Engineering Chemistry
Diploma 1st year

Government Polytechnic Kendrapara

Odisha

Dr. Ayusman Swain

Lecturer (Chemistry)

1st year
Each Semester distribution of marks

Theory	Practical & Seminars	Total
400	350	750

Engineering Chemistry Course

Theory	Practical	Total
100 (20 + 80) Internal Assessment + End Sem Exam	100 (50 + 50) Sessional evaluation + Practical Exam	200

Units	Chapters	Periods
Physical Chemistry	6	22
Inorganic Chemistry	2	8
Organic Chemistry	1	10
Industrial Chemistry	5	20

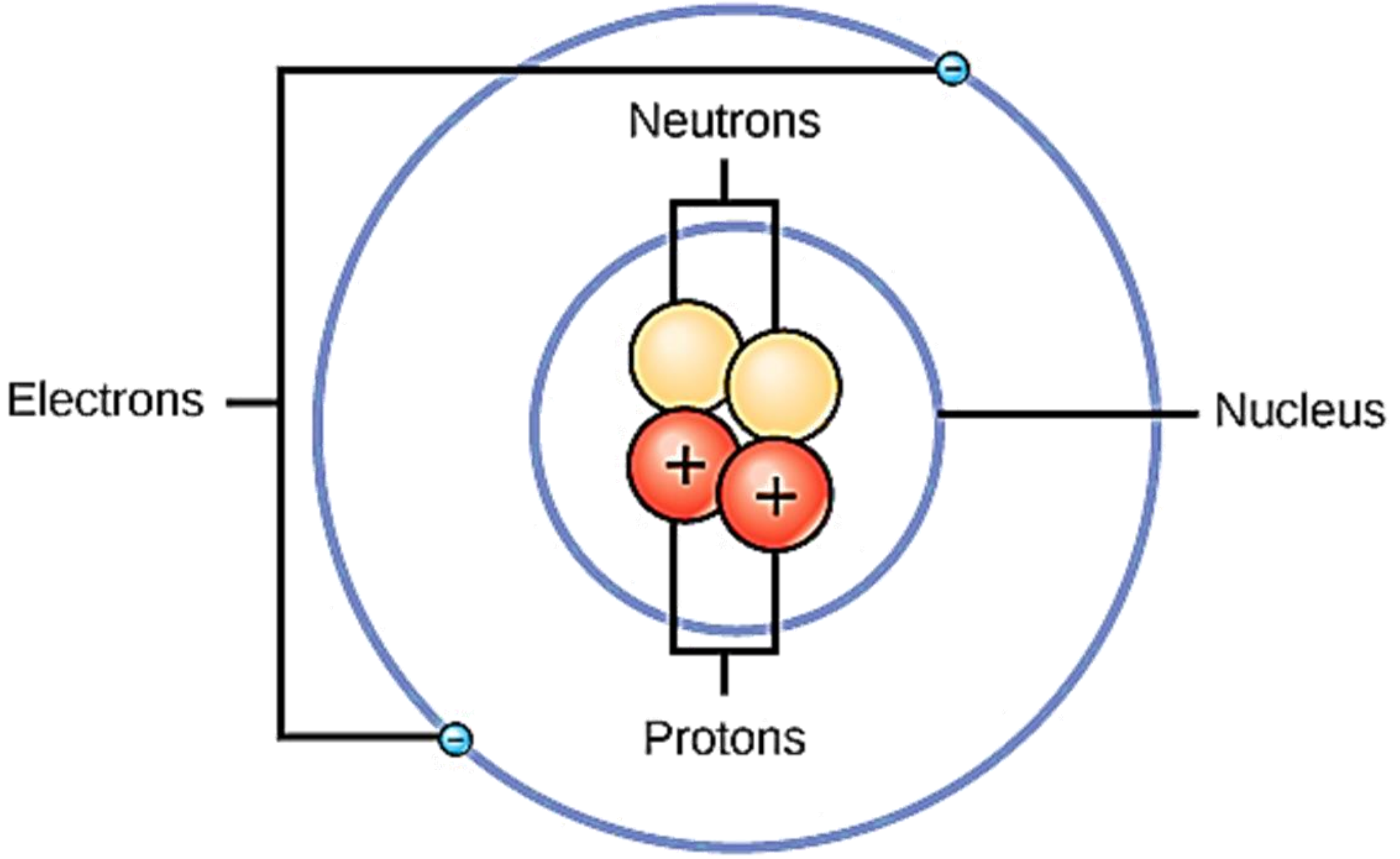
- Purpose: Students must be acquainted with basic chemistry for Industrial applications.
- Knowledge on different Materials and Chemical changes

A. PHYSICAL CHEMISTRY

Chapter 1: Atomic structure : Fundamental particles (electron, proton & neutron Definition, mass and charge).Rutherford's Atomic model (postulates and failure), Atomic mass and mass number, Definition, examples and properties of Isotopes, isobars and isotones. Bohr's Atomic model (Postulates only), Bohr-Bury scheme, Aufbau's principle, Hund's rule, Electronic configuration (up to atomic no 30).

Fundamental Particles

Particles	Relative Charge	Mass (amu)	Location
Proton	+1	1	Inside Nucleus
Electron	-1	0 .00055 or 0 (approx.)	Outside Nucleus
Neutron	0	1	Inside Nucleus



Schematic diagram of Helium (He) Orbital

1 a.m.u = 1.67×10^{-24} grams.

The number of protons determines an element's atomic number (Z) and distinguishes one element from another.
e.g. Hydrogen: Proton =1, Atomic number (Z) =1
Carbon: Proton = 6, Atomic number (Z) = 6

Mass number (A) of an element is the sum of the number of protons and the number of neutrons.
e.g. Hydrogen: Proton = 1, Neutron = 0, Mass number (A) = 1
Lithium: Proton = 3, Neutron = 4, Mass number (A) = 7
Carbon: Proton = 6, Neutron = 6, Mass number (A) = 12

In a neutral atom: Number of Protons = Number of Electrons

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H Hydrogen 1.008																	2 He Helium 4.002602
3 Li Lithium 6.94	4 Be Beryllium 9.0121831											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998403163	10 Ne Neon 20.1797
11 Na Sodium 22.98976928	12 Mg Magnesium 24.305											13 Al Aluminium 26.9815385	14 Si Silicon 28.085	15 P Phosphorus 30.973761998	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Caesium 132.90545196	56 Ba Barium 137.327	57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)

ATOMIC NUMBER	ELEMENT	Symbol	ATOMIC MASS
1	Hydrogen	H	1.008
2	Helium	He	4.0026
3	Lithium	Li	6.94
4	Beryllium	Be	9.0122
5	Boron	B	10.81
6	Carbon	C	12.011
7	Nitrogen	N	14.007*
8	Oxygen	O	15.999
9	Fluorine	F	18.998
10	Neon	Ne	20.180

ATOMIC NUMBER	ELEMENT	Symbol	ATOMIC MASS
11	Sodium	Na	22.990
12	Magnesium	Mg	24.305
13	Aluminium	Al	26.982
14	Silicon	Si	28.085
15	Phosphorus	P	30.974
16	Sulfur	S	32.06
17	Chlorine	Cl	35.45
18	Argon	Ar	39.948
19	Potassium	K	39.098
20	Calcium	Ca	40.078

Q1. How many neutrons are there in Boron (B) nucleus?

a) 3
b) 5
c) 6
d) 10

Q2. Number of neutrons in C^{13} and N^{15} respectively are

a) 7 and 8
b) 7 and 7
c) 6 and 8
d) 7 and 9

Atomic terms and definitions

Isotopes	Atoms or the elements with same atomic number but different mass number e.g. $_1H^1$, $_1H^2$, $_1H^3$. $_6C^{12}$, $_6C^{13}$, $_6C^{14}$,
Isobars	Atoms having the same mass number but different atomic numbers, e.g. $_{15}P^{32}$ and $_{16}S^{32}$
Isotones	Atoms having the same number of neutrons but different number of protons or mass number, e.g. $_6C^{14}$, $_8O^{16}$, $_7N^{15}$
Isoelectronic	Atoms, molecules or ions having same number of electrons e.g. N_2,CO, CN^-. K^+, Ca^{2+}
Isosteres	Molecules or ions having similar shape, same number of atoms and also same number of electrons are called isosteres. e.g., N_2 and CO

Isotopes	Isobars
Chemicals elements which have the same atomic number but different atomic mass	Chemicals elements which have the same atomic mass but different atomic numbers
e.g. $_{1}H^{1}$, $_{1}H^{2}$, $_{1}H^{3}$. $_{6}C^{12}$, $_{6}C^{13}$, $_{6}C^{14}$,	**e.g.** $_{15}P^{32}$ **and** $_{16}S^{32}$. $_{18}Ar^{40}$ $_{19}K^{40}$ $_{20}Ca^{40}$
Same chemical elements but in different forms	Chemical elements are different

Q3. NO^+ is isoelectronic with ________

a) N_2
b) O_2
c) C
d) B

Q4. ${}_6C^{13}$ and ${}_7N^{14}$ are ______________

a) Isotopes
b) Isosteres
c) Isotones
d) Isoelectronic

Assignments

1. **List out all the available isotopes of the elements from Atomic number 1 to 20.**
2. **Make a table of elements from Atomic number 1 to 30 with their symbol, atomic number and atomic mass.**

Submit assignments (photo of hand written content) in Google classroom.

Last date: Monday 7:00 PM

Go through the followings

1. **Atomic Structure chapter from NCERT books.**
2. **Atomic structure from 12th class text book (Kalyani Publishers)**

Download and grasp through the Chemistry syllabus for Diploma 1st year from SCTEVT website before reading books.

https://sctevtodisha.nic.in/en/student-welfare/?cat=diploma&unid=6677

A. PHYSICAL CHEMISTRY

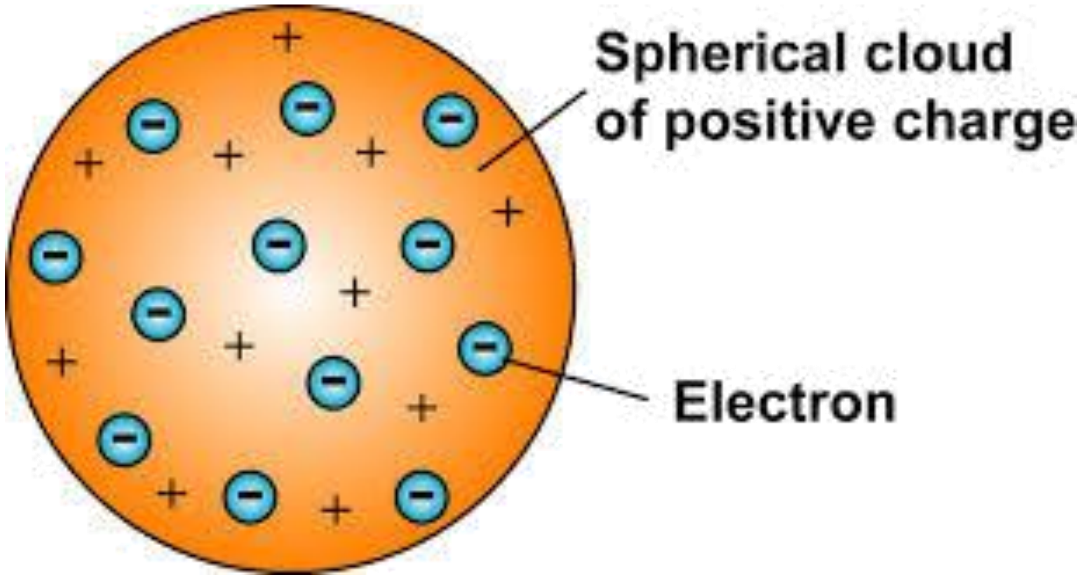
Chapter 1: Atomic structure : Fundamental particles (electron, proton & neutron Definition, mass and charge).Rutherford's Atomic model (postulates and failure), Atomic mass and mass number, Definition, examples and properties of Isotopes, isobars and isotones. Bohr's Atomic model (Postulates only), Bohr-Bury scheme, Aufbau's principle, Hund's rule, Electronic configuration (up to atomic no 30).

1. Explain the postulates of Rutherford’s Atomic model.
2. State the failures of Rutherford’s Atomic model. How Bohr rectified it.
3. Explain Bohr-Bury scheme.
4. Write notes on
    a) Aufbau’s principle
    b) Hund’s rule
5. Differentiate between Isotopes and Isobars with examples.

J.J. Thomson proposed in 1898

- **Shape of atom is in a sphere of positive charge, while the electrons are embedded in the positively charged sphere.**

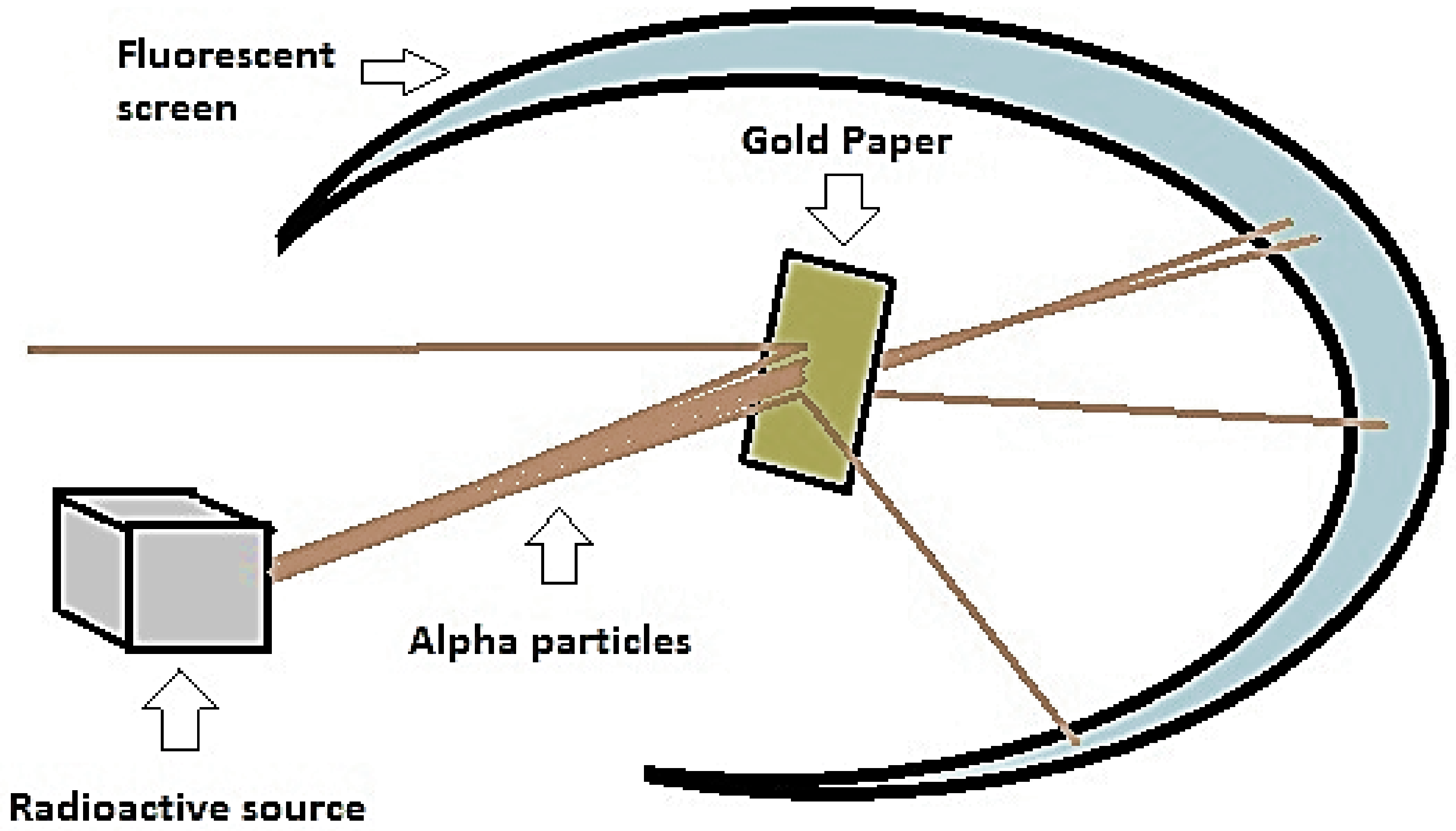
- **The positively charged particles are uniformly distributed with electrons arranged in such a manner that the atom is electrostatically stable.**

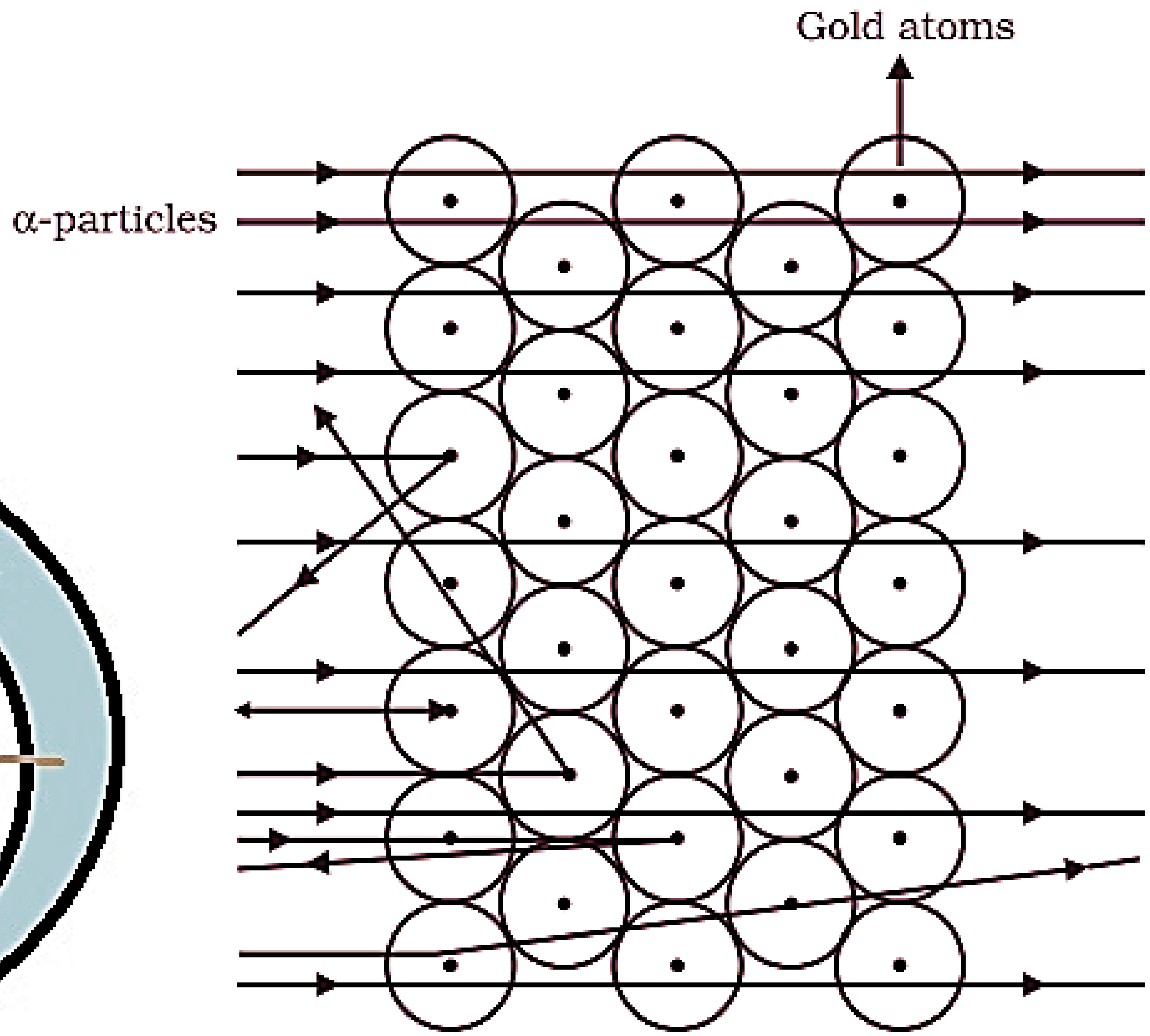


Limitations:

- The assumption that the total mass of an atom is uniformly distributed all over the atom was inconsistent with some experimental results.
- It also failed to explain an atom's stability.
- Unable to explain the scattering

Rutherford's Model of Atom 1911





Observations

- Most of the fast moving α-particles passed straight through the gold foil.
- Some of the α-particles were deflected by the foil by small angles.
- One out of every 12000 particles appeared to rebound.

Conclusion

- Most of the space inside the atom is empty because most of the α-particles passed through the gold foil without getting deflected.
- Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.
- A very small fraction of α-particles were deflected by the foil, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

Postulates

- There is a positively charged centre in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus.
- The electrons revolve around the nucleus in circular paths.
- The size of the nucleus is very small as compared to the size of the atom

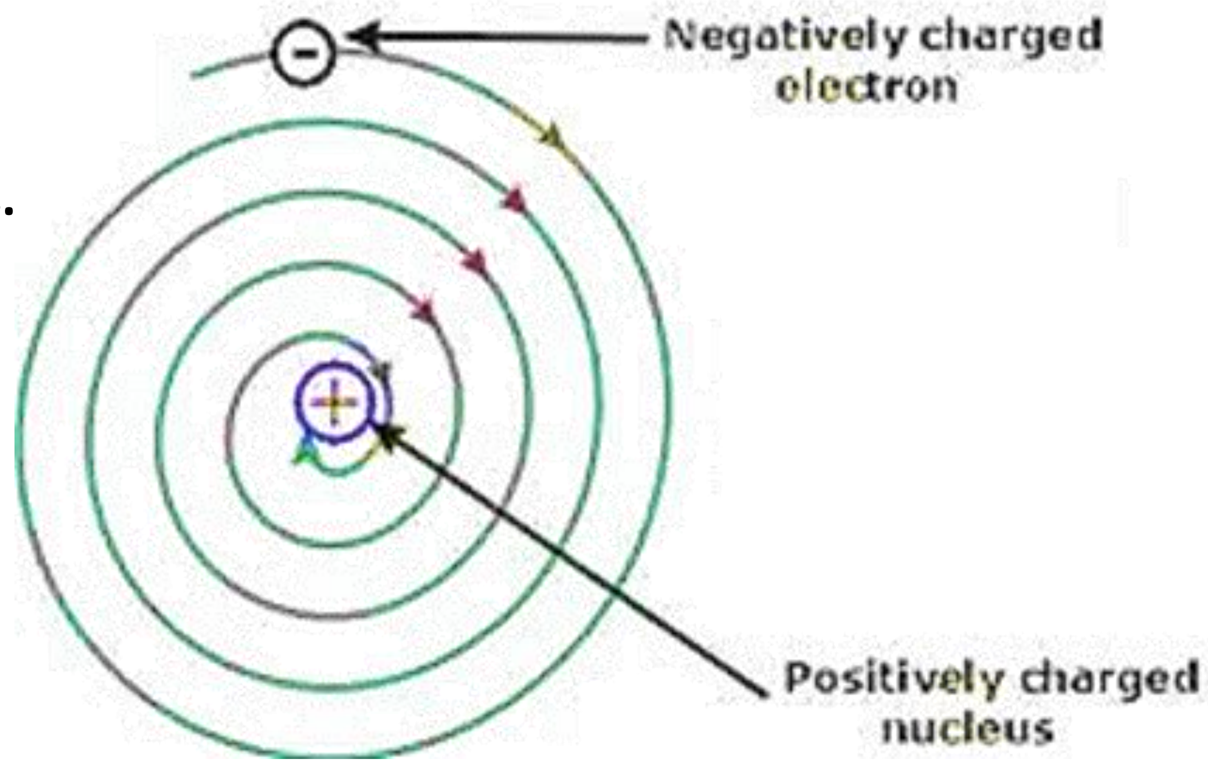
Limitations

- A charged particle in a circular orbit would undergo acceleration would radiate energy. Thus, the revolving electron would lose energy and finally fall into the nucleus. If this were so, the atom should be highly unstable and hence matter would not exist in the stable form. But atoms are quite stable and thus this model fails to explain the stability of atom.
- The model could not explain the spectra lines.

Limitations

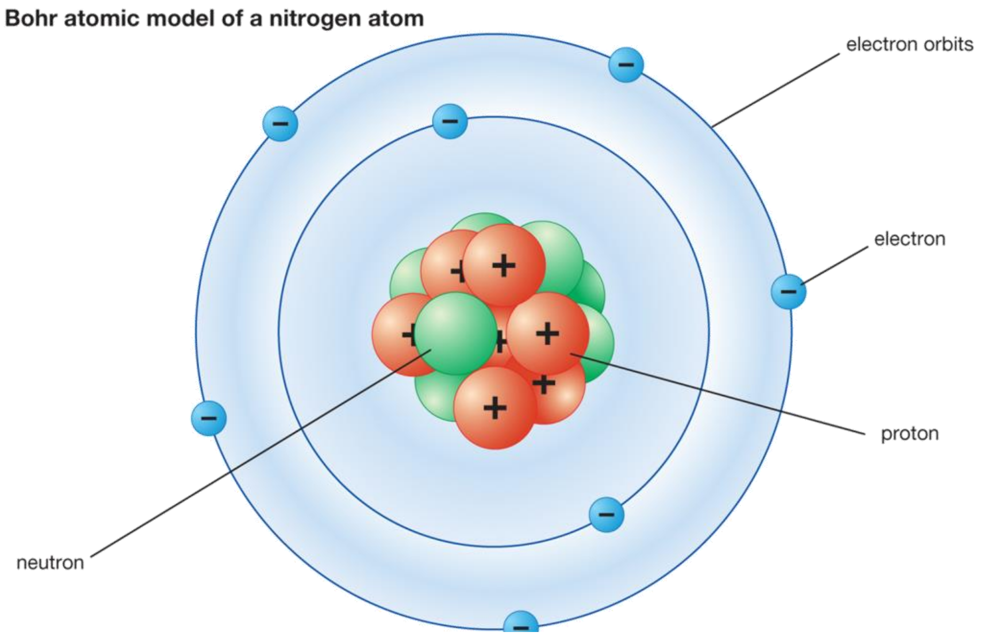
- A charged particle in a circular orbit would undergo acceleration would radiate energy. Thus, the revolving electron would lose energy and finally fall into the nucleus. If this were so, the atom should be highly unstable. But atoms are quite stable and thus this model fails to explain the stability of atom.

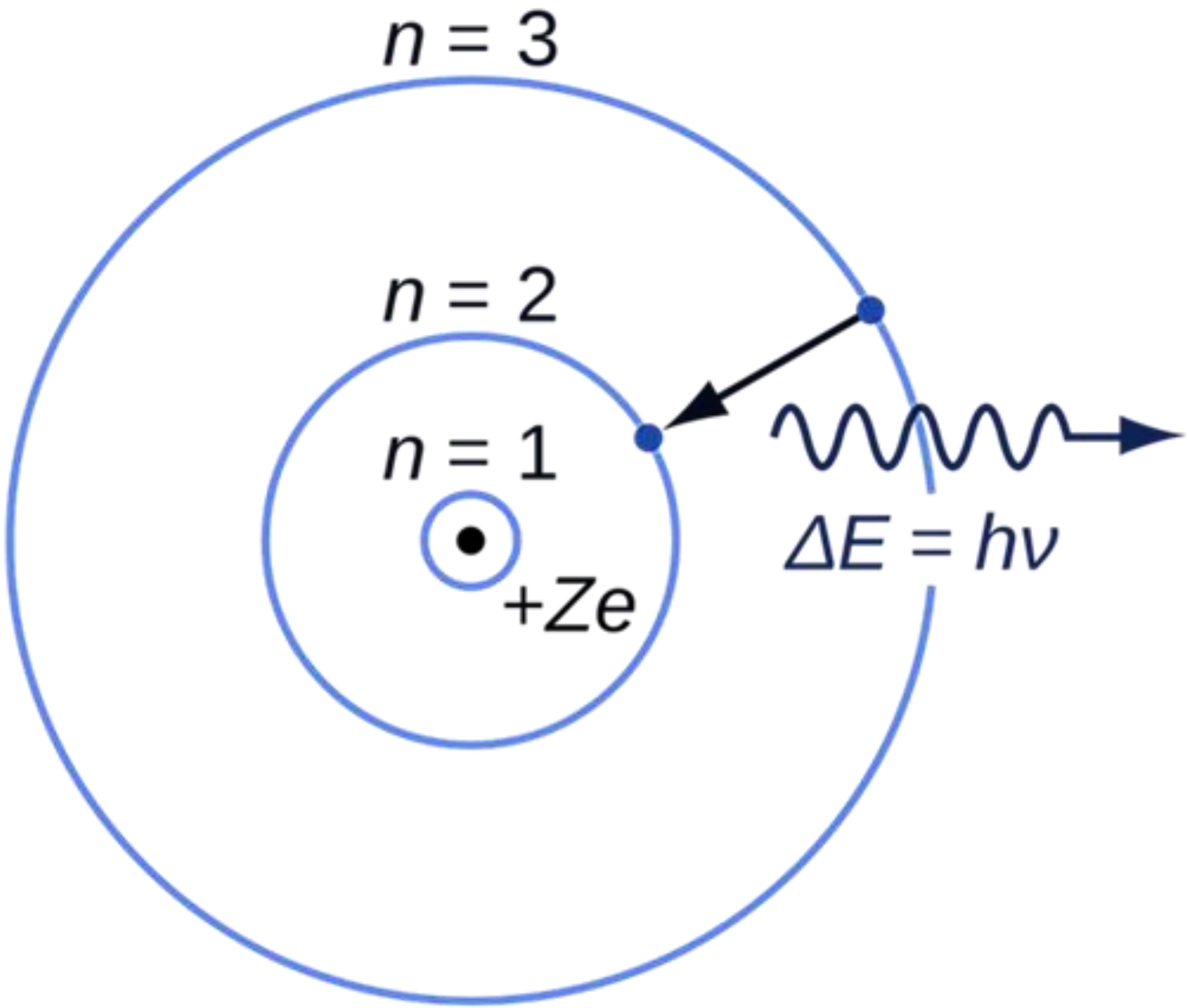
- The model could not explain the spectra lines.



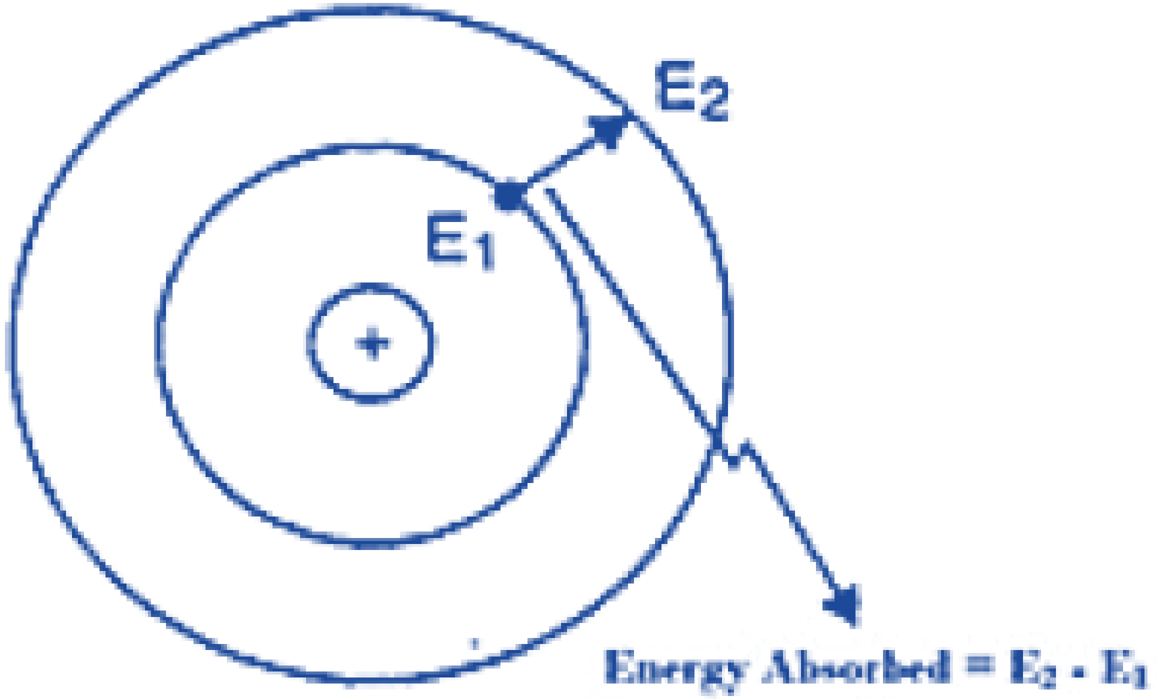
Postulates

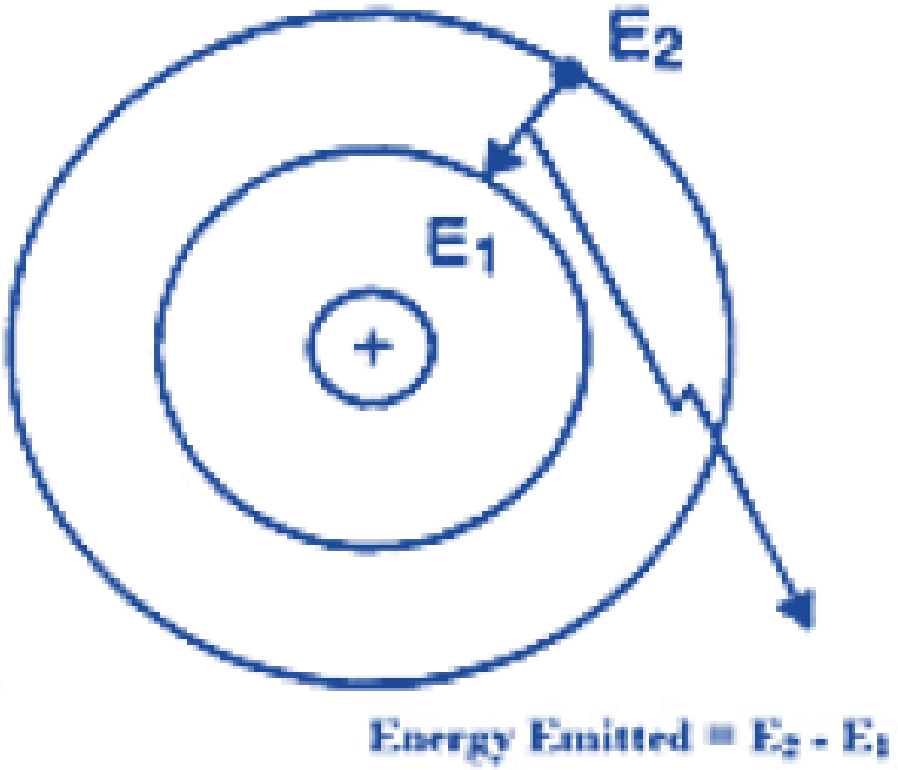
- **Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.**
- **While revolving in discrete orbits the electrons do not radiate energy. These orbits or shells are called energy levels.**
- **These orbits or shells are represented by the letters K,L,M,N,… or the numbers, n=1,2,3,4,….**
- **The electrons in an atom move from a lower energy level to a higher energy level by gaining the required energy and an electron moves from a higher energy level to lower energy level by losing energy.**


Bohr atomic model of a nitrogen atom
electron orbits
electron
proton
neutron


n = 3
n = 2
n = 1
+Ze
ΔE = hν

Bohr's Model





Postulates

- The energy of nth orbit or shell is:

$$E_n = -\frac{2\pi^2 m e^4 z^2}{n^2 h^2}$$

where, m = mass of an electron
e = charge of electron
z = Atomic number
n = No. of shell or principal quantum number (1,2,3.......)
h = Planck's constant = 6.625 x 10^{-27} erg sec.

$$E_n = -\frac{1312}{n^2} \; KJ / Mol$$

For H atom Z = 1. So Energy of nth orbit is

$$\text{radius of orbit} = r = \frac{n^2 h^2}{4\pi^2 m e^2} \times \frac{1}{Z}$$

Postulates

- The energy of shell increases on moving from lower to higher.

- Through a large number of concentric circles are possible around the nucleus, only those circular paths are allowed for the electrons to revolve for which the angular momentum value (mvr) is a whole number multiple of $h/2\pi$

$mvr = nh/2\pi$

Here, m = mass of the electron,
v = Angular velocity of the revolving electron,
r = radius of the orbit.
h = Planck's constant

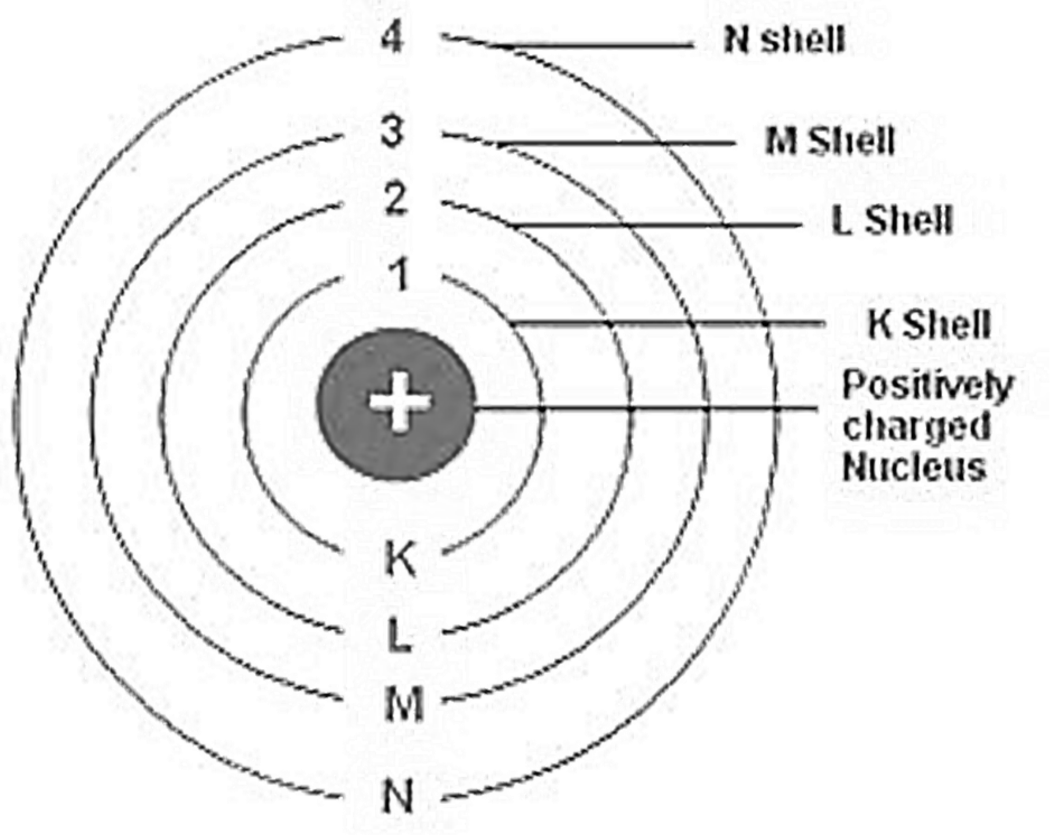
Limitations

- According to Bohr‘s atomic model, the electrons revolve in two-dimensional circular orbit. But modern researches such as Heisenberg‘s Uncertainty Principle revealed that electrons revolve in three dimensional paths called orbitals.
- It fails to explain the spectra of multi-electron species.
- It fails to explain the relative intensities of spectral lines.
- It fails to explain the splitting up of spectral lines when exposed to electric field (Stark Effect) and magnetic field (Zeeman Effect).
- It fails to explain the cause of chemical combinations.

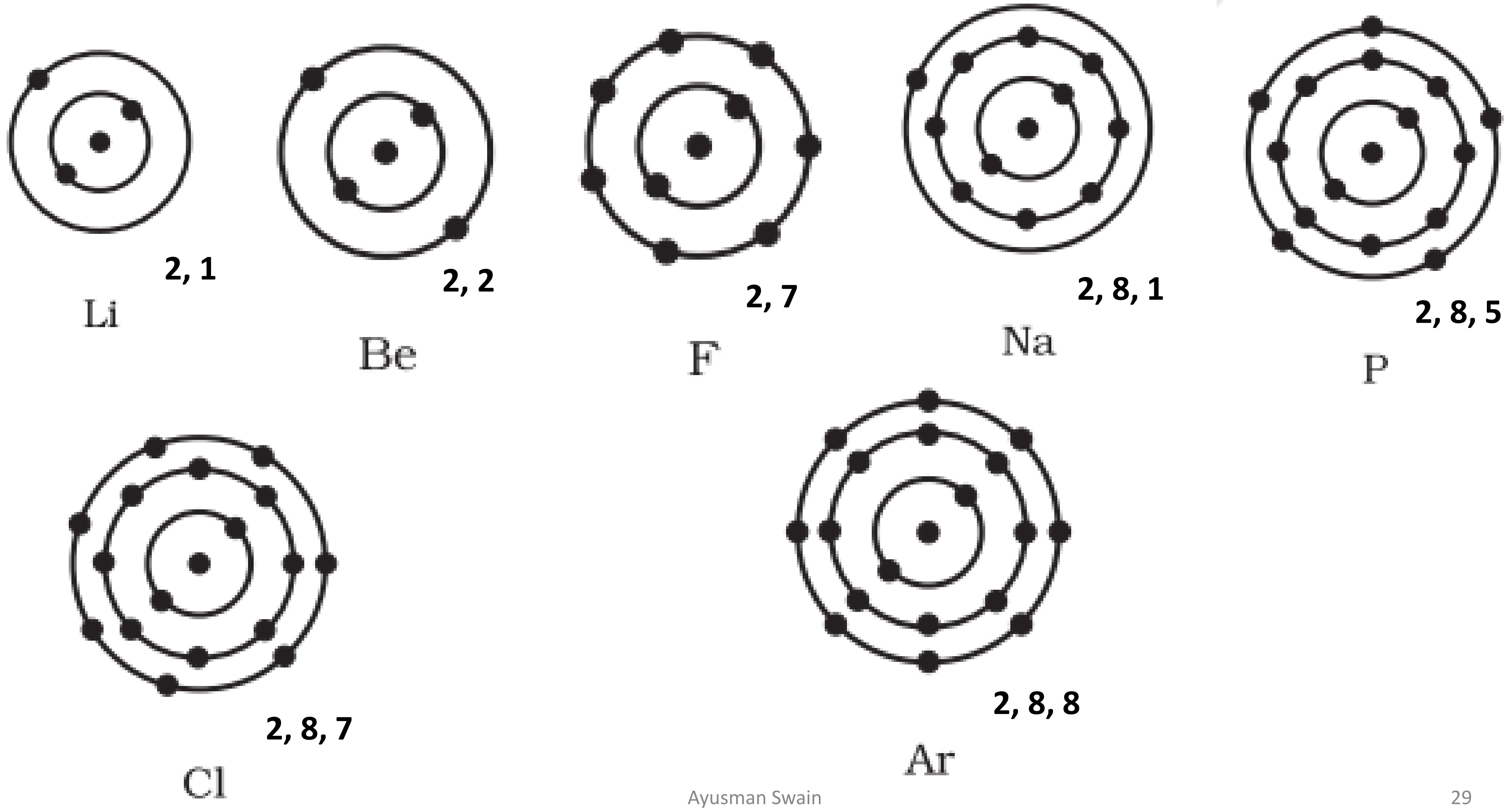
Bohr-Bury suggested How are the electrons distributed in different orbits

Maximum number of electrons in an orbit = $2n^2$

Orbit	Value of n	Maximum no. of electrons in the orbit
K	1	$2 \times 1^2 = 2$
L	2	$2 \times 2^2 = 8$
M	3	$2 \times 3^2 = 18$
N	4	$2 \times 4^2 = 32$



Bohr-Bury scheme



Orbit	Value of 'n'	Maximum no. of electrons in the orbit	Subshell
K	1	$2 \times 1^2 = 2$	1s
L	2	$2 \times 2^2 = 8$	2s 2p
M	3	$2 \times 3^2 = 18$	3s 3p 3d
N	4	$2 \times 4^2 = 32$	4s 4p 4d 4f

Maximum Capacity

s = 2
p = 6
d = 10
f = 14

Rule: Maximum number of electron in a subshell = 2 (2l + 1)

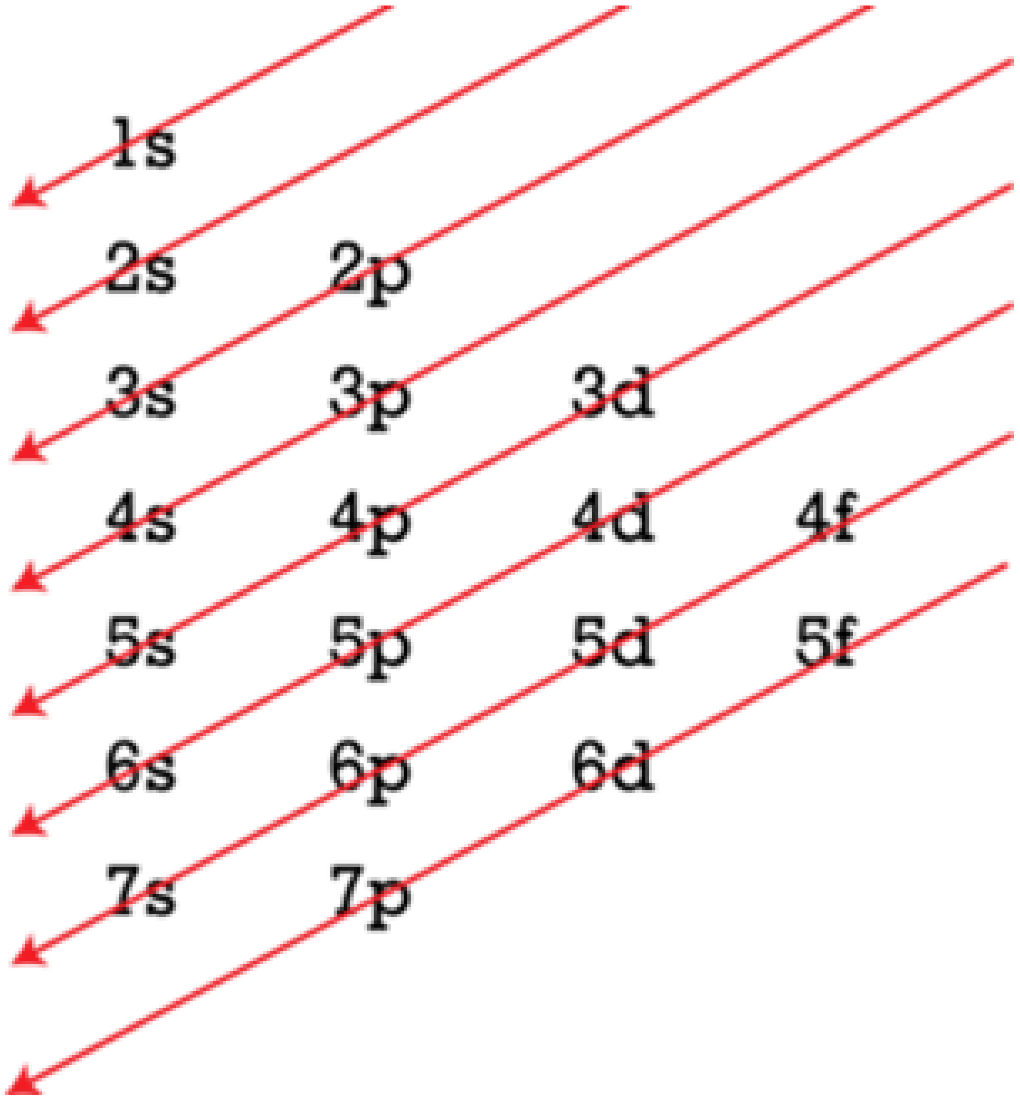
Sub-shell	l	Maximum electrons
s	0	2(2(0)+1)=2
p	1	2(2(1)+1)=6
d	2	2(2(2)+1)=10
f	3	2(2(3)+1)=14

Shell	Subshell	Total Number of Electrons in Shell
1st Shell K	1s	2
2nd Shell L	2s, 2p	2 + 6 = 8
3rd Shell M	3s, 3p, 3d	2 + 6 + 10 = 18
4th Shell N	4s, 4p, 4d, 4f	2 + 6 + 10 + 14 = 32

The Aufbau principle states that an electron occupies orbitals in order from lowest energy to highest.

Or

In the ground state of an atom or ion, electrons fill atomic orbitals of the lowest available energy levels before occupying higher levels.



- **The order in which the energy of orbitals increases can be determined with the help of the (n+l) rule, where the sum of the principal and azimuthal quantum numbers determines the energy level of the orbital.**
- **Lower (n+l) values correspond to lower orbital energies. If two orbitals share equal (n+l) values, the orbital with the lower n value is said to have lower energy associated with it.**
- **The order in which the orbitals are filled with electrons is: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p, and so on.**

Energy order of sub-shell

n+l rule

1s: 1 + 0 = 1
2p: 2 + 1 = 3
3d: 3 + 2 = 5

Sub-shell →	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f	5s	5p	5d
(n+l)	1	2	3	3	4	5	4	5	6	7	5	6	7

Energy increasing order:
1s < 2s < 2p < 3s < 3p <4s <3d < 4p < 5s < 5p < 4d < 4f …….

Na

F

Atomic Number	Name of the Element	Electronic Configuration
1	Hydrogen (H)	$1s^1$
2	Helium (He)	$1s^2$
3	Lithium (Li)	[He] $2s^1$
4	Beryllium (Be)	[He] $2s^2$
5	Boron (B)	[He] $2s^2$ $2p^1$
6	Carbon (C)	[He] $2s^2$ $2p^2$
7	Nitrogen (N)	[He] $2s^2$ $2p^3$
8	Oxygen (O)	[He] $2s^2$ $2p^4$
9	Fluorine (F)	[He] $2s^2$ $2p^5$
10	Neon (Ne)	[He] $2s^2$ $2p^6$

Maximum Capacity

s = 2
p = 6
d = 10
f = 14

Element No.	Name	Full Configuration	Shorthand Configuration
11	Sodium	$1s^2\ 2s^2\ 2p^6\ 3s^1$	$[Ne]\ 3s^1$
12	Magnesium	$1s^2\ 2s^2\ 2p^6\ 3s^2$	$[Ne]\ 3s^2$
13	Aluminum	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	$[Ne]\ 3s^2\ 3p^1$
14	Silicon	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$	$[Ne]\ 3s^2\ 3p^2$
15	Phosphorus	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$	$[Ne]\ 3s^2\ 3p^3$
16	Sulfur	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$	$[Ne]\ 3s^2\ 3p^4$
17	Chlorine	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	$[Ne]\ 3s^2\ 3p^5$
18	Argon	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	$[Ne]\ 3s^2\ 3p^6$

Assignment:

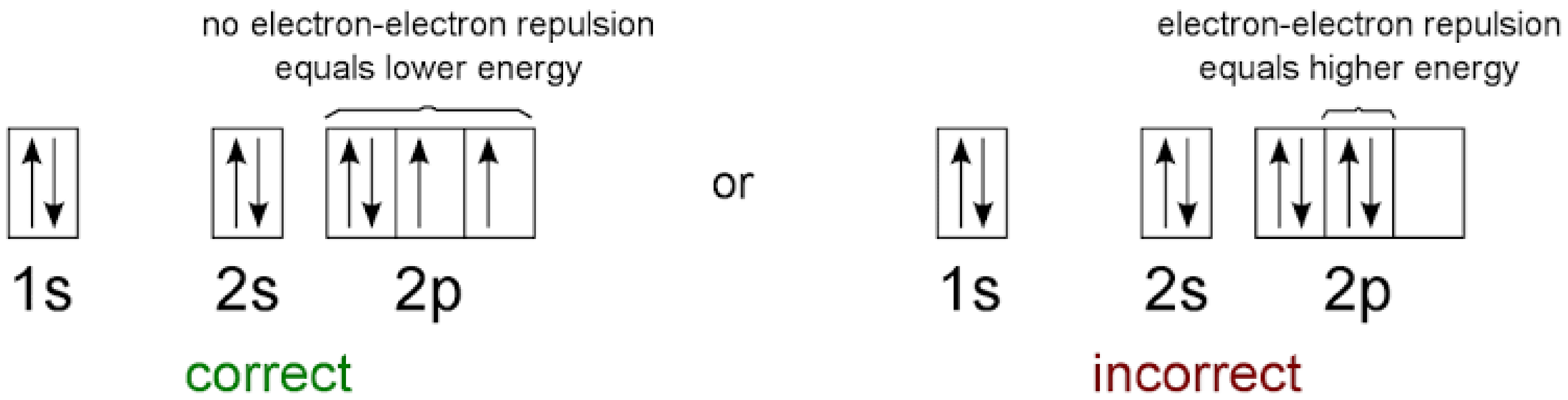
Write the electronic configuration from elements 1 to 30.

Atomic No.	Element	Symbol	Electronic Configuration
1			
2			
3			
4			

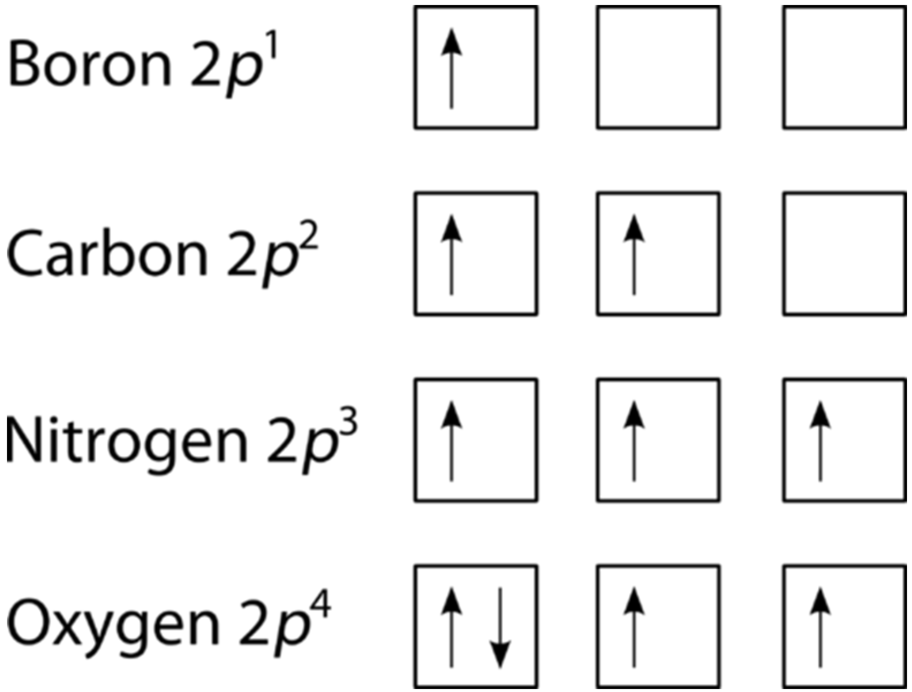
Anomaly in Electronic configuration of Cr and Cu

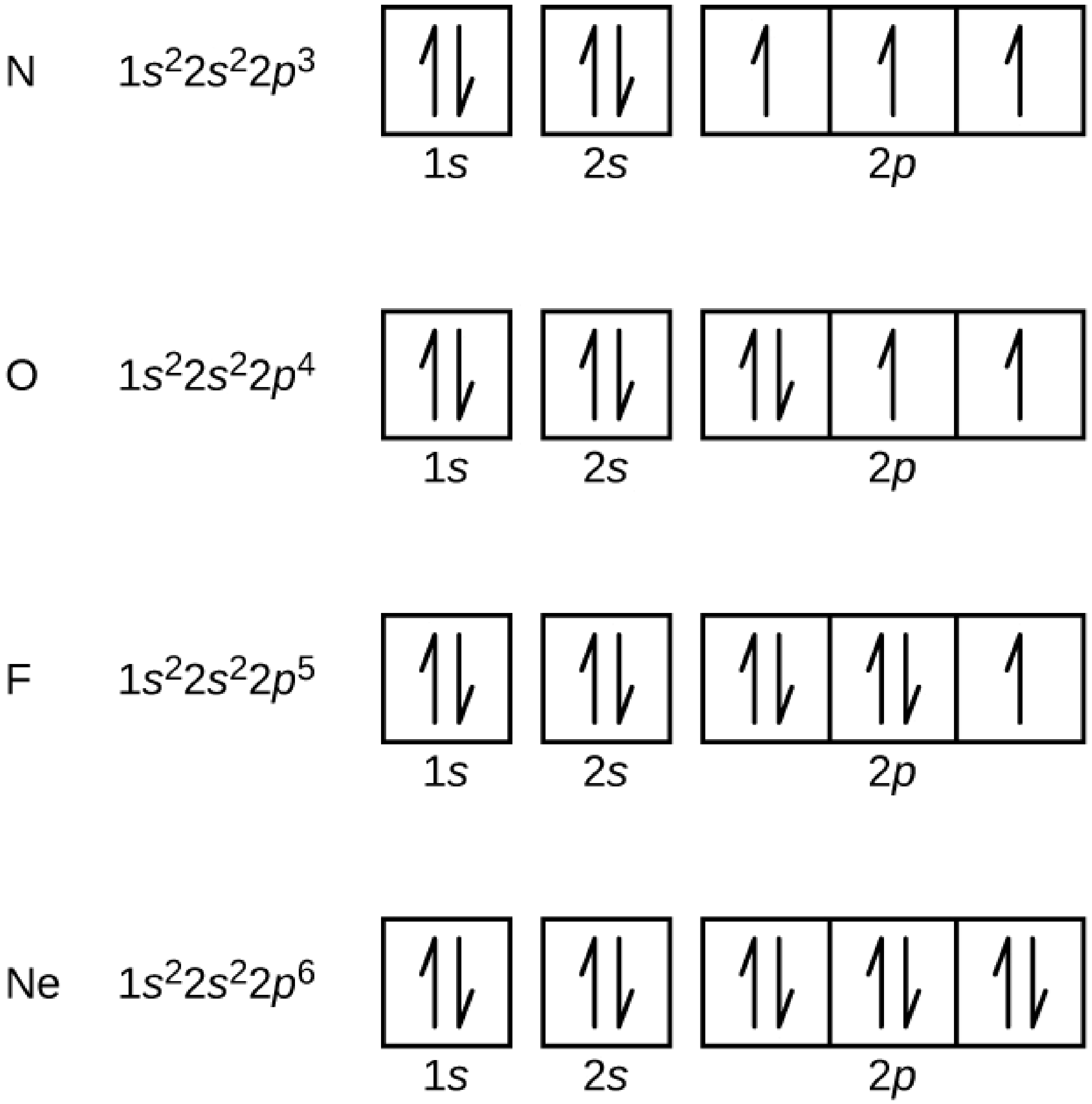
Hund's rule states that:

- **The greatest value of spin multiplicity has the lowest energy term.**
- **Every orbital in a sublevel is singly occupied before any orbital is doubly occupied.**
- **All of the electrons in singly occupied orbitals have the same spin (to maximize total spin).**



Hund's Rule


Boron 2p1
Carbon 2p2
Nitrogen 2p3
Oxygen 2p4


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

Assignment

1. **Arrange the following in increasing order of energy**

   2s, 2p, 5d, 4p, 6s, 3d, 5p, 4f, 6p, 3p,

2. **Fill the electrons in the sub-shells**

O

1s	2s	2p	3s	3p	4s	3d
_	_	_ _ _	_	_ _ _	_	_ _ _ _ _

P

1s	2s	2p	3s	3p	4s	3d
_	_	_ _ _	_	_ _ _	_	_ _ _ _ _

Atomic number and Elements	**Electronic Configuration**
1 Hydrogen, H	$1s^1$
2 Helium, He	$1s^2$
3 Lithium, Li	$1s^2 2s^1$
4 Beryllium, Be	$1s^2 2s^2$
5 Boron, B	$1s^2 2s^2 2p^1$
6 Carbon, C	$1s^2 2s^2 2p^2$
7 Nitrogen, N	$1s^2 2s^2 2p^3$
8 Oxygen, O	$1s^2 2s^2 2p^4$
9 Fluorine, F	$1s^2 2s^2 2p^5$
10 Neon, Ne	$1s^2 2s^2 2p^6$

Atomic number and Elements	**Electronic Configuration**
11 Sodium, Na	$1s^2 2s^2 2p^6 3s^1$
12 Magnesium, Mg	$1s^2 2s^2 2p^6 3s^2$
13 Aluminium, Al	$1s^2 2s^2 2p^6 3s^2 3p^1$
14 Silicon, Si	$1s^2 2s^2 2p^6 3s^2 3p^2$
15 Phosphorus, P	$1s^2 2s^2 2p^6 3s^2 3p^3$
16 Sulfur, S	$1s^2 2s^2 2p^6 3s^2 3p^4$
17 Chlorine, Cl	$1s^2 2s^2 2p^6 3s^2 3p^5$
18 Argon, Ar	$1s^2 2s^2 2p^6 3s^2 3p^6$
19 Potassium, K	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
20 Calcium, Ca	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Atomic number and Elements	Electronic Configuration
21 Scandium, Sc	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$
22 Titanium, Ti	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
23 Vanadium, V	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
24 Chromium, Cr	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$
25 Manganese, Mn	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
26 Iron, Fe	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
27 Cobalt, Co	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$
28 Nickel, Ni	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
29 Copper, Cu	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$
30 Zinc, Zn	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

End of Chapter1

Refer notes and materials provided in Google classroom