VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

Atomic structure

61. A body of mass x kg is moving with a velocity of $100 ms^{-1}$. Its de-Broglie wavelength is $6.62 \times 10^{-35} m$. Hence, x is: $(h = 6.62 \times 10^{-34}\ Js)$

$$\lambda = \frac{h}{mv}$$

$$6.62 \times 10^{-35} = \frac{6.62 \times 10^{-34}}{x \times 100}$$

$$x = 0.1\ kg$$

53. An electron, a proton and an alpha particle have KE of 16E, 4E and E respectively. What is the qualitative order of their de-Broglie wavelengths?

(A) $\lambda_e > \lambda_p = \lambda_\alpha$ ✓ (B) $\lambda_p = \lambda_\alpha > \lambda_e$

(C) $\lambda_p < \lambda_e < \lambda_\alpha$ (D) $\lambda_\alpha > \lambda_e > \lambda_p$

Sol^n →

$$\lambda = \frac{h}{\sqrt{2m K.E.}}$$

$$\lambda_{e^-} = \frac{h}{\sqrt{2 m_{e^-} \times 16 E}}$$

$$\lambda_{p^+} = \frac{h}{\sqrt{2 m_{p^+} \times 4E}}$$

$$\lambda_\alpha = \frac{h}{\sqrt{2(4 m_{p^+}) \times E}}$$

$$\lambda_{e^-} > \lambda_{p^+} = \lambda_\alpha$$

Heisenberg's uncertainty Principle → It is the consequence of dual behaviour of matter and radiation.

According to this Principle, it is impossible to measure simultaneously the Position and momentum (velocity) of small moving Particle with absolute accuracy.

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \cdot m\Delta v \geq \frac{h}{4\pi}$$

$$\boxed{\Delta x \cdot \Delta v \geq \frac{h}{4\pi m}}$$

where Δx = Uncertainty in Position

Δv = —" ——— velocity

Δp = —" ——— momentum

h = planck constant

m = mass of small moving Particle

18. If a 1.0 g body is travelling along X-axis at 100 cm s^{-1} with an uncertainty in velocity as 2 cms^{-1}. The uncertainty in its position is :

(A) 5.28×10^{-30} m (B) 2.64×10^{-30} m

(C) 1.30×10^{-30} m (D) 0.66×10^{-30} m

$$\Delta v = 2\ cm/sec. = 2 \times 10^{-2}\ m/sec.$$

$$\Delta x \cdot \Delta v = \frac{h}{4\pi m}$$

$$\Delta x \cdot 2 \times 10^{-2} = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times (1 \times 10^{-3})}$$

$$\Delta x = 2.635 \times 10^{-30}\ m$$

17. If uncertainty in the measurement of position and momentum of an electron are equal then uncertainly in the measurement of its velocity is approximately :

(A) 8×10^{12} m/s (B) 6×10^{12} m/s

(C) 4×10^{12} m/s (D) 2×10^{12} m/s

Sol^n →

$$\Delta x = \Delta p$$

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$(\Delta x)^2 = \frac{h}{4\pi}$$

$$\Delta x = \frac{1}{2}\sqrt{\frac{h}{\pi}}$$

$$\Delta x \cdot \Delta v = \frac{h}{4\pi m}$$

$$\frac{1}{2}\sqrt{\frac{h}{\pi}} \cdot \Delta v = \frac{h}{4\pi m}$$

$$\Delta V = \frac{1}{2}\sqrt{\frac{h}{\pi}} \times \frac{1}{m}$$

$$= \frac{1}{2}\sqrt{\frac{6.62\times10^{-34}}{3.14}} \times \frac{1}{9.1\times10^{-31}}$$

$$= 0.08 \times 10^{14}$$

$$= 8\times10^{12} \text{ m/sec.}$$

Q. A Proton is accelerated to $\frac{1}{10}$th of the velocity of light. The accuracy in the determination of the velocity of light is $\pm 1\%$. calculate the uncertainty in its Position.

Sol^n →

$$V = 3\times10^{8}\times\frac{1}{10} = 3\times10^{7} \text{ m/sec.}$$

$$\Delta V = 3\times10^{7}\times\frac{1}{100} = 3\times10^{5} \text{ m/sec.}$$

$$\Delta x \cdot 3\times10^{5} = \frac{6.62\times10^{-34}}{4\times3.14\times1.67\times10^{-27}}$$

$$\Delta x = 0.105 \times 10^{-12}$$

$$= 1.05\times10^{-13} \text{ m}$$

Quantum numbers ⟶ These numbers provide all the informations about an e^-.

(1) **Principal Q.no. (n)** ⟶ It represents orbit/shell/energy level/stationary state.

* Max. no. of e^- in an orbit $= 2n^2$
* No. of orbital in an orbit $= n^2$
* This Q.no. is related with size of atom
* It gives an idea about radius of orbit, velocity, Energy, angular momentum of e^- in an orbit.

		Max. e^-	No. of orbital
$n = 1$	1^{st} orbit (K)	$2e^-$	1
$n = 2$	2^{nd} orbit (L)	$8e^-$	4
$n = 3$	3^{rd} orbit (M)	$18e^-$	9
$n = 4$	4^{th} orbit (N)	$32e^-$	16

(2) **Azimuthal Q.no. (Angular Q.no. or subsidiary Q.no., l)** ⟶

* It represent subshell/suborbit.

	s	p	d	f	g
$l =$	0	1	2	3	4

* Value of l for a given value of $n \in 0$ to $(n-1)$
* No. of subshell in a given orbit $= n$
* Max. no. of e^- in a subshell $= 2(2l+1)$
* No. of orbitals in a subshell $= (2l+1)$
* It is related with shape of atom.
* orbital angular momentum $= \sqrt{l(l+1)} \cdot \frac{h}{2\pi}$

$$\frac{h}{2\pi} = \hbar = \text{reduced planck const.}$$

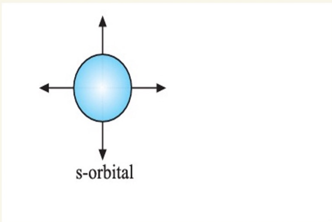
Value of n	Values of l	Max. no. of e^-	No. of subshells
1	$l = 0$ (s)	$2e^-$	1
2	$l = 0, 1$ (s) (P)	$2e^- + 6e^- = 8e^-$	2
3	$l = 0, 1, 2$ (s) (P) (d)	$2e^- + 6e^- + 10e^-$ $= 18e^-$	3
4	$l = 0, 1, 2, 3$ (s) (P) (d) (f)	$2e^- + 6e^- + 10e^-$ $+ 14e^- = 32e^-$	4

(3) Magnetic Q. no. (m_l) →

* It represents orbital (zone in the space where prob. of finding an e^- is max.)
* Values of m_l for a given value of $l \in (-l$ to $+l)$

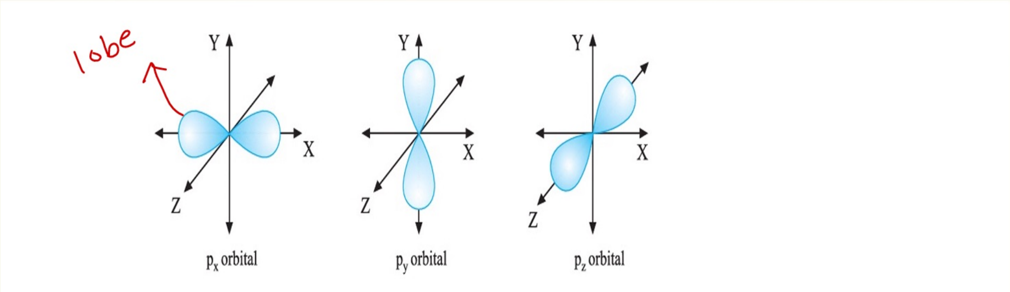
l	Possible values of m_l	No. of orbitals
0 (s)	0	1
1 (p)	−1, 0, +1	3
2 (d)	−2, −1, 0, +1, +2	5
3 (f)	−3, −2, −1, 0, +1, +2, +3	7

<u>S-orbital</u> $\Rightarrow$ $m_l = 0$



$\Rightarrow$ No Nodal plane

<u>P-orbital</u> $\Rightarrow$ $m_l = -1, 0, +1$

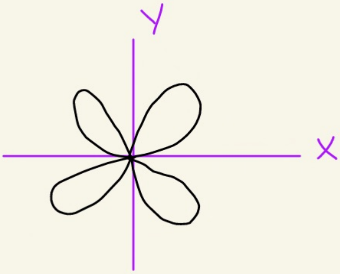


Nodal plane = YZ   XZ   XY

d-orbital $\Rightarrow$ $m_l = -2, -1, 0, +1, +2$

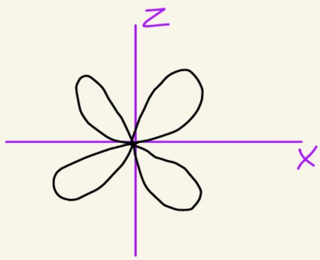
d-subshell $\Rightarrow$ 5-orbitals

(d_{xy}, d_{yz}, d_{zx}, $d_{x^2-y^2}$, d_{z^2})



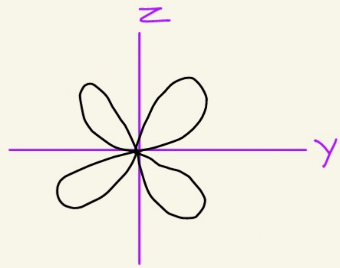
d_{xy}

Nodal plane $\Rightarrow$ XZ, YZ



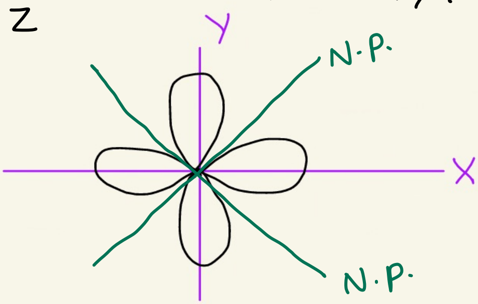
d_{xz} / d_{zx}

N.P. = XY, YZ



d_{yz}

N.P. = XY, XZ

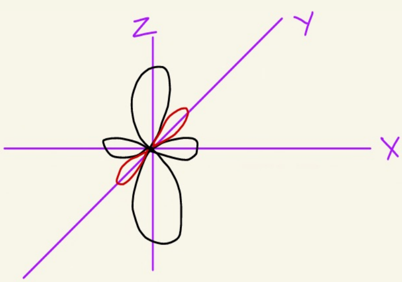


$d_{x^2-y^2}$

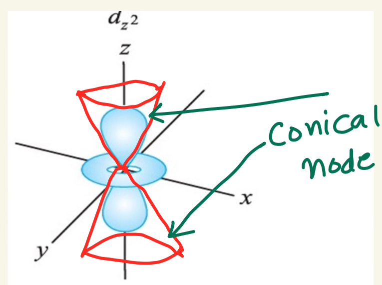
N.P. $\Rightarrow$ $Y = X$

$Y = -X$

* d_{z^2} orbital is a combination of two imaginary d-orbitals ($d_{z^2-x^2}$ and $d_{z^2-y^2}$)



$\Rightarrow$



* magnetic Q. no. tells about orientation of different orbitals in space.

(4) spin Q. no. (m_s) → while moving around the nucleus, e^- always spins about its own axis either in clockwise or in anticlockwise direction.

spin Q. no. represents direction of spin of e^- about its own axis.

so two Possible values of m_s are $+\frac{1}{2}$, $-\frac{1}{2}$.

These two spin Q. no. are two mechanical spin states which have no classical analogue.

* spin angular momentum = $\sqrt{s(s+1)} \cdot \frac{h}{2\pi}$

where s = total spin

*19. *Which of the following sets of quantum number(s) is(are) not possible ?*

	n	ℓ	m_ℓ	m_s		n	ℓ	m_ℓ	m_s
(A)	4	2	–2	+1/2	(B)	3	0	0	–1/2
(C)	3	2	–3	–1/2	(D)	5	3	0	+1/2

Q. Select set of quantum numbers which is **not** possible.

(A) 4, 3, +2, $-\frac{1}{2}$ (B) 6, 0, 0, 0 (C) 5, 3, +2, $-\frac{1}{2}$ (D) 3, 2, –1 $+\frac{1}{2}$

Q. Select set(s) of quantum number for 5p electron.

(A) 5, 0, 0, $-\frac{1}{2}$ (B) 5, 1, –1, 0

(C) 5, –1, 0, $+\frac{1}{2}$ (D) 5, 1, 0, $+\frac{1}{2}$

Aufbau Principle → According to this Principle e^-s are filled in the various subshells in the order of increasing energies.

(n+l) Rule → This rule is valid for species containing 2 or more e^-.

Acc. to this rule $\Rightarrow$ $E \propto (n+l)$

If $(n+l)$ values are equal $\Rightarrow$ $E \propto n$

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p$

	1s	2s	2p	3s	3p	4s	3d	4p	5s	4d	5p
$n=$	1	2	2	3	3	4	3	4	5	4	5
$l=$	0	0	1	0	1	0	2	1	0	2	1
$n+l=$	1	2	3	3	4	4	5	5	5	6	6

Note → This rule is not applicable for single e^- species.

For single e^- species, $E = -13.6 \dfrac{Z^2}{n^2}$ eV/atom

$\Rightarrow n\uparrow \Rightarrow E\uparrow$

n same $\Rightarrow$ E same

$1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f$

	1s	2s	2p	3s	3p	3d	4s	4p	4d	4f
$n=$	1	2	2	3	3	3	4	4	4	4

Q. Choose the correct option regarding energy of empty orbitals.

	n	l	m	s		n	l	m	s
(I)	4	0	0	$+\frac{1}{2}$	(II)	3	2	0	$-\frac{1}{2}$
(III)	3	1	1	$+\frac{1}{2}$	(IV)	3	0	0	$-\frac{1}{2}$

(A) I > IV (B) II > I

(C) II > III (D) I = III

I > III

Electronic configuration of atoms →

1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p

1s	2s 2p	3s 3p	4s 3d 4p	5s 4d 5p
1st Period	2nd Period	3rd Period	4th Period	5th Period

6s 4f 5d 6p	7s 5f 6d 7p	8s 5g 6f 7d 8p	9s 6g f d p
6th Period	7th Period	8th Period	9th period

$_{7}N = 1s^2, 2s^2 2p^3$

$_{11}Na = 1s^2, 2s^2 2p^6, 3s^1$

$_{27}Co = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 3d^7$

$_{30}Zn = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 3d^{10}$

* $_{24}Cr = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^1 3d^5$

* $_{29}Cu = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^1 3d^{10}$

Electronic configuration of anions →

* First count total no. of e^-

* write the e^- configuration on the basis of total no. of e^-.

Ex. $Cl^- = 18 e^- \Rightarrow 1s^2, 2s^2 2p^6, 3s^2 3p^6$

$N^{3-} = 10 e^- \Rightarrow 1s^2, 2s^2 2p^6$

Electronic configuration of cations →

Ex. $Fe^{2+} = ?$

$_{26}Fe = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 3d^6$

$= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6, 4s^2$

$Fe^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6$

$Fe^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5$

Ex. Cr^+, Cr^{2+}, Cr^{3+} ?

$_{24}Cr = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^1 3d^5$

$= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^1$

$Cr^{+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5$

$Cr^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^4$

$Cr^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^3$

Paragraph for Question No. 72 - 75

A neutral atom of an element has 2K, 8L, 9M and 2N electrons.

72. The atomic number of element is:

(A) 20 **(B)** 21 ✓ **(C)** 22 **(D)** 23

73. The total number of s electrons are:

(A) 8 ✓ **(B)** 6 **(C)** 4 **(D)** 10

74. The total number of p-electrons are:

(A) 6 **(B)** 12 ✓ **(C)** 18 **(D)** 24

75. The total number of d-electrons are:

(A) 1 ✓ **(B)** 2 **(C)** 3 **(D)** 4

$_{21}Sc = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 3d^1$

If there were 9 periods in the periodic table & each orbital can have maximum 5 electrons, then how many maximum number of elements will be present in period 9?

Sol^n → 9^{th} period $\Rightarrow$ s g f d p

Orbital = 1 9 7 5 3

$e^- = 5 + 45 + 35 + 25 + 15$

$= 125$

Homework

DTS- 1 to 11
Q.45,47,49,50,54,56,58-60,62,63,66,68,69,71-75,81, 84,86,93,97,114,120,122,123,125,127,130,135,136, 137,140

JEE MAIN ARCHIVE
Q.2,6-9,13,14,18,20

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Q.9,11,13,23,25,31,32,37,40,42,44,49,51