Republic of Iraq
Ministry of Higher Education & Scientific research
Al-Mustaqbal University
Science College

Department of Forensic Evidence

Introduction in Chemistry

For

First Year Student

Lecture 5

By

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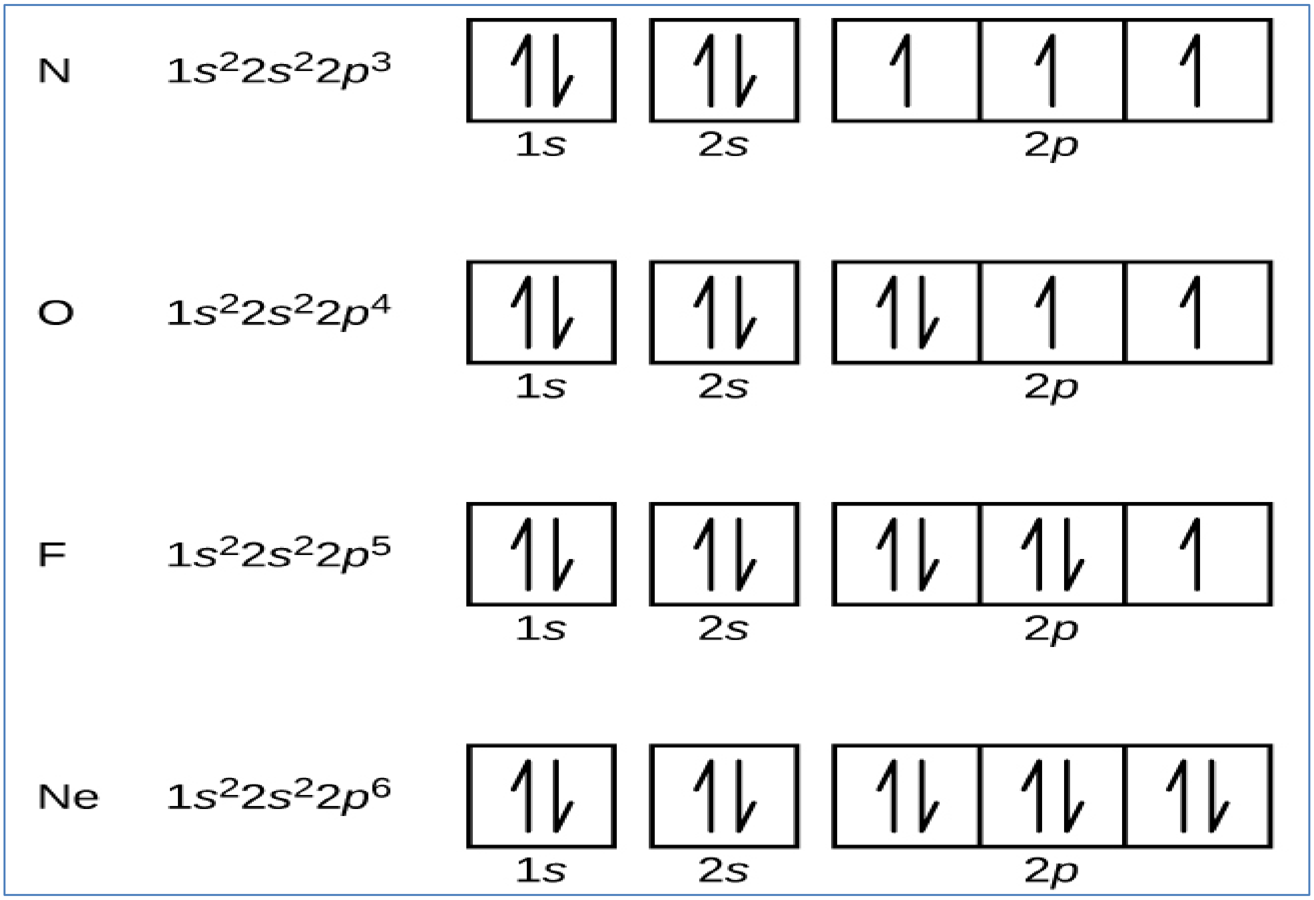
Electron Configurations

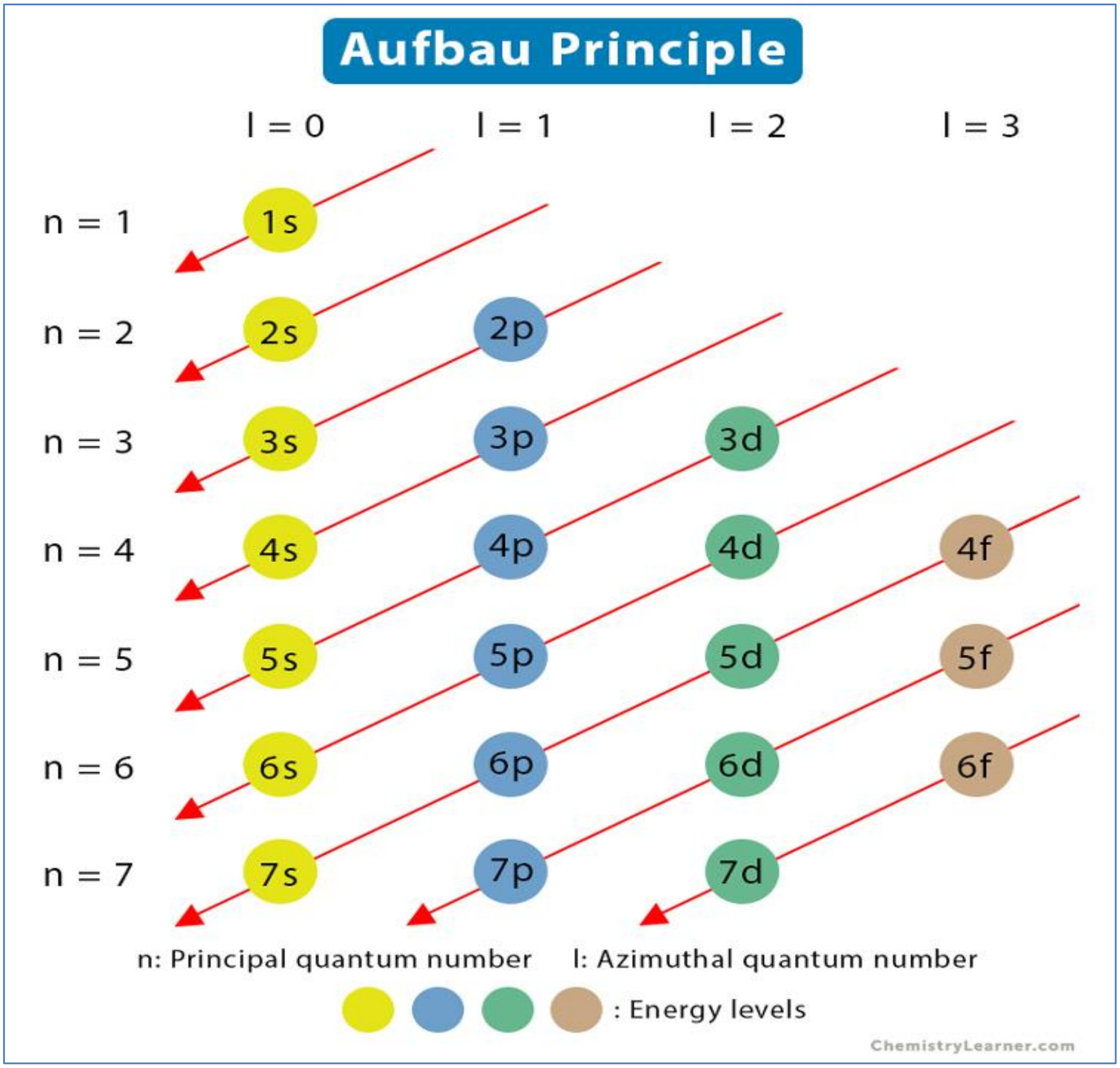
The energy of an electron depends on the type of orbital that it occupies. Orbitals with the same energy level are called degenerate orbitals. * The order in which the orbitals are filled by electrons is determined by just three simple principles:

1- The Aufbau (or Building up) principle. The lowest-energy orbital is filled first.
2- The Pauli Exclusion Principle. Each orbital can accommodate a maximum of two electrons that have opposite spin states.

3- Hund's Rule. When dealing with degenerate orbitals, such as p orbitals, one electron is placed in each degenerate orbital first, before electrons are paired up.

- ❖ The figure below shows the electron configuration of B, C, N, O, F and Ne.


N
1s²2s²2p³
O
1s²2s²2p⁴
F
1s²2s²2p⁵
Ne
1s²2s²2p⁶
1s
2s
2p


Aufbau Principle
l = 0
l = 1
l = 2
l = 3
n = 1
n = 2
n = 3
n = 4
n = 5
n = 6
n = 7
1s
2s
2p
3s
3p
3d
4s
4p
4d
4f
5s
5p
5d
5f
6s
6p
6d
6f
7s
7p
7d
n: Principal quantum number
l: Azimuthal quantum number
: Energy levels
ChemistryLearner.com

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

Ex: determine the four set of quantum number for the last electron in the following atoms 6C, 12Mg, 23V

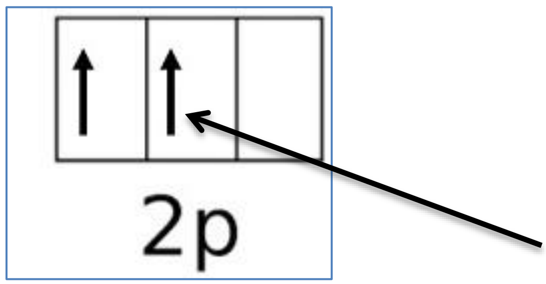
Solution:

1- Write the electron configuration

6C: $1s^2$ $2s^2$ $2p^2$

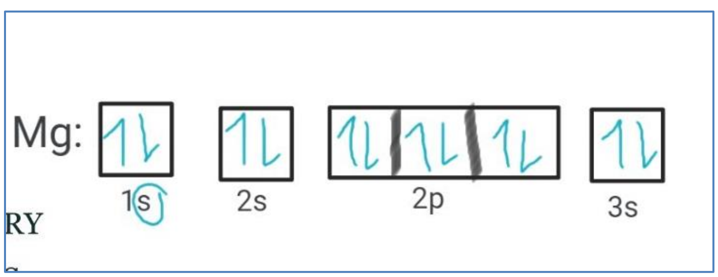
2- last electron in orbital p

n = 2, ℓ= 1 , mℓ= 0, ms = +1/2



Last electron

12Mg = [10Ne] $3s^2$ 3p0



n = 3, ℓ= 0 , mℓ= 0, ms = -1/2

Note:

The 4s orbital is slightly lower in energy than the 3d and fills first. In any period, the ns sublevel fills before the (n - 1)d sublevel. Other variations in the filling pattern occur at higher values of n because sublevel energies become very close together.

Categories of Electrons

There are three categories of electrons:

1. Inner (core): electrons are those an atom has in common with the previous noble gas and any completed transition series. They fill all the lower energy levels of an atom.

2. Outer electrons: are those in the highest energy level (highest n value). They spend most of their time farthest from the nucleus.

3. Valence electrons: are those involved in forming compounds: For main-group elements, the valence electrons are the outer electrons.

For transition elements, in addition to the outer ns electrons, the (n - 1)d electrons are also valence electrons, though the metals Fe (Z = 26) through Zn (Z = 30) may use only a few, if any, of their d electrons in bonding.

The relation between main energy level and sublevel energy:

1- **Main energy level** Each principal energy level can contain up to $2n^2$ electrons, where n is the number of the level. Thus, the first level can contain 2 electrons, $2(1^2) = 2$; the second 8 electrons, $2(2^2) = 8$; the third up to 18, $2(3^2) = 18$; and so on. Only seven energy levels are needed to contain all the electrons in an atom of any of those elements now known.

No. of electron = $2n^2$

2- **Sublevel energy**

a- No. of electron = $2(2\ell+1)$.

In s $\ell = 0$ $2(2(0)+1) = 2$ electron.

b- No. of electron in p sublevel .

in p $\ell=1$ $2(2(1)+1)= 6$ electron.

3- **Find the orbital in each sublevel**

No. of orbital = $(2\ell+1)$.

In s sublevel $\ell = 0$.

No. of orbital = $2(0) +1= 1$ orbital.

4- Find the highest energy by $n+\ell$

The (relative) energies of the orbitals can be predicted by the sum of $n +\ell$ for each orbital, according to the following rules:

a. Orbitals are filled in order of increasing $(n + \ell)$, which represents the relative energy.

b. If two orbitals have the same value of $(n + \ell)$, they are filled in order of increasing n.

Which one is the highest energy for the following? 1- 3d, 4s 2- 5s, 4p

Solution:

1- 3d   4s $n+\ell= 3+2= 5$ $4+0= 4$

So energy of 3d > 4s

2- 5s   4p $n+\ell= 5+0= 5$ $n+\ell= 4+1= 5$ 5s > 4p (choose high value for n)