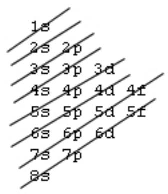
• An element is represented by ${}^{A}_{Z}X$
where A is the mass number and Z is the number of protons.
• $A = Z + N$ where N is the number of neutrons.
• electron configuration



We count diagonal by diagonal from the upper-right of the diagonal to the lower-left of it.

Thus, we get the following configuration:

1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p, 8s.

Note: These orbitals are arranged in the increasing order of energy (i.e. $1s < 2s < 2p < 3s < \ldots$)

• Relative atomic mass of $X = \frac{\sum_{i=1}^{n} m_i p_i}{100}$ = atomic weight of X
where m_i = mass of isotope i of X
and p_i = percentage of isotope i of X
• $N_A = 6.02 \times 10^{23}$ atoms
• 1u= 1a.m.u= 1.67×10^{-27}kg
$= \frac{1}{12} m({}^{12}_{6}C) = \frac{1}{12} \times \frac{0.012}{N_A} = 1.66 \times 10^{-27}$kg
• $-$e= charge of an electron= -1.6×10^{-19}c
• speed of light in vacuum $= c = \lambda f$
• visible light has wavelength λ such that 400nm$< \lambda <$ 800nm
The visible spectrum for Hydrogen corresponds to Balmer transitions.
• Photoelectric effect: Metal has work energy W_0.
To move an e^- from a metal, we must give it an energy E such that $E \geq W_0$
• Energy of a beam of n photons is equal to $nE_{photon} = nh\nu = n\frac{hc}{\lambda}$
• Power is given by $P = \frac{E}{t}$
• Bohr Model of Hydrogen
Note that these equations hold only for Hydrogen:
speed of the electron: $v = \frac{nh}{2\pi mr}$
Radius of orbit n: $r_n = n^2 a_0$ where $a_0 = r_0 = 0.529$ Åand 1Å= $10^{-10}m$
Energy of level n: $E_n = \frac{-13.6}{n^2}\ eV$
• Bohr Model of Hydrogenlike ions (Ions that contain only one electron)
$E_n = \frac{-13.6}{n^2} Z^2\ (eV)$
$r_n = \frac{n^2 a_0}{Z}$

• For a particle, we have De Broglie's Relation given by $\lambda_{De\ Broglie} = \frac{h}{mv}$
• Uncertainty Principle: $\Delta x \Delta p \geq \frac{h}{2\pi}$
$\Delta x \Delta(mv) \geq \frac{h}{2\pi}$
• $e \times N_A = F$ where F is the symbol for Farad.
• The energy of a photon is given by $E = h\nu = \frac{hc}{\lambda}$
• For photoelectric effect, $E_{photon\ absorbed} = E_{K\ of\ e^-\ ejected} + E_{criticial}$ where $E_{critical} = W_0$, that is the minimum energy to extract an electron from the metal.
• $1eV = 1.6 \times 10^{-19} J = 10^{-6} MeV$
• $1erg = 10^{-7} J$
• $m_{e^-} = 9.11 \times 10^{-31} kg$
• 1yard= 90cm=0.9m
• 1cal= 4.1858joule
• For an electron being accelerated under potential V, $E = |e| \times V \Rightarrow \frac{1}{2}mv^2 = e \times V$ where v is the speed of the electron and V is the potential.
• isotopes: Same Z but different A
isobars: Same A but different Z
isotones: Same number of neutrons $A - Z$
• 1a.m.u/atom=1g/mol
• For an electron passing from level n_1 to n_2 where $n_1 < n_2$ in Hydrogen, we have
$\frac{1}{\lambda_{photon}} = R_H(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ and we have $\frac{\Delta R_H}{R_H} = \frac{\Delta\lambda}{\lambda}$
where ΔR_H and $\Delta\lambda$ are respectively the absolute errors of R_H and λ
• The Rydberg's constant R_X of a hydrogenlike(hydrogenoide) ion X is given by the formula $R_X = R_\infty \frac{m_X}{m_X + m_{e^-}}$ where m_X is the mass of the atom, m_{e^-} is the mass of the electron and R_∞ is a constant given in the exam. Sometimes, it will be given that $R_\infty = R_H$.
• For an electron passing from level n_1 to n_2 where $n_1 < n_2$ in Hydrogen-like ion, we have
$\frac{1}{\lambda_{photon}} = R_X Z^2(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ where R_X is the Rydberg constant of the hydrogenlike ion.
• $m_X = A(\text{in u}) = 1840 \times m_{e^-}(\text{in u})$
since $m_{p^+} \approx m_{n^0} \approx 1840 m_{e^-}$
• Free particle inside a $1D$ box:
Conditions:
Inside Box: $E_p = 0$, $\Psi(0) = 0$
Outside Box: $E_p = \infty$, $\Psi(a) = 0$
Then, we have:
Energy is $E = \frac{n^2h^2}{8ma^2}$
$\Psi(x) = \sqrt{\frac{2}{a}} \sin\frac{n\pi x}{a}$ where $n \in \mathbb{N}$

and Ψ shoud satisfy the normalization condition $\int_{-\infty}^{+\infty} \Psi^2(x)dx = 1$

• The probability of finding an electron between $x = a$ and $x = b$ is given by $P = \int_a^b \Psi^2(x)dx$

• Quantum Numbers: n, l, m_l, m_s

Each electron has a unique set of quantum numbers n, l, m_l, m_s

a) Principal Quantum Number n, where $n = 1, 2, 3, \ldots$

-It describes the main energy level (shell) that the electron occupies.

-It describes the size of the orbital

-If two electrons belong to orbitals of the same n, then they belong to the same shell

-Shells are designated by the letters $K, L, M, N, \ldots$

-The maximum number of electrons that the shell can hold is $2n^2$

Letter	K	L	M	N	...
n	1	2	3	4	...
e^- capacity	2 electrons	8 electrons	18 electrons	32 electrons	...

b) Angular Momentum Quantum Number l, where $0 \leq l \leq n - 1$

-l indicates the subshell on which the electron is found

- Electrons having the same n and l belong to the same subshell.

-Subshells are designated by the letters $s, p, d, f, g, \ldots$

-The electron capacity of a subshell is given by $2(2l + 1)$

Letter	s	p	d	f	...
l	0	1	2	3	...
e^- capacity	2	6	10	14	...

-The subshell influences the energy of an orbit and it describes the shape and region of space that an electron occupies

c)Magnetic Quantum Number m_l where $-l \leq m_l \leq l$

-Describes orientation of the orbital

-For each subshell of quantum number l, there are $2l + 1$ possible values of m_l

d)Spin Qunatum Number m_s where $m_s = \frac{1}{2}$ or $m_s = -\frac{1}{2}$

-The electron behaves like a small bar magnet with a north and south pole. This spin quantum number indicates the magnetic momentum of the electron which is quantified. The two possible orientations are $m_s = \frac{1}{2}$ indicating a spin up and $m_2 = -\frac{1}{2}$ indicating a spin down.

Each electron in an atom is characterized by 4 quantum numbers, n, l, m_l and m_s.

No 2 electrons of an atom share the same set of quantum numbers. Each electron has a unique set of quantum numbers.

Quantum number	Name	Restrictions	Physical meaning
n	Principal Quantum number	$n > 0$	Size of orbital
l	Angular Momentum Quantum Number	$0 \leq l \leq n-1$	Shape of orbital
m_l	Magnetic Quantum Number	$-l \leq m_l \leq l$	Orientation in space
m_s	Spin Quantum Number	$\frac{1}{2}$ or $-\frac{1}{2}$	magnetic momentum

n	Shell	l	Subshell	m_l	Orbital	Number of e^-
1	K	0	1s	0	1 orbital s	2
2	L	0	2s	0	1 orbital s	2
		1	2p	-1,0,+1	3 orbitals p	6
3	M	0	3s	0	1 orbital s	2
		1	3p	-1,0,+1	3 orbitals p	6
		2	3d	-2,-1,0,+1,+2	5 orbitals d	10

• Degree of degeneracy for hydrogen and hydrogenlike atoms is given by n^2

• Note: H is isolated means that it is in fundamental state, that is $n = 1$

• nth excited level means that the electron is in the level $n + 1$

• Einstein's relation:

$E = mc^2$

$\Delta E = \Delta m \times c^2$