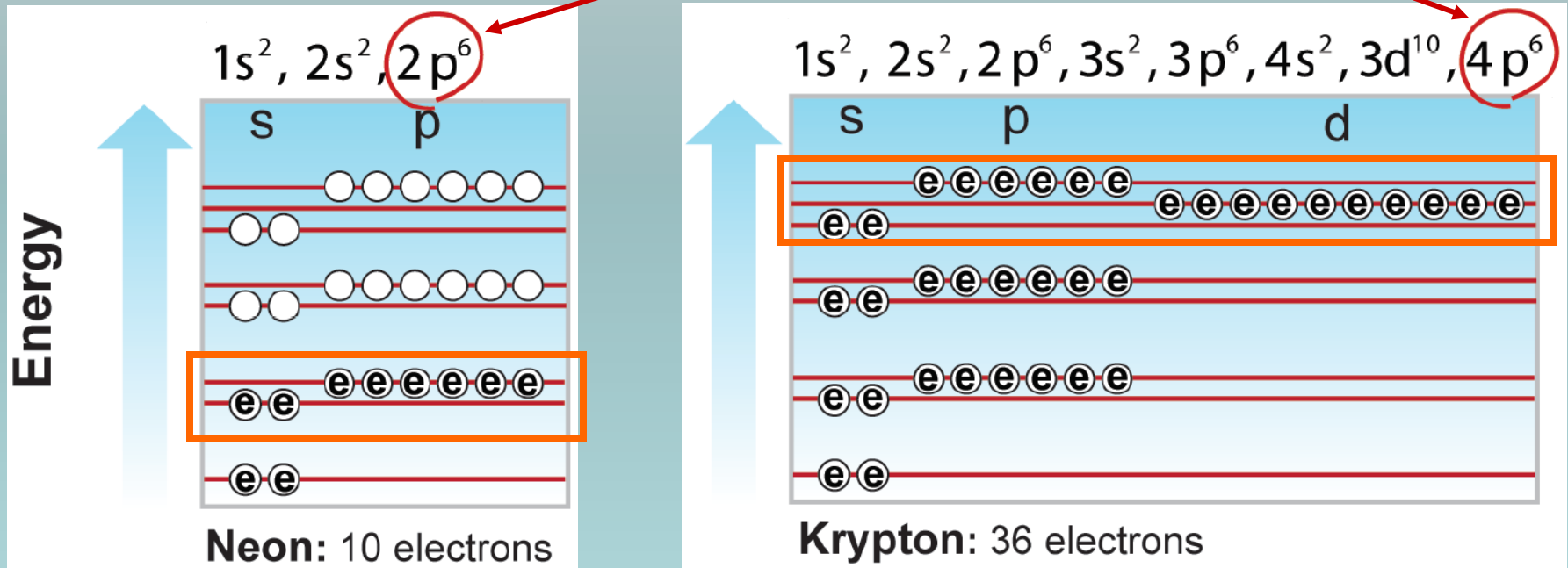
Why not?

										Nonmetals					2 He 4.0028 helium										
										Metals					10 Ne 20.180 neon										
										5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	18 Ar 39.948 argon										
										13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	36 Kr 83.80 krypton										
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										88 Ra (226) radium	89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium	118 Uuo (294) ununoctium

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (145) promethium	62 Sm 150.36 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.06 ytterbium
89 Ac (227) actinium	90 Th 232.04 thorium	91 Pa 231.04 protactinium	92 U 238.03 uranium	93 Np (237) neptunium	94 Pu (244) plutonium	95 Am (243) americium	96 Cm (247) curium	97 Bk (247) berkelium	98 Cf (251) californium	99 Es (252) einsteinium	100 Fm (257) fermium	101 Md (258) mendelevium	102 No (259) nobelium

Noble gases

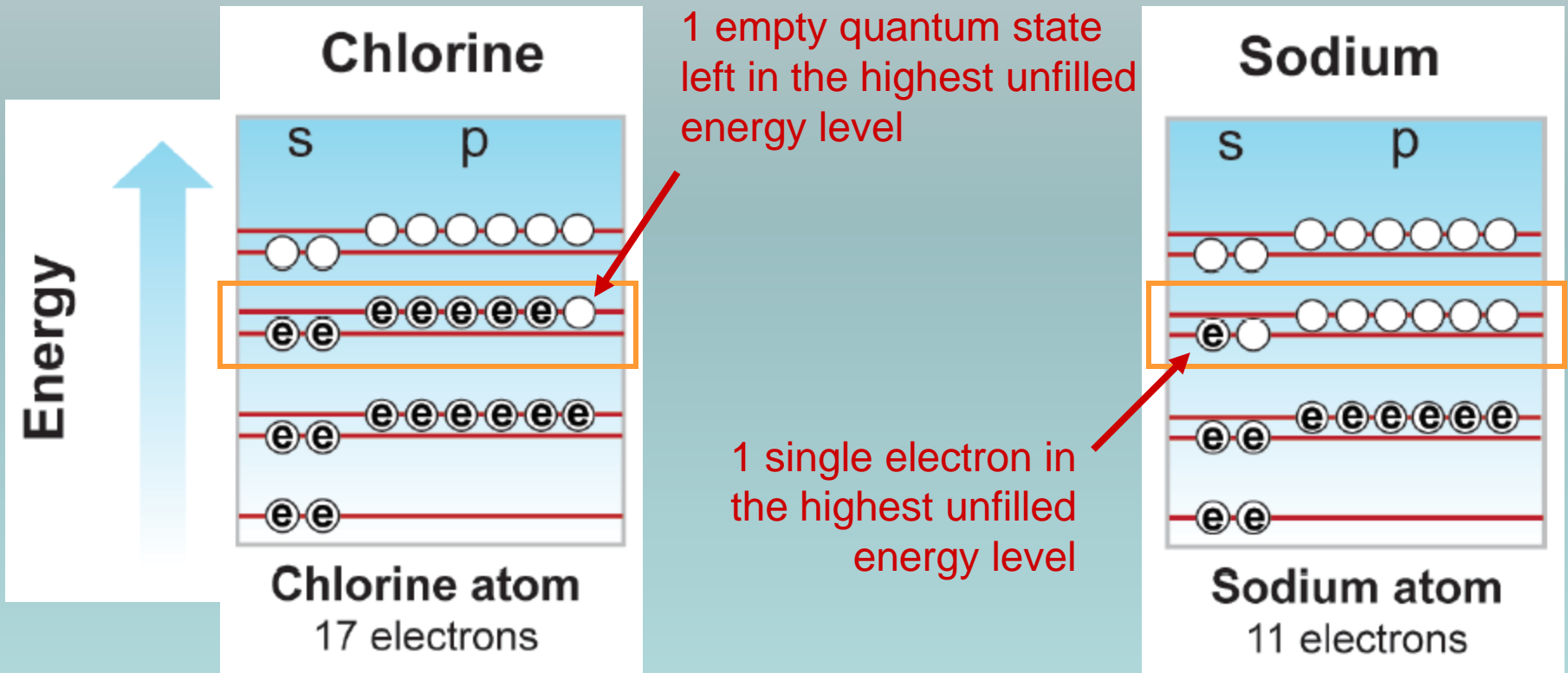
The highest energy levels are completely filled.



Electrons in completely filled energy levels do not make bonds.

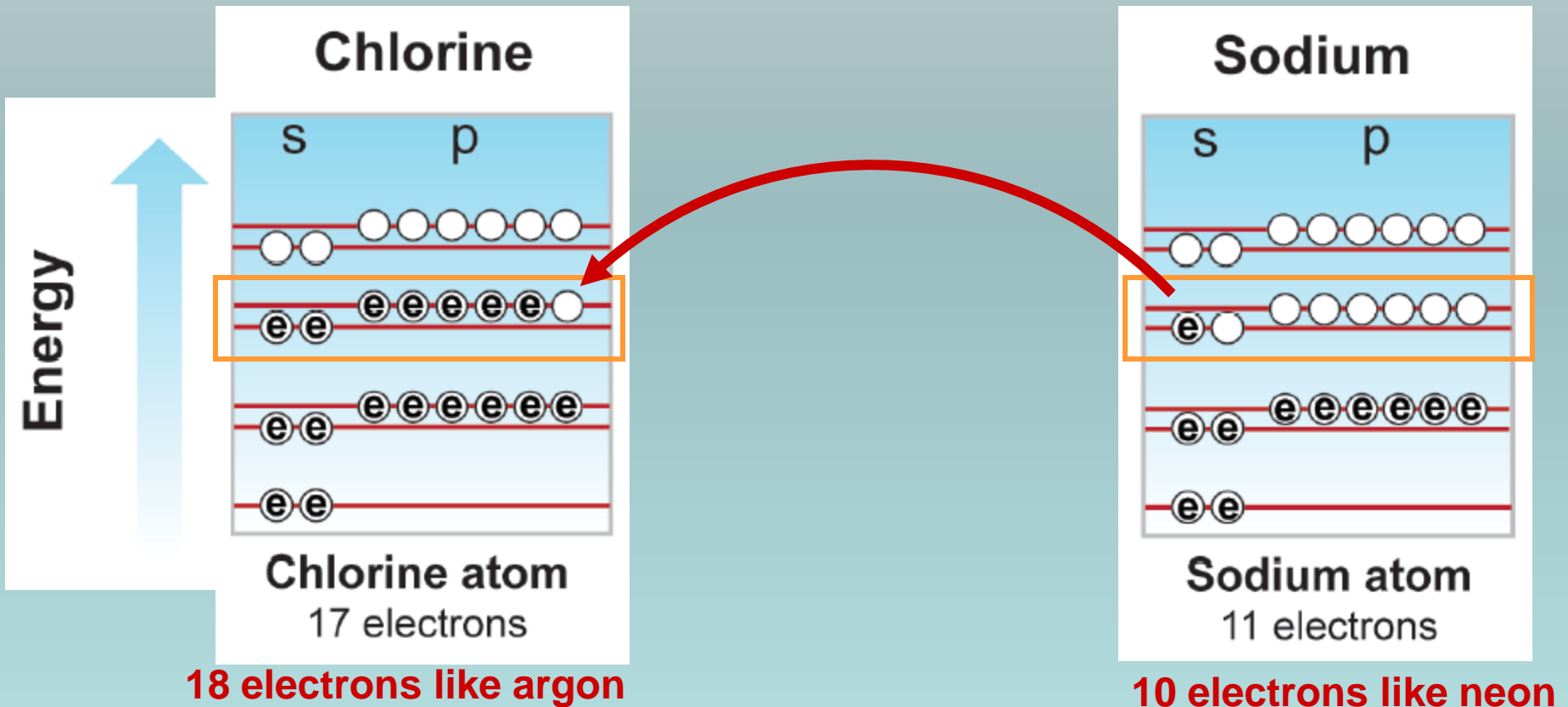
Bond formation

Remember: Electrons are responsible for bonding properties.

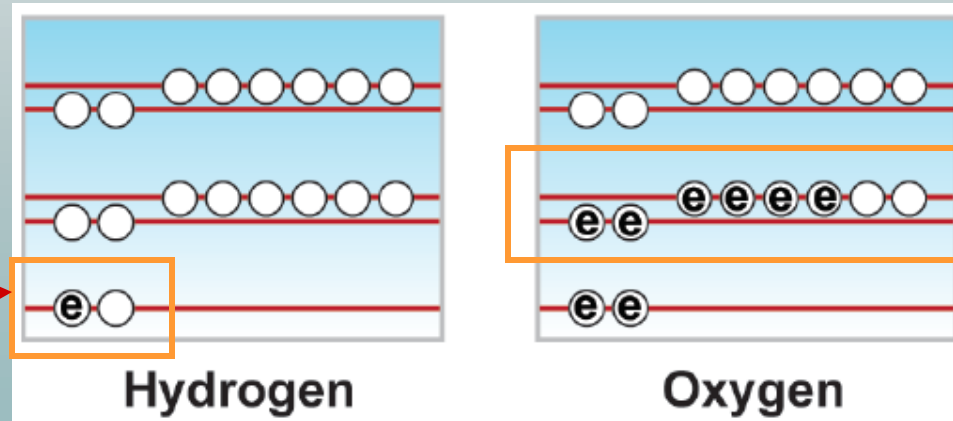


Bond formation

By forming the ionic compound sodium chloride, both chloride and sodium ions achieve **a noble gas electron structure!**



Bond formation



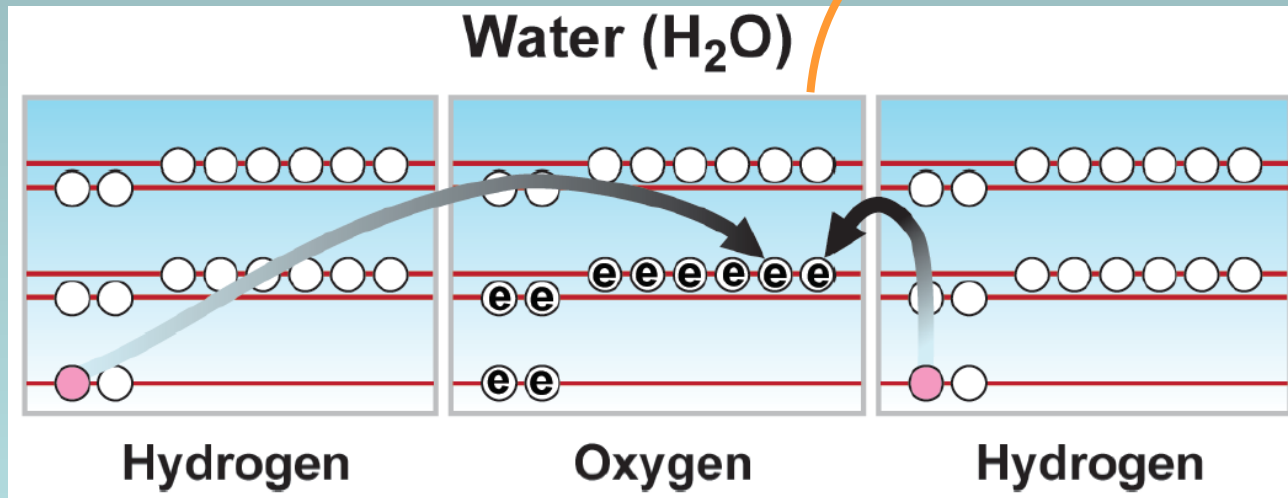
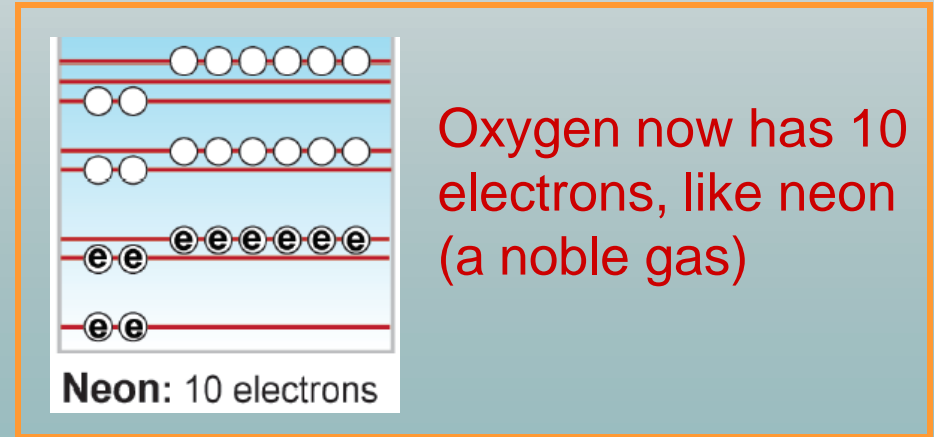
1 single electron in the highest unfilled energy level

2 empty quantum states left in the highest unfilled energy level

Can you form a molecule with hydrogen and oxygen atoms?

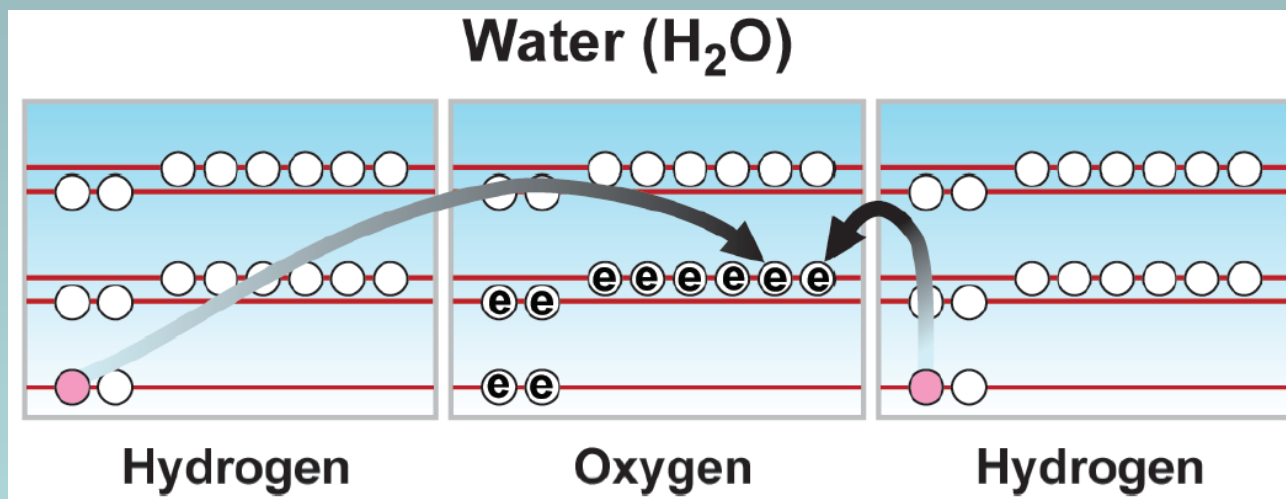
Bond formation

Each hydrogen atom donates one electron to the oxygen atom



Elements that belong to the same period in the periodic table have similar chemical properties.

This is because they have **similar electron configurations**, and **electrons are responsible for bonding properties**.



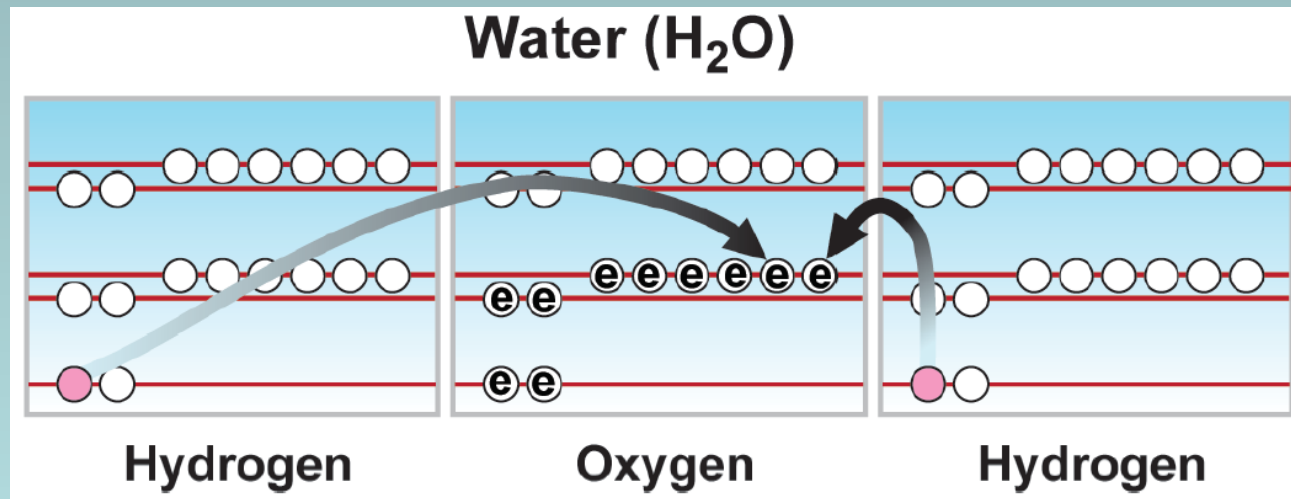
A noble gas electron structure is obtained through bond formation.

Elements and the Periodic Table

Valence


Only the electrons in the highest unfilled energy level form chemical bonds.

Does that mean we don't need to worry about electrons in filled energy levels?



Only the electrons in the highest unfilled energy level form chemical bonds.

Does that mean we don't need to worry about electrons in filled energy levels?



Yes!

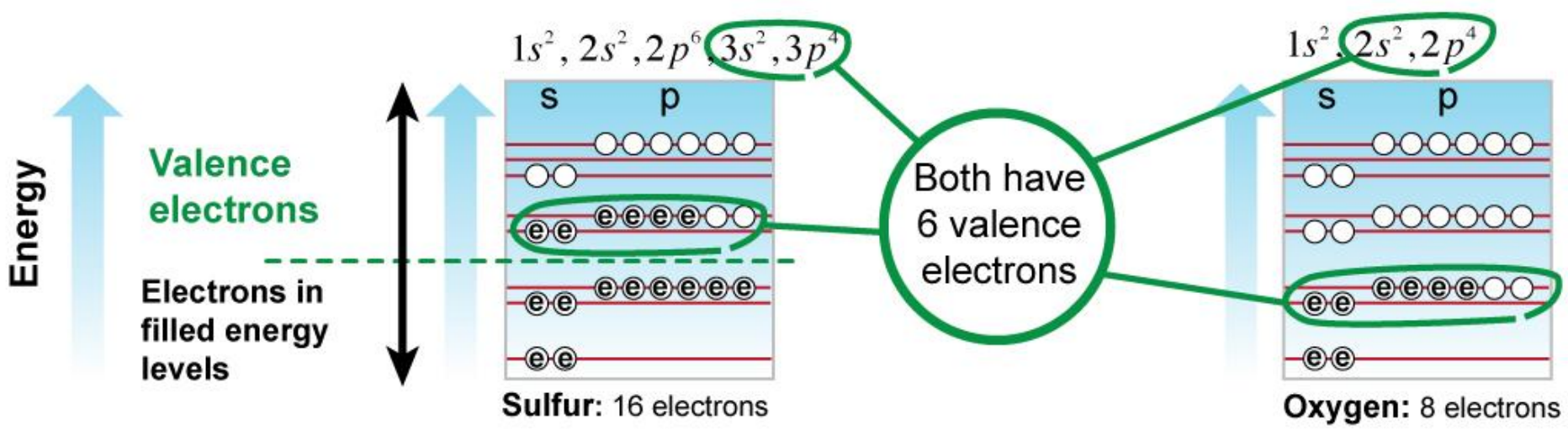
Chemistry terms

valence electrons: electrons in the highest unfilled energy level, responsible for making chemical bonds.

8	O	9
	15.999 oxygen	
16	S	17
	32.065 sulfur	
34		35

Oxygen and sulfur belong to the same group in the periodic table

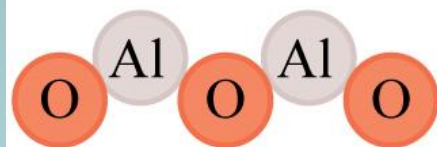
Remember that elements that belong to the same group have **similar chemical properties!**



Sulfur and oxygen have the same number of valence electrons. They form similar chemical compounds.



Aluminum sulfide
 Al_2S_3



Aluminum oxide
 Al_2O_3

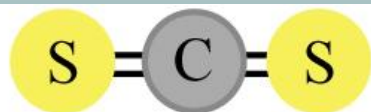


Magnesium sulfide
 MgS

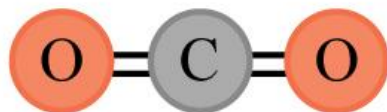


Magnesium oxide
 MgO

Sulfur and oxygen have the same number of valence electrons. They form similar chemical compounds.



Carbon disulfide
CS₂



Carbon dioxide
CO₂



Sodium sulfide
Na₂S



Sodium oxide
Na₂O

Determining valence electrons

17
Cl
35.453
chlorine

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.

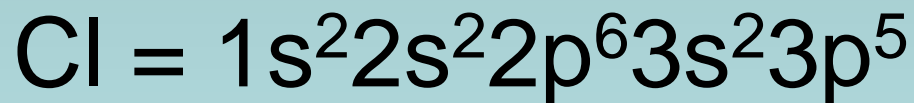
Determining valence electrons

17
Cl
35.453
chlorine

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.



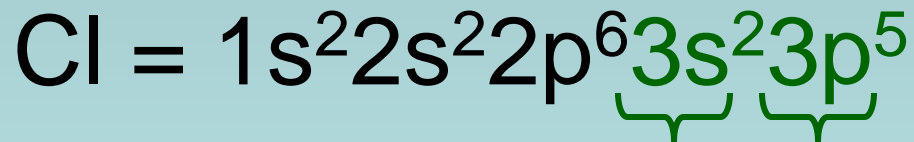
Determining valence electrons

17
Cl
35.453 chlorine

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.
2. Count how many electrons are in the highest s and p orbitals (it should be between 1 and 8).



Level 3 is the highest energy level

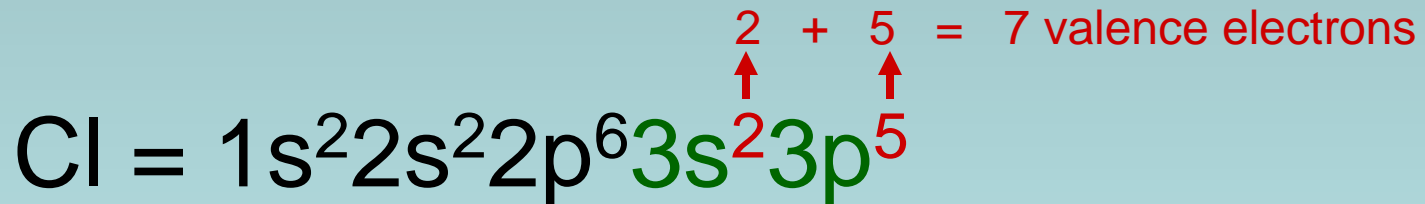
Determining valence electrons

17
Cl
35.453
chlorine

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.
2. Count how many electrons are in the highest s and p orbitals (it should be between 1 and 8).
3. These are the valence electrons.



Determining valence electrons

31
Ga
69.723
gallium

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.

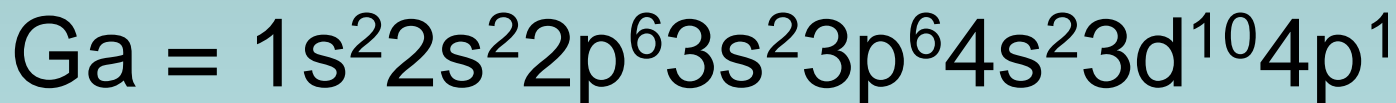
Determining valence electrons

31
Ga
69.723
galium

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.



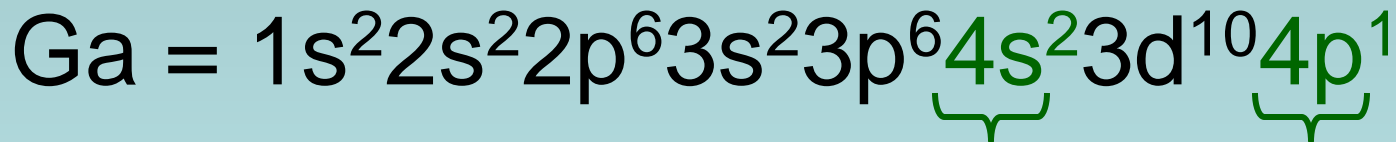
Determining valence electrons

31
Ga
69.723 gallium

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.
2. Count how many electrons are in the highest s and p orbitals (it should be between 1 and 8).



Level 4 is the highest energy level

Determining valence electrons

31
Ga
69.723
gallium

Electron configuration chart

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$	$3d^{10}$	$4p^6$	$5s^2$	$4d^{10}$	$5p^6$
2	4	10	12	18	20	30	36	38	48	54
Total number of electrons for full orbitals										

1. Write down the electron configuration.
2. Count how many electrons are in the highest *s* and *p* orbitals (it should be between 1 and 8).
3. These are the valence electrons.



Lewis dot diagram

Filled *d* orbitals do not contribute valence electrons!

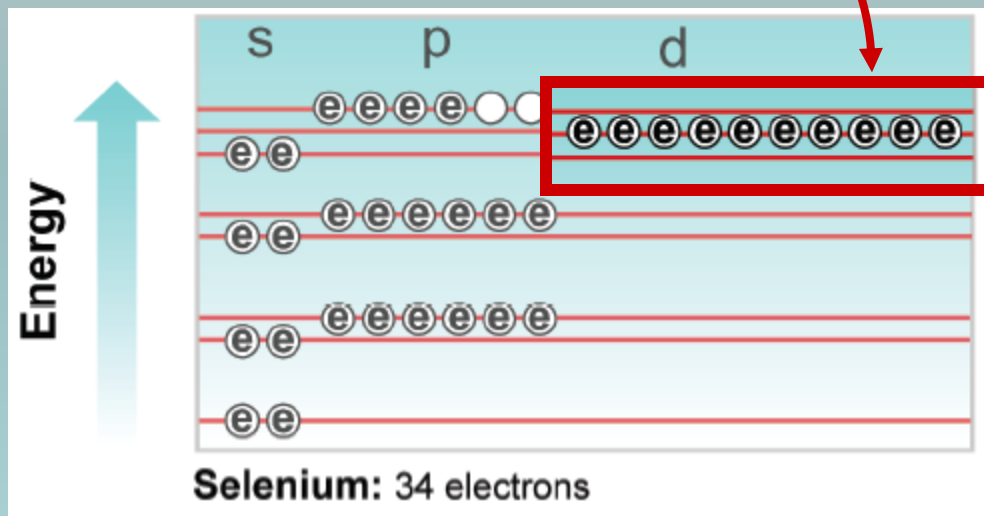
Valence electrons for selenium

2 + 4 = 6 valence electrons

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^4$

Filled energy levels

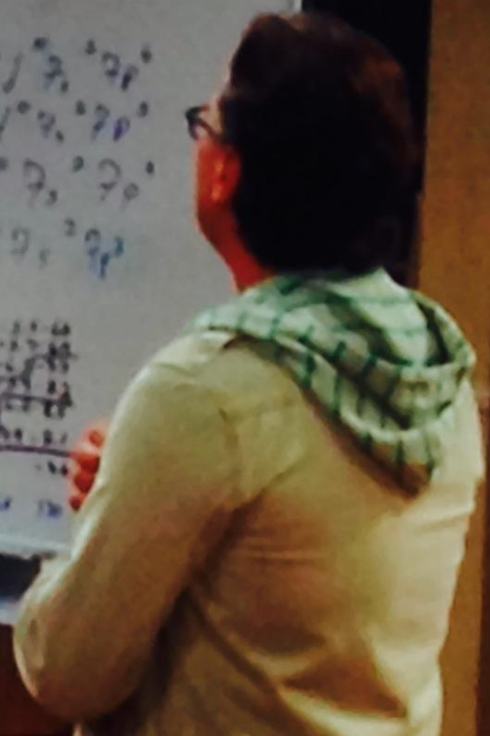
Filled d orbital





Handwritten mathematical notes on a whiteboard, including:

- Equations: $[u] = [u] S_0^*$, $[u] = [u] S_0^* S_1^*$, $[u] = [u] S_0^* S_1^* S_2^*$, $[u] = [u] S_0^*$, $[u] = [u] S_0^* S_1^* S_2^* S_3^*$, $[u] = [u] S_0^* S_1^* S_2^* S_3^* S_4^*$, $[u] = [u] S_0^* S_1^* S_2^* S_3^* S_4^* S_5^*$
- A diagram with a red arrow and the text "U = ..."
- A grid of numbers at the bottom, possibly a matrix or data table.



1	2	Valence electrons						3	4	5	6	7	8					
1A	Main group elements											8A						
1 H 1.0079 hydrogen	2A												2 He 4.0028 helium					
3 Li 6.941 lithium	4 Be 9.0122 beryllium	Transition metals (valence electrons vary)											5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
11 Na 22.990 sodium	12 Mg 24.305 magnesium	3B	4B	5B	6B	7B	8B		1B	2B	13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorous	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon		
19 K 39.098 potassium	20 Ca 40.078 calcium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 79.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon	
55 Cs 132.91 cesium	56 Ba 137.33 barium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.559 mercury	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	

1 2 Valence electrons 3 4

1A Main group elements 2A

How many valence electrons does magnesium (Mg) have?

Transition metals (valence electrons vary)

1 H 1.0079 hydrogen	
3 Li 6.941 lithium	4 Be 9.0122 beryllium
11 Na 22.990 sodium	12 Mg 24.305 magnesium
19 K 39.098 potassium	20 Ca 40.078 calcium
37 Rb 85.468 rubidium	38 Sr 87.62 strontium
55 Cs 132.91 cesium	56 Ba 137.33 barium

							8B			
3B	4B	5B	6B	7B				1B	2B	
21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc	
39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	
71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.559 mercury	

5A 13 Al 26.982 aluminum	6A 14 Si 28.086 silicon
7A 31 Ga 69.723 gallium	8A 32 Ge 72.64 germanium
9A 49 In 114.82 indium	10A 50 Sn 118.71 tin
11A 81 Tl 204.38 thallium	12A 82 Pb 207.2 lead

1 2 Valence electrons 3 4

1A Main group elements 2A

How many valence electrons does magnesium (Mg) have?

1 H 1.0079 hydrogen
3 Li 6.941 lithium
11 Na 22.990 sodium
19 K 39.098 potassium
37 Rb 85.468 rubidium
55 Cs 132.91 cesium

Transition metals (valence electrons vary)									
3B	4B	5B	6B	7B	8B			1B	2B
21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper	30 Zn 65.38 zinc
39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium
71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold	80 Hg 200.559 mercury

5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.06 sulfur	17 Cl 35.45 chlorine	18 Ar 39.948 argon
31 Ga 69.723 gallium	32 Ge 72.63 germanium	33 As 74.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton
49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.6 tellurium	53 I 126.905 iodine	54 Xe 131.29 xenon
81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po 209 polonium	85 At 210 astatine	86 Rn 222 radon

Mg is a group 2A element.
It has 2 valence electrons

Valence electrons		3	4	5	6	7	8
Main group elements							8A
		3A	4A	5A	6A	7A	2 He 4.0028 helium
Transition metals (electrons vary)		5 B 10.811 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
		13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon
		24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper
		30 Zn 65.38 zinc	8B		31 Ga 69.723 gallium	32 Ge 72.61 germanium	33 As 74.922 arsenic
		34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton	49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony
		52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon	81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth
		84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	79 Au 196.97 gold	80 Hg 200.59 mercury	
		74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	

How many valence electrons does carbon have?

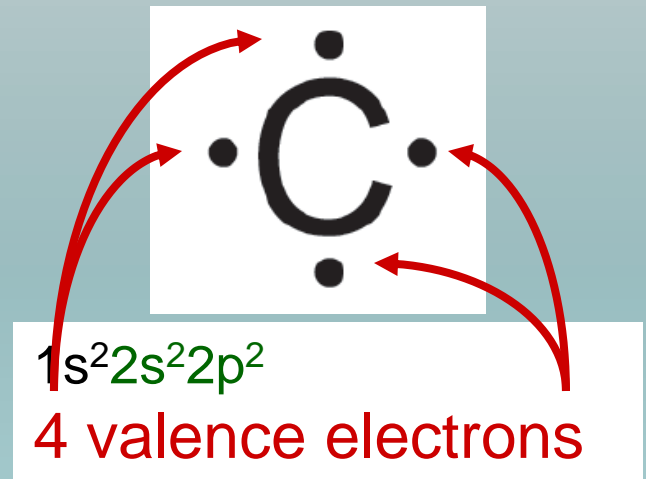


Chemistry terms

Lewis dot diagram: a diagram showing one dot for each valence electron an atom has, these dots surround the element symbol of the atom.

Valence electrons		3	4	5	6	7	8
Main group elements							8A
		3A	4A	5A	6A	7A	2 He 4.0028 helium
Transition metals (electrons vary)		5 B 10.81 boron	6 C 12.011 carbon	7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
		13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorus	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon
		24 Cr 51.996 chromium	25 Mn 54.938 manganese	26 Fe 55.845 iron	27 Co 58.933 cobalt	28 Ni 58.693 nickel	29 Cu 63.546 copper
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		42 Mo 95.96 molybdenum	43 Tc (98) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.42 palladium	47 Ag 107.87 silver
		49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon
		74 W 183.84 tungsten	75 Re 186.21 rhenium	76 Os 190.23 osmium	77 Ir 192.22 iridium	78 Pt 195.08 platinum	79 Au 196.97 gold
		81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon

Lewis dot diagram for carbon



Chemistry terms

Lewis dot diagram: a diagram showing one dot for each valence electron an atom has, these dots surround the element symbol of the atom.

Lewis dot diagram

Same number of valence electrons
causes similar bonding patterns

Lewis dot diagram
→
compound with oxygen or hydrogen

$\overset{\cdot}{\text{H}}$ H_2O						$\overset{\cdot\cdot}{\text{He}}$ n/a	
$\overset{\cdot}{\text{Li}}$ Li_2O	$\overset{\cdot\cdot}{\text{Be}}$ BeO	$\overset{\cdot\cdot}{\text{B}}$ B_2O_3	$\overset{\cdot}{\text{C}}$ CO_2	$\overset{\cdot\cdot\cdot}{\text{N}}$ N_2O_5	$\overset{\cdot\cdot\cdot}{\text{O}}$ H_2O	$\overset{\cdot\cdot\cdot\cdot}{\text{F}}$ HF	$\overset{\cdot\cdot\cdot\cdot}{\text{Ne}}$ n/a
$\overset{\cdot}{\text{Na}}$ Na_2O	$\overset{\cdot\cdot}{\text{Mg}}$ MgO	$\overset{\cdot\cdot}{\text{Al}}$ Al_2O_3	$\overset{\cdot}{\text{Si}}$ SiO_2	$\overset{\cdot\cdot\cdot}{\text{P}}$ P_2O_5	$\overset{\cdot\cdot\cdot}{\text{S}}$ H_2S	$\overset{\cdot\cdot\cdot\cdot}{\text{Cl}}$ HCl	$\overset{\cdot\cdot\cdot\cdot}{\text{Ar}}$ n/a
$\overset{\cdot}{\text{K}}$ K_2O	$\overset{\cdot\cdot}{\text{Ca}}$ CaO	$\overset{\cdot\cdot}{\text{Ga}}$ Ga_2O_3	$\overset{\cdot\cdot}{\text{Ge}}$ GeO_2	$\overset{\cdot\cdot\cdot}{\text{As}}$ As_2O_5	$\overset{\cdot\cdot\cdot}{\text{Se}}$ H_2Se	$\overset{\cdot\cdot\cdot\cdot}{\text{Br}}$ HBr	$\overset{\cdot\cdot\cdot\cdot}{\text{Kr}}$ n/a
$\overset{\cdot}{\text{Rb}}$ Rb_2O	$\overset{\cdot\cdot}{\text{Sr}}$ SrO	$\overset{\cdot\cdot}{\text{In}}$ In_2O_3	$\overset{\cdot\cdot}{\text{Sn}}$ SnO_2	$\overset{\cdot\cdot\cdot}{\text{Sb}}$ Sb_2O_5	$\overset{\cdot\cdot\cdot}{\text{Te}}$ H_2Te	$\overset{\cdot\cdot\cdot\cdot}{\text{I}}$ HI	$\overset{\cdot\cdot\cdot\cdot}{\text{Xe}}$ n/a

indicates
no reaction

Lewis dot diagram

Lewis dot diagrams							
$\dot{\text{Li}}$	$\cdot\text{Be}\cdot$	$\cdot\text{B}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot}{\text{C}}}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot\cdot}{\text{N}}}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot\cdot}{\text{O}}}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot\cdot}{\text{F}}}\cdot$	$\cdot\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{Ne}}}\cdot$
1	2	3	4	5	6	7	8
Valence electrons							

Valence electrons are the **most loosely bound electrons** in an atom. They are easiest to share or transfer.

Lewis dot diagrams							
$\dot{\text{Li}}$	$\cdot\text{Be}$	$\cdot\text{B}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot}{\text{C}}}\cdot$	$\cdot\overset{\cdot}{\underset{\cdot\cdot}{\text{N}}}\cdot$	$\overset{\cdot}{\underset{\cdot\cdot}{\text{O}}}\cdot$	$\overset{\cdot}{\underset{\cdot\cdot}{\text{F}}}\cdot$	$\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{Ne}}}\cdot$
1	2	3	4	5	6	7	8
Valence electrons							

Valence electrons are the **most loosely bound electrons** in an atom. They are easiest to share or transfer.

Is the periodic table just an organizational system?

Can it be used as a tool?

1	2	Valence				
1A		Main group				
1 H 1.0079 hydrogen	2A	Transition metals (valence electrons)				
3 Li 6.941 lithium	4 Be 9.0122 beryllium	3B	4B	5B	6B	7B
11 Na 22.990 sodium	12 Mg 24.305 magnesium	21 Sc 44.956 scandium	22 Ti 47.867 titanium	23 V 50.942 vanadium	24 Cr 51.996 chromium	25 Mn 54.938 manganese
19 K 39.098 potassium	20 Ca 40.078 calcium	39 Y 88.906 yttrium	40 Zr 91.224 zirconium	41 Nb 92.906 niobium	42 Mo 95.96 molybdenum	43 Tc 98.906 technetium
37 Rb 85.468 rubidium	38 Sr 87.62 strontium	71 Lu 174.97 lutetium	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.84 tungsten	75 Re 186.207 rhenium
55 Cs 132.91 cesium	56 Ba 137.33 barium					

Elements from the same group (column) have similar chemical properties, so they interact with neighboring atoms in a similar way.



Normal glass can be made stronger by replacing Na with K on its surface

- Elements that belong to the same group in the periodic table have the same number of valence electrons
- Only valence electrons are involved in chemical bonding
- The Lewis dot diagram is a way to show valence electrons for an atom

Carbon has
4 valence electrons



					8A
3A	4A	5A	6A	7A	2
	C 12.011 carbon				He 4.0028 helium
5 B 10.811 boron		7 N 14.007 nitrogen	8 O 15.999 oxygen	9 F 18.998 fluorine	10 Ne 20.180 neon
13 Al 26.982 aluminum	14 Si 28.086 silicon	15 P 30.974 phosphorous	16 S 32.065 sulfur	17 Cl 35.453 chlorine	18 Ar 39.948 argon
31 Ga 69.723 galium	32 Ge 72.61 germanium	33 As 79.922 arsenic	34 Se 78.96 selenium	35 Br 79.904 bromine	36 Kr 83.80 krypton
49 In 114.82 indium	50 Sn 118.71 tin	51 Sb 121.76 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.29 xenon
81 Tl 204.38 thallium	82 Pb 207.2 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon

Lewis dot
diagram
for carbon

