Atomic Structure

SOLUTIONS

EXERCISE (O-1)

1. Ans. (C)

Specific charge = $\frac{q}{m}$

Among all options

Charge to mass ratio $\left(\frac{q}{m}\right)$ is maximum for $H^{\oplus}$ because it has least mass.

2. Ans. (A)

$\because$ m_e (mass of 1 electron) = 9.1×10^{-31} kg

N_A = 1 mole = 6.023×10^{23}

$\therefore$ mass of N_A electron = 9.1×10^{-31} kg × 6.023×10^{23}

= $55 \times 10^{-8} \times 10^{3}$ gm

= 55×10^{-5} gm

= 0.55×10^{-3} gm

= 0.55 mg

3. Ans. (C)

P = 17

e = 18

n = 18

Charge = P – e

= 17 – 18

= –1

4. Ans. (C)

The Anode Rays are made up of positive residue of atoms and hence gets deflected towards negative terminal in electric field.

5. Ans. (C)

Since anode rays are positive residue of atoms.

Here $Li^{\oplus}$ i.e. P = 3

N = A – P

= 7 – 3 = 4

e = 2

6. Ans. (B)

For proton = $\frac{q}{m}$

then for α particles = $\frac{2q}{4m} = \frac{q}{2m} = 4.8 \times 10^{7}\,C/kg$

7. Ans. (C)

$\left(\frac{e}{m}\right)_{H^{\oplus}} : \left(\frac{e}{m}\right)_{D}$

$\frac{1}{1} \quad : \quad \frac{0}{2}$

$(1 \quad : \quad 0)$

8. Ans. (C)

Electron, proton and deuteron are charged particles so deflected in magnetic field and neutron is neutral particle.

9. Ans. (D)

For closest approach for α particle

$$\frac{1}{2}mv^2 = \frac{2KZe^2}{r}$$

$$r = \frac{4KZe^2}{mv^2}$$

$r \propto Z$ for same KE and same particle (r is the minimum distance)

So, the distance of closest approach will be minimum for $_{20}Ca$.

10. Ans. (D)

Electron revolves around the nucleus in definite orbits, it is given by Bohr Model.

11. Ans. (D)

$r \propto q$ [Neutron (q = 0)]

Using, $\frac{1}{2}mv^2 = \frac{Kq(ze)}{r}$

12. Ans. (D)

Rutherford model used α–particle beam $He^{2\oplus}$ (Doubly ionised Helium) or Helium Nuclei

13. Ans. (D)

Radius of atom $(r_a) = 1Å = 10^{-10}$ m $= 10^{-8}$ cm

Radius of Nucleus $(r_N) = 1.25 \times 10^{-13} \times A^{1/3}$ cm

$= 1.25 \times 10^{-13} \times (64)^{1/3}$ cm

$= 5.00 \times 10^{-13}$ cm

$$\frac{\text{Volume of Nucleus}}{\text{Volume of atom}} = \frac{\frac{4}{3}\pi r_N^3}{\frac{4}{3}\pi r_a^3} = \left(\frac{r_N}{r_a}\right)^3$$

$$= \left(\frac{5 \times 10^{-13}}{10^{-8}}\right)^3$$

$= 125 \times 10^{-15}$

$= 1.25 \times 10^{-13}$

14. Ans. (D)

Neutron has zero charge. So, distance of closest approach will be zero for neutrons

15. Ans. (D)

No change by doubling mass of electrons, however by reducing mass of neutron to half total atomic mass becomes 6 + 3 instead of 6 + 6. Thus, reduced by 25%.

16. Ans. (A)

$$\frac{E}{m}=\frac{2e}{4amu}=\frac{2\times1.60\times10^{-19}C}{4\times1.67\times10^{-27}kg} = 0.48 \times 10^{8}\ C/kg = 4.8 \times 10^{7}\ C/kg$$

17. Ans. (C)

Electromagnetic radiation travels through vacuum at a speed of light = $3 \times 10^{8}\ ms^{-1}$

18. Ans. (C)

The wavelength 5000Å lies in visible region

19. Ans. (C)

Frequency = 12×10^{16} Cycle/sec = 12×10^{16} Hz

$$V=\frac{C}{\lambda}$$

20. Ans. (D)

$$\bar{v}=\frac{1}{\lambda}=\frac{10^{9}}{600}\ m^{-1}$$

21. Ans. (A)

X–rays have greater frequency

22. Ans. (B)

$\because$ E = hv

$E \propto v$

if $v \rightarrow$ doubled $\Rightarrow E \Rightarrow$ doubled

23. Ans. (D)

$$\frac{\bar{v}_1}{\bar{v}_2}=\frac{2}{3} \qquad \left(\because\ \bar{v}=\frac{1}{\lambda}\right)$$

$$\Rightarrow \quad \frac{\frac{1}{\lambda_1}}{\frac{1}{\lambda_2}}=\frac{2}{3}$$

$$\Rightarrow \quad \frac{\lambda_2}{\lambda_1}=\frac{2}{3}$$

Also,

$$E = \frac{nhc}{\lambda}$$

$$\Rightarrow \quad \frac{E}{n}=\frac{hc}{\lambda}$$

$$\Rightarrow \quad \frac{E}{n}\propto\frac{1}{\lambda}$$

24. Ans. (B)

$E = E_1 + E_2$

$\Rightarrow \quad E = \frac{hc}{\lambda} \quad \Rightarrow \quad E \propto \frac{1}{\lambda}$

$\Rightarrow \quad \frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

$\Rightarrow \quad \frac{1}{400} = \frac{1}{500} + \frac{1}{\lambda_2}$

$\Rightarrow \lambda_2 = 2000$ nm

25. Ans. (B)

$E = nh\nu$

$\Rightarrow \quad \frac{n_g h\nu_g}{t} = \frac{n_r h\nu_r}{t}$ $\quad$ n_g = no. of photons (green)

$\Rightarrow \; n_g \nu_g = n_r \nu_r$ $\quad$ n_r = no. of red photons

$\Rightarrow \quad \frac{\nu_g}{\nu_r} = \frac{n_r}{n_g}$ $\quad$ $\nu \to$ frequency

$\nu_g > \nu_r \Rightarrow n_r > n_g$

26. Ans. (D)

$E = h\nu$	&	$E = \frac{hc}{\lambda}$
$E \propto \nu$	&	$E \propto \frac{1}{\lambda}$
Directly proportional		Inversely proportional

27. Ans. (D)

$E_{total} = N \times \frac{hc}{\lambda}$ $\quad$ (N = no. of photons)

$P \times t = N \times \frac{hc}{\lambda}$

$80 \text{ Watt} \times 1 \text{ sec.} = N \times \frac{6.6 \times 10^{-34} \text{ J sec} \times 3 \times 10^{8} \text{ m/sec}}{5000 \times 10^{-10} \text{ m}}$

$N = 20.2 \times 10^{19}$ photons/sec.

28. Ans. (D)

$E = \frac{hc}{\lambda}$

$$\frac{E_{photon(2000Å)}}{E_{photon(4000Å)}} = \frac{\frac{hc}{2000}}{\frac{hc}{4000}} = 2$$

29. **Ans. (C)**

Small packets of light are called photon

30. **Ans. (C)**

$\lambda = 310$ Å

$$E = \frac{12400}{310}\ \text{eV}$$

$$\Rightarrow \ KE = E - \phi$$

$$\Rightarrow \ KE = \frac{12400}{310} - 12.8$$

$$K.E. = 27.2\ \text{eV} \times 1.6 \times 10^{-19}$$

$$K.E. = 27.2 \times 1.6 \times 10^{-19}\ \text{J}$$

$$K.E. = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2K.E.}{m}} = \sqrt{\frac{2\times 27\times 1.6\times 10^{-19}}{9.1\times 10^{-31}}}$$

$$v = 2.18\sqrt{2} \times 10^6\ \text{m/s}$$

31. **Ans. (A)**

$\lambda = 155$ nm $= 1550$ Å

$$E = \frac{12400}{\lambda(\text{Å})}\ \text{eV}$$

$$E = \frac{12400}{1550}\ \text{eV}$$

$$\Rightarrow \ KE = E - \phi$$

$$\Rightarrow \ KE = \frac{12400}{1550} - 5 = 3\ \text{eV}$$

$$K.E. = 3 \times 1.6 \times 10^{-19}\ \text{J}$$

$$K.E. = eV_o$$

$$V_o = \frac{K.E.}{e} = \frac{3\times 1.6\times 10^{-19}}{1.6\times 10^{-19}} = 3\ \text{Volt}$$

32. **Ans. (B)**

$\lambda_0 = 330$ mm (given)

$$w = h\nu_0 = \frac{hc}{\lambda_0} = \frac{6.6\times 10^{-34}\times 3\times 10^{8}}{330\times 10^{-9}}$$

$$w = 0.06 \times 10^{-17}$$

$$w = 6 \times 10^{-19}\ \text{J}$$

33. Ans. (C)

K.E. = $h\nu - h\nu_0 \rightarrow$ remain same for particular metal

$E' = 2h\nu - w$

$E' - h\nu = h\nu - w$

$\rightarrow$ (new K.E.)

$\boxed{E' = E + h\nu}$

34. Ans. (D)

Einstein's equation

$E = W + KE_{max}$

W = work function = threshold energy

$W = \frac{hc}{\lambda_0}$

w = 3.3 eV (minimum energy required to remove the electron)

$3.3\text{ eV} = \frac{6.6 \times 10^{-34}\text{ Js} \times 3 \times 10^8}{\lambda_0}\text{ m/s}$

$1\text{eV} = 1.6 \times 10^{-19}\text{ J}$

$\Rightarrow \; 3.3 \times 1.6 \times 10^{-19}\text{ J} = \frac{6.6 \times 10^{-34}\text{ Js} \times 3 \times 10^8}{\lambda_0}\text{ m/s}$

$\lambda_0 = \frac{6}{1.6} \times 10^{-7}\text{ m}$

$= 3.75 \times 10^{-7}\text{m}$

35. Ans. (C)

$r = 0.529 \times \frac{n^2}{Z}$

For first orbit, n = 1

$R = 0.529 \times \frac{1}{Z}$

(A) for H, r = 0.529 Å

(B) for tritium atom, $r = 0.529 \times \frac{1}{1} \Rightarrow 0.529$ Å

(C) for $Be^{3\oplus}$, $r = 0.529 \times \frac{1}{4} \Rightarrow 0.132$ Å

(D) for $He^{2\oplus}$, $r = 0.529 \times \frac{1}{2} \Rightarrow 0.2645$ Å

36. Ans. (A)

Bohr's theory is applicable for single electron species

He atom has 2 electrons.

37. Ans. (C)

(A) $v = 2.18 \times 10^6 \times \frac{z}{n}$ (m/s)

$v \propto \frac{1}{n}$

(B) time period (T) = $\frac{2\pi r}{v}$

$$= \frac{2\pi \times 0.529 \times \left(\frac{n^2}{2}\right)}{2.18 \times 10^6 \times \left(\frac{z}{n}\right)}$$

$T \propto \frac{n^3}{z^2}$

Frequency $\propto \frac{1}{T}$

$\nu \propto \frac{z^2}{n^3}$

(C) $r = 0.529\ \frac{n^2}{z}$

$r \propto \frac{n^2}{z}$

(D) Force on electron = $\frac{mv^2}{r}$

$$F \Rightarrow \frac{m.\left(2.18 \times 10^6 \times \frac{z}{n}\right)^2}{\left(0.529\frac{n^2}{z}\right) \times 10^{-10}}$$

$$F \Rightarrow \frac{z^2}{n^2 \times \frac{n^2}{z}}$$

$F \propto \frac{z^3}{n^4}$

38. Ans. (A)

$E_1 = -13.6 \times \frac{Z^2}{n^2}$

For H–atom ground state z = 1, n = 1

$E_1 = -13.6$

$E_5 = -13.6 \times \frac{1}{n^2}$

$= -13.6 \times \frac{1}{5^2} \Rightarrow -0.54$ eV

39. Ans. (B)

$mvr = \frac{nh}{2\pi}$ (Quantisation of angular momentum)

40. Ans. (B)

$$r_n = \frac{n^2h^2}{4\pi^2 mk(ze)(e)}$$

$$r'_n = \frac{n^2h^2}{4\pi^2(2m)k(ze)(e)}$$

$$r'_n = \frac{1}{2}r_n$$

$$= \frac{1}{2} \times 0.529 \times \frac{n^2}{z} \text{Å}$$

$$= 0.265 \times \frac{n^2}{z} \text{Å}$$

41. Ans. (B)

$$V = 2.18 \times 10^6 \frac{z}{n} m/s$$

V = 1094 km/s = 1094 × 10^3 m/s

$\Rightarrow$ 1094 × 10^3 = 2.18 × 10^6 × $\frac{z}{4}$

Z = 2 (He)

42. Ans. (A)

Na^{10+} ion contains only one e^- because Bohr is model applied for single e^- species.

43. Ans. (C)

$$\frac{T_2}{T_3} = \frac{\frac{2\pi r_2}{v_2}}{\frac{2\pi r_3}{v_3}} = \frac{\frac{n^2}{z} / \frac{z}{n}}{\frac{n^2}{z} / \frac{z}{n}}$$

$$= \frac{n_2^3}{n_3^3} = \frac{(2)^3}{(3)^3} = \frac{8}{27}$$

44. Ans. (C)

$$2 \times 1.5 \frac{h}{2\pi} = \frac{3h}{2\pi}$$

$$2 \times 0.5 \frac{h}{2\pi} = \frac{h}{2\pi}$$

$$2 \times 1.25 \frac{h}{2\pi} = \frac{2.5h}{2\pi} \text{ (wrong)}$$

45. Ans. (A)

Angular momentum = $\frac{nh}{2\pi}$

$$\left.\begin{array}{lcccccc} & K & L & M & N & O & P \\ n = & 1 & 2 & 3 & 4 & 5 & 6 \end{array}\right] \Rightarrow \text{ for p–shell, the value of n = 6}$$

so angular momentum = $\frac{6h}{2\pi} = \frac{3h}{\pi}$

46. Ans. (D)

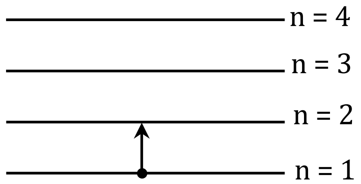
Angular momentum of 2nd Bohr orbit of H–atom = $\frac{nh}{2\pi}$

$$x = \frac{2h}{2\pi}$$

$$x = \frac{h}{\pi}$$

Angular momentum of 1st excited state (n = 2) of Li^{2+} atom = $\frac{2h}{2\pi} = \frac{h}{\pi} = x$

47. Ans. (A)



From n = 1, energy can only be absorbed but cannot be released, because only excitation is possible, de–excitation is not possible as there is no lower shell than n = 1.

48. Ans. (C)

Potential energy for a particular shell 'n' for H–like species with atomic number Z is given by–

$$= -27.2 \frac{z^2}{n^2} \text{eV}$$

Given: shell no 'n' = 1 (ground state)

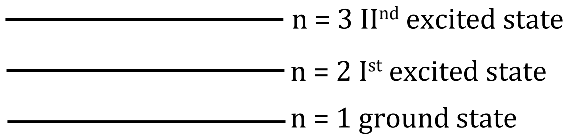
z = 1 (H–atom)

$$= -27.2 \frac{(1)^2}{(1)^2} \text{eV} = -27.2 \text{eV}$$

49. Ans. (B)

P.E. = – 3.02 eV

Formula of P.E. for atomic no. Z shell no. n



$$= -27.2 \frac{z^2}{n^2} \text{eV}$$

given: z = 1 (hydrogen)

$-27.2\frac{(1)^2}{n^2}\text{eV} = -3.02 \text{ eV}$

$n^2 = 9$

$n = 3$

If shell no. is 3, then it is 2nd excited state

50. **Ans. (D)**

Energy required to excite from shell no.'n_1' to shell no 'n_2' is given by:

$= 13.6z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\text{eV}$ for atomic number z

given: $n_1 = 3$, $n_2 = 4$, $z = 5$

$= 13.6(5^2)\left(\frac{1}{3^2}-\frac{1}{4^2}\right)\text{eV}$

$= 13.6 \times 25\left(\frac{1}{9}-\frac{1}{16}\right)\text{eV}$

$= 16.52$ eV

51. **Ans. (B)**

The energy change $\Delta E = 13.6\ Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\text{eV}$

where n_1 = initial state

n_2 = find state

z = atomic no.

formula for IE = $13.6\ Z^2\text{eV} = 13.6$ eV

$Z = 1$

in question, first excited state $\Rightarrow n = 2$

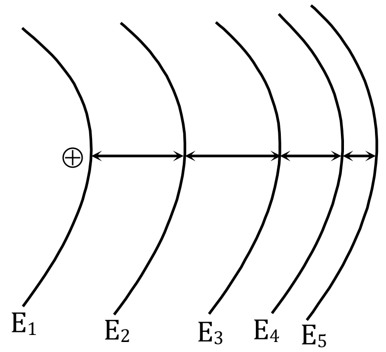
third excited state $\Rightarrow n = 4$

$\Delta E = 13.6\ (1)^2\left(\frac{1}{2^2}-\frac{1}{4^2}\right)\text{eV}$

$\Rightarrow\ 13.6\times\left(\frac{3}{16}\right)\text{eV} = 2.55 \text{ eV}$

52. **Ans. (A)**

In H–like species, as 'n' increases, energy of shell increases energy difference decreases



$(E_2 - E_1) > (E_3 - E_2) > (E_4 - E_3)$.........

53. Ans. (C)

$\Delta E = 13.6\,Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)eV\quad n_1 = 2, n_2 = 3$

$\Delta E = 47.2$ eV

$47.2\text{ eV} = 13.6\,Z^2\left(\frac{1}{2^2}-\frac{1}{3^2}\right)eV$

$\frac{59}{17} = Z^2\frac{5}{36}$

Solving Z = 5

54. Ans. (A)

Energy of shell (n) for atomic number (z) of H–like species = – 13.6

Given: $E_n = -13.6\frac{(1)^2}{n^2}eV$ ...(1) (for H–atom)

then for $E' = -13.6\left(\frac{2^2}{n^2}\right)eV$ ...(2) (for He^+–ion)

$\frac{(2)}{(1)} \Rightarrow \frac{E'}{E_n} = \frac{4}{1} \Rightarrow E' = 4 \times E_n$

55. Ans. (A)

To emit the photon, then electron should be in higher energy level but if electron is in 1s, there is no lower energy level than n = 1

Hence, electron present in 1s can only absorb energy, but cannot emit the photon

56. Ans. (D)

Violet	Indigo	Blue	Green	Yellow	Orange	Red

3800 4300 4500 4900 5500 5900 6500 7600

Visible spectrum (in Å)

Above is the range for visible spectrum

now $\frac{1}{\lambda} = R_H z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

& $\frac{1}{RH} = 912\text{Å}$

so $\frac{912\text{Å}}{\lambda} = 9\times\left(\frac{1}{4}-\frac{1}{n_2^2}\right)$

Taking $n_2 = 3$

$\lambda = \frac{912\times 36}{45} < 3800\text{Å}$

Taking $n_2 = 4$

$$\lambda = \frac{912 \times 64}{108} << 3800Å$$

so, for higher $n_2 > 4$ 'λ' will be even lesser, so not in visible range.

For "H–atom" z = 1

$$\frac{912Å}{\lambda} = \left(\frac{1}{4} - \frac{1}{n_2^2}\right)$$

$n_2 = 3$

$$\frac{912Å}{\lambda} = \left(\frac{1}{4} - \frac{1}{9}\right)$$

$$= \frac{5}{36}$$

$$\boxed{\lambda = \frac{912 \times 36}{5} = 6566.4Å}$$

$n_2 = 4$

$$\frac{912Å}{\lambda} = \left(\frac{1}{4} - \frac{1}{16}\right)$$

$$\frac{912Å}{\lambda} = \frac{12}{4 \times 16} = \frac{3}{16}$$

$$\boxed{\lambda = \frac{912 \times 16}{3} = 4864Å}$$

for $n_2 = \infty$

$$\frac{912Å}{\lambda} = \left(\frac{1}{4} - 0\right)$$

$$\boxed{\lambda = 3648Å}$$

so, in visible Range.

57. Ans. (B)

$$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{25}\right)$$

$$\frac{1}{\lambda} = R\left(\frac{25-4}{100}\right)$$

$$\frac{1}{\lambda} = \frac{21R}{100}$$

$$\lambda = \frac{100}{21R}$$

58. Ans. (B)

No of spectral lines = $\frac{(n_2-n_1)(n_2-n_1+1)}{2}=\frac{(4-1)(4-1+1)}{2}=\frac{3\times4}{2}=6$

59. Ans. (C)

$\frac{1}{\lambda}=R_H\times4\left[\frac{1}{4}\right]=\frac{1}{x}$

$\lambda=x=\frac{1}{R_H}$

for H–atom

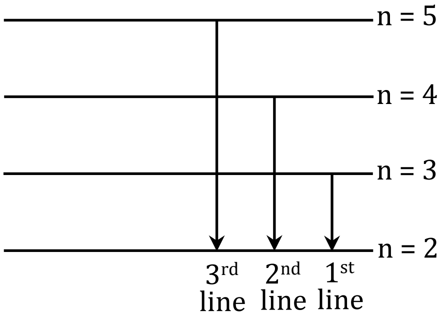
$\frac{1}{\lambda}=R_H\times1\left[\frac{1}{1^2}-\frac{1}{2^2}\right]$

$\frac{1}{\lambda}=R_H\times\frac{3}{4}$

$\lambda=\frac{4}{3}x$

60. Ans. (B)

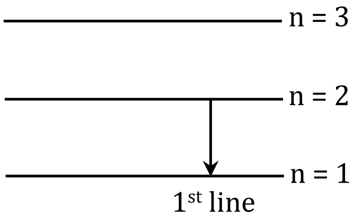
Balmer series $\Rightarrow$ final energy level $\Rightarrow$ n = 2



$5\rightarrow2\Rightarrow3^{rd}$ Balmer series line

61. Ans. (C)

First Lyman line $\Rightarrow 2\rightarrow1$



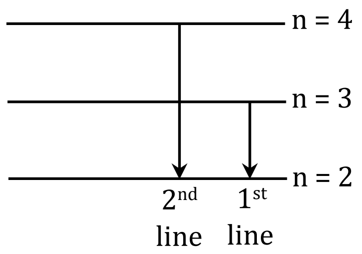
$\Delta E = 13.6\ Z^2 \left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) eV$

When $z = 1$

$n_1 = 1$

$n_2 = 2 \Rightarrow \Delta E = 10.2$ eV

second Balmer line $\Rightarrow 4\rightarrow2$



$\Delta E = 10.2$ eV

$n_1 = 2$

$n_2 = 4$ $\quad\quad$ $z = ?$

$$10.2 \text{ eV} = 13.6\, z^2\left(\frac{1}{2^2}-\frac{1}{4^2}\right)\text{eV}$$

$$\frac{3}{4}=z^2\left(\frac{3}{16}\right)$$

$z = 2$ (He^+ ion)

62. **Ans. (A)**

no. of spectral lines = $\dfrac{(n_2-n_1)(n_2-n_1+1)}{2}$

where $n_1 \rightarrow$ lower energy level

$n_2 \rightarrow$ higher energy level

So, total no. of lines

$$= \frac{(6-2)(6-2+1)}{2} = \frac{4\times5}{2}=10$$

no. of Balmer lines = $n_2 - 2$

$= 6 - 2 = 4$

Then total no. of lines (excluding Balmer series) = 10 – 4 = 6

63. **Ans. (B)**

For Rydberg equation

$$\frac{1}{\lambda}=R_H Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

For He^+, Balmer series shortest wave length

$\lambda = x, z = 2,$ $\quad\quad$ $n_1 = 2$ $\quad\quad$ $n_2 = \infty$

$$\frac{1}{x}=R_H\times4\left(\frac{1}{2^2}-\frac{1}{\infty}\right) \quad\quad ...(1)$$

For Li^{2+} ion, Paschen series longest wavelength

$z = 3,$ $\quad\quad$ $n_1 = 3$ $\quad\quad$ $n_2 = 4$

$$\frac{1}{\lambda}=R_H\times9\left(\frac{1}{3^2}-\frac{1}{4^2}\right) \quad\quad ...(2)$$

$\dfrac{(2)}{(1)}$ gives $\lambda=\dfrac{16x}{7}$

64. Ans. (A)

α–line of Lyman series

$n_1 = 1$ & $n_2 = 2$

β–line of Balmer series

$n_1 = 2$ & $n_2 = 4$

so, for H_α of Lyman series

$$\frac{1}{\lambda_\alpha^H} = R_H \times 1^2 \left[\frac{1}{1^2} - \frac{1}{2^2}\right] \quad ...(1)$$

So, for He_β^+ of Balmer series

$$\frac{1}{\lambda_B^{He^+}} = R_H \times 2^2 \left[\frac{1}{2^2} - \frac{1}{4^2}\right] \quad ...(2)$$

by $\frac{(2)}{(1)} = \frac{\lambda_\alpha^H}{\lambda_B^{He^+}} = 1:1$

65. Ans. (C)

$n_2 + n_1 = 4$ ...(1)

$n_2^2 - n_1^2 = 8$ ...(2)

$(n_2 - n_1)(n_2 + n_1) = 8$

$(n_2 - n_1) = \frac{8}{4} = 2$ ...(3)

from (1) & (3)

$n_2 = 3, n_1 = 1$

From Rydberg equation

$$\frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda} = R_H \times 2^2 \left(\frac{1}{1^2} - \frac{1}{3^2}\right]$$

$$\frac{1}{\lambda} = R_H \times 4 \left[\frac{8}{9}\right]$$

$$\lambda = \frac{9}{32R_H}$$

66. Ans. (B)

For Li^{2+} z = 3 & for ionisation energy

We need to calculate energy of ground state of e^- so

$$E = -13.6 \times \frac{z^2}{n^2} = -13.6 \times 9$$

$= -122.4$ ev

Now since e^- in Hydrogen atom is in ground state so its energy will be –13.6 ev ; & absorbed energy is 122.4 ev

so K.E. of e^- = (–13.6) + (13.6 × 9)

= 13.6 × 8 ev

so, wavelength of e^- will be calculate from De–Broglie's equation

$$\lambda = \sqrt{\frac{150}{v}}\text{Å}$$

$$= \sqrt{\frac{150}{13.6 \times 8}}\text{Å} = 1.17\text{Å}$$

option B correct.

67. Ans. (C)

K.E. = 2.8×10^{-23} J, De–Broglie wavelength = ?

$m_e = 9.1 \times 10^{-31}$ kg

$$\Rightarrow \lambda = \frac{h}{\sqrt{2 \times KE \times m_e}} \Rightarrow \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 2.8 \times 10^{-23} \times 9.1 \times 10^{-31}}}$$

$\lambda = 9.28 \times 10^{-8}$ m.

68. Ans. (C)

$2\pi r = n\lambda$

$2\pi r = 4 \times 4$ Å (n = 4)

$2\pi r = 16$Å

69. Ans. (A)

No. of waves in n^{th} orbit = n

$\therefore$ no. of waves in 4^{th} orbit = 4

70. Ans. (A)

Momentum $\Rightarrow$ mv

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

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

$$\Rightarrow mv = \frac{6.6252 \times 10^{-27}\text{ erg second}}{1 \times 10^{-8}\text{ cm}} = 6.6252 \times 10^{-19}\text{ g cm/s}$$

71. Ans. (A)

We know, $\lambda = \frac{h}{\sqrt{2 \times KE \times m}}$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{KE_2}{KE_1}}$$

$$\frac{3}{5} = \sqrt{\frac{KE_2}{KE_1}}$$

$KE_1 : KE_2 = 25 : 9$

72. Ans. (A)

$$\lambda_2 = \frac{h}{\sqrt{2km}}$$

λ_d : De-Broglie wavelength

$h \rightarrow$ Planck constant

$k \rightarrow$ kinetic energy

$m \rightarrow$ mass of particle

$$\lambda_2 \propto \frac{1}{\sqrt{km}}$$

So, $\lambda_e : \lambda_p : \lambda_\alpha$

$$\frac{1}{\sqrt{16E\times m_e}} : \frac{1}{\sqrt{4E\times m_p}} : \frac{1}{\sqrt{E\times m_\alpha}}$$

$$\frac{1}{4\sqrt{m_e}} : \frac{1}{2\sqrt{m_p}} : \frac{1}{\sqrt{m_\alpha}}$$

we know $m_p > m_e$

$m_\alpha = 4 \times m_p$

so

$$\frac{1}{4\sqrt{m_e}} : \frac{1}{2\sqrt{m_p}} : \frac{1}{2\sqrt{m_\alpha}}$$

$\therefore \lambda_e > \lambda_p = \lambda_\alpha$

73. Ans. (C)

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

$$= \frac{(6.22\times10^{-24}\,J-sec)}{(200\times10^{-3}\,kg)\left(\frac{5}{3600}\,m/sec\right)} \simeq 10^{-30}m$$

74. Ans. (A)

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

$h = 6.62 \times 10^{-34}$ J–sec

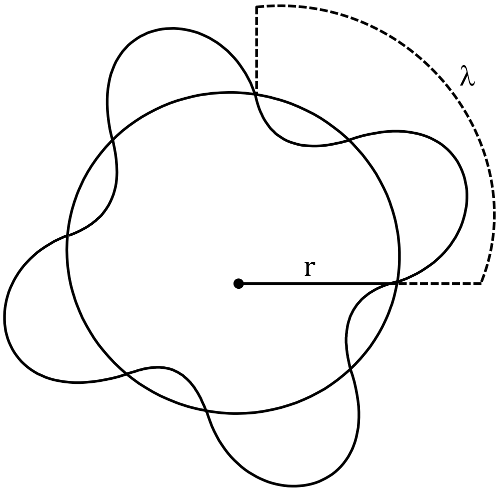
$m_e = 9.1 \times 10^{-31}$ kg

$v = 1.2 \times 10^5$ m/s

$$\lambda = \frac{6.62\times10^{-34}}{9.1\times10^{-31}\times1.2\times10^{5}}$$

$= 6.068 \times 10^{-9}$ m

75. Ans. (A)



If n no. of waves is formed then $2\pi r = n\lambda$

76. Ans. (B)

$\lambda = v$ (given)

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

$$\Rightarrow \quad v^2 = \frac{h}{m} \; ; \; v = \sqrt{\frac{h}{m}}$$

77. Ans. (B)

$$\lambda = \frac{h}{\sqrt{2mqV}}$$

$m \rightarrow$ mass of particle

$q \rightarrow$ charge

$v \rightarrow$ potential

$$\lambda \propto \frac{1}{\sqrt{mV}}$$

Slop of line is = $\frac{1}{\sqrt{m}}$

$m \uparrow$ slope $\downarrow$

$\therefore \quad M_A > M_B$

78. Ans. (A)

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

$$\Delta x_A \cdot m_A (\Delta V_A) = \frac{h}{4\pi} \qquad ...(1)$$

$$\Delta x_B \cdot m_B (\Delta V_B) = \frac{h}{4\pi} \qquad ...(2)$$

$$\frac{\Delta x_A}{\Delta x_B} = \frac{m_B (\Delta V_B)}{m_A (\Delta V_A)} = \frac{5 \times 0.02}{0.05} = 2$$

79. Ans. (C)

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

if $\Delta x = 0$

$\Delta p \geq \infty$

80. Ans. (C)

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

$\Delta x = 5 \times 10^{-5} \times 10^{-10}$ m $= 5 \times 10^{-15}$ m

$\Delta v = \frac{h}{4\pi m.\Delta x} = \frac{0.53\times10^{-34}}{9.1\times10^{-31}\times5\times10^{-15}m}$

$\boxed{\Delta v = 1.16\times10^{10} m/sec}$

81. Ans. (B)

Given graph had two radial nodes and probability function cannot be negative, so does option (B)

82. Ans. (A)

Given graph represents s–subshell and is having one node representing 2s–subshell.

Radial node = 1

i.e. $n - \ell - 1 = 1$

For 2s, $n = 2$, $\ell = 0$, Radial node = 1

83. Ans. (B)

$R(r) = \frac{1}{9\sqrt{6}}\left(\frac{1}{a_0}\right)(4-\sigma)\sigma e^{-\sigma/3}$

Let's compare with standard from.

$R(r) = (\text{constant})\ [\text{polynomial in } \sigma]\sigma^{\ell} \times e^{-k\sigma}$

Degree of polynomial = $n-\ell - 1 = 1$

Also : $\ell = 1$(p) : $n = 3$

So orbital is, 3p : one radial node.

Angular node = $\ell = 1$

3px, 3py or 3pz

Can be told only by knowing angular function

84. Ans. (B)

ψ represents amplitude of electron wave whereas, ψ^2 represents probability density

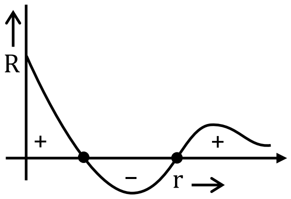
85. Ans. (C)

Schrodinger model is based on wave – particle duality of electron.

86. Ans. (A)

Both graphs represent s–subshell. Graph (A) represents 1s as it does not have any node, while graph (B) represents 2s as it has one radial node.

87. **Ans. (C)**



Number of radial nodes in the graph = 2

Number of radial nodes = n – l – 1 = 2 (n=3, l = 0 for 3s)

88. **Ans. (B)**

In graph (1) $\rightarrow$ only positive phase present i.e. this is R^2 vs r

In graph (2) $\rightarrow$ positive and negative phase present so, this is R vs r

In graph (3) $\rightarrow$ positive phases present & graph starts from origin so, this is $4\pi r^2R^2$ vs r.

89. **Ans. (D)**

For 3p orbital

n = 3, l = 1

Total Radial Node = n – l – 1 = 1

only 1 node is available in 3p, the probability distribution at the nucleus of 3p orbital is 0

90. **Ans. (D)**

$$\Psi_r = \frac{1}{9\sqrt{2}}\left(\frac{Z}{a_0}\right)^{3/2}\left[\sigma^2 - 4\sigma + 3\right]^{-\sigma/2}$$

To find radial nodes ; $\sigma^2 - 4\sigma + 3 = 0$

$\sigma^2 - 3\sigma - \sigma + 3 = 0$

$(\sigma - 1)(\sigma - 3) = 0$

$\sigma_1 = 1$ and $\sigma_2 = 3$

$\frac{2Zr_1}{a_0} = 1$ and $\frac{2Zr_2}{a_0} = 3$

$r_1 = \frac{a_0}{2Z}$ $\quad$ $r_2 = \frac{3a_0}{2Z}$

91. **Ans. (C)**

$$\psi_r = \frac{1}{9\sqrt{2}}\left(\frac{Z}{a_0}\right)^{3/2}[\sigma^2 - 4\sigma + 3]e^{-\sigma/2}$$

To find radical nodes: $\sigma^2 - 4\sigma + 3 = 0$

$\sigma^2 - 3\sigma - \sigma + 3 = 0$

$(\sigma - 1)(\sigma - 3) = 0$

$\sigma_1 = 1$ and $\sigma_2 = 3$

$\frac{2zr_1}{a_0} = 1$ and $\frac{2zr_2}{a_0} = 3$

$r_1 = \frac{a_0}{2z}$ $\quad$ $r_2 = \frac{3a_0}{2z}$

92. Ans. (B)

$R(r) = \frac{1}{9\sqrt{6}}\left(\frac{1}{a_0}\right)(4-\sigma)\sigma e^{-\rho/3}$

Let's compare with standard form

$R(r)$ = (constant) [polynomial in σ] $\sigma^l \times e^{-k\sigma}$

degree of polynomial = $n - \ell - 1 = 1$

Also: $\ell = 1$(p): $n = 3$

So, orbital is: 3p: one radial node angular node = ℓ = 1

$3p_x$, $3p_y$ or $3p_z$ can be told only by knowing angular function

93. Ans. (B)

Orbital angular momentum = $\sqrt{\ell(\ell+1)}\frac{h}{2\pi}$

$\frac{h}{2\pi} = \hbar$ {read as h cross}

For 2s: $\ell = 0$, orbital angular momentum = 0

94. Ans. (C)

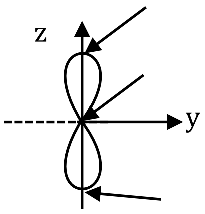
For d–electron: $\ell = 2$

Orbital angular momentum = $\sqrt{2(2+1)}\frac{h}{2\pi} = \sqrt{6}\,\hbar$

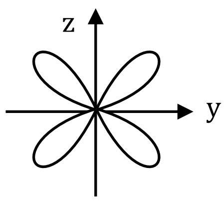
95. Ans. (D)

From given options : xy plane is nodal plane for : $5p_z$ and $6d_{yz}$ Both these have '3' radial nodes.

Now let's focus on observation : 2.



$5p_z \rightarrow$ Angular function
Intersects axis at
Points other than origin



$6pz \rightarrow$ intersection
With axis is at
Origin only

96. Ans. (C)

Number of angular nodes = ℓ

for d–orbital: $\ell = 2$: So, it has two angular nodes (or two nodal planes)

97. Ans. (A)

$d = 10^{-5}$ cm

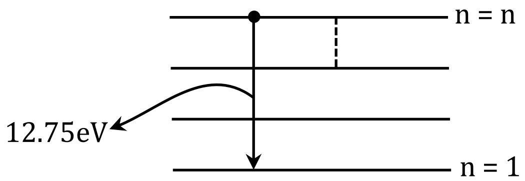
$r = 0.529 \times \frac{n^2}{2} = \frac{10^{-5}}{2} = \frac{10^{-7}}{2}(m)$

$r = \frac{10^3}{2}$ Å

$n^2 = \frac{1000}{2 \times 0.529} = 945.18$

$n = 31$

98. Ans. (C)



The energy change ΔE = 12.75 eV from n = n to n = 1 for atomic number z = 1

$$\Delta E = 13.6z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)eV$$

$$\Rightarrow \quad 12.75eV = 13.6\,eV(1)^2\left(\frac{1}{1^2}-\frac{1}{n^2}\right)$$

$$\Rightarrow \quad \frac{15}{16}=\frac{1}{1^2}-\frac{1}{n^2}$$

$\Rightarrow$ n = 4

99. Ans. (A)

n = 1 $\quad \ell = 0 \quad m = 0$

$$n=2\begin{cases}\ell=0 & m=0\\ \ell=1 & m=-1,0,+1\end{cases}$$

$$n=(3)\begin{cases}\ell=0 & m=0\\ \quad =1 & \quad =-1,0,+1\\ \quad =2 & \quad =-2,-1,0,+1,(+2)\end{cases}$$

So, no. of waves made = 3

100. Ans. (C)

Values of ℓ

$0 \le \ell \le (n-1)$

Values of m

$-\ell$ to $+\ell$

(C) n = 3, ℓ = 2, m = –3, $m_s = \frac{1}{2}$

for ℓ = 2, m should be from –2 to +2

101. Ans. (B)

(A) Principal quantum number = energy and size

(B) Azimuthal quantum number = Shape

(C) magnetic quantum number = orientation

(D) Spin quantum number = not applied for orbital

102. Ans. (C)

$$(n+\ell)\text{ value} : \underset{\substack{\Downarrow \\ 5}}{\overset{3d}{(3+2)}} \qquad \underbrace{\overset{4s}{(4+0)}}_{4} \qquad \underbrace{\overset{3p}{(3+1)}}_{4} \qquad \underbrace{\overset{3s}{(3+0)}}_{3}$$

for same value of (n + l), higher n value will have higher energy.

energy order 3d > 4s > 3p > 3s

103. Ans. (B)

$\uparrow\downarrow$	$\uparrow\uparrow$	$\uparrow$		

Pauli's exclusion principle

No two electrons in the same can have identical values for all four of their quantum numbers

$\rightarrow$ no more than two electrons can occupy the same orbital.

$\rightarrow$ two electrons in the same orbital must have opposite spin.

104. Ans. (A)

Hund's Rule of maximum multiplicity

$\rightarrow$ Before the double occupancy of any orbital every orbital in the sub-level is singly occupied

$\rightarrow$ For the maximization of total spin all electron in a single occupancy orbital must have the same spin.

105. Ans. (C)

Hund's Rule of maximum multiplicity

$\rightarrow$ Before the double occupancy of any orbital every orbital in the sub-level is singly occupied

$\rightarrow$ For the maximization of total spin all electron in a single occupancy orbital must have the same spin.

106. Ans. (D)

According (n + l) Rule

(n + l) $\rightarrow$ maximum $\rightarrow$ energy maximum

3d $\rightarrow$ 3+2=5

5p $\rightarrow$ 5+1=6

4s $\rightarrow$ 4+0=4

6d $\rightarrow$ 6+2=8 $\rightarrow$ maximum energy

107. Ans. (A)

$n + \ell = 7$

n	ℓ	name of subshell
7	0	7s
6	1	6p
5	2	5d
4	3	4f

Total number of subshells possible = 4

108. Ans. (A)

Hund's Rule of maximum multiplicity

$\rightarrow$ Before the double occupancy of any orbital every orbital in the sub-level is singly occupied

$\rightarrow$ For the maximization of total spin all electron in a single occupancy orbital must have the same spin.

109. Ans. (A)

Total spin = $n \times \frac{1}{2}$(n = number of unpaired $e^{\ominus}$)

$d^9 = \boxed{\uparrow\downarrow \,|\, \uparrow\downarrow \,|\, \uparrow\downarrow \,|\, \uparrow\downarrow \,|\, \uparrow}$

$n = 1$

Total spin $= \frac{1}{2}$

110. Ans. (B)

A neutral atom of an element 2K, 8L 9M, 2N

electron so it has total 21 electrons

So, it has 21 protons and it's atomic number = 21

electronic configuration

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

111. Ans. (C)

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

number of unpaired electron is 6.

112. Ans. (A)

${}_{46}Pd = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ \underbrace{\boxed{3d^{10}}\,4p^6\,\boxed{4d^{10}}}_{\text{d-electrons}}$

Here

for $\ell = 2$ (d – orbital)

$\boxed{\text{Total electron} = 20}$

113. Ans. (C)

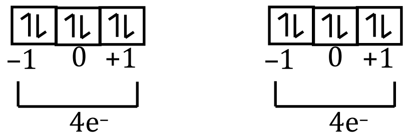
Here we need minimum value of $\left|\frac{n}{\ell \times m_\ell}\right|$

Electronic configvration of Ca

Ca =	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^2$
n =	1	2	2	3	3	4
ℓ =	0	0	1	0	1	0

only Non zero value of ℓ

So Selected subshells = $2p^6$ $3p^6$

m_ℓ value =


$\Rightarrow$ Now for minimum value for $\left|\dfrac{n}{\ell \times m}\right|$

n. should be minimum, so selected shell = 2

$\Rightarrow$ Total electrons for selected values of

$(n, , m_\ell)$ = 4 electron of 2 p

114. Ans. (B)

Iso-sters : Species having same no. of electrons and same no of atoms.

(A) N_2O, CH_4 = have different no. of atoms and electrons

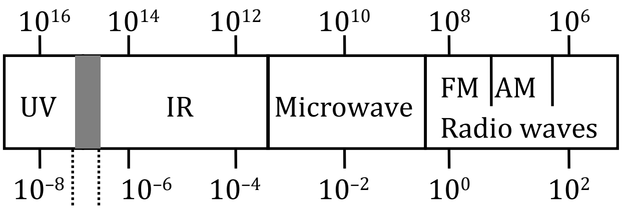
(B) N_2O, CO_2 = have same no of electrons (22) and atoms (3)

(C) CO_2, SO_2 = have same no of atoms and different no of electrons.

(D) N_2O, HOCl = have same no of atoms and different no of electrons

EXERCISE (O-2)

1. Ans. (A, C)



(A) correct order is

Radio > Micro > IR > Visible > UV

(B) $r_n = \dfrac{0.529n^2}{z}$

so, if 'n' increases 'r' increases

so $r_4 > r_3 > r_2 > r_1$

(C) $E_n = \dfrac{-13.6z^2}{n^2}$

So, as n increases En also increases {negative (–ve) sign}

(D) $V_n = 2.18 \times 10^6 (m/s) \times \dfrac{z}{n}$

Given is n = 2 for all so as z increases, velocity increases

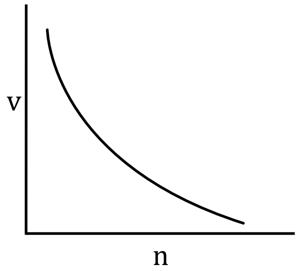
Be^{3+}	>	Li^{2+}	>	He^+	>	H
(z=4)		(z=3)		(z=2)		(z=1)

2. Ans. (B,C,D)

$v = 2.18 \times 10^6 \times \frac{z}{n}$

so, v × n = constant hence

x × y = k type curve.

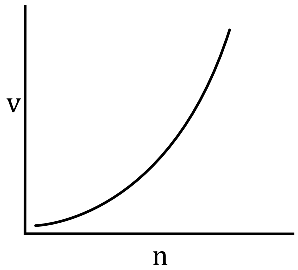


so, A wrong.

$r = 0.529 \times \frac{n^2}{z}$

or $r = \text{const} \times n^2$

i.e., y = const. × x^2 (parabolic curve)



so, B correct.

$P.E. = -27.2 \frac{z^2}{n^2} ev$

or $y = -K_{constant} \times x^2$

where $\left(x = \frac{1}{n}\right)$

so, C is correct

$K.E. = +13.6 \frac{z^2}{n^2}$

so, D is correct.

3. Ans. (C, D)

(A) Angular momentum = $n\frac{h}{2\pi}$

For successive orbit it will be $\frac{nh}{2\pi}$ & $\frac{(n+1)h}{2\pi}$ so difference will be $\frac{h}{2\pi}$ hence A wrong.

(B) energy of orbit will change but difference remains same.

(C) ΔE hv more ΔE more v as 'n' increases ΔE increases

so $\Delta E_{4-1} > \Delta E_{3-1} > \Delta E_{2-1}$

so $v_{4\to1} > v_{3\to1} > v_{2\to1}$

(D) $K.E. = \frac{13.6z^2}{n^2}$ as 'n' increases K.E. decreases.

4. Ans. (B,D)

5^{th} excited state means n = 6

2^{nd} excited state mean n = 3

Total no. of distinct spectral line

$$=\frac{\Delta n(\Delta n+1)}{2}=\frac{3\times 4}{2}=6$$

Lines in Balmer series where base line is 2 will be

$6\to 2 \quad 5\to 2 \quad 4\to 2 \quad 3\to 2$

but e^- only goes up to n = 3 so no. Balmer line.

For Paschen series base line is n = 3 so

$6\to 3 \quad 5\to 2 \quad 4\to 2$ 3 lines in Paschen series.

5. Ans. (B,C)

Probability of finding an electron at spherical surface increases, peak increases.

Order of probability of finding an electron at points is $P_4 = P_5 = P_6$

6. Ans. (A,B,C)

1s does not have any node, graph A is correct.

3p will have one radial node, graph B is correct.

3s will have two radial node, graph D is wrong.

7. Ans. (A,B,C,D)

1s does not contain any node, while 2s contains one node.

8. Ans. (B,C)

		n	ℓ	n + ℓ
(A)	3p =	3	1	4
(B)	5p =	5	1	6
(C)	4d =	4	2	6
(D)	5s =	5	0	5

9. Ans. (A,B)

$Rb_{37} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ \underbrace{5s^1}_{\text{Valence shell } e^-}$

So set of Quantum Number $5s^1 \Rightarrow n = 5, \ell = 0,\quad m = 0, m_s = +\frac{1}{2}$ or $\frac{1}{2}$

10. Ans. (B,D)

Cr = $\underbrace{\boxed{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6}}_{\text{first } 18e^-}\ \underbrace{4s^1}_{19^{th}e^-}\ 3d^5$

Possible set

of Quantum No = $4s^1 \Rightarrow n = 4\ \ \ell = 0\ m = 0\ m_5 = +\frac{1}{2}$

$n = 4\ \ \ell = 0\ m = 0\ \ m_5 = -\frac{1}{2}$

11. Ans. (B,D)

(A) $Ca = 1s^2\ 2s^2\ 2p^6\ \underbrace{3s^2\ \ 3p^6}_{8e^-}\ \underbrace{4s^2}_{2e^-}$

(B) $Ar = 1s^2\ \underbrace{2s^2\ \ 2p^6}_{8e^-}\ \underbrace{3s^2\ \ 3p^6}_{8e^-}$

(C) $V = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$

$V^{3+} = 1s^2\ \underbrace{2s^2\ \ 2p^6}_{8e^-}\ \underbrace{3s^2\ \ 3p^6\ \ 3d^2}_{10e^-}$

(D) $Sc^{3+} = 1s^2\ \underbrace{2s^2\ \ 2p^6}_{8e^-}\ \underbrace{3s^2\ \ 3p^6}_{8e^-}$

Same

12. Ans. (A,B,D)

According to Aufbau's rule energy order

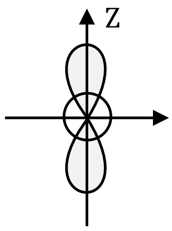
1s, 2s, 3s, 3p, 4s, 4d, 3d, 4p, 5s, 4d, 5p, 6s, 4f ____

According to $(n + \ell)$ rule

⇒ lower energy subshells filled before 4f subshell

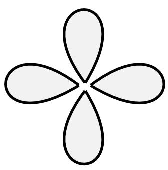
13. Ans. (B,C,D)

(A) d_{z^2}



Shape of d_{z^2}

Given statement is correct



Shape of $d_{xy}, d_{x^2y^2}$

d_{yz}, d_{xz}

(double dumbell)

(B) for the formation of cation electrons are always from Outermost subshell .

Given statement is <u>incorrect</u>

(C) Zn is a d Block element

Given statement is <u>incorrect</u>

(D) Value of Azimuthal quantum no. = $\underbrace{0 \text{ to } (n-1)}_{\substack{\text{Depends on n} \\ \text{(Principal Q. No.)}}}$

Given statement is <u>incorrect</u>

14. Ans. (A) S, (B) R (C) Q (D) P

(A) n = 2, z = 2

$$r_n = 0.529 \times \frac{n^2}{z} = 0.529 \times \frac{4}{2} = 0.529 \times 2$$

$$TE = -13.6 \times \frac{4}{4} = -13.6 (ev)$$

so K.E. = 13.6 ev

$$\& \ \lambda = \sqrt{\frac{150}{K.E.}} = \sqrt{\frac{150}{13.6}} \text{Å}$$

$$v_n = 2.18 \times 10^6 \times \frac{z}{n} = 2.18 \times 10^6$$

so, $A \rightarrow S$

(B) z = 1, n = 3

$$r_n = 0.529 \times \frac{n^2}{z} = 0.529 \times 9$$

$$v_n = 2.18 \times 10^6 \times \frac{z}{n} = \frac{2.18 \times 10^6}{3}$$

$$E_n = -13.6 \times \frac{z^2}{n^2} = \frac{-13.6}{9}$$

$$K.E. = \frac{13.6}{9} \qquad \text{so } \lambda = \sqrt{\frac{150 \times 9}{13.6}} \text{Å}$$

hence $B \rightarrow R$

(C) n = 1, z = 3

$$r_n = 0.529 \times \frac{n^2}{z} = 0.529 \times \frac{1}{3} \text{Å}$$

$$v_n = 2.18 \times 10^6 \times \frac{z}{n} = 2.18 \times 10^6 \times 3 \, m/s$$

$$E_n = -13.6 \times \frac{(3)^2}{1} = -13.6 \times 9 \text{ ev}$$

$$K.E. = 13.6 \times 9 \text{ so } \lambda = \sqrt{\frac{150}{13.6 \times 9}} \text{Å}$$

so, $C \rightarrow Q$

(D) z = 4, n = 2

$$r_n = 0.529 \times \frac{n^2}{z} = 0.529 \times \frac{4}{4} = 0.529$$

$$v_n = 2.18 \times 10^6 \times \frac{z}{n} = 2.18 \times 10^6 \times \frac{4}{2} m/sec$$

$$E_n = -13.6 \times \frac{z^2}{n^2} = -13.6 \times \frac{16}{4} = -13.6 \times 4 ev$$

K.E. = 13.6 × 4 ev

$$\text{so } \lambda = \sqrt{\frac{150}{13.6 \times 4}} Å$$

hence D $\to$ P

15. Ans. (A) P, (B) P,Q,S (C) P,R (D) Q,S

No. of nodes = n – 1

No. of Angular nodes = ℓ

No. of Radial nodes = n – ℓ – 1

In graph A no. of Radial nodes = 3

so, n – ℓ – 1 = 3 $\Rightarrow$ n – ℓ = 4

but it does not start from zero on 'y' axis so it must be 's' orbital hence ℓ = 0 so n = 4

& it becomes 4s

In graph B no of Radial nodes = 3

so, n – ℓ = 4

so, n = 4	ℓ = 0	4s
n = 5	ℓ = 1	5p
n = 6	ℓ = 2	6d

all are trues so B $\to$ P, Q, S

for 's' orbital only ψ = independent of θ & ϕ

hence C $\to$ P, R

so 'p' & 'd' orbitals hence

C $\to$ Q, S

16. Ans. (D)

(P) $P_{15} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ n = 3, ℓ = 1

(Q) $N_7 = 1s^2\ 2s^2\ 2p^3$ n = 2, ℓ = 1

(R) $Pb_{82} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10} 5p^6\ 6s^2\ \underbrace{4f^{14}}_{\boxed{\ell = 3}}\ 5d^{10}\ \underbrace{6p^2}_{\boxed{n = 6}}$

(S) $Cs_{55} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^1$

$\boxed{\ell = 2}$ $\boxed{n = 6}$

17. Ans. (C)

(P) $\rightarrow$ 4
$$\left.\begin{array}{lll} Li & \rightarrow & [He]2s^1 \\ Na & \rightarrow & [Ne]3s^1 \\ K & \rightarrow & [Ar]4s^1 \end{array}\right\}\text{same no. of Unpaired } e^{\ominus} \text{ (excluding zero)}$$

(Q) $\rightarrow$ 1
$$\left.\begin{array}{lll} Na^+ & \rightarrow & [Ne] \\ Mg^{2+} & \rightarrow & [Ne] \\ F^- & \rightarrow & [Ne] \end{array}\right\}\text{Isoelectronic specie, with same no. of S \& P electorns}$$

(R) $\rightarrow$ 1, 2, 3
$$\left.\begin{array}{lll} Na^+ & \rightarrow & [Ne] \\ Mg^{2+} & \rightarrow & [Ne] \\ F^- & \rightarrow & [Ne] \end{array}\right\}\text{same no. of 'p'} (\ell = 1) \text{ electrons.}$$

$$\left.\begin{array}{lll} F^- & \rightarrow & [Ne] \\ Mg & \rightarrow & [Ne]3s^2 \\ O^{2-} & \rightarrow & [Ne] \end{array}\right\}\text{same no. of 'p'} (\ell = 1) \text{ elctrons.}$$

$$\left.\begin{array}{lll} Mg & \rightarrow & [Ne]3s^2 \\ Ne & \rightarrow & [Ne] \\ O^{2-} & \rightarrow & [Ne] \end{array}\right\}\text{Same no of 'p'} (\ell = 1) \text{ electrons.}$$

(S) $\rightarrow$ 1
$$\left.\begin{array}{lll} Na^+ & \rightarrow & [Ne] \\ Mg^{2+} & \rightarrow & [Ne] \\ F^- & \rightarrow & [Ne] \end{array}\right\}\text{Iso electronic specie}$$

18. Ans. (C)

(A) In correct option {as (Na^+, Mg^{+2}, F^-) all are diamagntic}

(B) In correct option {as for (S^{-2}, Cl^-, P^{-3})} $\boxed{1s^2\,2s^2\,2p^6\,3s^2\,3p^6}$

maximum possible value of m = +1, thus m = $\pm$ 2 not possible.

(C) Correct option

all Fe^{3+}, Co^{2+}, Ni^{2+} belongs to same period.

for 3d electrons value of m = $\pm$ 2 is possible.

(D) In correct option {as it is not possible that last e^- must have value of $m_s = \frac{+1}{2}$

It may be $\frac{-1}{2}$ also.}

19. Ans. (B)

(A) Correct option $\Rightarrow$

Fe^{3+}, Co^{2+}, Ni^{2+} all are paramagnetic due to Unpaired electrons present in 3d subshell last.

electron in Fe^{3+}, Co^{2+}, Ni^{2+} is present in 3d subshell for which n = 3 (same for all)

(B) Incorrect option $\Rightarrow$

for Li, Na, K value of principal Quantum number

for last $e^{\ominus}$ is 2,3,4 respectively.

(C) Correct option $\Rightarrow$ Na^+, Mg^{2+}, F^- are isoelectronic as total No of electrons are same.

(D) Correct option $\Rightarrow$ S^{2-}, $C1^-$, P^{3-} are isoelectronic.

in S^{2-}, $C1^-$, P^{3-} no of e^- for which n = 3 ,|≤| is 6

20. Ans. (B)

(A) Incorrect $\Rightarrow$ Because last electrons of Li, Na, K can, have any value of m_s either $\frac{+1}{2}$ or $\frac{-1}{2}$.

(B) Correct $\Rightarrow$ S^{2-}, Cl^-,P^{3-} all isoelectronic value of n = for last e^-.

(C) Incorrect $\Rightarrow$ Na^+, Mg^{2+}, F^- are not paramagnetic as all the $e^\ominus$ are paired.

(D) Incorrect $\Rightarrow$ Fe^{3+}, Co^{2+}, Ni^{2+} have e^- in d_{xy}, d_{yz}, d_{xz} for which no. of nodal plane is two.

It is given in the question that filled partially filled orbital must have number of nodal plane ≤ 1

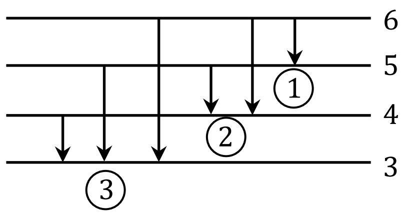
21. Ans. (A)

$\Delta E = hc\bar{v}$

$(6 \times 10^{-34})\ (3 \times 10^{8})\ (11 \times 10^{3} \times (f_2 - f_1)) = 1.76 \times 10^{-18}$ J

22. Ans. (C)

$n_2 = 6$ to $n_1 = 3$



Total lines = 3 + 2 + 1 = 6

23. Ans. (B)

$$\frac{1}{\lambda_{L_1}} = R_H\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3R_H}{4}$$

$$\frac{1}{\lambda_{B-2}} = R_H\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{R_H \times 3}{16}$$

$$\lambda_{B-2} - \lambda_{L_1} = \frac{16}{3R_H} - \frac{4}{3R_H} = \frac{12}{3R_H} = \frac{4}{R_H}$$

24. Ans. (C)

$$\bar{v} = R_H.z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \begin{bmatrix} n_1 + n_2 = 4 \\ n_2 - n_1 = 2 \\ n_2 = 3 \\ n_1 = 1 \end{bmatrix}$$

$$= R_H \times 3^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$$

$$= R_H \times 9 \times \frac{8}{9} = 8R_H$$

25. **Ans. (A)**

$$\lambda_d = \frac{h}{\sqrt{2mKE}}$$

$$\lambda_d \propto \frac{1}{\sqrt{m}}$$

$\because m_H < m_D < m_T$

so $\lambda_H > \lambda_D > \lambda_T$

26. **Ans. (C)**

$$\lambda_d = \frac{h}{mv} = \frac{h}{mv_o \times \frac{z}{n}} \quad \left[\because v_n = v_0 \times \frac{z}{n}\right]$$

$$\lambda_d = \frac{nh}{mv_0 z}$$

$\lambda_d \propto n$

$$\frac{\lambda_2}{\lambda_1} = \frac{n_2}{n_1}$$

$$3 = \frac{n_2}{n_1}$$

$n_2 = 3n_1$

27. **Ans. (A)**

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

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

$\because \Delta x = \Delta v$ (Given)

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

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

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

$$\Delta p = m\Delta v = m\sqrt{\frac{h}{4\pi m}} = \sqrt{\frac{hm}{4\pi}}$$

28. **Ans. (C)**

$P_x \Rightarrow$ NODAL PLANE (yz)

lobes of P_y, P_z and d_{yz} Present in yz plane

29. **Ans. (A)**

$$\left.\begin{matrix} p_x = yz \\ p_y = xz \end{matrix}\right]$$ (yz, xz) Nodal plane for d_{xy} so lobes of dxy is not present in (yz) and (xz) plan.

EXERCISE (S)

1. Ans. (1)

$$\frac{\left(\frac{q}{m}\right)_A}{\left(\frac{q}{m}\right)_B}=\frac{2}{3},\frac{m_A}{m_B}=\frac{2}{3}$$

$$\frac{q_A}{q_B}\frac{m_B}{m_A}=\frac{2}{3}$$

$$\frac{q_A}{q_B}\times\frac{3}{2}=\frac{2}{3}$$

$$\frac{q_A}{q_B}=\frac{4}{9}$$

$$\Rightarrow \quad \frac{18}{8}\times\frac{4}{9}=1$$

2. Ans. (1)

α–particle $\rightarrow {}_2^4He$; Deuteron $\rightarrow D \rightarrow {}_1^2H$

$$\frac{(q/m)_\alpha}{(q/m)_D}=\frac{2e/(2m_p+2m_n)}{e/(m_p+m_n)}=1$$

3. Ans. (8)

$$\frac{V_{nucleous}}{V_{atom}}=\frac{r_n^3}{r_a^3}=\frac{\left(4\times10^{-15}\right)^3}{\left(2\times10^{-10}\right)^3}=8\times10^{-15}$$

4. Ans. (4)

$$\overline{\nu_1}=\frac{1}{\lambda_1}=4\times10^6\ m^{-1}$$

$$\Rightarrow \lambda_1=\frac{10^{-6}}{4}\ m$$

$$\overline{\nu_2}=\frac{1}{\lambda_2}=2\times10^5\ cm^{-1}$$

$$\lambda_2=\frac{1}{2\times10^5}\ cm$$

$$\lambda_2=\frac{10^{-7}}{2}\ m$$

$$\frac{\nu_1}{\nu_1}=\frac{\lambda_2}{\lambda_1}=\frac{1}{5}$$

$$\Rightarrow \quad 20\times\frac{1}{5}=4$$

5. Ans. (150)

$\upsilon = 2 \times 10^5$ Hz or s^{-1}, $c = 3 \times 10^8$ m/s

$$\because\ E = h\upsilon = \frac{hc}{\lambda} \Rightarrow \upsilon = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{\upsilon}$$

$$\Rightarrow \lambda = \frac{3\times10^8}{2\times10^5}\frac{m/s}{s^{-1}}$$

$$\Rightarrow \boxed{\lambda = 1500\,\text{Å}}$$

6. Ans. (150)

$$\upsilon = \frac{c}{\lambda} = \frac{3\times10^8}{2000} = 150\,\text{kHz}$$

7. Ans. (1)

$\upsilon = 5 \times 10^{13}\ s^{-1}$

$E_{photon} = h\upsilon$

$= (6.6 \times 10^{-34}) \times (5 \times 10^{13})$

For 1 gram of ice

$\Delta H_f = 330$ J/g

$= (330 \times 1)$ Joule

$\Rightarrow (\Delta H_f)_{ice} = 330$ Joule

$$\therefore \text{ Number of photon} = \frac{330}{6.6\times10^{-34}\times5\times10^{13}} = \boxed{10^{22}}$$

8. Ans. (3)

$$\text{Percent yield} = \frac{\text{Actual yeild}}{\text{Theoritical yeild}}\times100$$

$$\Rightarrow 0.2\times100 = \frac{0.01}{\text{Th.yeild}}\times100$$

$\Rightarrow$ Theoretical yield = 0.05 moles

So, number of photons in 0.05 moles

$= 0.05 \times 6 \times 10^{23}$

$= 3 \times 10^{22}$ photons

9. Ans. (50)

$\Delta H = 482.5$ kJ/mol $\quad\because$ 96.5 kJ/mol = 1 eV/atom

$\lambda = 124$ nm $\quad\Rightarrow$ 482.5 kJ/mol = 5 eV/atom

$$\because\quad E = \frac{1240}{\lambda_{nm}}\text{eV / atom}$$

$$= \frac{1240}{124} = 10\,\text{eV / atom}$$

$$\text{So, percent of energy that converted into KE} = \frac{5}{10}\times100 = 50\%$$

10. Ans. (1240)

λ = 960Å = 96 nm

$E = \frac{hc}{\lambda}$ per atom

$E = \frac{1240}{96}$ ev per atom

$= \frac{1240}{96} \times 96$ kJ/mol

$\boxed{E = 1240\,kJ/mol}$

11. Ans. (2)

$\phi = 13.24 \times 10^{-19}$ J

$\Rightarrow \phi = h\nu_o$

$\nu_o = \frac{13.24 \times 10^{-19}}{6.62 \times 10^{-34}\,J/sec} \Rightarrow 2 \times 10^{15}\,sec^{-1}$

$\Rightarrow y = 2$

12. Ans. (1)

wavelength $\rightarrow \lambda$

KE = 1 eV

$\frac{hc}{\lambda} = \phi + 1$

multiply by 3

$\Rightarrow 3\frac{hc}{\lambda} = 3\phi + 3$ ...(1)

wavelength $\rightarrow \lambda$

KE = 5 eV

$\frac{hc}{(\lambda/3)} = \phi + 5$

$\Rightarrow \frac{3hc}{\lambda} = \phi + 5$

from (1) – (2), we get $\boxed{\phi = 1\,ev}$

13. Ans. (9)

2^{nd} excited state, means electron is present in 3^{rd} shell of hydrogen (n = 3)

$r_3 = 0.529 \times \frac{(3)^2}{1} = 0.529 \times 9$

1^{st} excited state, means electron is present in 2^{nd} shell of $Li^{2\oplus}$ (n = 2)

$r_2 = 0.529 \times \frac{(2)^2}{3}$

$= 0.529 \times \frac{4}{3} \quad \Rightarrow \frac{(r_3)_H}{(r_2)_{Li^{2\oplus}}} = \frac{0.529 \times \frac{9}{1}}{0.529 \times \frac{4}{3}}$

$= \frac{\text{radius of } 2^{nd} \text{ excited state of hydrogen}}{\text{radius of } 1^{st} \text{ excited state of } Li^{2\oplus}} \Rightarrow \frac{(r_3)_H}{(r_2)_{Li^{2\oplus}}} = \frac{27}{4} = \frac{p}{q} \Rightarrow \frac{4}{3} \times \frac{27}{4} = 9$

14. Ans. (2)

$$\Delta E = (IE)\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 14.4 \times \left(\frac{1}{4} - \frac{1}{9}\right) = 2\ \text{eV}$$

15. Ans. (4)

$\because\ (mvr)_{II} = 2.(mvr)_{I}$

$$\frac{n_2 h}{2\pi} = 2 \times \frac{n_1 h}{2\pi}$$

$$\Rightarrow \frac{n_2}{n_1} = 2$$

$$\because r = 0.529 \times \frac{n^2}{z} \Rightarrow r \propto n^2$$

$$\Rightarrow \frac{r_1}{r_2} = \frac{n_1^2}{n_2^2}$$

$$\Rightarrow \boxed{\frac{r_2}{r_1} = x = 4}$$

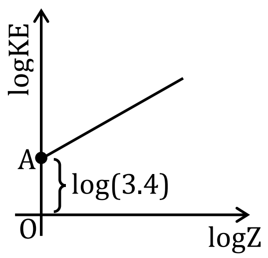
16. Ans. (65)

$$T = \frac{2\pi r}{v}$$

$$\Rightarrow \upsilon = \frac{v}{2\pi r} = \frac{2.188 \times 10^6 \times \left(\frac{1}{1}\right)}{2 \times \frac{22}{7} \times 0.529 \times \frac{1}{1} \times 10^{-10}}$$

$$\Rightarrow \boxed{\upsilon = 65 \times 10^{14}\ s^{-1}}$$

17. Ans. (2)



Ionisation energy $\Rightarrow$ n = ∞ to n = 1

$$\because\ KE = \frac{1}{2} m_e v^2$$

$$= \frac{1}{2} \times m_e \times \left(\frac{2\pi z e^2}{nh}\right)^2$$

$$\Rightarrow K.E. = \underbrace{\boxed{\dfrac{2\pi^2 me^4}{n^2h^2}}}_{\text{let k}} z^2$$

on taking log

logKE = logK + log(z^2)

$\Rightarrow$ logKE = logK + 2logz

$\because \dfrac{2\pi^2 me^4}{n^2} = 13$

from graph

k = 3.4

$$\Rightarrow \frac{13.6}{n^2} = 3.4 \Rightarrow \boxed{n=2}$$

18. **Ans. (5280)**

$(E_2)_{Li^{+2}} = -4.9\times10^{-18}\,J$

$(E_\infty - E_1)_{He^+} = ?$

$\because E \propto \dfrac{z^2}{n^2}$

$$\Rightarrow \frac{(E_2)_{Li^{+2}}}{(E_1)_{He^+}} = \frac{\frac{9}{4}}{\frac{4}{1}}$$

$$\Rightarrow (E_1)_{He^+} = \left(-4.9\times10^{-18}\times\frac{16}{9}\right)J$$

Ionisation energy $\rightarrow$

= $E_\infty - E_1$

$$= 0 - \left(-4.9\times10^{-18}\times\frac{16}{9}\right)J$$

$$= 4.9\times10^{-18}\times\frac{16}{9}\times10^{-3}\,kJ$$

$$= \frac{4.9\times10^{-18}}{N_A}\times\frac{16}{9}\times10^{-3}\,\frac{kJ}{mol}$$

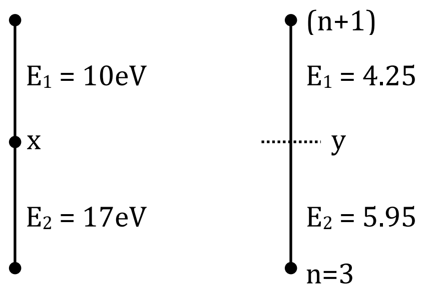
$\Rightarrow$ IE = 5280 kJ/mol

19. **Ans. (3)**

Case I

n^{th} excited state or (n+1) state

Case II



n=2 (Ist excited state)

$$10 = 13.6z^2\left[\frac{1}{x^2} - \frac{1}{(n+1)^2}\right] \quad \text{...(a)}$$

$$17 = 13.6z^2\left[\frac{1}{4} - \frac{1}{x^2}\right] \quad \text{...(b)}$$

$$a + b \Rightarrow\ 27 = z^2 \times 13.6\left[\frac{1}{4} - \frac{1}{(n+1)^2}\right] \quad \text{...(1)}$$

similarly, for Case–II

$$(4.25+5.95) = 13.6\times z^2\left[\frac{1}{9} - \frac{1}{(n+1)^2}\right]$$

$$\Rightarrow 10.20 = 13.6\times z^2\left[\frac{1}{9} - \frac{1}{(n+1)^2}\right]$$

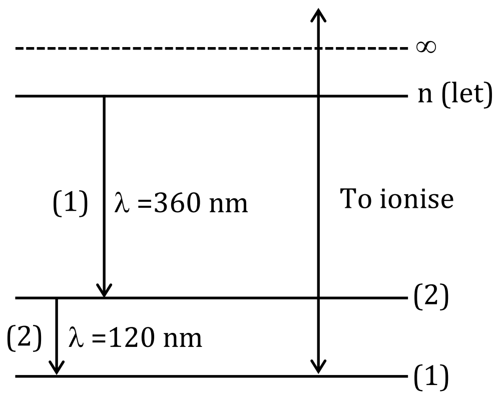
(I) – (II)

$$16.80 = 13.6\times z^2\left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\Rightarrow z^2 = \frac{16.80\times 9\times 4}{13.6\times 5}$$

$$\Rightarrow \boxed{z=3}$$

20. Ans. (90)



longest wavelength of lymen $\Rightarrow n_2 = 2$ to $n_1 = 1$; (λ = 120 nm)

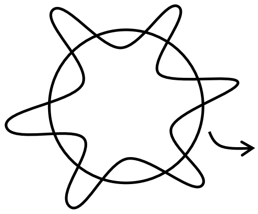
shortest wavelength of balmer $\Rightarrow n_2 = \infty$ to $n_1 = 2$; (λ = 360 nm)

$\because \quad E_{total} = E_1 + E_2$

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\Rightarrow \frac{1}{\lambda_3} = \frac{1}{360} + \frac{1}{120}\ ; \quad \boxed{\lambda_3 = 90\text{ nm}}$$

21. Ans. (3)



$2\pi r = n\lambda$
$n = 6$
Paschen lines = (6 – 3)
= 3

22. Ans. (8)

Hydrogen atom $\rightarrow$ 4^{th} orbit $\Rightarrow \lambda = a \times (\pi r_0)$

r_0 = radius of 1^{st} orbit

$\because\ 2\pi r = n\lambda$

$$\Rightarrow \lambda = \frac{2\pi r_4}{4} = a.\pi.r_1 \quad \Rightarrow \quad a = \frac{1}{2} \times \frac{r_4}{r_1} \Rightarrow a = \frac{1}{2} \times \frac{16}{1} = \boxed{8}$$

23. Ans. (8)

$\Delta x = \Delta p$ given

$\Delta V = x \times 10^{12}$, x = ?

Using Heisenberg's uncertainty principle

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

$$\text{So, } (\Delta P)^2 = \frac{h}{4\pi}$$

$$m^2(\Delta V)^2 = \frac{h}{4\pi} \Rightarrow \Delta V = \frac{1}{m}\sqrt{\frac{h}{4\pi}}$$

$$\Delta V = \frac{1}{9.1 \times 10^{-31}} \times \sqrt{\frac{6.6 \times 10^{34}}{4 \times 3.14}}$$

$$\Delta V = \frac{0.72 \times 10^{-17}}{9.1 \times 10^{-31}} = 7.91 \times 10^{2}\,m \quad \Rightarrow \quad x \times 10^{12}$$

x = 7.9148

24. Ans. (8)

Given $\Delta p_x = \Delta x$ (for an electron)

By Heisenberg principle

$$\Delta p_x.\Delta x = \frac{h}{4\pi}$$

$$\Rightarrow \Delta p_x.\Delta p_x = \frac{h}{4\pi}$$

$$\Rightarrow (m_e.\Delta v_x)^2 = \frac{h}{4\pi}$$

$$\Rightarrow (9.1 \times 10^{-31} \times x \times 10^{12}) = \frac{6.625 \times 10^{-34}}{2 \times 3.14}$$

$\therefore$ on solving, $\boxed{x = 8}$

25. **Ans. (5)**

Shape of orbital is double dumb-bell so it is d-orbital

From the curve, Radial node = 3

for d-orbital, angular node (l) = 2

so, answer is 3 + 2 = 5

26. **Ans. (6)**

At node $\Psi^2(r)=0$

$\Rightarrow \Psi(r)=0$

l = 0

n – l – 1 = 3 $\Rightarrow$ n = 4

$\Rightarrow(1-\sigma)(\sigma^2-8\sigma+12)=0$

When σ = 1 ⇒ $\frac{2r}{4a_0}$

r = $2a_0$

When $\sigma^2 - 8\sigma + 12 = 0$

σ = 6 & 2

When $\sigma=6$ & $\frac{2r}{4a_0}=6$

$\Rightarrow r=12a_0$

When $\sigma=2$

$\frac{2r}{4a_0}$ = 2 ⇒ r = $4a_0$

distance of nearest radial node = $2a_0$ = xa_0 ⇒ x = 2

distance of farthest radial node = $12a_0$

= ya_0

∴ y = 12

$\therefore \frac{y}{x}=\frac{12}{2}$ = 6

27. **Ans. (2)**

∵ The number of radial nodes for a subshell = n – ℓ – 1

Number of angular nodes for a subshell = ℓ

Hence, $\frac{\text{number of angular nodes of '3d'}}{\text{Number of radial nodes of 3p}}=\frac{x}{1}=\frac{2}{1}$

Hence, x = 2.

28. Ans. (3)

$n \leq 4$

	At lest two maxima i.e., (n–l) = 2	three maxima i.e., (n–l) = 3	four maxima n–l = 4
For n = 4	l = 2	l = 1	l = 0 (sphere)
n = 3	l = 1	l = 0 (sphere)	–
n = 2	l = 0 (sphere)	–	–
n = 1	–	–	–

so non–spherical subshells possible = 3

29. Ans. (9)

Here we need only $m_S = \left(-\frac{1}{2}\right)$, electrons

	Cr_{24} = $1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$4s^1$	$3d^5$
	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	↑	↑ ↑ ↑ ↑ ↑
$m_s = -\left(\frac{1}{2}\right)$ electron	= 1	1	3	1	3	0	0

if ↑ = $+\frac{1}{2}$spin

↓ = $-\frac{1}{2}$spin

then total electrons with $-\frac{1}{2}$spin = 9

30. Ans. (8)

$n = 1$ to ∞ , $\ell = 0$ to $(n + 1)$

$$\boxed{\begin{array}{ll} n=1 & ,\ell=0,1,2 \\ n=2 & ,\ell=0,1,2,3 \end{array}}$$

$\ell = 0$ (s)

$\ell = 1$ (p)

$\ell = 2$ (d)

$\ell = 3$ (f)

Aufbau's diagram

$\underbrace{(1s^2 \ \ 1p^6)}$ $\underbrace{(2s \ \ 1d \ 2p)}$

$8e^-$ can be filled for 2^{nd} shell start filling electron

$(1s^1\ 1p^0)$, $(1s^2\ 1p^0)$, $(1s^2\ 1p^1)$, $(1s^2\ 1p^2)$, $(1s^2\ 1p^3)$, $(1s^2\ 1p^4)$

$(1s^2\ 1p^5)$ $(1s^2\ 1p^6)$ = Represents Total 8 different elements

31. Ans. (0)

Here if $(n + \ell)$ rule not followed and filling of electron takes shell after shell then orbital energy order

$\Rightarrow$ 1s 2s 2p 3s 3p 3d 4s 4p ....

$\Rightarrow$ Electronic configuration of Fe

$\boxed{Fe_{26} = 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^8}$

Now <u>Hunds rule is not obeyed</u> then box diagram

$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$3d^8$
↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ □

$\Rightarrow$ Zero unpaired electron

32. Ans. (4)

Suitable value $|m| \le | \Rightarrow m = (-1, 0, +1)$

Ni_{28} =	$1s^2$	$2s^2$	$2p^6$			$3s^2$	$3p^6$			$4s^2$	$3d^8$				
	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑
m =	0	0	−1	0	+1	0	−1	0	+1	0	−2	−1	0	+1	+2
|m| =	0	0	+1	0	+1	0	+1	0	+1	0		+1	0	+1	

Total orbitals with m = (−1, 0,+1) $\Rightarrow$ 13

33. Ans. (2)

max. no of unpaired e^- in an orbital = 1

No of maximum unpaired e^-

In one 5g orbital = 1

In one 6g orbital = 1

Total = 2 electrons

34. Ans. (6)

Fe_{26} = $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2$

$[Ar]_{18}\ 3d^5\,4s^2$

Magnetic moment = 4.89 B.M.

$\sqrt{n(n+2)} = 4.89 \Rightarrow \boxed{n = 4}$

n = Unpaired electrons

$\Rightarrow$ $Fe^{+1} = [Ar]_{18}\ 3d^6\,4s^1$ [5 unpaired e^-]

min $Fe^{+2} = [Ar]_{18}\ 3d^6\,4s^0$ [4 unpaired e^-]

$Fe^{+3} = [Ar]_{18}\,3d^5\,4s^0$ [5 unpaired e^-]

max. $Fe^{+4} = [Ar]_{18}\,3d^4\,4s^0$ [4 unpaired e^-]

maximum value of 'x' = 4

minimum value of 'x' = 2

sum = 6

35. Ans. (1.60)

$q \times v = 1.6 \times 10^{-15}$ J

$\Rightarrow q \times 10{,}000 = 1.6 \times 10^{-15}$

$\Rightarrow q = 1.6 \times 10^{-19}$ J/V or coulomb

36. Ans. (1.28)

K.E. of $\alpha = 5.4 \times 10^6 \times 1.6 \times 10^{-19}$ Joule.

i.e. $r = \dfrac{Kq_1q_2}{K.E.}$

$= \dfrac{9\times10^9\times(1.6\times10^{-19})^2\times24\times2}{5.4\times10^6\times1.6\times10^{-19}}$

$= \dfrac{345.6\times10^{-10}\times2}{5.4\times106}$

$= \dfrac{691.2}{5.4}\times10^{-16}$ M

$= 128 \times 10^{-16}$ M

$= 1.28 \times 10^{-14}$ M

37. Ans. (0.50)

$\Rightarrow \dfrac{1}{2}mv^2 = \dfrac{kq_1q_2}{r}$; $k = 9 \times 10^9 \dfrac{Nm^2}{c^2}$; $q_1q_2 = z.e^2$

$\Rightarrow r = 2.\dfrac{kze^2}{K.E.}$ $\nearrow$ $r_p = \dfrac{2.k.1.e^2}{(KE)_p}$ ...(1)

$\searrow$ $r_\alpha = \dfrac{2.k.(2e).e}{(KE)_\alpha}$ ...(2)

Given $(KE)_p = (KE)_\alpha$

$\boxed{\dfrac{r_p}{r_\alpha} = \dfrac{1}{2}}$

38. Ans. (1.44)

For He particle $\Rightarrow m_{He} = 2\ m_p + 2.m_n$

$\approx 4.\ m_p$

Given,

$r = 2.4 \times 10^{-14}$ m

$z = 36$

we know, at distance of closest approach

KE = PE

$\dfrac{1}{2}mv^2 = \dfrac{kq_1q_2}{r}$

$$\Rightarrow \frac{1}{2}\times(4\times m_p)\times v^2 = \frac{(9\times10^9)\times(2.e)\times(36.e)}{2.4\times10^{-14}}$$

On putting values and solving, we get

$$\boxed{v = 1.44\times10^7 \text{ m/s}}$$

39. **Ans. (7.50)**

Given $\rightarrow$ 5000 waves in 20 cm

$\Rightarrow \bar{\upsilon}$ = number of waves per unit length

$$\bar{\upsilon} = \frac{5000}{20} = 250\,\text{cm}^{-1}$$

$$\Rightarrow \lambda = \frac{1}{\bar{\upsilon}} = \frac{1}{250}\text{cm} = \frac{1}{250}\times10^{-2}\text{ m}$$

$$\upsilon = \frac{c}{\lambda} = \frac{3\times10^8}{(10^{-2}/250)} = 7.5\times10^{12}\text{ Hz}$$

40. **Ans. (0.20)**

$$\nu = \frac{C}{\lambda}$$

Wave No. = $\frac{1}{\lambda} = \bar{\nu}$

$$\nu = C\bar{\nu}$$

$$\frac{\nu_1}{\nu_2} = \frac{\bar{\nu}_1}{\bar{\nu}_2}$$

$$\frac{\nu_1}{\nu_2} = \frac{4\times10^6\,\text{m}^{-1}}{\frac{2\times10^5}{10^{-2}}\text{m}^{-1}} = \frac{4\times10^6}{2\times10^7}$$

$$\frac{\nu_1}{\nu_2} = \frac{1}{5}$$

41. **Ans. (0.62)**

$$E = eV_0 = \frac{hc}{\lambda}$$

Given, $V_0 = 2\times10^4$ V

$$1.6\times10^{-19}\times2\times10^4 = \frac{6.626\times10^{-34}\times3\times10^8}{\lambda}$$

$$\lambda = \frac{6.626\times10^{-34}\times3\times10^8}{3.2\times10^{-15}} = 6.21\times10^{-11}\text{ m}$$

$= 0.621\text{Å}$

42. Ans. (7.50)

Wave number :- No. of waves present in unit length.

$$\bar{\nu} = \frac{5000}{20} = 250\,cm^{-1}$$

$$= 25000\,m^{-1}$$

$$\nu = C\bar{\nu}$$

$$= 3\times 10^8 \times 25000$$

$$= 7.5\times 10^{12}\ Hz$$

43. Ans. (2.66)

Radio waves travel at the speed of light

$\Rightarrow$ Distance = speed × time

$\Rightarrow$ $8 \times 10^5 \times 10^3\ m = 3 \times 10^8 \frac{m}{s} \times$ time

$\Rightarrow$ $\frac{8}{3}$ S = time

time = 2.66 sec.

44. Ans. (0.50)

Given λ_{abs} = 4000 Å

λ_{emit} = 5000 Å

Since

$$E_{abs} \times \frac{40}{100} = E_{emit}$$

$$\downarrow \qquad\qquad \searrow$$

$$\left\{n_{abs} \times \frac{hc}{\lambda_{abs}}\right\} \times \frac{40}{100} = \left(n_{emit} \times \frac{hc}{\lambda_{emit}}\right)$$

$$\Rightarrow \frac{n_{emit}}{n_{abs}} = \frac{5000}{4000} \times \frac{40}{100} = \frac{1}{2} = 0.5$$

45. Ans. (3.06)

K.E. = 3.06 eV

$$V_0 = \frac{K.E.}{q} = \frac{K.E.}{e} = \frac{3.06eV}{e}$$

V_0 = 3.06 volt

46. Ans. (3.06)

KE = 3.06 eV

To bring this e^- into rest

voltage required $= \frac{E}{q_e} = \frac{3.06}{e} eV = 3.06\,volts$

47. Ans. (a) 75.00; (b) 1.65

λ = 12.4 nm

$$E = \frac{1240}{\lambda_{nm}}(ev)$$

ϕ = 25 ev

(i) E = ϕ + KE

$$\frac{1240}{12.4} = 25 + KE$$

$$\boxed{KE = 75ev}$$

(ii) $\frac{1240}{\lambda_{nm}} = 75$

$$\lambda_{nm} = \frac{1240}{75}$$

$$\boxed{\lambda = 1.65Å}$$

48. Ans. (0.26)

$$r = \frac{n^2h^2}{4\pi^2 m.k.ze^2} \Rightarrow r = 0.529 \times \frac{n^2}{z} Å$$

Since mass is in Denominator

So, if mass is doubled then new radius of 1st orbit of H–atom (n = 1, z = 1)

$$r_{new} = \frac{0.529}{2} \times \frac{(1)^2}{1} = 0.2645Å$$

49. Ans. (5.40 to 5.50)

Given radius = 0.85 nm

$$\because\ 0.529 \times \frac{n^2}{z} \times 10^{-10} = 0.85 \times 10^{-9} \qquad (\because z = 1)$$

$$\Rightarrow n^2 = \frac{0.85 \times 10}{0.529}$$

$$\Rightarrow n \approx 4$$

$$v = 2.188 \times 10^6 \times \frac{z}{n} m/s$$

$$\Rightarrow v = 2.188 \times 10^6 \times \frac{1}{4} m/s$$

$$\Rightarrow \boxed{v = 5.47 \times 10^5 m/s}$$

50. Ans. (8.20 to 8.40)

$\because$ For 2nd orbit of hydrogen :–

$$\text{velocity} \rightarrow v = 2.188 \times 10^6 \times \frac{1}{2}$$

$$\text{radius} \rightarrow r = 0.529 \times 10^{-10} \times \frac{4}{1}$$

$$\text{Timpe period for } e^- = \frac{2\pi r}{v} = \frac{2 \times \pi \times 0.529 \times 10^{-10} \times 4 \times 2}{2.188 \times 10^6}$$

$$\because \text{ Number of revolutions } = \frac{\text{Total time period}}{\text{Time taken for one revolution}}$$

$$= \frac{10^{-8} \times 2.188 \times 10^6}{2 \times \pi \times 0.529 \times 10^{-10} \times 4 \times 2}$$

$$\approx \boxed{8} \times 10^6$$

51. Ans. (0.85)

$r_n = 16.r_1$

$$\Rightarrow 0.529\times\frac{n^2}{1}=\left(0.529\times\frac{1}{1}\right)\times 16$$

$$\Rightarrow \boxed{n=4}$$

$$E_4=-13.6\times\frac{z^2}{n^2}eV$$

$$E_4=-13.6\times\frac{1}{16}eV$$

$$\Rightarrow \boxed{E_4=-0.85eV}$$

52. Ans. (2.10 to 2.11)

$(En)_H = -3.4$ eV $\Rightarrow \boxed{n=2}$

$$\text{Angular momentum } =\frac{nh}{2\pi}=\frac{2h}{2\pi}$$

$$=\frac{2\times 6.6}{2\times\frac{22}{7}}\times 10^{-34}$$

$$\text{Angular momentum } =\boxed{2.1\times 10^{-34}}$$

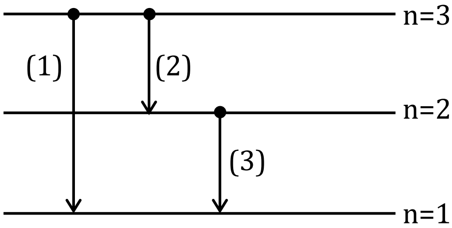
53. Ans. (6566.40; 1216.00; 1026.00)

Induced radiation wavelength $\Rightarrow \lambda$ = 1028 Å

Induced energy $\Rightarrow E=\frac{hc}{\lambda}=\frac{1240}{\lambda_{nm}}eV$

$$E=\frac{1240}{102.8}eV = 12.06\text{ eV}$$

for n = n to n = 1 $\Rightarrow$



ΔE = 12.06 eV

$E_n - E_1$ = 12.06 eV

So E_n = (– 13.6 + 12.06) = – 1.54 eV

related orbit with this energy $\Rightarrow$

$$E = -13.6\times\frac{z^2}{n^2}$$

$$1.54 = 13.6\times\frac{1}{n^2}$$

$$n^2=\frac{13.6}{1.54}\Rightarrow\boxed{n\approx 3}$$

So related wavelengths related to line 1, 2, 3 are $\Rightarrow$ 1026 Å, 1216 Å and 6563Å respectively.

54. **Ans.** $\left(E=\frac{n^6h^6}{384\times\pi^6.m^3\cdot k^2\cdot e^4}\right)$

$\because \quad PE=-\frac{ke^2}{3r^3}$

$\because \quad dE = F.dr$

$\Rightarrow \quad F=\frac{dE}{dr}=\frac{\delta}{dr}\left(\frac{-ke^2}{3r^3}\right)=\frac{ke^2}{r^4}$

First postulate $\rightarrow \frac{mv^2}{r}=\frac{ke^2}{r^4} \Rightarrow mv^2=\frac{ke^2}{r^3}$ ...(1)

Second postulate $\rightarrow mvr=\frac{nh}{2\pi} \Rightarrow m^2r^2r^2=\frac{n^2h^2}{4\pi^2}$ ...(2)

$\frac{2}{1}$

$\Rightarrow \quad \frac{m^2v^2r^{12}}{m.v^2}=\frac{n^2h^2}{4\pi^2}\times\frac{r^3}{ke^2}$

$\Rightarrow \quad r=\frac{4\pi^2m.ke^2}{n^2h^2}$ ...(3)

As we know, $TE=\frac{PE}{2}=-\frac{1}{2}\times\frac{ke^2}{r^3}$ ...(4)

putting value of r from equation (3),

we get $TE=\frac{n^6h^6}{384\times\pi^6.m^3\cdot k^2\cdot e^4}$

55. **Ans. (435.20)**

$E=\frac{2\pi^2mz^2e^4}{n^2.h^2}=-13.6\times\frac{z^2}{n^2}$ (ev)

New case: $E_{new}=\frac{2\pi^2(2m).z^2.(2e)^4}{n^2h^2}=-32\times 13.6\times\frac{z^2}{n^2}$

for 1st orbit of H–atom $\Rightarrow E_{new} = -32 \times 13.6 = -435.2$ eV

56. **Ans. (9.68 or 9.69)**

Given, angular momentum, $mvr=\frac{nh}{2\pi}=3.1652\times 10^{-34}$

$\downarrow$

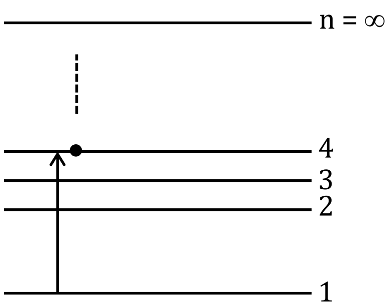
$\boxed{n=3}$

For H–atom, from n = 3 to n = 1

$\vec{v}=R(1)^2\left[1-\frac{1}{g}\right]$

$\vec{v}=\frac{8R}{9}=\boxed{9.69}\times 10^{+6}\,m^{-1}$

57. Ans. (972.54 or 972.55)



$$\frac{1}{\lambda} = R(1)^2\left[1-\frac{1}{16}\right]$$

$$\lambda = \frac{16}{15}\times\frac{1}{R}$$

$$\Rightarrow \boxed{\lambda \approx 972.55\,\text{nm}}$$

58. Ans. (300.00, 0.26)

Given : $13.6 \times z^2(1-0) = 4$ Rydberg's

$\Rightarrow 13.6 \times 1.6 \times 10^{-19} \times z^2 = 4 \times 2.20 \times 10^{-18}$

Joule Joule

$$\Rightarrow z^2 = \frac{4\times2.20\times10^{-18}}{13.6\times1.6\times10^{-19}} \Rightarrow \boxed{z=2}$$

(i) from n = 2 to n = 1, $\frac{1}{\lambda} = R(2)^2\left(1-\frac{1}{4}\right)$

$$\Rightarrow \boxed{\lambda = 300\text{Å}}$$

(ii) $r = 0.529\times\frac{n^2}{z}$ for first orbit : n = 1

$$r_{\perp} = \frac{0.529}{2}\,\text{Å}$$

$$\boxed{r_{\perp} = 0.26\text{Å}}$$

59. Ans. (6.03)

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$V = \frac{h^2}{2me\lambda^2}$$

$$= \frac{(6.62\times10^{-34})^2}{2\times9.1\times10^{-31}\times1.6\times10^{19}\times(500\times10^{-10})^2}$$

$\Rightarrow \quad 6.03\times10^{-4} = (y\times10^{-4})$

y = 6.03

60. Ans. (0.11)

Proton is accelerated to one tenth of velocity of light

$v = \frac{c}{10}$, c = 3 × 10^8

Since, velocity can be measured with a precision ± 1%

So, $\Delta V = \frac{c}{10} \times 0.01 = 3 \times 105$ m/sec

Now Δx = ?, $m_p = 1.67 \times 10^{-27}$ kg

As we know

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

$$\Delta x.m\Delta V = \frac{h}{4\pi}$$

$$\Delta x = v = \frac{h}{4\pi} \times \frac{1}{m.\Delta V}$$

$$\Delta x = 5.2 \times 10^{-35} \times \frac{1}{1.67 \times 10^{-27} \times 3 \times 10^5} = 1.03 \times 10^{-13}$$

$\Delta x = 1.03 \times 10^{-13}$m

$\Delta x = 1.03 \times 10^{-13}$ m

61. Ans. (0.17)

m = 9.1 × 10^{-31} kg

v = 3 × 10^4 cm/s = 3 × 10^2 m/s (error = 0.011%)

$$\Delta v_x = \left(3 \times 10^2 \times \frac{0.011}{100}\right)$$

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

on solving, we get

$\boxed{\Delta x = 0.17}$ cm

62. Ans. (0.50)

m = 10^{-3} gm = 10^{-6} kg,

d = 2Å

= 2 × 10^{-10} m

$$\Delta v_x = \frac{3.31}{\pi} \times 10^{-3}$$

$$\Delta p_x.\Delta x = \frac{h}{4\pi}$$

$$\Rightarrow m.\Delta v_x.\Delta x = \frac{h}{4\pi}$$

$$\Rightarrow 10^{-6} \times \frac{3.31 \times 10^{-3}}{\pi} \times \Delta x = \frac{6.62 \times 10^{-34}}{4 \times \pi}$$

$$\Rightarrow \boxed{\Delta x = 5 \times 10^{-26}\,m}$$

63. Ans. (3.75)

The spherical nodes will be present, where $\psi_R^2 .dv = 0$ or $\psi_R^2 = 0$ or $\psi_R = 0$

$\psi_{3s} = R_{3s} = \dfrac{1}{9\sqrt{3}a_1^{3/2}}(6.6\sigma + \sigma^2)e^{-\sigma/2} = 0$ (where $\sigma = \dfrac{2r}{na_0}$)

6 – 6s + s^2 = 0

$$\sigma = \frac{6 \pm \sqrt{36-24}}{2}$$

$\sigma = \dfrac{6 \pm \sqrt{36-24}}{2} \Rightarrow \dfrac{2r}{na_0} = \dfrac{6 \pm 2\sqrt{3}}{2}$ (where n = 3)

$$r = \frac{9+3\sqrt{3}}{2}a_0, \frac{9-3\sqrt{3}}{2}a_0$$

64. Ans. (0.63)

B^{+4} $\quad R(r) = \dfrac{1}{9\sqrt{6}} . \left(\dfrac{z}{a_0}\right)^{3/4} .(4-\sigma).\sigma.e^{-\sigma/2}$

↓ ↓

z = 5 $\quad \ell = 1$

$a_0 = 0.529$Å $\quad n - \ell - 1 = 1$

n = 3

for radial node $\psi(r) = 0$

i.e., $4 - \sigma = 0$

$$\Rightarrow \sigma = \frac{2zr}{na_0} = 4$$

$$\Rightarrow r = \frac{4 \times 3 \times 0.529}{2 \times 5} = 0.63\text{Å}$$

65. Ans. (i) 2.00; (ii) 9.60 to 9.80

Given $\dfrac{v}{c} = \dfrac{1}{275}$

$$\Rightarrow v = \frac{c}{275}$$

$$\Rightarrow 2.188 \times \frac{z}{n} \times 10^6 = \frac{3 \times 10^8}{275}$$

$$\Rightarrow \boxed{n = 2}$$

$$\Rightarrow \bar{\upsilon} = R \times 1 \times \left[1 - \frac{1}{9}\right]$$

$\because E = -13.6 \times \dfrac{z^2}{n^2}$

$\therefore E_{(n+1)} - E_n = \Delta E$

$$\bar{\upsilon} = RZ^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\boxed{\begin{array}{l} n_2 \xrightarrow{\text{to}} n_1 \\ n = (2+1) \xrightarrow[\text{to}]{} n = 1 \\ n = 3 \end{array}}$$

putting the value of R (Rydberg constant we get,

$$\Rightarrow \bar{\upsilon} \approx 9.6 \times 10^{+6} \text{m}^{-1}$$

66. Ans. (a) Z = 3 ; (b) n_1 = 12 , n_2 = 15 ; (c) 0.08

Given: Six different wavelength observed that means six spectrum lines observed.

i.e. $\frac{(n_2-n_1)(n_2-n_1+1)}{2}=6$

$\Rightarrow \boxed{n_2-n_1=3}$ ...(1)

since,

$\because \quad E_{n_2}=-13.6\times\frac{z^2}{n_2^2} = -0.544$ ...(2)

$E_{n_1} = -13.6 \times \frac{Z^2}{n_1^2} = -0.85$ ...(3)

$\frac{(3)}{(2)}\Rightarrow\frac{n_2^2}{n_1^2}=\frac{0.85}{0.544}\Rightarrow\boxed{\frac{n_2}{n_1}=\frac{5}{4}}$ ...(4)

from equation (1) & (4), we get $\Rightarrow n_2-\frac{4}{5}n_2=3 \Rightarrow \boxed{\begin{matrix}n_2=15\\ n_1=12\end{matrix}}$ ...(5)

from equation (2) & (5), we get $\Rightarrow 13.6\times\frac{z^2}{225} = 0.544$

$\Rightarrow \boxed{Z=3}$ ...(6)

from maximum wavelength $\Rightarrow$ {n = 15 $\rightarrow$ n = 14}

So energy of longest wavelength $\Rightarrow \Delta E = E_{15} - E_{14}$

$\Rightarrow \quad \Delta E = 13.6 \times (3)^2 \left[\frac{1}{(14)^2}-\frac{1}{(15)^2}\right]$

$\boxed{\Delta E=0.08 \text{ eV}}$

EXERCISE - JEE (Main) PYQ

1. Ans. (3)

The theory given by the Dalton was for the atoms and its properties, it does not depend on volume.

C option is wrong.

2. Ans. (798)

For one photon E = hv

For one mole photon,

$E=6\cdot023\times10^{23}\times6\cdot626\times10^{-34}\times2\times10^{12}$

$= 798\cdot16$ J

≈ 798 J

3. Ans. (2)

Total energy per sec. = 50 J

$$50 = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^{8}}{795 \times 10^{-9}}$$

$n = 1998.49 \times 10^{17}$ [n = no. of photons per second]

$= 1.998 \times 10^{20}$

$\simeq 2 \times 10^{20}$

$= x \times 10^{20}$

$x = 2$

4. Ans. (3)

$W = h\nu_\circ$

$= 6.6 \times 10^{-34} \times 1.3 \times 10^{15}$

$= 8.58 \times 10^{-19}$ J

5. Ans. (10)

5^{th} excited state $\Rightarrow n_1 = 6$

1^{st} excited state $\Rightarrow n_2 = 2$

$\Delta n = n_1 - n_2 = 6 - 2 = 4$

Maximum number of spectral lines

$$= \frac{\Delta n(\Delta n + 1)}{2} = \frac{4(4+1)}{2} = 10$$

6. Ans. (494)

$$E = \frac{1240}{\lambda(\text{nm})} \text{eV}$$

$$= \frac{1240}{242} \text{eV}$$

$= 5.12$ eV

$= 5.12 \times 1.6 \times 10^{-19}$

$= 8.198 \times 10^{-19}$ J/atom

$= 494$ kJ/mol

7. Ans. (4)

$$E_n = \frac{-2.18 \times 10^{-18} Z^2}{n^2}$$

$$\text{i.e. } E_n \propto \frac{1}{n^2}$$

8. Ans. (4)

$a_0 = 0.529$ Å

$$r = a_0 \times \frac{n^2}{z} \quad (n = 2, z = 3)$$

$$\Rightarrow a_0 \times \frac{4}{3}$$

$$\Rightarrow \frac{4a_0}{3}$$

9. Ans. (4)

$r = 0.529 \times \dfrac{n^2}{z}$Å

$\Rightarrow \quad 0.529 \times \dfrac{(2)^2}{1}$

$\Rightarrow \quad 2.12$ Å

10. Ans. (1)

$E_1 = \dfrac{hc}{\lambda} = 2.178 \times 10^{-18} \left[\dfrac{1}{1^2}\right]$

$E_2 = \dfrac{hc}{\lambda} = 2.178 \times 10^{-18} \left[\dfrac{1}{2^2}\right]$

So, $E = E_2 - E_1$

$E = \dfrac{hc}{\lambda} = 2.178 \times 10^{-18} \left[\dfrac{1}{1^2} - \dfrac{1}{2^2}\right]$

$E = \dfrac{hc}{\lambda} = 2.178 \times 10^{-18} \left(\dfrac{3}{4}\right)$

$\Rightarrow \lambda = 1.214 \times 10^{-7}$ m

11. Ans. (3)

A – II, B – IV, C – III, D – I

Fact based.

12. Ans. (2)

For H: $\dfrac{1}{\lambda} = R_H \times 1^2 \left(\dfrac{1}{1^2} - \dfrac{1}{\infty^2}\right)$ ...(1)

$\dfrac{1}{\lambda_{He^+}} = R_H \times 2^2 \times \left(\dfrac{1}{4} - \dfrac{1}{9}\right)$ ...(2)

From (1) & (2) $\dfrac{\lambda_{He^+}}{\lambda} = \dfrac{9}{5}$

$\lambda_{He^+} = \lambda \times \dfrac{9}{5}$

$\lambda_{He^+} = \dfrac{9\lambda}{5}$

13. Ans. (2)

$\bar{\nu} = R_H \left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$

(I) As the wavelength decreases the energy increases and formed a converging series.

(II) For Balmer series $n_1 = 2$

(III) At longest wavelength, the higher state energy will be minimum therefore excited state will be $n_2 = 3$.

(IV) $E = 13.6 \dfrac{z^2}{n^2}$ for H atom z = 1

So, we cannot find ionization energy directly by only wave number, we also required transition state(n) value.

14. Ans. (4)

For emission line. ($n_i = 8 \rightarrow n_f = n$)

$\bar{v} = R_H Z^2 \left(\frac{1}{n^2} - \frac{1}{64}\right)$ {z = 1, for H}

$\bar{v} = \frac{R_H}{n^2} - \frac{R_H}{64}$

y = mx + c

graph of $\bar{v}$ us $\frac{1}{n^2}$ will be linear with slope R_H and intercept

15. Ans. (2)

$\frac{1}{\lambda} = RZ^2 \left(\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right)$

Here if $n_f = 3$ and $n_i = \infty$

$\frac{1}{\lambda} = 10^7 \times 1^2 \left(\frac{1^2}{3^2} - \frac{1}{\infty^2}\right)$

λ = 900 nm

16. Ans. (2)

$$\frac{\frac{1}{\lambda_2} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2}{\frac{1}{\lambda_1} = R_H\left(\frac{1}{m_1^2} - \frac{1}{m_2^2}\right)Z^2}$$

As for shortest wavelengths both n_2 and m_2 are ∞

$\therefore \frac{\lambda_1}{\lambda_2} = \frac{9}{1} = \frac{m_1^2}{n_1^2}$

$m_1 = 3$

$n_1 = 1$

17. Ans. (2)

Limiting line of Balmer series ($\infty \rightarrow 2$)

$v = 3.29 \times 10^{15} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) s^{-1}$

$= 3.29 \times 10^{15} \times \frac{1}{4} = 8.22 \times 10^{14}\ s^{-1}$

18. Ans. (1)

According to Bohr's model the angular momentum is quantised and equal to $\frac{nh}{2\pi}$.

Heisenberg uncertainty principle explains orbital concept, which is based on probability of finding electron.

19. Ans. (1)

According to Bohr's postulates, radii of the n^{th} and 1^{st} orbit are related to

$r_n = n^2 r_1$ ...(1)

$2\pi r_n = n\lambda_n$

$2\pi(n^2 r_1) = n\lambda_n \longrightarrow$ from equation (1)

$\Rightarrow 2\pi r_1 n = \lambda_n$

For n = 4

$2\pi r_1 \times 4 = \lambda_4$ $\qquad r_1 = a_0$

$8\pi a_0 = \lambda_4$

20. Ans. (2)

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

K.E. → 4 K.E.

$\lambda_1 = \frac{h}{\sqrt{2(4K.E.)m}}$

$\lambda_1 = \left(\frac{\lambda_2}{2}\right)$

21. Ans. (1)

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

$mvr = \frac{nh}{2\pi} \Rightarrow \frac{h}{mv} = \frac{2\pi r}{n}$

$\lambda = \frac{2\pi r}{n}$

$r = a_0 \times \frac{n^2}{1}$

$\therefore \lambda = 2\pi a_0 \times n$

For 3^{rd} orbit n = 3

$\therefore \lambda = 6\pi a_0$

22. Ans. (4)

At node $\Psi_{2s} = 0$

$\therefore 2 - \frac{r_0}{a_0} = 0$

$\therefore \quad r_0 = 2a_0$

23. Ans. (1)

For 3p : n = 3, ℓ = 1

Number of radial node = n – ℓ – 1

= 3 – 1 – 1 = 1

24. Ans. (2)

(A) n = 3; l = 0; m = 0 ; 3s orbital

(B) n = 4; l = 0; m = 0 ; 4s orbital

(C) n = 3; l = 1; m = 0 ; 3p orbital

(D) n = 3; l = 2; m = 0 ; 3d orbital

As per Hund's rule energy is given by (n+*l*) value. If value of (n+*l*) remains same then energy is given by n only.

25. Ans. (2)

no. of orbitals in a given shell (n) = n^2

So, in 5^{th} shell no. of orbitals $= (5)^2$

$= 25$

26. Ans. (2)

As the value of $(n+\ell)$ increases energy increases. In case of same value of $(n+\ell)$ energy increases with increase in value of 'n'.

		$(n+\ell)$
(I) n = 4,	$\ell = 2$	6
(II) n = 3,	$\ell = 2$	5
(III) n = 4,	$\ell = 1$	5
(IV) n = 3,	$\ell = 1$	4

So, increasing order of energy.

(iv) < (ii) < (iii) < (I)

27. Ans. (1)

Number of orbitals in given shell = n^2

So, in 5^{th} shell number of orbitals $= (5)^2 \Rightarrow 25$

28. Ans. (1)

For single electron species the energy depends upon principal quantum number 'n' only. So, statement II is false.

Statement I is correct definition of degenerate orbitals.

29. Ans. (4)

Electronic Configuration of element X with atomic number 71 is $[Xe]4f^{14}6s^2 5d^1$.

The last electron will enter in 5d orbital.

EXERCISE - JEE (ADVANCED) PYQ

1. Ans. (D)

Rutherford used α–particles in his experiment.

2. Ans. (30)

$$\lambda = \frac{h}{p} \Rightarrow p = \frac{6.6\times10^{-34}}{330\times10^{-9}} = \frac{4\times10^{-3}}{6\times10^{23}}\times v \quad (p = m\times v)$$

v = 0.3 m/s = 30 cm/s

3. Ans. (4)

Energy associated with λ = 300nm

$$\Rightarrow E = \frac{1240}{300} = 4.13\text{eV}$$

For photoelectric effect to take place, $E \geq \phi$

Metals which will show photoelectric effect : Li, Na, K, Mg

4. Ans. (B)

$$KE = +13.6 \times \frac{Z^2}{n^2}$$

(A) $KE_{1,H} = +13.6 \times \frac{1^2}{1^2} = 13.6\,eV$

(B) $KE_{1,He^+} = +13.6 \times \frac{2^2}{1^2} = 13.6 \times 4$ eV

(C) $KE_{2,He^+} = +13.6 \times \frac{2^2}{2^2} = 13.6$ eV

(D) $KE_{2,Li^{2+}} = +13.6 \times \frac{3^2}{2^2} = 13.6 \times \frac{9}{4}$ eV

5. Ans. (30)

For single electron system

$$r = 52.9 \times \frac{n^2}{Z} \text{ pm}$$

Given Z = 2 for $He^{\oplus}$

$r_2 = 105.8$ pm

So, $105.8 = 52.9 \times \frac{n_2^2}{2}$

$n_2 = 2$

$r_1 = 26.45$

So, $26.45 = 52.9 \times \frac{n_1^2}{2}$

$n_1 = 1$

So, transition is from 2 to 1.

Now $\frac{hc}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

So $\lambda = 30 \times 10^{-9}$ m = 30 nanometer.

Here 'R_H' is given in terms of energy value.

6. Ans. (C)

Radius of n^{th} orbit : $r_n = 0.529 \frac{n^2}{z}$ Å

Angular momentum of e^- in n^{th} orbit : $\frac{nh}{2\pi}$

K.E. energy of e^- in n^{th} orbit : $13.6\frac{z^2}{n^2}$ eV / atom

P.E. energy of e^- in n^{th} orbit : $-27.2\frac{z^2}{n^2}$ eV / atom

Option (C) is correctly matched

7. Ans. (D)

(A) Radius of the n^{th} orbit

$$r_n \propto \frac{n^2}{z}$$

(B) Angular momentum

$$mvr = \frac{nh}{2\pi}$$

(C) Kinetic Energy of the electron $\propto \frac{z^2}{n^2}$

(D) Potential Energy of the electron $\propto \frac{z^2}{n^2}$

8. Ans. (C)

According to Bohr's model

$$mvr = \frac{nh}{2\pi}$$

$$\Rightarrow mv = \frac{nh}{2\pi r}$$

$$\Rightarrow mv^2 = \frac{n^2h^2}{(2\pi r)^2 m} = \frac{n^2h^2}{4\pi^2 r^2 m}$$

$$\Rightarrow K.E. = \frac{1}{2}mv^2 = \frac{n^2h^2}{8\pi^2 r^2 m}$$

For H – atom, $r = n^2 a_0$

$$\Rightarrow K.E. = \frac{n^2h^2}{8\pi^2 n^4 a_0^2 m} = \frac{h^2}{8\pi^2 n^2 a_0^2 m}$$

For n = 2 (second orbit)

$$\Rightarrow K.E. = \frac{h^2}{32\pi^2 m a_0^2}$$

9. Ans. (D)

(1) P.E = -2 K.E

$$\frac{P.E}{K.E} = -2$$

(2) $r_n \propto \frac{n^2}{Z}$, $E \alpha \frac{Z^2}{n^2}$

$$r_n \propto n^2,\ E \alpha \frac{1}{n^2}$$

$$\frac{1}{r_n} \alpha E^x$$

x = 1

(3) $r_n \propto \frac{n^2}{Z}$

$r_n \, \alpha \, Z^{-1}$

$r_n \, \alpha \, Z^{y}$

$y = -1$

(4) For n = 1 $\ell = 0$

Angular momentum = 0

10. **Ans. (A)**

$V = 2.197 \times 10^6$ m/s ;

11. **Ans. (D)**

Radius as per Bohr's model

$r = 0.529 \frac{n^2}{z} \text{Å}$

Radius of first orbit of hydrogen

$r = 0.529(1)^2 = 0.529\text{Å}$

Radius of n=2 for $Be^{3\oplus}$

$r = 0.529 \times \left(\frac{2^2}{4}\right) = 0.529\,\text{Å}$

[same as first orbit of H–atom]

12. **Ans. (B)**

$2\pi r = n\lambda$, $\lambda = 3.32$ Å ;

13. **Ans. (A,B,C)**

(A) Uncertainity principle talks about probability of finding electrons in different regions around the nucleus rather than definite paths.

(B) With increase in distance of electron from the nucleus, its energy increases.

(C) Energy of electron $E_n = -13.6 \times \frac{Z^2}{n^2}$ eV/atom.

(D) Velocity of electron $V_n = 2.19 \times 10^6 \times \frac{Z}{n}$ m/sec.

14. **Ans. (B)**

Radial probability distribution graph for 1s orbital is represented by (B)

15. **Ans. (B)**

Since s, is spherically symmetrical (ℓ=0), it corresponds to s–subshell and since it has one radial node

$\Rightarrow$ $n - \ell - 1 = 1$ [No. of radial nods]

$\Rightarrow$ $n - 0 - 1 = 1$

$\Rightarrow$ $n = 2$

$\Rightarrow$ 2s

16. Ans. (C)

Energy of e^- in ground state of H – atom.

$\Rightarrow E = -13.6\frac{z^2}{n^2} = -13.6\,eV/atom$

For S_1 of Li^{+2} i.e., 2s orbital

$\Rightarrow E = -13.6\frac{3^2}{2^2} = -\frac{9}{4}\times 13.6\ eV/atom$

Energy of S_1 = $\frac{9}{4}$ × Energy of ground state of H – atom

= 2.25 × Energy of ground state of H – atom

17. Ans. (B)

At state S_2, energy is equal to ground state energy of H – atom

$\Rightarrow Es_2 = -13.6\frac{3^2}{n^2} = -13.6\left(\frac{1^2}{1^2}\right)$

$\Rightarrow n = 3$

Since state S_2 has one radial node $\Rightarrow n - \ell - 1 = 1$

$\Rightarrow 3 - \ell - 1 = 1$

$\Rightarrow \ell = 1$

$\Rightarrow$ 3p

18. Ans. (A)

At node e^- finding probability is zero

$\Rightarrow |\Psi^2| = 0$ so $\Psi = 0$

$\Rightarrow 2 - \frac{r_0}{a_0} = 0$

$\Rightarrow r_0 = 2a_0$

19. Ans. (D)

For H – like species D is correct

In (A) For $3d_{z^2}$ xy plane is not a nodal plane

In (B) $2p_z$ orbital has no radial node

In (C) 1s orbital has no radial node

20. Ans. (A)

For 1s orbital is non-directional so Ψ will not depend upon $\cos\theta$

21. Ans. (C)

For H – atom 1s orbital $\Psi \propto \left(\frac{Z}{a_0}\right)^{3/2} e^{-\left(\frac{Zr}{a_0}\right)}$

In hydrogen $E_4 - E_2 = \frac{3}{16}$

$E_6 - E_2 = \frac{2}{9}$

Hence $(E_6 - E_2)\times\frac{27}{32} = E_4 - E_2$

22. **Ans. (C)**

Orbital angular momentum $= \frac{h}{2\pi}\sqrt{\ell(\ell+1)} = \sqrt{2}.\frac{h}{2\pi}$

23. **Ans. (A,C)**

For He^{+} atom, $E = -13.6\left[\frac{2^2}{n^2}\right] = -3.4$

$n = 4$

and since $\ell = 2$, $m = 0$

$\Rightarrow$ It represents 4d subshell $\Rightarrow$ 4d orbital which will have 2 angular nodes, 1 radial node.

24. **Ans. (6)**

$n = 4$; $\ell = 0, 1, 2, 3$

Also $|m_1| = 1$; $m_\ell = (+1)$ and (-1)

$\ell = 0 \longrightarrow m = 0$

$\ell = 1 \longrightarrow m = -1, 0, +1$

only circled values are permitted

$\ell = 2 \longrightarrow m = -2, -1, 0, +1, +2$

$\ell = 3 \longrightarrow m = -3, -2, -1, 0, +1, +2, +3$

$\Rightarrow$ Total permitted values of $m_\ell = 6$

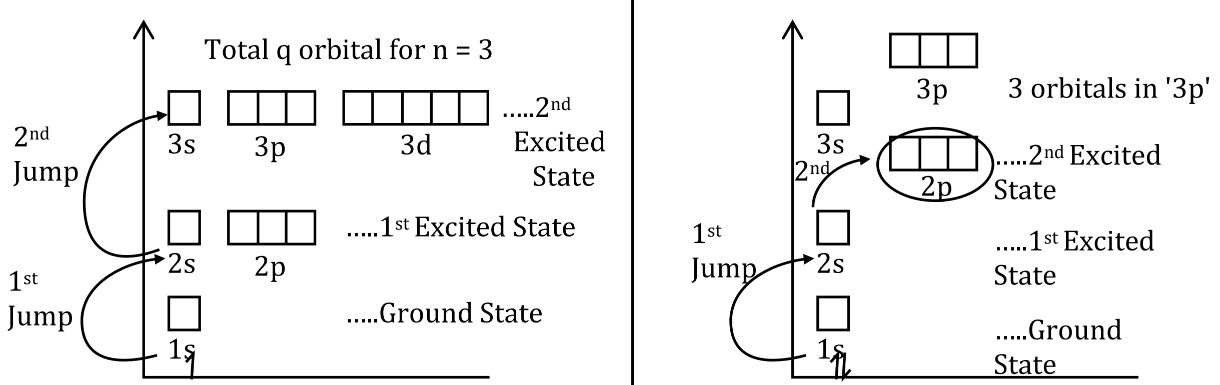
$\Rightarrow$ Since $m_s = -\frac{1}{2}$, only one e^- will counted in each orbital

Total $e^- = 6 \times 1 = 6$

Answer = 6.

25. **Ans. (3)**

Energy level diagrams



'H' or single electron system

$H^{\ominus}$ $(2e^{\ominus})$ or multi electron system

$\Rightarrow$ For a single $e^{\ominus}$ system, the value of degeneracy (number of orbitals having same energy) is equal to total number of orbitals in s shell

For H ; in n = 3 , total orbitals = $3^2 = 9$

$\Rightarrow$ This means total 9 degenerate orbitals are present in second excited state (n=3) of H. (Given in question)

$\Rightarrow$ Now H is like He (a multi electron system) and in multi-electronic system, energy of subshells is based on AUFBAU's RULE

Hence the e^- present in is will 1^{st} excite to 2s and then to 2p.

$\Rightarrow$ Hence 2^{nd} excited state for H = 2p

In 2p, only 3 degenerate orbitals are present.

Answer = 3

26. **Ans. (9)**

For n = 3 $\Rightarrow$ 3s, 3p, 3d

subshell are possible each subshell's orbital can have $1e^{\ominus}$ each with s = $-\frac{1}{2}$

$\Rightarrow$ 3s $\Rightarrow$ $1e^{\ominus}$

$\Rightarrow$ 3p $\Rightarrow$ $3 \times 1 = 3e^{\ominus}$

$\Rightarrow$ 3d $\Rightarrow$ $5 \times 1 = 5e^{\ominus}$

Total electrons = 5 + 3 + 1 = $9e^{\ominus}$

27. **Ans. (A)**

(A) Q, R ; (B) P, Q, R, S ; (C) P, Q, R ; (D) P, Q

(A) Orbital angular momentum (L) = $\sqrt{\ell(\ell+1)}\,\frac{h}{2\pi}$

L depends on azimuthal quantum number

(B) To describe hydrogen like one electron atom's obeying Pauli's principle as a wave function all four quantum numbers i.e. n, ℓ, m, s are needed.

(C) To describe shape, size and orientation only n, ℓ, and m are needed.

(D) Probability density (Ψ^2) can be determined is n, ℓ, and m are known.