TOPIC : ATOMIC STRUCTURE
EXERCISE # 1

SECTION (A)

9. Net charge is –1. (17 e+ 18 p)

12. Isoelectronic species should have same number of electrons.

13. It is fact.

14. It is fact.

SECTION (B)

1. More energy means less wavelength.

2. Violet colour has minimum wavelength so maximum energy.

3. $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \ \ ms^{-1}}{600 \times 10^{-9} m} = 5.0 \times 10^{14} Hz$

5. (1) $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{400 \times 10^{-9}} = 7.5 \times 10^{14}$ Hz.

(2) $\bar{\nu} = \frac{1}{\lambda} = \frac{1}{400 \times 10^{-9}} = 2.5 \times 10^6 \ m^{-1}$

(3) It is a fact

7. $\lambda = \frac{12400}{2} A^o = 6200 \ A^o$

9. λ (in Å) = $\frac{12400 \ \ eVÅ}{4eV}$ = 3100 Å.

10. $\lambda = \frac{hc}{E} = \frac{(6.63 \times 10^{-34} J \ . \ s)(3.00 \times 10^8 m/s)}{3.31 \times 10^{-20} J} = 6.01 \times 10^{-6}$ m.

11. For photoelectric effect to take place, $E_{light} \geq W \ \therefore \ \frac{hc}{\lambda} \geq \frac{hc}{\lambda_0}$ or $\lambda \leq \lambda_0$.

15. The number of photoelectrons emitted depend on the intensity or brightness of incident radiation.

SECTION (C)

2. Bohr radius = $= \frac{r_2}{r_1} = \frac{(2)^2}{(1)^2} = 4$

7. Radius of He^+ is = $\frac{0.53}{2} = 0.265Å$

8. Radius of ground state of hydrogen atom = 0.529 Å

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

$0.529 = 0.529 \times \frac{n^2}{4} \qquad \therefore \qquad n = 2$

9. $v_3 = v_1 \times \left(\frac{Z}{n}\right)$

$v_3 = 2.18 \times 10^6 \times \left(\frac{1}{3}\right) = 7.27 \times 10^5$ m/s

11. Angular momentum J = mvr

$J^2 = m^2v^2r^2$ or $\frac{J^2}{2} = \left(\frac{1}{2}mv^2\right) mr^2$ or K.E. = $\frac{J^2}{2mr^2}$

14. It is fact.

17. $\because$ Total energy (E_n) = KE + PE

In first excited state = $\frac{1}{2}mv^2 + \left[-\frac{ze^2}{r}\right] = +\frac{1}{2}\frac{Ze^2}{r} - \frac{ze^2}{r} - 3.4 \text{ eV} = -\frac{1}{2}\frac{Ze^2}{r}$ $\therefore$ KE = = + 3.4 eV

22. E_1 for Li^{+2} = E_1 for H × Z^2 [for Li, Z = 3] = 13.6 × 9 = **122.4 eV**

23. 1.51 Z^2 = 13.6. So, Z = 3 (Li^{+2})

25. Given binding energy of Ist excited state (n = 2) = 54.4 eV

$\Rightarrow$ 3.4 Z^2 = 54.4 eV $\Rightarrow$ Z^2 = 16 $\Rightarrow$ Z = 4

26. $40.8 = (\Delta E)_{2\to1} \times Z^2$ $\Rightarrow$ $40.8 = 10.2 \times Z^2$ $\Rightarrow$ $Z^2 = 4$ or Z = 2

IE = 13.6 Z^2 = 13.6 × 4 = 54.4 eV

27.

(1) Energy of ground state of He^+	$= -13.6 \times 2^2 = -54.4$ eV	(iv)
(2) Potential energy of I orbit of H-atom	$= -27.2 \times 1^2 = -27.2$ eV	(ii)
(3) Kinetic energy of II excited state of He^+	$= 13.6 \times \frac{2^2}{3^2} = 6.04$ eV	(i)
(4) Ionisation potential of He^+	$= 13.6 \times 2^2 = 54.4$ V	(iii)

SECTION (D)

7. For 1st line of Balmer series ($3 \to 2$)

$E_3 - E_2 = \frac{hc}{\lambda}$

9. Visible lines $\Rightarrow$ Balmer series $\Rightarrow$ 3 lines. ($5 \to 2$, $4 \to 2$, $3 \to 2$).

10. When electron falls from n to 1, total possible number of lines = n – 1.

13. For Bracket Series, electrons jump from high energy level to 4th energy level
if high energy level is 10th ,then number of spectral line belong to bracket series is 6
(5 to 4), (6 to 4) , (7 to 4),(8 to 4) , (9 to 4) and (10 to 4)

SECTION (E)

1. An electron has particle and wave nature both.

2. For a charged particle $\lambda = \frac{h}{\sqrt{2mqV}}$, $\therefore$ $\lambda \propto \frac{1}{\sqrt{V}}$.

4. According to de-Broglie equation, $\lambda = \frac{h}{mv}$

Given, $h = 6.6 \times 10^{-34}$ J s

$m = 0.66$ kg

$v = 100$ m s^{-1}

$\therefore \quad \lambda = \frac{6.6 \times 10^{-34}}{0.66 \times 100} = 1 \times 10^{-35}$ m

5. $\lambda = \frac{h}{\sqrt{2mkE}} = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 1 \times 0.5}} = 6.62 \times 10^{-34}$

6. $\lambda = \frac{h}{mv} = 1.33 \times 10^{-3}$ Å

7. $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{200}{50}} = \frac{2}{1}$.

8. $\lambda = \frac{h}{mv} = 0.416$ nm

9. $\lambda = v$ then $\lambda = \frac{h}{mV}$ or $\lambda^2 = \frac{h}{m}$ So, $\lambda = \sqrt{\frac{h}{m}}$.

10. $\lambda \propto \frac{n}{Z}$ $\therefore$ $\frac{n_1}{Z_1} = \frac{n_2}{Z_2}$ or $\frac{2}{3} = \frac{4}{6}$ (n = 4 of C^{5+} ion)

11. $v = 2.18 \times \frac{z}{n} 10^{-6}$ m/s

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

13. $\Delta X . \Delta P \geq \frac{h}{4\pi}$

$\Delta X \rightarrow 0 \Rightarrow \Delta P \rightarrow \infty$

14. $\Delta p . \Delta x = \frac{h}{4\pi} \quad \Rightarrow \quad \Delta x = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 1 \times 10^{-10}} = 5.27 \times 10^{-25}$ m.

SECTION (F)

2. Any orbital can accommodate only 2 electrons with opposite spins.

4. $n = 4, \ell = 2, s = -\frac{1}{2}$ or $+\frac{1}{2}$

6. Maximum no. of electrons in a subshell = $2(2\ell + 1) = 4 + 2$.

7. Two electrons in K shell will differ in spin quantum number $s = +\frac{1}{2}$ or $-\frac{1}{2}$.

9. Total number of electrons in an orbital $= 2(2\ell + 1)$.

The value of ℓ varies from 0 to n – 1. $\therefore$ Total numbers of electrons in any orbit = $\sum_{\ell=0}^{\ell=n-1} 2(2\ell + 1)$.

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

For 2s-orbital ℓ = 0 $\Rightarrow$ Orbital angular momentun = 0

15. (1) This set of quantum number is permitted.
(2) This set of quantum number is not permitted as value of 's' cannot be zero.
(3) This set of quantum number is not permitted as the value of 'l' cannot be equal to 'n'.
(4) This set of quantum number is not permitted as the value of 'm' cannot be greater than 'l'.

16. No two electrons in an atom can have identical set of all the four quantum numbers.

20. Hund's rule states that pairing of electrons in the orbitals of a subshell (orbitals of equal energy) starts when each of them is singly filled.

21. $1s^2\ 2s^2\ 2p^6\ 3s^1$
m = 0 is for 2 + 2 + 2 + 1 electrons = 7 e^-

22. Zn^{2+} : [Ar] $3d^{10}$ (0 unpaired electrons).
Fe^{2+} : [Ar] $3d^6$ (4 unpaired electrons) maximum.
Ni^{3+} : [Ar] $3d^7$ (3 unpaired electrons).
Cu^+ : [Ar] $3d^{10}$ (0 unpaired electrons).

23. d^7 : 3 unpaired electrons. $\therefore$ Total spin = $\pm\frac{n}{2} = \pm\frac{3}{2}$.

SECTION (G)

1. s orbital is spherical so non-directional.

9. Factual

10. Spherical node = n $- \ell - 1$

non spherical = ℓ

11. Factual

12. n, ℓ and m.

EXERCISE # 2

3. $\frac{(e/m)_e}{(e/m)_\alpha} = \frac{e/m_e}{2e/4\times1836\ \ m_e} = \frac{3672}{1}$

4. Charge on oil drop = 6.39 × 10^{-19} C $\because$ 1.602 × 10^{-19} C is charge on one electron

$\therefore$ 6.39 × 10^{-19} C is charge on = $\frac{6.39\times10^{-19}}{1.602\times10^{-19}}$ = 4 electrons.

5. Volume of nucleus = $\frac{4}{3}\pi r^3 = \frac{4}{3}\pi(10^{-13})^3$ cm^3 $\Rightarrow$ Volume of atom $\frac{4}{3} = \pi(10^{-8})^3$ cm^3

$\frac{V_N}{V_{Atom}} = \frac{10^{-39}}{10^{-24}} = 10^{-15}$ $\Rightarrow$ $V_{Nucleus}$ = $\mathbf{10^{-15} \times V_{Atom}}$

8. $\lambda = \frac{c}{\nu} = \frac{3\times10^8\ \ m/s}{1200\times10^3\ \ s^{-1}}$ = 250 m = 0.25 km.

$\bar{\nu}$ = Wave no. = $\frac{1}{\lambda} = \frac{2 \quad km}{0.25 \quad km}$ = 8 wave per km.

9. $E = \frac{nhc}{\lambda} \Rightarrow n = 28$

10. $n = \frac{E\lambda}{hc} = 2.5 \times 10^{18}$ photons

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

$3 \times \frac{hc}{\lambda} = 4 + \phi$ ...(2) from, e.q., (1) and (2) $\phi = 0.5$ eV

12. $E_{absorbed} = E_{emitted}$

$\therefore \quad \frac{hc}{300} = \frac{hc}{400} + \frac{hc}{\lambda} \quad \therefore \quad \lambda = 1200$ nm.

$\therefore \quad \frac{hc}{300} = \frac{hc}{400} + \frac{hc}{\lambda}. \quad \therefore \quad \lambda = 1200$ nm.

14. $$\frac{T_{He^+}}{T_{Li^{2+}}} = \frac{\left(\frac{n^3}{Z^2}\right)_{He^+}}{\left(\frac{n^3}{Z^2}\right)_{Li^{2+}}} = \frac{\left(\frac{2^3}{2^2}\right)}{\left(\frac{4^3}{3^2}\right)} = \frac{9}{32}$$

18. E_1 for Li^{+2} = E_1 for H × Z^2 = E_1 for H × 9

E_1 for He^+ = E_1 for H × Z^2_{He} = E_1 for H × 4

or E_1 for Li^{+2} = $\frac{9}{4}$ E_1 for He^+ = $19.6 \times 10^{-18} \times \frac{9}{4}$ **= 44.10 × 10^{-18} J/atom**

19. $E_n = \frac{-13.6 \quad Z^2}{n^2}$

$E_1 = -13.6Z^2 = 100$ unit $\Rightarrow$ $E2 = \frac{-13.6Z^2}{4}$ = 25 unit

21. $KE = \frac{1}{2}\frac{KZe^2}{r} = \frac{3e^2}{8\pi\varepsilon_0 r}$.

22. $E_2 - E_1$ = 1312 – 1312/4 = 984 kJ/mol

23. $E_{ionisation} = E_{\infty} - E_n = \frac{13.6Z^2_{eff}}{n^2}$ eV $\Rightarrow$ $\left[\frac{13.6Z^2}{n_2^2} - \frac{13.6Z^2}{n_1^2}\right] \Rightarrow E = h\nu = \frac{13.6 \times 1^2}{(1)^2} - \frac{13.6 \times 1^2}{(2)^2}$

$h\nu = 13.6 - 3.4 \Rightarrow \upsilon = \frac{E}{h} = \frac{10.2 \times 1.6 \times 10^{-19}}{6.625 \times 10^{-34}}$ = 2.46×10^{-15} sec^{-1}

25. $\frac{1}{\lambda_{lyman}} = R_H\left(\frac{1}{1}\right) \Rightarrow \frac{1}{\lambda_{Balmer}} = R_H\left(\frac{1}{4}\right)$; $\Rightarrow \frac{\lambda_{Balmer}}{\lambda_{Lyman}} = 4$

26. For 1st line of Balmer series $\bar{\nu}_1 = R_H(3)^2\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = 9R\left(\frac{5}{36}\right) = \frac{5}{4}R$

For last line of Pachen series $\bar{v}_2 = R_H (3)^2 = R$ so, $\bar{v}_1 - \bar{v}_2 = \frac{5}{4}R - R = \frac{R}{4}$.

27. Shortest wave length of Lyman series of H-atom $\frac{1}{\lambda} = \frac{1}{x} = R\left[\frac{1}{(1)^2} - \frac{1}{(\infty)^2}\right]$ so, $x = \frac{1}{R}$

For Balmes series $\frac{1}{\lambda} = R\,(1)^2 \left\{\frac{1}{(2)^2} - \frac{1}{(3)^2}\right\}$

$\frac{1}{\lambda} = \frac{1}{x} \times \frac{5}{36}$ so, $\lambda = \frac{36x}{5}$.

28. *According to energy, $E_{4\to1} > E_{3\to1} > E_{2\to1} > E_{3\to2}$.*

According to energy, Violet > Blue > Green > Red. $\therefore$ Red line $\Rightarrow$ $3 \to 2$ transition.

29. $\frac{1}{\lambda_H} = R(1)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$ & $\frac{1}{\lambda_{He^+}} = R\,(2)^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

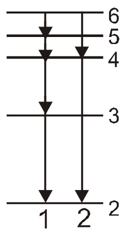
But $\lambda_H = \lambda_{He+}$ $\therefore$ from above 2 equations, $n_1 = 2$ & $n_2 = 4$.

30. Number of lines in Balmer series = 2. $\therefore$ n = 4 (lines will be $4 \to 2$, $3 \to 2$).

KE of ejected photoelectrons = $E_{photon} - BE_n = 13 - \frac{13.6}{4^2} = 13 - 0.85 = 12.15$ eV.

32. Number of lines = $\frac{n(n-1)}{2} = 1 + 2 + 3$ .... $(n - 1)$

34. To produce a maximum of 6 spectral lines, minimum two atoms/ions must be present in the sample, as shown in the diagram.



37. $\lambda = \frac{h}{\sqrt{2mK}} = 3.328 \times 10^{-10}$ m

38. $r_1 = 0.529$ Å

$r_3 = 0.529 \times (3)^2$ Å = 9x

So, $\lambda = \frac{2\pi r}{n} = \frac{2\pi\ (9x)}{3} = 6\,\pi x$.

43. Magnetic moment = $\sqrt{n(n+2)} = \sqrt{24}$ B.M. $\therefore$ No. of unpaired electron = 4.

X_{26} : $1s^2\ 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$.

To get 4 unpaired electrons, outermost configuration will be $3d^6$.

$\therefore$ No. of electrons lost = 2 (from $4s^2$). $\therefore$ n = 2.

48. I : For n = 5, $l_{min} = 0$. $\therefore$ Orbital angular momentum = $\sqrt{\ell\ (\ell+1)}\ \hbar = 0$.(False)

II : Outermost electronic configuration = $3s^1$ or $3s^2$. $\therefore$ possible atomic number = 11or 12 (False).

III : Mn_{25} = [Ar] $3d^5\ 4s^2$. $\therefore$ 5 unpaired electrons. $\therefore$ Total spin = $\pm \frac{5}{2}$ (False).

IV : Inert gases have no unpaired electrons. $\therefore$ spin magnetic moment = 0 (True).

49. Cr (Zn = 24)

Electronic configuration is : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

so, no of electron in ℓ = 1 i.e. p subshell is 12 and no of electron in ℓ = 2 i.e. d subshell is 5.

50. Number of values of ℓ = total number of subshells = n.

Value of ℓ = 0,1,2........(n – 1).

$\ell = 2 \Rightarrow m = -2, -1, 0, +1, +2$ (5 values)

m = + ℓ to – ℓ through zero.

51. n = 4, m = – 3 $\therefore$ only possible value of ℓ is 3.

$\therefore$ Orbital angular momentum = $\sqrt{\ell(\ell+1)} = \frac{2\sqrt{3}\,h}{2\pi} = \frac{\sqrt{3}\,h}{\pi}$.

52. Number of unpiared electron are given by

Magnetic moment = $\sqrt{[n(n+2)]}$ B.M.

where n is number of unpaired electrons

or $1.73 = \sqrt{[n(n+2)]}$ or $1.73 \times 1.73 = n^2 + 2n$ $\therefore$ n = 1

Now Vanadium atom must have one unpaired electron and thus its configuration is

$_{23}V^{4+}$: $1s^2$, $2s^2\ 2p^6$, $3s^2\ 3p^6\ 3d^1$

53. E.C. ⇒ $1s^2,2s^2,2p^6,3s^2,3p^6,3d^1,4s^2$

54. Number of radial nodes = n – ℓ – 1 = 1, n = 3. $\therefore$ ℓ = 1.

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

55. Dumbell lies at 45º to x & y axis.

EXERCISE # 3

PART - I

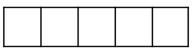
1. According to formula, $E = \frac{hc}{\lambda}$

$3.03 \times 10^{-19} = \frac{hc}{\lambda}$

$\lambda = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{3.03 \times 10^{-19}} = 6.56 \times 10^{-7}$ m = $6.56 \times 10^{-7} \times 10^{9}$ nm = 6.56×10^{2} nm = 256 nm

2. n = 3, l = 2, m = + 2, s = ± 1/2

These values of quantum numbers are possible for only one of the five 3d orbitals as + 2 value of m is possible only for one orbital. m is possible only for one orbitals.

m 

3. $\because$ Total energy (E_n) = KE + PE. In first excited state = $\frac{1}{2}mv^2 + \left[-\frac{ze^2}{r}\right]$

$= +\frac{1}{2}\frac{Ze^2}{r} - \frac{ze^2}{r}$ – 3.4 eV = $-\frac{1}{2}\frac{Ze^2}{r}$ $\therefore$ KE = $\frac{1}{2}\frac{Ze^2}{r}$ = + 3.4 eV

4. $\lambda = \frac{c}{v} = \frac{3\times10^8 \text{ m s}^{-1}}{8\times10^{15} \text{ s}^{-1}}$ = 0.375 × 10^{-7} m = 37.5 × 10^{-9} m = 37.5 nm = 4.0 × 10 nm

5. I.E = $E_\infty - E_1 = 0 - E_1 = 2.18 \times 10^{-18}$ J atom^{-1}

Thus, $E_n = -\frac{2.18\times10^{-18}}{n^2}$ J atom^{-1}

$\Delta E = E_4 - E_1 = -2.18 \times 10^{-18} \left(\frac{1}{4^2} - \frac{1}{1^2}\right) = 2.044 \times 10^{-18}$ J atom^{-1}

$\Delta E = hv$ or $v = \frac{\Delta E}{h} = \frac{2.044 \times 10^{-18} \text{ J}}{6.625 \times 10^{-34} \text{ Js}} = 3.085 \times 10^{15}$ s^{-1}

6. $_{22}Ti = 3d^2 4s^6$, $Ti^{2+} = 3d^2$,

$_{23}V = 3d^3 4s^2$, $V^{3+} = 3d^2$,

$_{24}Cr = 3d^4 4s^2$, $Cr^{4+} = 3d^2$,

$_{25}Mn = 3d^5 4s^2$, $Mn^{5+} = 3d^2$.

7. $E_2 = -\frac{K}{2^2} = -328$ kJ mol^{-1} $\therefore$ K = 1312 kJ mol^{-1}

$E_4 = -\frac{K}{4^2} = -\frac{1312}{16} = -82$ kJ mol^{-1}

8. $\Delta x\, m\Delta v = h/4\pi$

$\therefore$ (0.1 × 10^{-10} m) (9.11 × 10^{-31} kg) (Δv) = $\frac{6.626\times10^{-34} \text{ kgm}^2\text{s}^{-1}}{4 \times 3.14}$ or $\Delta v = 5.79 \times 10^6$ ms^{-1}

10. (ii) is not possible because when n = 2 , l $\neq$ 2

(iv) is not possible because when l = 2 , m $\neq$ –1

(v) is not possible because when l = 2 , m $\neq$ 3

	n	l	m	s
(ii)	2	1	1	+1/2
(iv)	1	0	0	-1/2
(v)	3	2	2	+1/2

11. $\Delta p = m \times \Delta v$

$\therefore$ 1 × 10^{-18} g cm s^{-1} = 9 × 10^{-28} g × Δv or $\Delta v = 1 \times 10^9$ cm s^{-1}

12. $\Delta x.\Delta p = \frac{h}{4\pi}$. If $\Delta x = \Delta p$, then $(\Delta p)^2 = \frac{h}{4\pi}$

or $\Delta p = \sqrt{\frac{h}{4\pi}}$, i.e, $m\,\Delta v = \sqrt{\frac{h}{4\pi}}$ or $\Delta v = \frac{1}{m}\sqrt{\frac{h}{4\pi}} = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$

13. Total number of subshells = $(2\ell + 1)$

∴ Maximum number of electrons in the subshell = 2 (2l + 1) = 4l + 2

14. KE of molecule = energy absorbed by molecule – BE per molecule

= $(4.4 \times 10^{-19}) - (4.0 \times 10^{-19})$ J = 0.4×10^{-19} J

KE per atom $= \frac{0.4 \times 10^{-19}}{2}$ J = 2.0×10^{-20} J

15. If n = 3

l = 0 to (3 – 1) = 0, 1, 2

m = l to + l = – 2, – 1, 0, +1, + 2

s = $\pm \frac{1}{2}$. Therefore, option (3) is not a permissible set of quantum numbers.

16. According to de-Broglie equation, $\lambda = \frac{h}{mv}$

Given, h = 6.6×10^{-34} J s ⇒ m = 0.66 kg ⇒ v = 100 m s^{-1}

∴ $\lambda = \frac{6.6 \times 10^{-34}}{0.66 \times 100}$ = 1×10^{-35} m

17. Total No. of atomic orbital in a shell = n^2

18. E_1 = 25 eV, E_2 = 50 eV

$E_1 = \frac{hc}{\lambda_1}$, $E_2 = \frac{hc}{\lambda_2}$ ⇒ $\frac{25}{50} = \frac{\lambda_2}{\lambda_1}$

$\lambda_1 = 2\lambda_2$

19. ns → (n – 2) f → (n – 1)d → np n = 6

20. Energy of photon obtained from the transition n = 6 to n = 5 will have least energy.

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

21. (n = 4, ℓ = 3) ⇒ 4f subshell

So, total No. of electron in subshell = 2 (2 ℓ + 1) = 2 (2 × 3 + 1) = 14 electron.

22. Electronic configuration = [Kr] $5s^1$

Set of quantum numbers ⇒ n = 5

ℓ = 0

m = 0

s = 1/2

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

ℓ = 1

So = $\frac{h}{2\pi}\sqrt{2} = \frac{h}{\sqrt{2}\pi}$

24. C = $\nu\lambda$

$\lambda = \frac{C}{\nu} = \frac{3 \times 10^{17}}{6 \times 10^{15}} = 50$ nm

25. One orbital of 3p sub shell
Any orbital can accomodate maximum 2 electron.

26. Electron is more tightly bound in the smallest allowed orbit.

27. It is 3P orbital with magnetic Q.N. = 0
So, it should be $3P_z$

28. $E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{45\times10^{-9}} = 4.4\times10^{-18}$

29. $Be^{2} = 1s^{2} = Li^{+}$

30. Magnetic moment = $\sqrt{n(n+2)}$

2.84 Bohr magneton, means 2 unpaired electrons are present in ion.

$Ni^{+2} = 4s^{0}\,3d^{8}$

↑↓	↑↓	↑↓	↑	↑

31. $Fe^{+2} = 3d^{6}4s^{0}$ six d electrons, p-electrons in chlorine ($1s^22s^22p^63s^23p^5$) are = 11
as p-electrons = 6 + 5 = 11

32. Angular momentum = $\sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{\ell(\ell+1)}\,\hbar$

For d orbital $\ell = 2$

Angular momentum = $\sqrt{2(2+1)}\,\hbar = \sqrt{6}\,\hbar$

33. Same orbital can have two different values of spin of e- of +½ and -½ (spin quantum number)

34. n = 3 $\ell = 1$

3p orbital can have only 2 elelctron.

36. For a single electronic species like H, energy depends on value of n and does not depend on value of l.

37. According to Hund's rule.

38. Ist four line of Balmer series of spectrum of hydrogen atom falls in visible region.

39. Energy α value of (n+l)

Orbitals	(n+l) value
5f	5 + 3 = 8
6p	6 + 1 = 7
4d	4 + 2 = 6
5p	5 + 1 = 6

40. The total no. of modes = (n – 1)
angular nodes = ℓ
the radial nodes = n – ℓ – 1
n = principal Q. No.
ℓ = Azimethel Q. No.
Total nodes = 3
n – 1 = 3
(n – 4)
ℓ = 3 for f – orbital have 4f orbital.

41. For 2nd bohr orbit $\Rightarrow$ (n = 2)

$2\pi r = n\lambda$

$\lambda = \frac{2\pi r}{n}$

$r = r_0 n^2$

$r = 52.9 \times 4$

$\lambda = 52.9 \times 4 \times \pi$

PART - II

1. Electron in ClO_2^- = 17 + 9 × 2 – 1= 34

Electron in ClF_2^+ = 17 + 2 × 8 + 1= 34

2. α, β and γ radiations can be detected by using ZnS screen. α rays cause maxiumum glow of ZnS screen and γ rays cause minimum glow.

3. $r_n = \frac{52.9 \times n^2}{Z}$ pm $\therefore$ For He^+, $r_1 = \frac{52.9 \times 1^2}{2}$ = 26.5 pm.

4. $\frac{1}{2}mv^2 = 0.5$ J $\Rightarrow$ $\frac{1}{2} \times 1$ kg $\times v^2 = 0.5$ J or $v^2 = 1$ or $v = 1$ ms^{-1}

$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ kgm^2s^{-1}}{1\ kg \times 1\ m\ s^{-1}} = 6.626 \times 10^{-34}$ m.

5. According to Heisenberg

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

For particle A :

$\Delta x = \Delta x_A$

$m = m$

$\Delta v = 0.05$

So, $\Delta x_A \times m \times 0.05 = \frac{h}{4\pi}$ ...... (i)

For particle B :

$\Delta x = \Delta x_B$

$m = 5m$

$\Delta v = 0.02$

So, $\Delta x_B \times 5m \times 0.02 = \frac{h}{4\pi}$ ...... (ii)

Eq. (i) / (ii), we get

$\frac{\Delta x_A}{\Delta x_B} = 2.$

6. $V_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 298}{4 \times 10^{-3}}} = 1363$ ms^{-1}

$\lambda = \frac{h}{4\pi} = \frac{6.626 \times 10^{-34} \times 6.023 \times 10^{23}}{4 \times 10^{-3} \times 1363} = 7.34 \times 10^{-11}$ m

7. Lower the (n + l) of an electron, lower will be its energy. If for any two electrons (n + l) is same, the electron with lower value of n, has lower energy. Hence, the correct order of energy is :

$n = 2, \ell = 1 \quad < \quad n = 3, \ell = 0 \quad < \quad n = 4, \ell = 0 \quad < \quad n = 3, \ell = 2$

$(n + \ell = 3) \qquad (n + \ell = 3) \qquad (n + \ell = 4) \qquad (n + \ell = 5)$

11. $E = \frac{hc}{\lambda}$; $\frac{\lambda_2}{\lambda_1} = \frac{6000}{3000} = 2 : 1$

12. Both assertion and reason are correct. Reason is not the correct explanation of assertion.

13. Magnetic moment $\mu = \sqrt{n(n+2)}$ where n = number of unpaired electrons $\sqrt{15} = \sqrt{n(n+2)}$ $\therefore$ n =3

17. $\Delta E = 2.178 \times 10^{-18} \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{hC}{\lambda}$

$2.178 \times 10^{-18} \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{6.62 \times 10^{-34} \times 3.0 \times 10^8}{\lambda}$

$\therefore \lambda \approx 1.214 \times 10^{-7}$m

21. $\frac{1}{\lambda} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right) \times Z^2$

for $\lambda_{He^+} = \frac{400}{2^2} = \frac{400}{4} = 100$ nm

22. $M^{+2} \rightarrow 23\ e^-$

$M \rightarrow 25\ e^-$ (It should be M_n)

$3d^5 4s^2$ $\quad \mu = \sqrt{5(5+2)} = \sqrt{35} = 59$

23. $\frac{1}{\lambda} = 1.09 \times 10^7 \times 1^2 \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ (transition $3 \rightarrow 2$)

24. $v = 2.18 \times 10^6 \times \frac{1}{2} = 1.09 \times 10^6$ m/sec

25. $\frac{hc}{\lambda_1} - h\upsilon_0 = \frac{1}{2}mv_1^2$

$\frac{hc}{\lambda_2} - h\upsilon_0 = \frac{1}{2}mv_2^2$

$\frac{hc}{\lambda_2} - \frac{hc}{\lambda_1} = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$

$\frac{2hc}{m}\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)\left(v_2^2 - v_1^2\right)$

PART - III

1. Mn^{2+} has the maximum number of unpaired electrons (5) andtherefore has maximum moment.

2. 2nd excited state will be the 3rd energy level. $\quad E_n = \frac{13.6}{n^2}$ eV or $E = \frac{13.6}{9} = 1.51$ eV.

3. $\Delta x.\ \Delta v = \dfrac{h}{4\pi m}$ $\Delta v = \dfrac{6.6\times10^{-34}}{4\times3.14\times25\times10^{-5}}$ $\therefore$ $\Delta v = 2.1 \times 10^{-18}\ ms^{-1}$.

4. $\lambda = \dfrac{h}{mv} = \dfrac{6.63\times10^{-34}\times1000}{60\times10} = 11.05 \times 10^{-34} = 1.105 \times10^{-33}$ metres.

5. The electron has minimum energy in the first orbit and its energy increases as n increases. Here n represents number of orbit, i.e., 1[at], 2[nd], 3[rd] ....The thired line from the red end corresponds. To yellow region i.e., 5. In order to obtain less energy electron tends to come 1[st] or 2[nd] orbit. So jump may be involved either $5 \rightarrow 1$ or $5 \rightarrow 2$. Thus option (2) is correct here.

6. $_{26}Fe = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$,
$Fe^{++} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$
The number of d -electrons retained in $Fe^{2+} = 6$.
Therefore, (4) is correct option.

7. The value of ℓ (azimuthal quantum number) for s -electron is equal to zero.

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

Substituting the value of l for s-electron = $\sqrt{0(0+1)}.\dfrac{h}{2\pi} = 0$

8. $\dfrac{1}{\lambda} = R\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$ $\dfrac{1}{\lambda} = 1.097 \times 10^{7}\ m^{-1}$ $\left(\dfrac{1}{1^2} - \dfrac{1}{\infty^2}\right)$ $\therefore$ $\lambda = 91 \times 10^{-9}$ m = 91 m.

9. For $4f$ orbital electrons, n = 4
$\ell = 3$ (because $\begin{matrix} s & p & d & f \\ 0 & 1 & 2 & 3 \end{matrix}$) m = + 3, + 2, + 1, 0, –1, –2, –3 s = + 1/2.

10. $_{24}Cr \rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$ $\ell = 1, \ell = 1, \ell = 2$

(we know for p, $\ell = 1$ and for d, $\ell = 2$). For $\ell = 1$, total number of electrons = 12

For $\ell = 2$, total number of electron = 5.

11. The electron having same principle quantum number and azimuthal quantum number will be the same energy in absence of magnetic and electric field.
(iv) n = 3, l = 2, m =1
(v) n = 3, l = 2, m = 0
Have same n and l value.

12. For hydrogen the energy order of orbital is $1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f$.

13. According to Heisenberg's uncertainity principle

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

$$\Delta x \times (m.\Delta v) = \frac{h}{4\pi} \Rightarrow \Delta x = \frac{h}{4\pi m.\Delta v}$$

$\Delta v = \dfrac{0.001}{100} \times 300 = 3 \times 10^{-3}\ ms^{-1}$ $\therefore$ $\Delta x = \dfrac{6.63\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times3\times10^{-3}} = 1.29 \times 10^{-2}$m.

14. Angular momentum of the electron, mvr = $\frac{nh}{2\pi}$ where n = 5 (given)

$\therefore$ Angular momentum = $\frac{5h}{2\pi} = 2.5\frac{h}{\pi}$

15. ${}_{28}Ni \rightarrow [Ar]3d^8\, s^2$ 3d: ↿⇂ ↿⇂ ↿⇂ ↿ ↿ 4s: ↿⇂ 4p: □ □ □

Number of unpaired electrons (n) = 2

$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = \sqrt{8} \approx 2.84$

16. The atoms of the some elements having same atomic number but different mass numbers are called isotopes.

(1) ${}^{A}_{Z}X \xrightarrow{-\alpha} {}^{A-4}_{Z-2}Y$ (2) ${}^{A}_{Z}X \xrightarrow{-\beta} {}^{A}_{Z+1}Y$ (3) ${}^{A}_{Z}X \xrightarrow{-{}^{1}_{0}n} {}^{A-1}_{Z}Y$ X (4) ${}^{A}_{Z}X \xrightarrow{-\beta+} {}^{A}_{Z-1}Y$

17. I.E. = 1.312×10^6 J mol^{-1}

The energy required to excite the electron in the atom from n_1 = 1 to n = 2.

$$= 1.312 \times 10^6 \left[1 - \frac{1}{4}\right] = 1.312 \times 10^6 \times \frac{3}{4} = 9.84 \times 10^5 \text{ J mol}^{-1}$$

18. The electron have n + l higher value have hegher energy.

n + l = 3 + 0 = 3

n + l = 3 + 1 = 4

n + l = 3 + 2 = 5 (highest energy)

n + l = 4 + 0 = 4

19. $Cl–Cl(g) \longrightarrow 2Cl(g)$; $\Delta H = 242$ KJ mol = $\frac{242 \times 10^3}{6.02 \times 10^{23}}$ J molecule^{-1}

$$E = \frac{hc}{\lambda} \Rightarrow \frac{242 \times 10^{-23} \times 10^3}{6.02} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\lambda = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{242 \times 10^{-23} \times 10^3} = \frac{6.6 \times 3 \times 6.02}{242} \times 10^{-6} = 0.494 \times 10^{-6} = 494 \times 10^{-9} \text{ m} = 494 \text{ nm}$$

20. I.E. of He^+ = 19.6×10^{-18} J atom^{-1}

I.E. = – E_1

E_1 for He^+ is = – 19.6×10^{-18} J atom^{-1}

$$\frac{(E_1)_{He^+}}{(E_1)_{Li^{3+}}} = \frac{(Z_{He^+})^2}{(Z_{Li^{2+}})^2} \Rightarrow \frac{-19.6 \times 10^{-18}}{(E_1)_{Li^{2+}}} = \frac{4}{9}$$

$$E_1(Li^{2+}) = \frac{-19.6 \times 9 \times 10^{-18}}{4} = -44.1 \times 10^{-18} = -4.41 \times 10^{-17} \text{ J atom}^{-1}$$

21. $E = E_1 + E_2$

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2} \Rightarrow \frac{1}{355} = \frac{1}{680} + \frac{1}{\lambda_2}$$

λ_2 = 742.76 nm.

22. $$h\nu = \Delta E = 13.6\, z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \nu_{He+} = \nu_H \times z^2 \left(\frac{1}{\left(\frac{n_1}{2}\right)^2} - \frac{1}{\left(\frac{n_2}{2}\right)^2}\right) = \nu_H \left(\frac{1}{\left(\frac{2}{2}\right)^2} - \frac{1}{\left(\frac{4}{2}\right)^2}\right)$$

For H-atom $n_1 = 1$, $n_2 = 2$

23. (a) 4 p (b) 4 s (c) 3 d (d) 3 p

Acc. to $(n + \ell)$ rule, increasing order of energy (d) < (b) < (c) < (a)

25. Z = 37.

Rb is in fifth period.

[Kr]$5s^1$ is its configuration.

So n = 5, l = 0, m = 0, s = $+\frac{1}{2}$ or $-\frac{1}{2}$

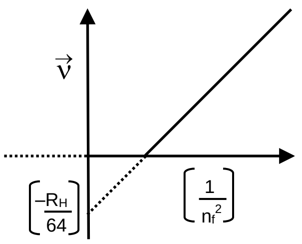
26. $(E_n)_H = -13.6\ \frac{1^2}{n^2}$ eV

n = 2 $\Rightarrow$ $E_2 = -3.4$ eV

27. K.E. = eV

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

28. $R = 0.529\ \frac{n^2}{z}\ \mathring{A} = 0.529\ \frac{2^2}{1}\ \mathring{A} = 2.12\ \mathring{A}$

28. 

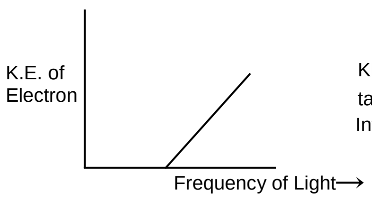
$$\bar{\nu} = R_H Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = R_H(1)^2\left(\frac{1}{n_{f^2}} - \frac{1}{8^2}\right)$$

$$\bar{\nu} = \frac{R_H}{n_{f^2}} - \frac{R_H}{64}$$

Slope for graph of $\bar{\nu}$ & $\frac{1}{n_{f^2}}$ is $+R_H$

29. $mvr = \frac{nh}{2\pi}$

According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$.

30. 

$KE_{max} = h\nu - h\nu_0$

$\tan\theta = h$

Intercept = $-h\nu_0$

31. $E = -13.6\left(\frac{Z^2}{n^2}\right) = -13.6\left(\frac{2^2}{3^2}\right) = -6.04$ eV

32. $h\nu = h\nu_0 + \frac{1}{2}mv^2 \Rightarrow h(\nu - \nu_0) = \frac{1}{2}mv^2 \Rightarrow v = \left(\frac{2h(\nu - \nu_0)}{m}\right)^{1/2}$

$\lambda = \frac{h}{mv} = \frac{h}{m}\frac{\sqrt{m}}{\sqrt{2h(\nu - \nu_0)}} = \sqrt{\frac{h}{m(\nu - \nu_0)}} \Rightarrow \lambda \propto \frac{1}{(\nu - \nu_0)^{1/2}}$

33. $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \frac{1}{\lambda} = 10^7\left(\frac{1}{(3)^2} - \frac{1}{\infty}\right)$

$\lambda = 9 \times 10^{-7}$ m

$\lambda = 900$ nm

34. $2\pi r = n\lambda$

$2\pi a_0 \frac{n^2}{Z} = n\lambda \Rightarrow 2\pi a_0 \frac{n^2}{Z} = n1.5\pi\ a_0 \Rightarrow \frac{n}{Z} = \frac{1.5}{2} = \frac{3}{4} = 0.75$