The Periodic Table

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(Chemistry Notes)

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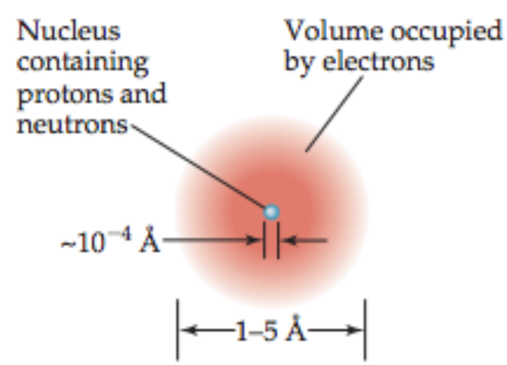
Subatomic Particles

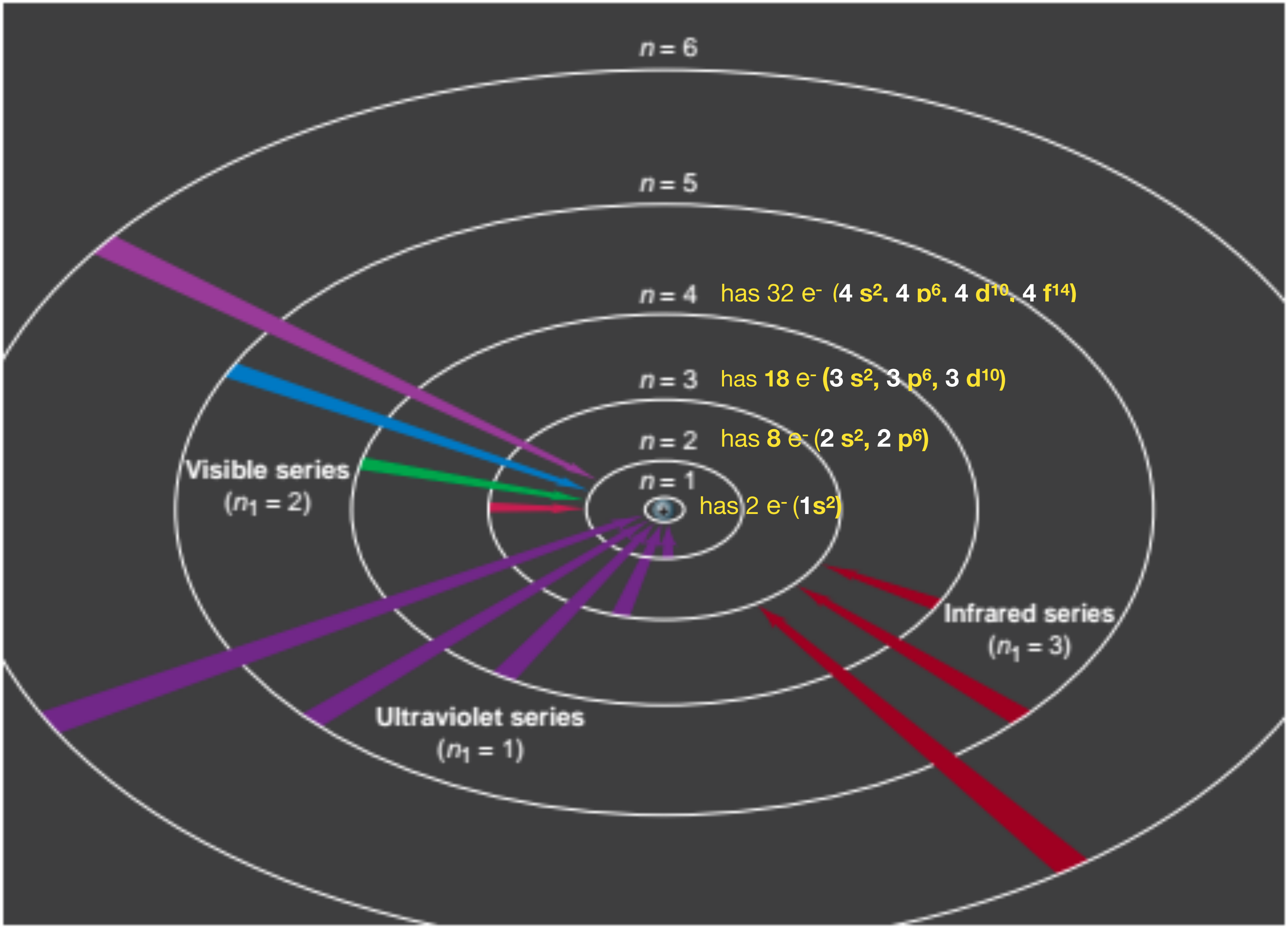
The small parts that make up atoms are called subatomic particles. Electrons and protons are two of the subatomic particles.

An electron has a negative charge of -1.602 x 10^{-19} coulombs. A proton has the same opposite charge of +1.602 x 10^{-19} coulombs. Protons are located in the nucleus.
Opposite charges attract each other. Therefore, there is an attraction between the nucleus and the electrons.

The electron has a mass of 9.109 x 10^{-31} kg. The proton has a mass of 1.673 X 0^{-27} kg. The mass of the proton is about 2000 times the mass of an electron. The nucleus has the heavy protons, so it has most of the weight of the atom (very heavy).

The radius of the atom is 10000 times larger than the radius of the nucleus. The nucleus is extremely small comparing to the size of the atom. If the nucleus of an atom were the size of a marble, then the whole atom would be about the size of a football stadium.





n = 6
n = 5
n = 4
has 32 e- (4 s2, 4 p6, 4 d10, 4 f14)
n = 3
has 18 e- (3 s2, 3 p6, 3 d10)
n = 2
has 8 e- (2 s2, 2 p6)
n = 1
has 2 e- (1s2)
Visible series
(n1 = 2)
Infrared series
(n1 = 3)
Ultraviolet series
(n1 = 1)

Remember

Atomic Number, Period Number, Group Number, Atomic Radius
Atomic Number (Z) = Number of Electrons = Number of Protons (nucleus)
Occupied Energy Levels = Period Number
Electrons on the Last Energy Level = Valence Electrons = Group Number
Relative Size of the Atom = Atomic Radius, Radii in Picometers
The More the Protons, the Stronger the Nucleus

Potassium, K

Atomic number (Z) = Number of Electrons = Number of Protons (nucleus)
19 = 19 electrons (e^-) = 19 protons (P^+)

Electron Configuration:

$1\,s^2,\ 2\,s^2,\ 2\,p^6,\ 3\,s^2,\ 3\,p^6,\ 4\,s^1$

Period Number:

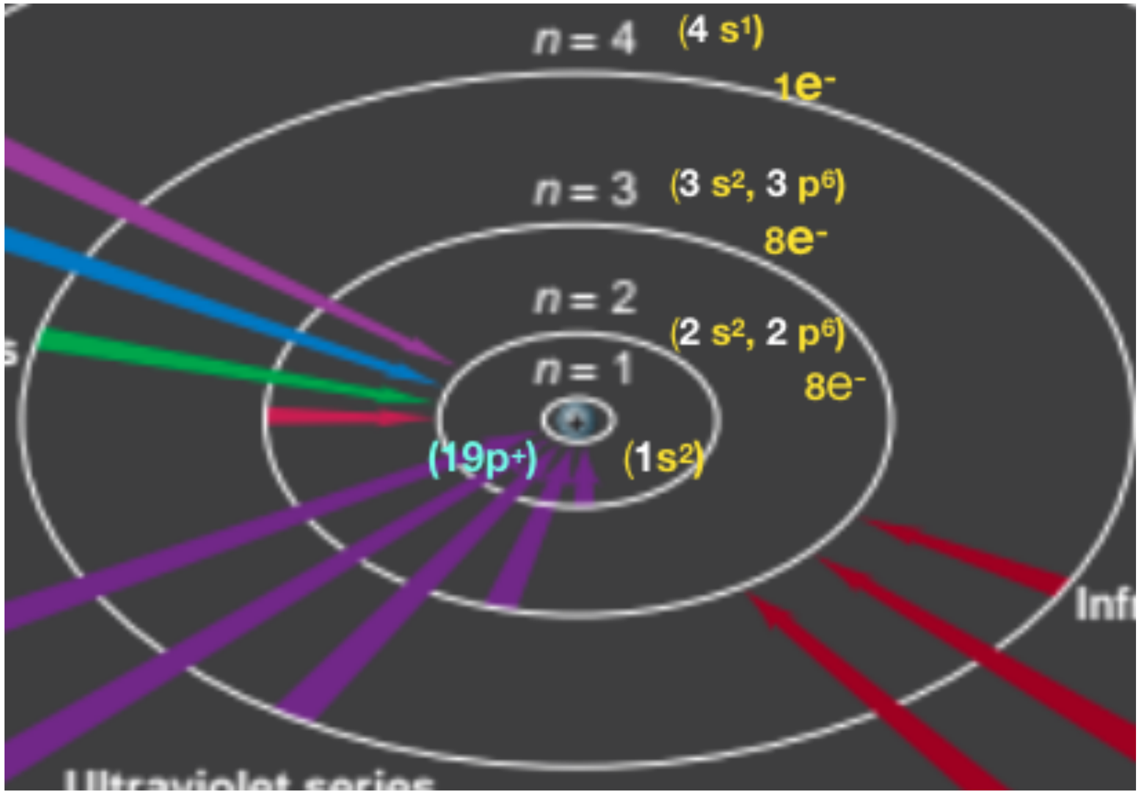
Occupied Energy Levels = Period Number
The electrons are on 4 energy levels (n = **4**) = Period **4.**

K is in period **4**

Group Number:

Electrons on the last energy level = Valence Electrons = Group Number
1 electrons (e^-) on the last energy level = **1** Valence electron = Group **1**

K is in group **1A**



Relative size of the atom = Atomic Radius, Radii in Picometers

Potassium (K) has 4 energy levels. The radius size of a potassium atom is 243 Picometers.

Chlorine, Cl

Atomic number (Z)	= Number of Electrons	= Number of Protons (nucleus)
17	= 17 electrons (**e**$^-$)	= 17 protons (**P**$^+$)

Electron Configuration:

1 **s**^{2}**,** 2 **s**^{2}**,** 2 **p**^{6}**, 3 s**^{2}**, 3 p**^{5}

Period Number:

Occupied Energy Levels = Period Number

The electrons are on 3 energy levels (n = **3**) = Period **3.**

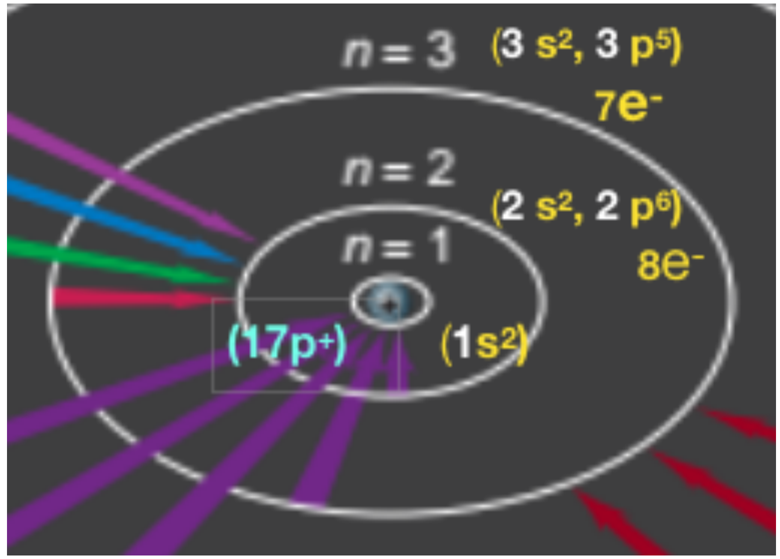
Cl is in period **3**

Group Number:

Electrons on the last energy level = Valence Electrons = Group Number

7 electrons (**e**$^-$) on the last energy level = **7** Valence electron = Group **7**

Cl is in group **7A** or **17**



Relative size of the atom = Atomic Radius, Radii in Picometers

Chlorine (Cl) atom has 3 energy levels. The radius size of a chlorine atom is 79 Picometers.

79

Neon, Ne

Atomic number (Z) = Number of Electrons = Number of Protons (nucleus)

10 = 10 electrons (**e^-**) = 10 protons (**P^+**)

Electron Configuration:

$1\ s^2, 2\ s^2, 2\ p^6$

Period Number:

Occupied Energy Levels = Period Number

The electrons are on 4 energy levels (n = 2) = Period **2.**

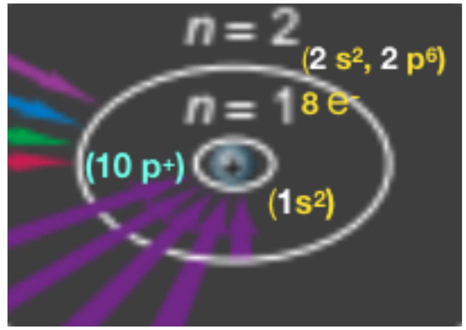
Ne is in period **2**

Group Number:

Electrons on the last energy level = Valence Electrons = Group Number

8 electrons (**e^-**) on the last energy level = **8** Valence electron = Group **8**

Ne is in group **8A** or **18**

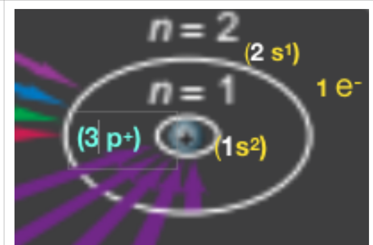
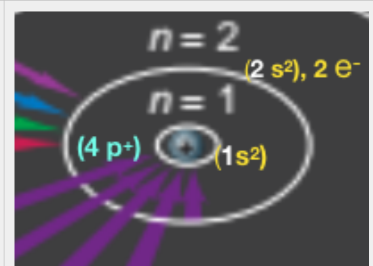
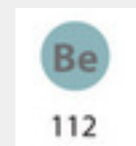
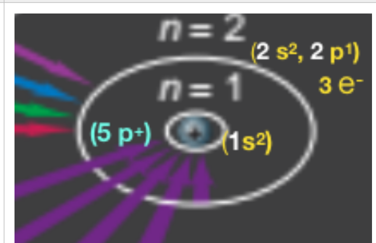


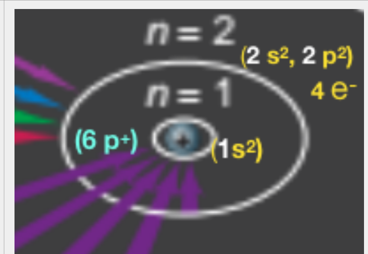
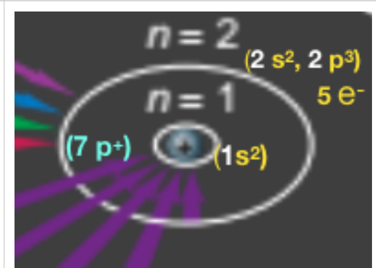
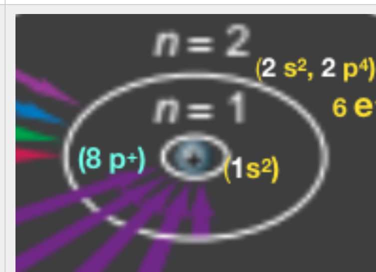
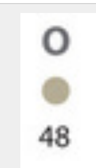
Relative size of the atom = Atomic Radius, Radii in Picometers

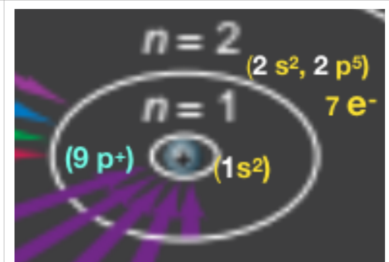
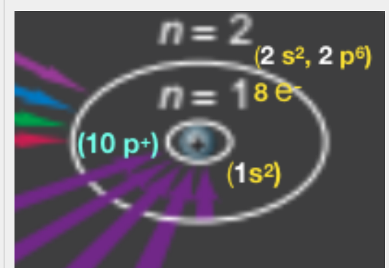
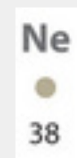
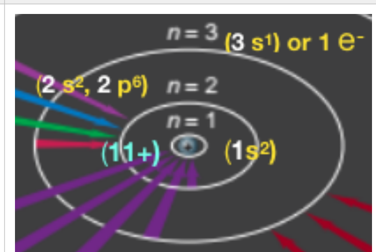
Neon (Ne) atom has 2 energy levels. The radius size of a neon atom is 38 Picometers.

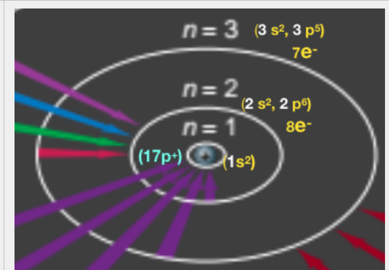
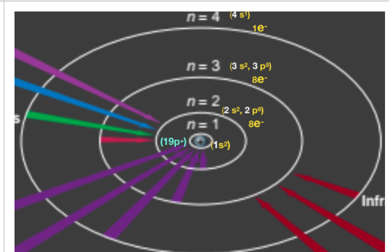
Practice:

More examples in the table in the following pages for practice.

Element Symbol	Atomic number (Z) = Electrons = Protons Electron Configuration	Valence Electrons on the last energy level = Group Number	Occupied Energy Levels = Period Number	Structure and Electron Configuration	Relative size of the atom. Atomic Radius, Radii in Picometers.
Lithium Li	Z = 3 3 electrons (e^-) 3 protons (P^+) 1 s^2, 2 s^1	1 electron (e^-) on the last energy level = 1 Valence electron Li is in group 1A	The electrons are on 2 energy levels (n = 2) Period 2		
Beryllium Be	Z = 4 4 electrons (e^-) 4 protons (P^+ 1 s^2, 2 s^2	2 electrons (e^-) on the last energy level = 2 Valence electron. Be is in group 2A	The electrons are on 2 energy levels (n = 2) Period 2		
Boron B	Z = 5 5 electrons (e^-) 5 protons (P^+) 1 s^2, 2 s^2, 2 p^1	3 electrons (e^-) on the last energy level = 3 Valence electron. B is in group 3A or (13)	The electrons are on 2 energy levels (n = 2) Period 2		

Element Symbol	**Atomic number (Z)** **=** **Electrons** **=** **Protons** **Electron Configuration**	**Valence Electrons on the last energy level** **=** **Group Number**	**Occupied Energy Levels** **=** **Period Number**	**Structure and Electron Configuration**	**Relative size of the atom.** **Atomic Radius, Radii in Picometers.**
Carbon C	Z = 6 6 electrons (**e^-**) 6 protons (**P^+**) 1 **s^2**, 2 **s^2**, 2 **p^2**	4 electrons (**e^-**) on the last energy level = 4 Valence electron. C is in group 4A or (14)	The electrons are on 2 energy levels (n = 2) C is in period 2		
Nitrogen N	Z = 7 7 electrons (**e^-**) 7 protons (**P^+**) 1 **s^2**, 2 **s^2**, 2 **p^3**	5 electrons (**e^-**) on the last energy level = 5 Valence electron. N is in group 5A or (15)	The electrons are on 2 energy levels (n = 2) N is in period 2		
Oxygen O	Z = 8 8 electrons (**e^-**) 8 protons (**P^+**) 1 **s^2**, 2 **s^2**, 2 **p^4**	6 electrons (**e^-**) on the last energy level = 6 Valence electron. O is in group 6A or (16)	The electrons are on 2 energy levels (n = 2) O is in period 2		

Element Symbol	**Atomic number (Z)** **=** **Electrons** **=** **Protons** **Electron Configuration**	**Valence Electrons on the last energy level** **=** **Group Number**	**Occupied Energy Levels** **=** **Period Number**	**Structure and Electron Configuration**	**Relative size of the atom.** **Atomic Radius, Radii in Picometers.**
Fluorine F	Z = 9 9 electrons (**e-**) 9 protons (**P+**) 1 **s²,** 2 **s²,** 2 **p⁵**	7 electrons (**e-**) on the last energy level = 7 Valence electron. F is in group 7A or (17)	The electrons are on 2 energy levels (n = 2) F is in period 2		
Neon Ne	Z = 10 10 electrons (**e-**) 10 protons (**P+**) 1 **s²,** 2 **s²,** 2 **p⁶**	8 electrons (**e-**) on the last energy level = 8 Valence electron. Ne is in group 8A or (18)	The electrons are on 2 energy levels (n = 2) Ne is in period 2		
Sodium Na	Z = 11 11 electrons (**e-**) 11 protons (**P+**) 1 **s²,** 2 **s²,** 2 **p⁶,** 3 **s¹**	1 electrons (**e-**) on the last energy level = 1 Valence electron. Na is in group 1A	The electrons are on 3 energy levels (n = 3) Na is in period 3		

Element Symbol	Atomic number (Z) = Electrons = Protons Electron Configuration	Valence Electrons on the last energy level = Group Number	Occupied Energy Levels = Period Number	Structure and Electron Configuration	Relative size of the atom. Atomic Radius, Radii in Picometers.
Chorine Cl	Z = 17 17 electrons (e^-) 17 protons (P^+) 1 s^2, 2 s^2, 2 p^6, 3 s^2, 3 p^5,	7 electrons (e^-) on the last energy level = 7 Valence electron. Cl is in group 7A or (17)	The electrons are on 3 energy levels (n = 3) Cl is in period 3		 79
Potassium K	Z = 19 19 electrons (e^-) 19 protons (P^+) 1 s^2, 2 s^2, 2 p^6, 3 s^2, 3 p^6, 4 s^1,	1 electrons (e^-) on the last energy level = 1 Valence electron. K is in group 1A	The electrons are on 4 energy levels (n = 4) K is in period 4		 243

Periodic Table (next page)

The periodic table is the most significant tool that chemists use for organizing and recalling chemical facts. Elements are arranged according to their atomic numbers (Z).

Periodic law is the law that states that the repeating physical and chemical properties of elements change periodically with their atomic number.

Group:

Elements in the **same column** contain the same number of outer-shell electrons or valence electrons. They are in the **same group**.

Example:

H, Li, Na, K, Rb, Cs, Fr are all in group 1A. They have 1 valence electron (on the outer shell or energy level).

Period:

A **horizontal row** on the periodic table is called a **period**. Elements in the same period have the same number of occupied energy levels (highest occupied energy level).

Example:

Li, Be, B, C, N, O, F , Ne are all in period 2. They have 2 energy levels.

Representative Elements | *d*-Transition Elements | Representative Elements | Noble Gases

Group numbers

Period number, highest occupied electron level

Period	1 1A ns^1	2 2A ns^2	3	4	5	6	7	8	9	10	11	12	13 3A ns^2np^1	14 4A ns^2np^2	15 5A ns^2np^3	16 6A ns^2np^4	17 7A ns^2np^5	18 8A ns^2np^6
1	1 H $1s^1$																	2 He $1s^2$
2	3 Li $2s^1$	4 Be $2s^2$											5 B $2s^22p^1$	6 C $2s^22p^2$	7 N $2s^22p^3$	8 O $2s^22p^4$	9 F $2s^22p^5$	10 Ne $2s^22p^6$
3	11 Na $3s^1$	12 Mg $3s^2$											13 Al $3s^23p^1$	14 Si $3s^23p^2$	15 P $3s^23p^3$	16 S $3s^23p^4$	17 Cl $3s^23p^5$	18 Ar $3s^23p^6$
4	19 K $4s^1$	20 Ca $4s^2$	21 Sc $4s^23d^1$	22 Ti $4s^23d^2$	23 V $4s^23d^3$	24 Cr $4s^13d^5$	25 Mn $4s^23d^5$	26 Fe $4s^23d^6$	27 Co $4s^23d^7$	28 Ni $4s^23d^8$	29 Cu $4s^13d^{10}$	30 Zn $4s^23d^{10}$	31 Ga $4s^24p^1$	32 Ge $4s^24p^2$	33 As $4s^24p^3$	34 Se $4s^24p^4$	35 Br $4s^24p^5$	36 Kr $4s^24p^6$
5	37 Rb $5s^1$	38 Sr $5s^2$	39 Y $5s^24d^1$	40 Zr $5s^24d^2$	41 Nb $5s^14d^4$	42 Mo $5s^14d^5$	43 Tc $5s^14d^6$	44 Ru $5s^14d^7$	45 Rh $5s^14d^8$	46 Pd $4d^{10}$	47 Ag $5s^14d^{10}$	48 Cd $5s^24d^{10}$	49 In $5s^25p^1$	50 Sn $5s^25p^2$	51 Sb $5s^25p^3$	52 Te $5s^25p^4$	53 I $5s^25p^5$	54 Xe $5s^25p^6$
6	55 Cs $6s^1$	56 Ba $6s^2$	57 La* $6s^25d^1$	72 Hf $4f^{14}6s^25d^2$	73 Ta $6s^25d^3$	74 W $6s^25d^4$	75 Re $6s^25d^5$	76 Os $6s^25d^6$	77 Ir $6s^25d^7$	78 Pt $6s^15d^9$	79 Au $6s^15d^{10}$	80 Hg $6s^25d^{10}$	81 Tl $6s^26p^1$	82 Pb $6s^26p^2$	83 Bi $6s^26p^3$	84 Po $6s^26p^4$	85 At $6s^26p^5$	86 Rn $6s^26p^6$
7	87 Fr $7s^1$	88 Ra $7s^2$	89 Ac** $7s^26d^1$	104 Rf $7s^26d^2$	105 Db $7s^26d^3$	106 Sg $7s^26d^4$	107 Bh $7s^26d^5$	108 Hs $7s^26d^6$	109 Mt $7s^26d^7$	110 Ds $7s^26d^8$	111 Rg $7s^16d^{10}$	112 Uub $7s^26d^{10}$	113 Uut $7s^26d^{10}7p^1$	114 Uuq $7s^26d^{10}7p^2$	115 Uup $7s^26d^{10}7p^3$			

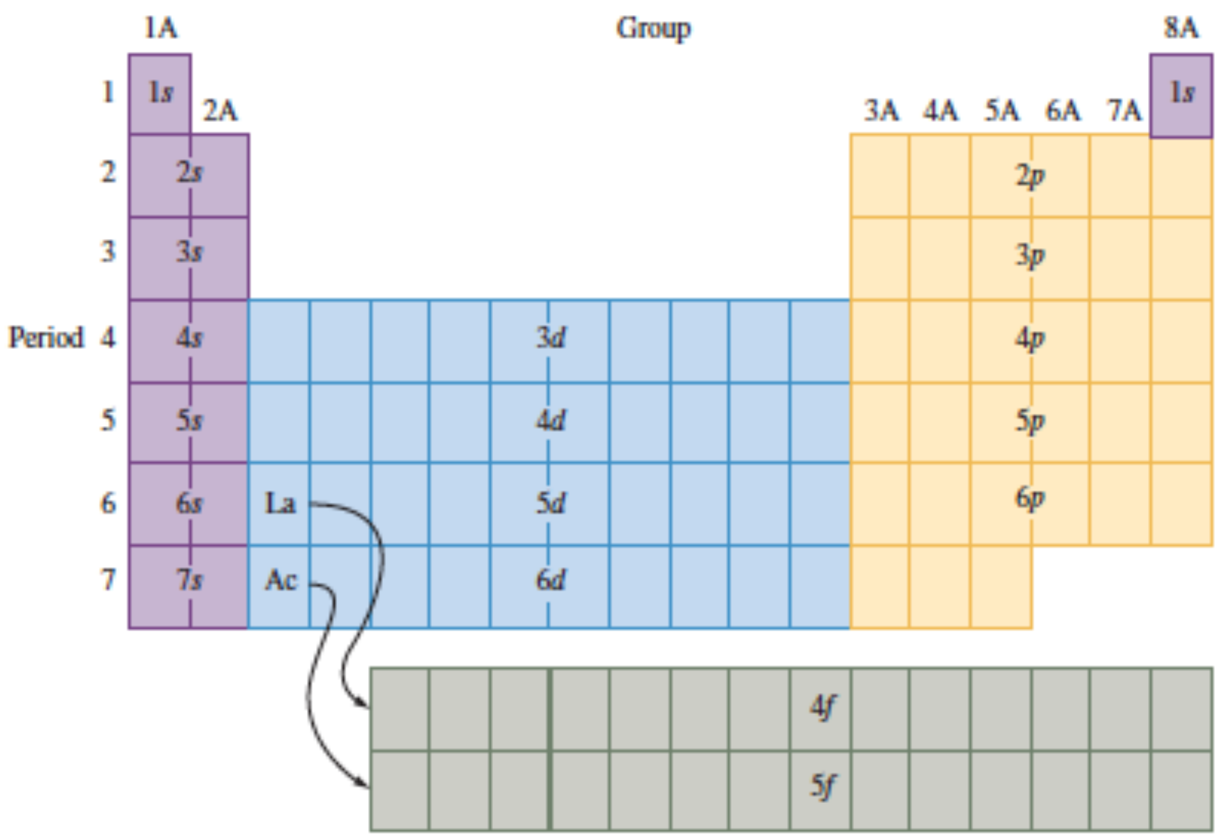
f-Transition Elements

*Lanthanides	58 Ce $6s^24f^15d^1$	59 Pr $6s^24f^35d^0$	60 Nd $6s^24f^45d^0$	61 Pm $6s^24f^55d^0$	62 Sm $6s^24f^65d^0$	63 Eu $6s^24f^75d^0$	64 Gd $6s^24f^75d^1$	65 Tb $6s^24f^95d^0$	66 Dy $6s^24f^{10}5d^0$	67 Ho $6s^24f^{11}5d^0$	68 Er $6s^24f^{12}5d^0$	69 Tm $6s^24f^{13}5d^0$	70 Yb $6s^24f^{14}5d^0$	71 Lu $6s^24f^{14}5d^1$
**Actinides	90 Th $7s^25f^06d^2$	91 Pa $7s^25f^26d^1$	92 U $7s^25f^36d^1$	93 Np $7s^25f^46d^1$	94 Pu $7s^25f^66d^0$	95 Am $7s^25f^76d^0$	96 Cm $7s^25f^76d^1$	97 Bk $7s^25f^96d^0$	98 Cf $7s^25f^{10}6d^0$	99 Es $7s^25f^{11}6d^0$	100 Fm $7s^25f^{12}6d^0$	101 Md $7s^25f^{13}6d^0$	102 No $7s^25f^{14}6d^0$	103 Lr $7s^25f^{14}6d^1$

The entire periodic table can be represented as shown below in terms of which orbitals are being filled. It can be used as a guide for electron configurations.

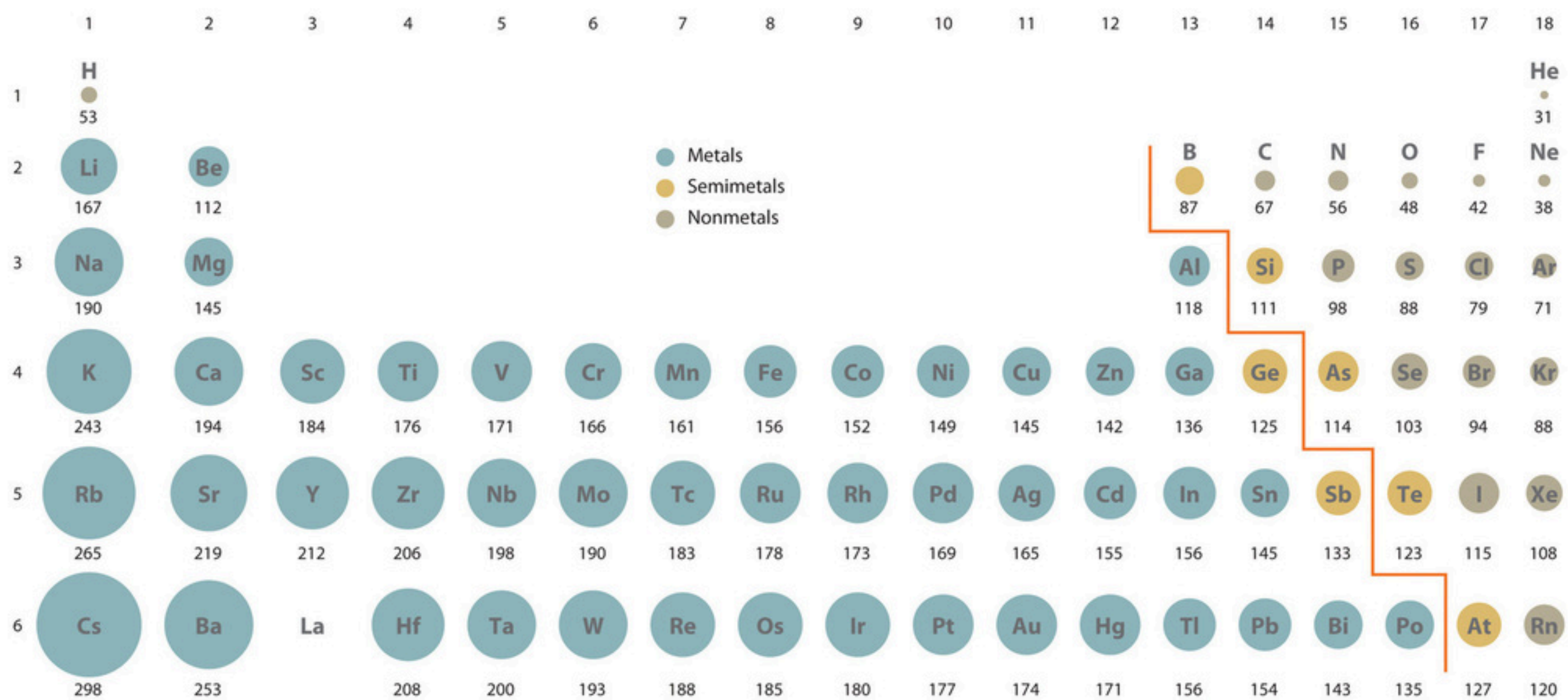
The period number is the value of *n*. Groups 1A and 2A have their *s* orbitals being filled. Groups 3A – 8A have their p orbitals being filled. The *s*-block and *p*-block of the periodic table contain the representative or main-group elements. The lanthanides and actinides have their *f* orbitals being filled. The actinides and lanthanide elements are collectively referred to as the ***f*-block** metals.

Note that the 3*d* orbitals fill after the 4*s* orbital. Similarly, the 4*f* orbitals fill after the 5*d* orbitals.



Periodic Trends in Atomic Radii

Atomic radius increases down a group and decreases across a period as shown below.



The sizes of the circles illustrate the relative sizes of the atoms. Atomic Radii are in Picometers.

Atomic Radius Increases as You Move Down the Same Group.

Occupied Energy Levels = Period Number

In the same group, as you go down from one element down to the next, the period number increases, which means that the number of energy levels increases. Having more energy levels means that the atom is bigger.

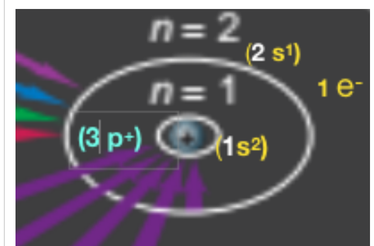
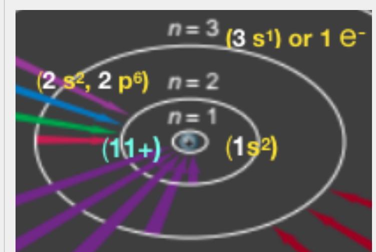
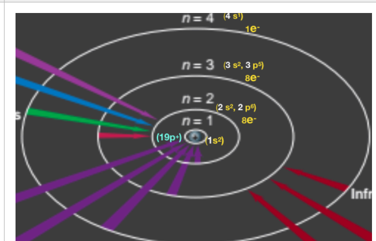
Example:
Consider the elements of group 1A. Starting from the top, they are lithium, sodium, potassium, rubidium cesium and francium.

Li is in period 2. It has 2 energy levels (review table 1 above).
Na is in period 3. It has 3 energy levels.
K is in period 4. It has 4 energy levels.
Rb is in period 5. It has 5 energy levels.
Cs is in period 6. It has 6 energy levels.

More energy levels means bigger size.

So the atomic radius (size) of Cs > Rb > K > Na > Li

See the table next page for more explanation.

Element Symbol	Atomic number (Z) = Electrons = Protons Electron Configuration	Valence Electrons on the last energy level = Group Number	Occupied Energy Levels = Period Number	Structure and Electron Configuration	Atomic Radius, Radii in Picometers.
Lithium Li	Z = 3 3 electrons (**e**$^-$) 3 protons (**P**$^+$) 1 **s^2**, 2 **s^1**	1 electron (**e**$^-$) on the last energy level = 1 Valence electron Li is in group 1A	The electrons are on **2 energy levels** (n = 2) Period 2		
Sodium Na	Z = 11 11 electrons (**e**$^-$) 11 protons (**P**$^+$) 1 **s^2**, 2 **s^2**, 2 **p^6**, 3 **s^1**	1 electrons (**e**$^-$) on the last energy level = 1 Valence electron. Na is in group 1A	The electrons are on **3 energy levels** (n = 3) Na is in period 3		
Potassium K	Z = 19 19 electrons (**e**$^-$) 19 protons (**P**$^+$) 1 **s^2**, 2 **s^2**, 2 **p^6**, 3 **s^2**, 3 **p^6**, 4 **s^1**,	1 electrons (**e**$^-$) on the last energy level = 1 Valence electron. K is in group 1A	The electrons are on **4 energy levels** (n = 4) K is in period 4		

Atomic Radius Decreases as You Move Across the Same Period.

Atomic Number (Z) = Number of Electrons = Number of Protons (nucleus)
The <u>more the protons</u>, the <u>stronger the nucleus</u>.

As you move across the same period, the number of energy levels stays the same, but the atomic number increases. so, the number of protons in the nucleus increases.

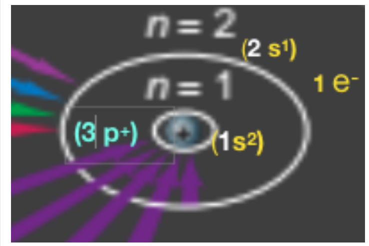
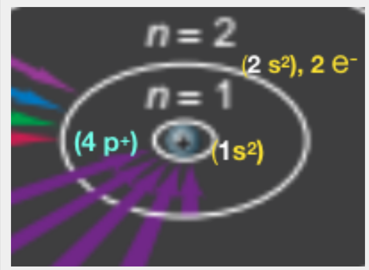
When the number of protons in the nucleus gets larger, the nucleus gets stronger and pulls the electrons closer to it. Consequently, the atomic radius (size) gets smaller.

Example:
Consider the elements of period 2: lithium (Li, Z = 3), beryllim (Be, Z = 4) and boron (B, Z = 5). All three elements have 2 energy levels.

The nucleus of Li has 3 protons and is pulling 2 energy levels.
The nucleus of Be has 4 protons and is pulling 2 energy levels.
The nucleus of B has 5 protons and is pulling 2 energy levels.

Boron has a stronger nucleus than beryllium. Boron pulls the 2 energy level closer to it than beryllium does. Therefore, the radius of B is smaller (87) than the radius of Be (112).

Lithium nucleus is the weakest with only 3 electrons. It does not pull the 2 energy levels very close to it. The last energy levels is far from it. So, the radius is the largest (167).

Element Symbol	Atomic number (Z) = Electrons = Protons Electron Configuration	Valence Electrons on the last energy level = Group Number	Occupied Energy Levels = Period Number	Structure and Electron Configuration	Atomic Radius, Radii in Picometers.
Lithium Li	Z = 3 3 electrons (e^-) **3 protons (P^+)** 1 s^2, 2 s^1	1 electron (e^-) on the last energy level = 1 Valence electron Li is in group 1A	The electrons are on **2 energy levels** (n = 2) Period 2		
Beryllium Be	Z = 4 4 electrons (e^-) **4 protons (P^+)** 1 s^2, 2 s^2	2 electrons (e^-) on the last energy level = 2 Valence electron. Be is in group 2A	The electrons are on **2 energy levels** (n = 2) Period 2		
Boron B	Z = 5 5 electrons (e^-) **5 protons (P^+)** 1 s^2, 2 s^2, 2 p^1	3 electrons (e^-) on the last energy level = 3 Valence electron. B is in group 3A or (13)	The electrons are on **2 energy levels** (n = 2) Period 2