HINTS & SOLUTIONS

EXERCISE - 1

Single Choice

1. $R = R_0 A^{1/3} = 1.3 \times 64^{1/3} = 5.2$ fm

2. Hydrogen atom contains 1 proton, 1 electron and no neutrons.

3. $\dfrac{(e/m)_e}{(e/m)_\alpha} = \dfrac{e/m_e}{2e/4 \times 1836 m_e} = \dfrac{3672}{1}$

4. $\text{Volume fraction} = \dfrac{\text{Volume of nucleus}}{\text{Total vol. of atom}}$

$$= \frac{(4/3)\pi(10^{-13})^3}{(4/3)\pi(10^{-8})^3} = 10^{-15}$$

5. Ne contains 10 electrons
O^{2-} and F^- contain 10 electrons

6. I.E. of one sodium atom $= \dfrac{hC}{\lambda}$

& I.E. of one mole Na atom $= \dfrac{hC}{\lambda} N_A$

$$= \frac{6.62 \times 10^{34} \times 3 \times 10^8 \times 6.02 \times 10^{23}}{242 \times 10^{-9}} = 494.65 \text{ kJ.mol.}$$

7. Violet colour has minimum wavelength so maximum energy.

8. $\lambda = \dfrac{c}{\nu} = \dfrac{3 \times 10^8}{400 \times 10^6} = 0.75$ m

9. $\lambda = \dfrac{c}{\nu} = \dfrac{3 \times 10^8}{8 \times 10^{15}} = 3.75 \times 10^{-8}$ m

10. Photoelectric effect is a random phenomena. So, electron It may come out with a kinetic energy less than $(h\nu - w)$ as some energy is lost while escaping out.

11. For photoelectric effect to take place, $E_{light} \geq W$

$\therefore \dfrac{hc}{\lambda} \geq \dfrac{hc}{\lambda_0}$ or $\lambda \leq \lambda_0$.

12. $\text{Power} = \dfrac{nhC}{\lambda \times t} \Rightarrow 40 \times \dfrac{80}{100}$

$$= \frac{n \times 6.62 \times 10^{-34} \times 3 \times 10^8}{620 \times 10^{-9} \times 20} \Rightarrow n = 2 \times 10^{21}$$

13. $E_n = -78.4$ kcal/mole $= -78.4 \times 4.2 = -329.28$ kJ/mole

$= -\dfrac{329.28}{96.5}$ eV $= -3.4$ eV.

(energy of II orbit of H atom).

14. $r\,\alpha \left(\dfrac{n^2}{Z}\right)$ As Z increases, radius of I orbit decreases.

15. $\text{Radius} = 0.529 \dfrac{n^2}{Z}$ Å $= 10 \times 10^{-9}$ m

So, $n^2 = 189$ or, $n \approx 14$ **Ans.**

16. $E_1(H) = -13.6 \times \dfrac{1^2}{1^2} = -13.6$ eV ;

$E_2(He^+) = -13.6 \times \dfrac{2^2}{2^2} = -13.6$ eV

$E_3(Li^{2+}) = -13.6 \times \dfrac{3^2}{3^2} = -13.6$ eV ;

$E_4(Be^{3+}) = -13.6 \times \dfrac{4^2}{4^2} = -13.6$ eV

$\therefore E_1(H) = E_2(He^+) = E_3(Li^{2+}) = E_4(Be^{3+})$

17. $V = 2.188 \times 10^6 \dfrac{Z}{n}$ m/s

Now, $V \propto \dfrac{Z}{n}$ so, $\dfrac{V_{Li^{2+}}}{V_H} = -\dfrac{Z_1/n_1}{Z_2/n_2} = \dfrac{3/3}{1/1} = 1$

or, $V_{Li^{2+}} = V_H$

18. $r_1 - r_2 = 24 \times (r_1)_H$

$\dfrac{0.529 \times n_1^2}{1} - \dfrac{0.529 \times n_2^2}{1} = 24 \times 0.529$

$\therefore (n_1^2 - n_2^2) = 24$

So, $n_1 = 5$ and $n_2 = 1$

19. I.P. $= 340$ V so, I.E. $= 340$ eV $= 13.6 \dfrac{Z^2}{(1)^2}$

so, $Z^2 = 25$ so, $Z = 5$ Therefore, **(B)** is correct option.

20. Velocity $\propto \dfrac{Z}{n}$; Frequency $\propto \dfrac{Z^2}{n^3}$;

Radius $\propto \dfrac{n^2}{Z}$; Force $\propto \dfrac{Z^2}{n^4}$.

21. **S1 :** Potential energy of the two opposite charge system decreases with decrease in distance,

S4 : The energy of I[st] excited state of He^+ ion

$= -3.4\,Z^2 = -3.4 \times 2^2$

-13.6 eV.

S_2 and S_3 are correct statement.

22. **S1 :** Be^{2+} ion has 2 electron so Bohr model is not applicable.

S_2, S_3 and S_4 are correct statement.

23. **(a)** Energy of ground state of He^+ $= -13.6 \times 2^2 = -54.4$ eV **(iv)**

(b) Potential energy of I orbit of H-atom $= -27.2 \times 1^2 = -27.2$ eV **(ii)**

(c) Kinetic energy of II excited state of He^+ $= 13.6 \times \frac{2^2}{3^2} = 6.04$ eV **(i)**

(d) Ionisation potential of He^+ $= 13.6 \times 2^2 = 54.4$ V **(iii)**

24. $\lambda = \frac{hc}{\Delta E}\ \therefore \lambda \alpha \frac{1}{\Delta E}$

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

26. $E_n = E_1 \frac{Z^2}{n^2}$ $\quad E_5 = -13.6 \times \frac{(1)^2}{(5)^2} = -0.54$ eV

27. 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.

28. For 1[st] line of Balmer series

$$\bar{v}_1 = R_H(3)^2\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = 9R\left(\frac{5}{36}\right) = \frac{5}{4}R$$

For last line of Pachen series

$$\bar{v}_2 = R_H(3)^2\left[\frac{1}{(3)^2} - \frac{1}{(\infty)^2}\right] = R$$

so, $\bar{v}_1 - \bar{v}_2 = \frac{5}{4}R - R = \frac{R}{4}$.

29. Li^{2+}, H and He^+ are single electron species.

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

31. Infrared lines = total lines – visible lines – UV lines

$= \frac{6(6-1)}{2} - 4 - 5 = 15 - 9 = 6.$

(visible lines = 4 $6\to2, 5\to2, 4\to2, 3\to2$)

(UV lines = 5 $6\to1, 5\to1, 4\to1, 3\to1, 2\to1$)

32. $r_1 = 0.529$ Å

$r_3 = 0.529 \times (3)^2$ Å $= 9x$

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

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

34. $\lambda = \frac{h}{mv} = \frac{6.625 \times 10^{-34}}{0.2 \times 5} \times 3600 \approx 10^{-30}$ m.

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

36. $\Delta p \,.\, \Delta x = \frac{h}{4\pi} \quad \Rightarrow \quad \Delta x = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 1 \times 10^{-5}}$

$= 5.27 \times 10^{-30}$ m.

37. For an α particle, $\lambda = \frac{0.101}{\sqrt{V}}$ Å.

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

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

40. 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).

41. Orbital angular momentum $= \sqrt{\ell(\ell+1)}\,\frac{h}{2\pi} = 0.$

$\therefore\ \ell = 0$ (s orbital).

42. Cu : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$.

$\therefore$ Cu^{2+} : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ or $[Ar]3d^9$.

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.

44. 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 $\ell = 1$ i.e. p subshell is 12 and no of electron in $\ell = 2$ i.e. d subshell is 5.

45. X_{23} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$.

No. of electron with $\ell = 2$ are 3 ($3d^3$).

46. Orbital angular momentum = $\sqrt{\ell(\ell+1)}\ \dfrac{h}{2\pi} = 0$

(since $\ell = 0$ for s orbital).

47. Cl_{17}^{-} : [Ne] $3s^2\ 3p^6$.

Last electron enters 3p orbital.

$\therefore$ $\ell = 1$ and m = 1, 0, –1.

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

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

49. Cl_{17} : [Ne] $3s^2\ 3p^5$.

Unpaired electron is in 3p orbital.

$\therefore$ n = 3, $\ell = 1$, m = 1, 0, – 1.

50. **(A)** $_{24}Cr$: $[Ar]3d^5 4s^1$

(B) m = – ℓ to + ℓ through zero.

(C) $_{47}Ag$: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^{10}$.

Since only one unpaired electron is present.

62. $^{11}_{6}C \longrightarrow {}^{11}_{5}B + {}^{0}_{+1}e$

64. $\dfrac{n}{p} > 1$

65. $\dfrac{n}{p}$ is minimum for this isotope.

66. It is the order of penetrating power.

67. Nucleides having $\dfrac{n}{p} > 1$ undergoes β-emission to decrease $\dfrac{n}{p}$ ratio in order to attain belt of stability.

68. $^{A}_{Z}X \longrightarrow {}^{A-1}_{Z}X + {}^{1}_{0}n$

69. $^{238}_{92}U \longrightarrow {}^{214}_{82}Pb + m\,{}^{4}_{2}He + n\,{}^{0}_{-1}e$

$\therefore$ m = 6 and m = 2. Total = 8.

70. λ = v

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

71. s orbital is spherical so non-directional.

72. Total number of electrons in an orbital = 2 (2ℓ +1).

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

73. $\Delta x = 2\Delta p$

$$\Delta x\,.\,\Delta p = \frac{\hbar}{2} = \frac{h}{4\pi} \Rightarrow 2\,\Delta p\,.\,\Delta p = \frac{\hbar}{2}$$

$$\Rightarrow 2(m\Delta V)^2 = \frac{\hbar}{2} \quad ; (\Delta V)^2 = \frac{\hbar}{4m^2}$$

$$\Rightarrow \Delta V = \frac{\sqrt{\hbar}}{2m}.$$

74. The lobes of d_{xy} orbital are at an angle of 45° with X and Y axis. So along the lobes, angular probability distribution is maximum.

75. $\left.\begin{matrix} n_1 + n_2 = 4 \\ n_1 - n_2 = 2 \end{matrix}\right\}$ so $n_1 = 3$ and $n_2 = 1$.

$$\bar{v} = R\,(3)^2 \left\{\frac{1}{(1)^2} - \frac{1}{(3)^2}\right\} = 8R.$$

76. 2πr = nλ = circumference

77. Spin quantum number does not comes from Schrodinger equation.

$s = +\dfrac{1}{2}$ and $-\dfrac{1}{2}$ have been assigned arbitrarily.

78. $\dfrac{\lambda_y}{\lambda_x} = \dfrac{m_x v_x}{m_y v_y}$. $\Rightarrow \dfrac{\lambda_y}{1} = \dfrac{m_x v_x}{(0.25 m_x)(0.75\,v_x)} = \dfrac{16}{3}$.

$\therefore$ $\lambda_y = 5.33$Å.

79. For an electron accelerated with potential difference V volt, $\lambda = \frac{h}{\sqrt{2mqV}} = \frac{12.3}{\sqrt{V}}$ Å.

80. $\nu = RC\,Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$.

$\nu_1 = RC\,Z^2\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = RC\,Z^2$,

$\nu_2 = RC\,Z^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4}RC\,Z^2$.

$\nu_3 = RC\,Z^2\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{1}{4}RC\,Z^2$. $\therefore$ $\upsilon_1 - \upsilon_2 = \upsilon_3$.

EXERCISE - 2

Part # I : Multiple Choice

1. Ground state binding energy = 13.6 Z^2 = 122.4 eV.
$\therefore$ Z = 3.
1^{st} excitation energy = 10.2 Z^2 = 91.8 eV.
$\therefore$ an 80 eV electron cannot excite it to a higher state.

2. $\nu = \frac{c}{\lambda} = \frac{3\times10^8}{600\times10^{-9}} = 5\times10^{14}\ \text{sec}^{-1}$

$E = \frac{12400}{6000} = 2.07$ eV.

3. $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}} = \frac{h}{\sqrt{2mqV}}$.

When v, KE and V are same, as m increasing, λ decreases.
$\lambda_e > \lambda_p > \lambda_\alpha$ (if v, KE and V are same).

4. Max. number of different photons emitted is 4 [(4 $\to$ 3 $\to$ 1 and 4 $\to$ 2 $\to$ 1) or (4 $\to$ 3 $\to$ 2 $\to$ 1 and 4 $\to$ 1)].
Minimum number of different photons emitted is 1(4 $\to$ 1 and 4 $\to$ 1).

5. n = 4, m = 2
Value of ℓ = 0 to (n – 1) but m = 2. $\therefore$ ℓ = 2 or 3 only
Value of s may be +1/2 or – 1/2

6. $m_e = 9.1\times10^{-31}$ kg $= 9.1\times10^{-28}$ g.

$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ (m_0 : rest mass ; m : dynamic mass).

As v $\uparrow$, $\left(1-\frac{v^2}{c^2}\right)\downarrow$ $\therefore$ m $\uparrow$

Molar mass of e = $9.1\times10^{-28}\times6.023\times10^{23}$ = 5.48×10^{-4} g/mole.

For electron, $\frac{e}{m} = \frac{1.6\times10^{-19}}{9.1\times10^{-28}} = 1.7\times10^8$ c/g.

7. From α particle scattering experiment, distance of closest approach of α particle with nucleus came out to be of the order of 10^{-14} m.

8. **(A)** Since the number of photons is not specified (it may or may not be equal to 4 N_A). So, this statement is not always true.
(B) No.of photon emitted per day × Energy of one photon = Energy emitted per day.

For bulb A, $n_{e_A}\times\frac{12400}{2000}\times1.6\times10^{-19} = 40\times24\times3600$.

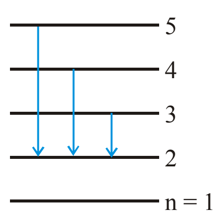
For bulb B, $n_{e_B}\times\frac{12400}{3000}\times1.6\times10^{-19} = 30\times24\times3600$.

$\therefore$ $n_{e_A} : n_{e_B} = 8 : 9$.

(C) When an electron make transition from lower to higher orbit, a photon is absorbed.

9. Transition is taking place from 5 $\to$ 2 $\Rightarrow$ $\Delta n = 3$
Hence maximum number of spectral line observed

$= \frac{3(3+1)}{2} = 6$.



(C) number of lines belonging to the Balmer series
= 3 (5 $\to$ 2,4 $\to$ 2,3 $\to$ 2)
as shown in figure.

Number of lines belonging to Paschen series = 2 (5 $\to$ 3,4 $\to$ 3).

10. **(A)** λ can be calculated as : $\lambda = \frac{h}{mv} = \frac{6.626\times10^{-34}}{1\times100}$

$= 6.626\times10^{-36}$ m. (very small).

(B) de-Broglie wavelength associated with macroscopic particles is extremely small and so, difficult to observe.

(C) de-Broglie wavelength associated with electron can be calculated by using $\lambda = \frac{h}{mv}$.

(D) $KE_f = 5 + 20 = 25$ eV.

$\therefore \quad \lambda = \sqrt{\frac{150}{KE_f}} = \sqrt{\frac{150}{25}} = \sqrt{6}$ Å.

11. 1st excitation potential $= 10.2\,Z^2 = 24$ V

$\therefore \quad Z^2 = 24/10.2$

$\therefore \quad IE = 13.6\,Z^2 = \frac{13.6 \times 24}{10.2} = 32$ eV.

Binding energy of 3rd excited state $= 0.85\,Z^2$

$= \frac{0.85 \times 24}{10.2} = 2$eV.

2nd excitation potential of sample $= 12.09\,Z^2 = \frac{12.09 \times 24}{10.2}$

$= \frac{32 \times 8}{9}$ V.

12. $\sqrt{n(n+2)} = 1.732$

Number of unpaired electrons, n = 1.

${}_{25}X : [Ar]\,4s^2 3d^5$

For having one unpaired electron, 6 electrons are to be removed (2 from 4s & 4 from 3d).

$\therefore \quad Y = 6.$

13. No. of neutrons in ${}^{76}_{32}Ge = A - Z = 76 - 32 = 44.$

No. of neutrons in ${}^{77}_{33}As = 77 - 33 = 44.$

No. of neutrons in ${}^{78}_{34}Se = 78 - 34 = 44.$

14. Since most part of atom is empty space, so, when α particles are sent towards a thin metal foil, most of them go straight through the foil.

15. Zn^{2+} : 0 unpaired electron ; Cu^{+} : 0 unpaired electron
Co^{2+} : 3 unpaired electron ; Ni^{2+} : 2 unpaired electron
Mn^{4+} : 3 unpaired electron ; Mg^{2+} : 0 unpaired electron
Sc^{+} : 2 unpaired electron.

16. If photon A has more energy than photon B, then λ of photon A must be less than λ of photon B. If λ of photon B is in IR region, λ of photon A can be in Infrared region or visible region or ultra violet region.

17. Non integral atomic masses of elements are due to existence of isotopes of that element which have different masses.

18. Bohr model is only valid for single electron species i.e., Total no. of electrons in the species should be 1.

19. In all the given cases, only one quantum of energy is emitted since only one electronic transition occurs.

20. Spin angular momentum $S = \sqrt{s(s+1)}\,\frac{h}{2\pi}$.

$s = \frac{1}{2} \qquad \therefore \qquad S = \frac{\sqrt{3}}{2} \times \frac{h}{2\pi}$.

21. Change in angular momentum for $3 \to 2$ transition

$= (3-2)\frac{h}{2\pi} = \frac{h}{2\pi}$.

Change in angular momentum for $4 \to 2$ transition

$= (4-2)\frac{h}{2\pi} = \frac{h}{\pi}$.

22. ${}_{24}Cr : [Ar]\,3d^5\,4s^1$; ${}_{29}Cu : [Ar]\,3d^{10}4s^1$
${}_{46}Pd : [Kr]\,4d^{10}\,5s^0$; ${}_{78}Pt : [Xe]\,5d^9\,6s^1$

23. ${}_{8}O : [He]\,2s^2 2p^4$; ${}_{16}S : [Ne]\,3s^2 3p^4$

24. For 1s, 3s, 3d and 2p orbital, $\ell = 0, 0, 2, 1$ respectively.

Orbital angular momentum $= \sqrt{\ell(\ell+1)}\,\hbar$.

25. Magnetic moment = 2.83 so, no. of unpaired electrons = 2 so, Ni^{2+} is the answer.

26. $\frac{r_1}{r_2} = \frac{n_1^2}{n_2^2} = \frac{R}{4R} \Rightarrow \frac{n_1}{n_2} = \frac{1}{2}$

$\therefore \quad \frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \frac{1}{8}$.

27. After np orbital, (n + 1) s orbital is filled.

28. $\frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \frac{1^3}{2^3} = \frac{1}{8}$.

$\because \quad \left(T = \frac{2\pi r}{V}\right)$ so, $T \propto \frac{n^3}{Z^2}$

29. Cr : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^1\,3d^5$

$n + \ell = 3$

so the combinations are 2p, 3s. So 8 electrons.

30. 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. $= \frac{J^2}{2mr^2}$

31. $I_n = \frac{eV_n}{2\pi r_n} = \frac{e\times\left(\frac{2\pi Ke^2}{nh}\right)}{2\pi\times\left(\frac{n^2h^2}{4\pi^2 me^2K}\right)} = \frac{4\pi^2mk^2e^5}{n^3h^3}$.

32. Rb_{37} : [Kr] $5s^2$. $\therefore$ $n = 5, \ell = 0, m = 0, s = \pm\frac{1}{2}$.

33. Visible lines $\Rightarrow$ Balmer series

$\Rightarrow$ 3 lines. ($5 \to 2, 4 \to 2, 3 \to 2$).

34. 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, $\lambda = \frac{36x}{5}$.

35. 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).

36. $\frac{hc}{\lambda} = E_1 - E_2 = KE_2 - KE_1$

$\therefore$ $\lambda = \frac{h}{mV}$ $(mV)^2 = \left(\frac{h}{\lambda}\right)^2$; $\frac{1}{2}mV^2 = \frac{1}{2m}\frac{h^2}{\lambda^2}$

$\therefore$ $\frac{hc}{\lambda} = \frac{h^2}{2m\lambda_2^2} - \frac{h^2}{2m\lambda_1^2}$.

$\therefore$ $\lambda = \frac{2mc}{h}\left\{\frac{\lambda_1^2\lambda_2^2}{\lambda_1^2 - \lambda_2^2}\right\}$.

37. IP = $13.6Z^2$ = 16 (given).

1^{st} excitation potential $= 13.6\times\frac{3}{4}\times Z^2 = 16\times\frac{3}{4} = 12$ V.

38. Change is angular momentum $= \frac{\Delta nh}{2\pi} = (5-2)\frac{h}{2\pi}$

$= \frac{3h}{2\pi}$.

39. $\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha KE_\alpha}{m_p KE_p}} = \sqrt{\frac{4m_p\times 325}{m_p\times 50}} = \sqrt{26} \approx 5$.

40. Total energy $= \frac{13.6Z^2}{n^2} = \frac{13.6(Z)^2}{(4)^2} = 3.4$ eV

Now K.E. = 3.4 – 1.4 = 2 eV

Now, Total energy = 2 + 4 = 6 eV i.e. potential = 6 V

For electron $\lambda = \sqrt{\frac{150}{V}}$ so $\lambda = 5$ Å.

41. 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.

42. The lobes of $d_{x^2-y^2}$ orbital are alligned along X and Y axis. Therefore the probability of finding the electron is maximum along x and y-axis.

43. 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.

44. $E_n \propto Z^2$ $\therefore$ Z doubled $\Rightarrow$ E_n becomes four times.

$R_n \propto 1/Z$ $\therefore$ Z doubled $\Rightarrow$ R_n becomes half.

$v_n \propto Z$ $\therefore$ Z doubled $\Rightarrow$ v_n becomes two times.

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

$\therefore$ $\frac{hc}{300} = \frac{hc}{496} + \frac{hc}{\lambda}$.

$\therefore$ λ = 759 nm.

46. KE = – TE = 3.4 eV. $\therefore$ $\lambda = \sqrt{\frac{150}{KE}} = \sqrt{\frac{150}{3.4}}$ Å.

47. $\lambda_e = \dfrac{h}{\sqrt{2m_eKE_e}} = \dfrac{h}{\sqrt{2\times 1/1837m_p \times 16E}}$,

$\lambda_p = \dfrac{h}{\sqrt{2m_pKE_p}} = \dfrac{h}{\sqrt{2m_p \times 4E}}$.

$\lambda_\alpha = \dfrac{h}{\sqrt{2m_\alpha KE_\alpha}} = \dfrac{h}{\sqrt{2\times 4m_p \times E}}$ $\therefore$ $\lambda_e > \lambda_p = \lambda_\alpha$.

48. P.E. $= \dfrac{Kq_1q_2}{r} = \dfrac{K(-e)(+4e)}{r} = \dfrac{1}{4\pi\varepsilon_0} \times -\dfrac{4e^2}{r}$

$= \dfrac{-e^2}{\pi\varepsilon_0 r}$.

49. $\sqrt{n(n+2)} = 4.9$

$\therefore$ No. of unpaired electrons, n = 4.

$_{25}Mn : [Ar]4s^2 3d^5$

For having 4 unpaired electrons, a Mn atom should lose 3 electrons (2 from 4s and 1 from 3d).

$\therefore$ a = +3.

50. d_{z^2} orbital has two lobes along Z axis and a ring along XY plane.

51. Energy of one photon $= \dfrac{12400}{3100}$ = 4ev = 4 x 96

= 384 kJ mol^{-1}

$\therefore$ % of energy converted to K.E. $= \dfrac{384-288}{384}$

$= \dfrac{96}{384}$ x 100 = 25%

52. 1st line from red end in Balmer series.

$\Rightarrow$ Line of minimum energy in Balmer series.

$\therefore$ Transition = $(3 \to 2)$.

53. Since some visible quanta were observed along with other quanta, electrons must have made transition from some higher state to n = 2 and then from n = 2 to n = 1.

$\therefore$ Transition from 2 $\to$ 1 is compulsory, because electron from n = 2 will finally fall into n = 1.

54. $\dfrac{R_{n_1}}{R_{n_2}} = \dfrac{n_1^2}{n_2^2} = \dfrac{1}{4}$ $\therefore$ $\dfrac{n_1}{n_2} = \dfrac{1}{2}$.

Among the first four orbits n_1 and n_2 can be 1 and 2 or 2 and 4.

$\therefore$ Energy difference can be :

$E_{2\to 1} = 10.2$ eV or $E_{4\to 2} = 2.55$ eV.

55. $\lambda_p = \dfrac{h}{\sqrt{2m_pq_pV}}$ $\lambda_a = \dfrac{h}{\sqrt{2m_\alpha q_\alpha V}}$

$\lambda_a = \dfrac{h}{\sqrt{2\times 4m_p \times 2q_p \times V}}$

$\dfrac{\lambda_p}{\lambda_\alpha} = \dfrac{\sqrt{8}}{1} = \dfrac{2\sqrt{2}}{1}$.

56. $IE_A > IE_B$

$\therefore$ $Z_A > Z_B$.

$r \propto 1/Z$. $\therefore$ $r_A < r_B$.

$u \propto Z$ $\therefore$ $u_A > u_B$.

$E \propto Z^2$ (But it is negative). $\therefore$ $E_A < E_B$.

L does not depends on Z.

$\therefore$ For same n, $L_A = L_B$.

57. In H–atom, 4 lines are observed in Balmer series. So, electron is in n = 6(6 $\to$ 2, 5 $\to$ 2,4 $\to$ 2,3 $\to$ 2). In He^+ ion, one line is observed in Paschen series. So electron is in n = 4 (4 $\to$ 3).

$(H)_{6\to 2} = (He^+)_{12\to 4}$

$\therefore$ electron in He^+ will jump from n = 4 to n = 12.

58. $(He^+)_{2\to 4} = (Li^{2+})_{n_4 \to n_3}$

$\therefore$ $\dfrac{Z_1}{Z_2} = \dfrac{n_2}{n_4} = \dfrac{n_1}{n_3}$ or $\dfrac{2}{3} = \dfrac{2}{n_4} = \dfrac{4}{n_3}$

$\therefore$ $n_4 = 3$ and $n_3 = 6$.

$\therefore$ Transition in Li^{2+} ion = 3 $\to$ 6

59. $KE_1 = E_{photon} - BE_{n=1}$

$KE_2 = E_{photon} - BE_{n=n}$

$KE_2 - KE_1 = BE_{n=1} - BE_{n=n} = 13.6\, Z^2 \left[\dfrac{1}{1^2} - \dfrac{1}{n^2}\right]$

= 12.75 (given).

$\therefore$ $n^2 = 16$ or n = 4.

BE : Binding energy.

60. Number of lines of Paschen series

= 5 (8 $\to$ 3, 7 $\to$ 3, 6 $\to$ 3, 5 $\to$ 3, 4 $\to$ 3).

61. $E_{A\to C} = E_{A\to B} + E_{B\to C}$

$$\frac{12400}{3000} = \frac{12400}{\lambda(\text{Å})} + \frac{12400}{6000} \Rightarrow \lambda = 6000\ \text{Å}.$$

62. $E_{emitted} = \frac{50}{100} \times E_{absorbed}$

No. of emitted photons × Energy of emitted photon

$= \frac{50}{100} \times$ No. of absorbed photon × Energy of absorbed photon.

$\therefore\ n_e \times \frac{12400}{5000} = \frac{50}{100} \times n_a \times \frac{12400}{4000}$.

$\therefore\ \frac{n_e}{n_a} = \frac{5}{8}$.

63. $\frac{(e/m)_p}{(e/m)_\alpha} = \frac{e_p/m_p}{2e_p/4m_p} = \frac{2}{1}$.

64. $\Delta x = 0.1 \times 10^{-9}$ m.

$\Delta V = 5.27 \times 10^{-27}\ ms^{-1}$.

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

$\therefore\ 0.1 \times 10^{-9} \times m \times 5.27 \times 10^{-27} = 0.527 \times 10^{-34}$.

$\therefore\ m = 0.1$ kg. $= 100$ gm.

65. $\frac{1}{\lambda_1} = R(1)^2\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$ and $\frac{1}{\lambda_2}$

$= R(1)^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$

$\therefore\ \lambda_1 = \frac{1}{R}$ and $\lambda_2 = \frac{16}{3R}$.

$\therefore\ \frac{16}{\lambda_2} = \frac{3}{\lambda_1}$.

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

67. $v_1 = Rc(1)^2\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = Rc.$

$v_2 = Rc(2)^2\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = 4Rc.$

$v_3 = Rc(2)^2\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = Rc.$

$\therefore\ 2(v_1 + v_3) = v_2$ and $v_1 = v_3$ and $4v_1 = v_2$.

Part # II : Assertion & Reason

1. $q_\alpha = 2q_p$ and $m_\alpha = 4m_p$

2. For principle quantum number n

$\ell = 0$ to $(n-1)$ and $m = -\ell$ to ℓ including zero.

4. $\lambda = \sqrt{\frac{150}{V}}$ Å

5. **Statement-1 :** Correct statement.

Statement-2 : $\frac{1}{\lambda} = R_H Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$.

6. For Humphry series, ($n_2 = 7,8,9$.......) and $n_1 = 6$.

7. Since interaction between a photon and a molecule is always one to one, so a photon of energy 12eV can break only one molecule of A_2 into atoms and remaining 8eV energy becomes kinetic energy of atoms.

8. e/m ratio for particles in cathode rays comes out to be same for all gases.

$e/m = 1.76 \times 10^{11}$ C/kg.

This led to the conclusion that electrons were fundamental particles.

9. e/m ratio for particles in anode rays is different for different gases as different gases produce different positively charged particles upon ionisation.

EXERCISE - 3

Part # I : Matrix Match Type

2. $f_n = \frac{v_n}{2\pi r_n}$, $f_n \propto \frac{Z^2}{n^3}$, $T_n = \frac{2\pi r_n}{v_n}$, $T_n \propto \frac{n^3}{Z^2}$.

$E_n = -13.6\frac{Z^2}{n^2}$, $E_n \propto \frac{Z^2}{n^2}$, $r_n \propto \frac{n^2}{Z}$.

3. i : For Lyman series, $\bar{v}$ for second line $(3 \to 1)$

$= R(1)^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{8R}{9}$ **(c)**.

ii : For Balmer series, $\bar{v}$ for second line $(4 \to 2)$

$= R(1)^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = \frac{3R}{16}$ **(d)**.

iii : In a sample of H-atom for $5 \to 2$ transition, maximum number of spectral lines observed

$= \frac{(5-2)(5-2+1)}{2} = 6$ **(a)**.

iv : In a single isolated H-atom for $3 \rightarrow 1$ transition, maximum number of spectral lines observed $= 2\ (3 \rightarrow 2,\ 2 \rightarrow 1)$ **(b)**.

Part # II : Comprehension

Comprehension # 1 :

1. Last line of Bracket series for H-atom

$$\frac{1}{\lambda_1} = R\left[\frac{1}{(4)^2} - \frac{1}{(\infty)^2}\right] \qquad \text{so, } \lambda_1 = \frac{16}{R}$$

2^{nd} line of Lyman series

$$\frac{1}{\lambda_2} = R\left[\frac{1}{(1)^2} - \frac{1}{(3)^2}\right] \qquad \text{so, } \lambda_2 = \frac{9}{8R}$$

or, $$\frac{128}{\lambda_1} = \frac{9}{\lambda_2}$$

2. 1. Spectral lines of H atom only belonging to Balmer series are in visible range.
2. In the Balmer series of H-atom, first 4 lines are in visible region and rest all are in ultra violet region.
3. 2^{nd} line of Lyman series of He^+ ion has energy $= (E_{3\rightarrow 1}) \times 2^2 = 12.1 \times 4 = 48.4$ eV.

3. $$\bar{v} = R\,(4)^2\left[\frac{1}{(3)^2} - \frac{1}{(4)^2}\right] = \frac{7R}{9}.$$

Comprehension # 2 :

1. As the frequency of incident radiations increases, the kinetic energy of emitted photoelectrons increases.
Decreasing order of $\nu \Rightarrow$ Violet > Blue > Orange > Red
$\therefore$ Decreasing order of KE of photoelectrons $\Rightarrow$ Violet > Blue > Orange > Red

2. The interaction between photon and electron is always one to one for ejection of photoelectrons,
Frequency of incident radiations > threshold frequency
$\therefore\ 5.16 \times 10^{15} > 6.15 \times 10^{14}$

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

Comprehension # 3 :

1. Multiply Angular part and Radial part of 1s orbital and square this.

2. $$\Psi_{2s} = \frac{1}{\sqrt{32\pi}}\left[\frac{1}{a_0}\right]^{3/2}\left[2 - \frac{r}{a_0}\right]e^{-r/2a_0}$$

For radial node at $r = r_0$, $\Psi_{2s}^2 = 0$. This is possible only when

$$\left[2 - \frac{r_0}{a_0}\right] = 0.$$

$\therefore \quad r_0 = 2a_0$.

3. For s-orbital probability of finding an electron is same at all angles at specific radius.

Comprehension # 4 :

1. Two unpaired electrons present in carbon atom are in different orbitals. So they have different magnetic quantum number.

2. Electronic configuration of Zn^{2+} ion is $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}$ so no electron in 4s orbital.

3. $$\sqrt{s(s+1)}\,\frac{h}{2\pi} = \sqrt{\frac{1}{2}\left(\frac{1}{2}+1\right)}\,\frac{h}{2\pi} = \frac{\sqrt{3}}{2}\,\frac{h}{2\pi} = 0.866\,\frac{h}{2\pi}$$

Comprehension # 5 :

1. $$\Delta x = \frac{h}{4\pi\,Me} \times \frac{1}{\Delta V} \qquad \Delta V = V' \ \frac{0.001}{100} = 300 \times 10^{-5}\ \text{m/s}$$

$$\Delta x = 5.8 \times 10^{-5} \times \frac{1}{300 \times 10^{-5}} = 1.92 \times 10^{-2}\ \text{m}$$

2. The maximum KE of potoelectron is corresponding to maximum stopping = 22 eV

$\therefore\ E_{incident} = E_{thresold} + KE_{maxi} = 40\ \text{eV} + 22\text{eV} = 62\ \text{eV}$

$$\lambda_{incident} = \frac{12400\ \text{Å}}{62} = 200\ \text{Å}$$

3. Circumference $= 2\pi r = n\lambda$

$$\text{de-broglie} - \lambda = \frac{2\pi r}{n} = \frac{3\text{nm}}{3} = 1\ \text{nm} = 10\text{Å}$$

$$\therefore\ \lambda = \frac{12.3}{\sqrt{V}}\ \text{Å}$$

$$\Rightarrow \quad KE = \left(\frac{12.3}{10}\right)^2 = 1.51\ \text{eV}.$$

$\therefore$ KE of electron in third orbit = 1.51 eV $\equiv$ binding energy of third orbit in this atom

$$\lambda = \text{of photon required to ionise} = \frac{1240\ \text{eV Å}}{1.51\ \text{eV}} = 821\ \text{nm}$$

Comprehension # 6 :

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

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

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

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

2. $\sqrt{n(n+2)} = 1.73$

n (n + 2) = 3

n + 2n = 3

$n^2 + 2n - 3 = 0$

(n + 3) (n – 1) = 0

n = 1

Number of unpaired electron = 1

$V^{4+} \Rightarrow [Ar]\ 3s^1\,4s^0$

3. $Fe^{3+} = [Ar]\ 3d^5$

$Ti^{3+} = [Ar]\ 3d^1$

$Co^{3+} = [Ar]\ 3d^6$

all are having unpaired electron hence paramagnetic & coloured.

4. $Fe = [Ar]\ 3d^6\,4s^2$

↑↑	↑	↑	↑	↑		↑↓

Hund's and Pauli's principle is voileted.

5. Spin quantum number $(m_s) = -\frac{1}{2}, 0, +\frac{1}{2}$ that is one orbital accomodate maximum $3e^-$

Number of element in any period = $3r^2$

$n = \frac{p+2}{2}$ (for even period no.)

$n = \frac{2+2}{2} = 2$

number of element $\Rightarrow 3 \times 4 \Rightarrow 12$

6. for g - sub-shell

n = 5

$\ell = 0, 1, 2, 3, 4$

$\ell = 4$ {g - subshell}

number of electron $= 2\,(2\ell + 1)$

$= 2 \times 9 \Rightarrow 18$

number of orbital $= (2\ell + 1) \Rightarrow 9$

any orbital can have more two electron

EXERCISE - 4

Subjective Type

1. Distance to be travelled from mars to earth= 8×10^7 km

$\because$ Velocity = 3×10^8 m/sec

$\therefore$ Time = D/V = $\frac{8 \times 10^{10}}{3 \times 10^8} = 2.66 \times 10^2$ sec.

2. **(a)** I.P. $= \underset{1=\infty}{\Delta E} = E_\infty - E_1 = 0 - (-15.6) = 15.6$ l.v.

(b) $n = \infty \qquad n = 2$

$\Delta E = [0 - (-5.3)] = 5.3$ l.v.

$\Delta E = \frac{1240}{\lambda(nm)} \qquad \lambda = \frac{1240}{5.3} = 233.9nm$

(c) $|\Delta E_{3\to1}| = |-3.08 - (-15.6)| = 15.6 – 3.08 = 12.52$ l.v.

$= \frac{1240}{\lambda} = \frac{12.52}{1240} = \frac{1}{\lambda}(n.m)$

$\lambda = 1.808 \times 10^7\ m^{-1}$

(d) **(I)** $E = -15.6 - (-6) = -15.6 + 6 = -9.6$

(II) $E = -15.6 - (-11) = -15.6 + 11 = -4.6$

3. 1.6×10^{-19} J = 1 eV

$10^{-17} = \frac{10^{-17}}{1.6 \times 10^{-19}}\ eV = 0.655 \times 10^2$

$E = \frac{n\,hc}{\lambda} \qquad 0.625 \times 10^2 = n\frac{1240}{550}$

$2.77 \times 10 = n$

4. 330 J = n(hν)

$330\ J = n[6.62 \times 10^{-34} \times 5 \times 10^{13}]$

$\frac{330}{6.62 \times 10^{34} \times 5 \times 10^{13}} = n \qquad 10^{22} = n$

5. $E = \frac{hL}{\lambda} \qquad n = \frac{3.15 \times 10^{-14} \times 850 \times 10^{-9}}{6.62 \times 10^{-34} \times 3 \times 10^8}$

$n = 134.8 \times 10^3 \qquad n = 1.35 \times 10^5$

6. $\lambda = 1093.6$ nm $\qquad R_H = 1.09 \times 10^7\ m^{-1}$

$= 1093.6 \times 10^{-9}$ m. $n_2 = ? \qquad n_1 = 3$

$\frac{10^9}{1093.6 \times 10^7 \times 1.09} = \frac{1}{9} - \frac{1}{n_2^2}$

$\frac{1}{n_2^2} = \frac{1}{9} = -0.83 \qquad \frac{1}{n_2^2} = \frac{9}{0.253}$

$n_2^2 = 36 \qquad \boxed{n_2 = 6}$

7. $n_2 = 3 \quad n_1 = 2$ [first line]

$n_2 = 4 \quad n_1 = 2$ [second line]

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

$$\frac{1}{6565}\text{Å} = R_H\left[\frac{1}{4} - \frac{1}{9}\right] \ldots\text{(i)}$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{4} - \frac{1}{16}\right] \ldots\text{(ii)} \qquad \frac{\text{(i)}}{\text{(ii)}}$$

$$\frac{\lambda}{6565} = \frac{\frac{5}{36}}{\frac{3}{16}} = \frac{5\times 16}{36\times 3} \qquad \lambda = 4863\ \text{Å}$$

8. $3 \to 2$

$$\frac{1}{\lambda_1} = R_H \times Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R_H \times 4\left[\frac{1}{4} - \frac{1}{9}\right] \quad \ldots\text{(I)}$$

$$2 \to 1 \quad \frac{1}{\lambda_2} = R_H \times 4\left[\frac{1}{1} - \frac{1}{4}\right] \quad \ldots\text{(II)}$$

$$(\lambda_1 - \lambda_2) = 133.7\ \text{nm} \quad \ldots\text{(III)}$$

we will solve the three equation and we will get $R = 1.096 \times 10^7\ m^{-1}$

9. $\Delta E = 13.6\left[\frac{1}{9} - \frac{1}{4}\right] \times 96.3368$ kJ/mole

$$= 13.6\left[\frac{4-9}{36}\right] \times 96.368 = 182.074$$

$= 1.827 \times 10^5$ J/mole

10. $IE = \frac{hc}{\lambda} = \frac{1240}{85.4}$

$$= \frac{1240}{85.4} \times 96.368\ \text{kJ / mole} \approx 1399.25\ \text{kJ/mol}$$

11. Radius = 16(RH) = 16 × 0.0529

$$16 \times 0529 = 0.0529 \times \frac{n^2}{Z}$$

$$16 = \frac{n^2}{1} \qquad \boxed{n = 4}$$

$$\text{T.E.} = -13.6 \times \frac{n^2}{Z^2}\text{l.v.} = 0.85\ \text{l.v.} = -1.36 \times 10^{-19}\text{J}$$

12. $E_n = \frac{-21.7\times 10^{-12}}{n^2}$ $\qquad$ 1 erg = 10^{-7} Joule

$$E_n = \frac{-21.7\times 10^{-12}}{4}$$

$$\text{J.E.} = 0 - \left[\frac{-21.7\times 10^{-12}}{4}\right] = \frac{21.7\times 10^{-12}}{4}$$

$= 5.425 \times 10^{-12}$ ergs

(b) $5.425 \times 10^{-12} = \frac{6.624\times 10^{-34}\times 10^8}{\lambda}$

$$\lambda = \frac{6.624\times 3\times 10^8\times 10^{12}}{5.425\times 10^{34}} = 3.7 \times 10^{-14}\ \text{(nm)}$$

$= 3.7 \times 10^{-14} \times 10^9$ cm $= 3.7 \times 10^{-5}$ cm

13. $\underset{2\to 1}{\Delta E} = \text{I.E.}\left[\frac{1}{4} - \frac{1}{1}\right]$

$$2.17 \times 10^{-11}\ \text{erg/atom}\left[\frac{1}{4} - \frac{1}{1}\right] = \frac{hc}{\lambda(m)}$$

$$2.17 \times 10^{-11} \times 10^{-7}\text{J}\left[\frac{1}{4} - \frac{1}{1}\right] = \frac{6.626\times 10^{-34}\times 3\times 10^8}{\lambda}$$

$$\lambda = \frac{6.626\times 10^{34}\times 3\times 10^8\times 4}{2.17\times 10^{-18}\times 3} = \frac{6.626\times 4\times 10^8}{2.17}$$

$= 12.20 \times 10^{-8}$ m

1 m $\to 10^{10}$ Å

$$6.10 \times 10^{-8}\text{m} \to \frac{12.2\times 10^{10}}{10^8} = 1220\ \text{Å}$$

14. $V_n = 2.18 \times 10^6 \times \frac{Z}{n} = \frac{2.18\times 10^6}{n}$

$$\frac{2.18\times 10^6}{n} = \frac{1}{275}$$

$$\frac{2.18\times 10^6}{n} = \frac{1}{3\times 10^8} = \frac{1}{275}$$

$$\frac{2.18}{n(300)} = \frac{1}{275} \qquad \frac{1}{n} = \frac{300}{599.5}$$

$$n = \frac{599.5}{300} = \frac{1}{275} \qquad \frac{1}{n} = \frac{300}{599.5}$$

$n = 1.99 \simeq 2$

15. $Z = 3,\ n_1 = 1, n_2 = 3$

$$E_n = 13.6 \times (Z^2)\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 13.6 \times 9\left[\frac{1}{1} - \frac{1}{9}\right]$$

$$= 13.6 \times 9 \times \frac{8}{9} = 108.8 \text{ eV}$$

16.(i) $$E_{n_2 \to n_1} = 13.6 \times Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 13.6\,[1]^2\left[\frac{1}{1} - \frac{1}{4}\right]$$

$$= 13.1 \times 1 \times \frac{3}{4} = 10.22 \text{ eV}$$

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

$$\frac{1}{3 \times 10^{-8}} = 1.09 \times 10^7 \times Z^2\left[\frac{1}{4} - \frac{1}{1}\right]$$

$$\frac{10^8}{3 \times 10^7 \times 1.09} = Z^2 \times \frac{x-3}{4}$$

$$\frac{10 \times 4}{3 \times 1.09x - 3} = Z^2 \qquad Z^2 = -4 \quad Z = 2$$

17. 1.8 mole = (1.8 Na) atoms
27% = IIIrd energy level = 1.8 × Na × 0.27
15% = IInd energy level = 1.8 × Na × 0.15

$$\Delta E = \Delta E_{1\,(3\to1)} + \Delta E_{2\,(2\to1)} = 1.8 \times N_A \times 0.27 \times IE\left[\frac{1}{9} - \frac{1}{1}\right] + 1.8 \times$$

$$N_A \times 0.15 \times IE\left[\frac{1}{4} - \frac{1}{1}\right] = 292.68 \times 10^{21} \text{ atom}$$

18. Number of atom in 3rd orbit = 0.5 N_A
Number of atom in 2nd orbit = 0.25 N_A
Total energy evolve=0.5 $N_A(E_3 - E_1) + 0.25 N_A(E_2 - E_1)$

19. Angular momentum = $n\left(\frac{h}{2\pi}\right)$

$$\left(\frac{hc}{\lambda}\right) = -3.4\,\text{eV} \qquad -3.4 = -13.6 \times \frac{(1)^2}{n^2}$$

$$\frac{-3.4}{-13.6} = \frac{1}{n^2} \qquad n^2 = \frac{3.4}{3.4}$$

$n^2 = 4 \Rightarrow n = 2$

$$= 2\left(\frac{6.626 \times 10^{-34} \times 7}{2 \times 22}\right) = \frac{h}{\pi} \text{ or } \frac{6.62 \times 10^{-39} \times 7}{2}$$

20. $$4.5 \text{ eV} = \frac{1240}{\lambda(\text{nm})} \qquad \frac{1}{\lambda} = \frac{4.5}{1240}$$

$$\frac{1}{\lambda} = 0.0036 \text{ nm}^{-1} \qquad 1 \text{ nm} \to 10^{-9} \text{m}^{-1}$$

$0.0036 \text{ nm}^{-1} \to 3.6 \times 10^6 \text{m}^{-1}$

21. $$\frac{n(n-1)}{2} = 15 \qquad n^2 - n = 30$$

$n^2 - n - 30 = 0 \qquad n = 6$

$$\frac{1}{\lambda Å} = R_H\left[\frac{1}{1} - \frac{1}{36}\right]$$

$$\frac{1}{x} = \frac{1}{912} \times \frac{35}{36} = \frac{35 \times 2496}{32832}$$

$$\boxed{\lambda = 932\,Å}$$

22. $$V_2 = V_0 \times \frac{1}{2} = \frac{V_0}{2}$$

$x = v \times t$

$$x = \frac{V_0}{2} \times 10^{-8} \sec = \left(\frac{V_0 \times 10^{-8}}{2}\right)\text{m}$$

$2\pi r \to 1$ round

$$\frac{V_0 \times 10^{-8}}{2} = \frac{V_0 \times 10^{-8}}{2} \times \frac{1}{2\pi r}$$

$r_2 = r_0 \times n^2 = 4r_0$

$$\text{so, no. of revolutions} = \frac{V_0 / 2 \times 10^{-8}}{2\pi \times 4r_0} = \frac{V_0 \times 10^{-8} \times 1}{2 \times 2\pi \times 4r_0}$$

$$= \frac{2.18 \times 10^6 \times 10^{-18}}{2 \times 2 \times 3.14 \times 4 \times 0.529}$$

$$= \frac{2.18 \times 10^{-12}}{2.6 \times 10^{-21}} = 0.838 \times 10^9 = \boxed{8 \times 10^6}$$

23. $$V = \frac{\nu}{\lambda}$$

E of Ist Bohr orbit = –13.6

$$-13.6 = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\text{or} -13.6 = \frac{1240}{\lambda\,(\text{in nm})}$$

$$\lambda = \frac{1240}{136} \times 10$$

$$\lambda = 91.17 \text{ (nm)}$$

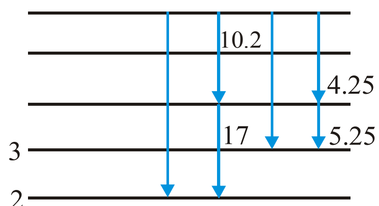
$$= 912 \text{ Å}$$

$$V = \frac{3 \times 10^8}{912 \times 10^{10}}$$

$$= \frac{3}{912} \times 10^{+R}$$

$$= 6530 \times 10^{12} \text{ Hz}$$

24.



$$\Delta E_{2\to n} \; -(10.2 + 17) = 13.6 \times 2^2 \left[\frac{1}{4} - \frac{1}{n^2}\right]$$

$$\Delta E_{3\to n} \; = 4.25 + 5.95 = 13.6 \times Z^2 \left[\frac{1}{9} - \frac{1}{n^2}\right]$$

25. $E = -2.18 \times 10^{-18} \frac{\cancel{Z}}{n^2} g / \text{atom}$

$$\Delta E = (E_2 - E_1) = \frac{1}{2} m v^2$$

$v = 1.89 \times 10^6$ m/sec

$v = 1.89 \times 10^8$ cm/sec

26. $V_2 = V_0 \times \frac{1}{2} = \frac{V_0}{2}$ $\qquad r = r_0 \times 4$

$$N = \frac{(V_0 / 2) \times 10^{-8}}{2\pi \times 4 r_0} \qquad \lambda_p = \frac{0.286}{\sqrt{V}} \text{Å}$$

$$\lambda_\infty = \frac{101}{\sqrt{V}} \text{Å}$$

27. (a) $\frac{1}{\lambda} = \left(\frac{1}{\lambda_1} + \frac{1}{\lambda_2}\right) = r \times 4 \left[\frac{1}{1^2} - \frac{1}{n^2}\right]$

(b) $\Delta E_{2\to 4} = 2.7 = IE\left[\frac{1}{4} - \frac{1}{16}\right]$

$$IE = 2.7 \times \frac{16}{3} \text{eV}$$

(c) $\Delta E^{max}_{4\to 1} = IE\left[\frac{1}{k} - \frac{1}{1}\right]$

$$\Delta E_{4\to 3} = IE\left[\frac{1}{16} - \frac{1}{9}\right]$$

29. B.E. = 180.69 kJ/mole $\quad \Rightarrow \quad w = h\nu_0$

$$\frac{180.69}{96.368} \text{eV/atom} = h\nu_0$$

$$\frac{180.69}{96.368} \times 1.6 \times 10^{-19} = 6.6 \times 10^{-34} \times \nu_0$$

$\nu_0 = 6.626 \times 10^{-34}$

30. $E = \frac{1240}{240}$ eV $\qquad E = 5.167$ eV

$E = 497.9$ kJ/mol

31. $h\nu_1 = h\nu_0 + 2E_1 \qquad h\nu_2 = h\nu_0 + E_1$

$h\nu_1 - w_0 + 2E_1 \qquad h\nu_2 - w_0 + E_1$

$$2 = \frac{h\nu_1 - w_0}{h\nu_2 - w_0} \qquad 2h\nu_2 - 2w_0 = h\nu_1 - w_0$$

$h\,[2\nu_2 - \nu_1] = w_0$

$w_0 = 6.62 \times 10^{-34} (2 \times 10^{15} - 3.2 \times 10^{15})$

$w_0 = 6.62 \times 10^{-34} \times 0.8 \times 10^{15}$

$w_0 = 5.29 \times 10^{-19} \qquad w_0 = 318.9$ kJ/mol

32. $\frac{hc}{\lambda_1} = w_0 + E_1 \qquad \frac{hc}{\lambda_2} = w_0 + E_2$

$$\frac{hc}{\lambda_1} - E_1 = w_0 \qquad \text{.........(I)}$$

$$\frac{hc}{\lambda_2} - E_2 = w_0 \qquad \text{........(II)}$$

$$\frac{hc}{\lambda_1} - E_1 = \frac{hc}{\lambda_2} - E_2$$

33. $2000 \text{ eV} = \frac{hc}{\lambda} = \frac{1240}{\lambda(\text{nm})}$

$$\lambda = \frac{1240}{20000} = 62 \times 10^{-3} \text{ nm} = 0.62 \text{ Å}$$

34. (KE) max = stopping potential

$\therefore$ stopping potential = 3.06 V

35. $U_{avg.} = \sqrt{\frac{8kJ}{\pi m}}$

$$U_{avg.} = \sqrt{\frac{8 \times 1.38 \times 10^{-23} \times 298}{3.14 \times 4 \times 1.67 \times 10^{-27}}}$$

$U_{avg.} = 1.25 \times 10^3$

$$\lambda = \frac{h}{mV} \Rightarrow \frac{6.62 \times 10^{-34}}{4 \times 1.67 \times 10^{-27} \times 1.25 \times 10^3}$$

$\lambda = 0.79$ Å

36. $500=\sqrt{\dfrac{150}{V}}$

$\therefore \dfrac{150}{250000}=V \qquad \therefore V = 6\times10^{-4}$ volt

37. $\dfrac{1}{10}\times3\times10^{8} = \Delta V = 3\times10^{7}$

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

$\Delta x\times1.672\times10^{-27}\,\text{kg}\times3\times10^{7}=\dfrac{6.626\times10^{-34}}{4\times3.14}$

$\Rightarrow \Delta x=\dfrac{6.626\times10^{-34}\times100}{1.672\times10^{-27}\times3\times10^{7}\times4\times314}$

$\boxed{\Delta x=1.05\times10^{-13}\,\text{m}}$

38. $1\times10^{-10}=6.6\times10^{-34}$

$=\sqrt{2\times1.67\times10^{-27}\times1.6\times10^{-19}\times V}$

$\therefore 1=6.6\times10^{-24}=\sqrt{5.344\times10^{-8}}\text{ eV}$

$\therefore 1=6.6\times10^{-20}=\sqrt{5.344\times V}$

$\therefore \sqrt{5.344\times V}=6.6\times10^{-20}$

39. Cu = [Ar]. 4s, $3d^{9}$

or

$\boxed{\uparrow\downarrow}\quad\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}$

no. of ex change pair $=\dfrac{n(n+1)}{2}=\dfrac{5\times4}{2}=10$

$\dfrac{4\times3}{2}=6$

Total exchanges = 10 + 6 = 16

41. E of light absorbed in one photon $=\dfrac{hc}{\lambda_{absorbed}}$

Let n_1 photons are absorbed, therefore,

Total energy absorbed $=\dfrac{n_1hc}{\lambda_{absorbed}}$

Now, E of light re-emitted out in one photon $=\dfrac{hc}{\lambda_{emitted}}$

Let n_2 photons are re-emitted then

Total energy re-emitted out $= n_2\times\dfrac{hc}{\lambda_{emitted}}$

As given $\quad E_{absorbed}\times\dfrac{47}{100}=E_{re\text{-}emitted\ out}$

$\dfrac{hc}{\lambda_{absorbed}}\times n_1\times\dfrac{47}{100}=n_2\times\dfrac{hc}{\lambda_{emitted}}$

$\therefore \dfrac{n_1}{n_2}=\dfrac{47}{100}\times\dfrac{\lambda_{emitted}}{\lambda_{absorbed}}=\dfrac{47}{100}\times\dfrac{5080}{4530}$

$\therefore \dfrac{n_1}{n_2}=0.527$

42. $H_2+Br_2\xrightarrow{hv}2HBr$

$Br_2\xrightarrow{hv}2Br$

BE = 192 kJ / mole

$\dfrac{192}{93.368}$ eV/mole $=\dfrac{hv}{\lambda}$ or $\dfrac{192}{96.368}=\dfrac{1240}{\lambda(\text{nm})}$

$\lambda = 6235$ Å

43. $\dfrac{0.2\,n}{Na}=0.01\,\text{mole} \qquad \dfrac{0.2\times n}{1+128}=0.01$

$\dfrac{0.2\times n}{10\times127}=\dfrac{1}{100} \qquad 2\times n=\dfrac{127}{10}$

$n=\dfrac{127}{10\times2}=\dfrac{12.7}{2}=6$

No. of protons $=\dfrac{6\times10^{22}}{2}=3\times10^{22}$

44. $\dfrac{243}{96.368}=\dfrac{1240}{\lambda(\text{nm})}$

$\lambda=\dfrac{1240\times96.368}{243}=491.75\times10^{-9}\,\text{m}\approx4.9\times10^{-7}\text{m}$

45. Energy required to break H–H bond

$=\dfrac{430.53\times10^{3}}{6.023\times10^{23}}$ J/molecule $=7.15\times10^{-19}$ J

Energy of photon used for this purpose $=\dfrac{hc}{\lambda}$

$=\dfrac{6.625\times10^{-34}\times3.0\times10^{8}}{253.7\times10^{-9}}=7.83\times10^{-19}$ J

$\therefore$ Energy left after dissociation of bond

$= (7.83 - 7.15) \times 10^{-19}$

or Energy converted into K.E. = 0.68×10^{-19}J

$\therefore$ % of energy used in kinetic energy =

$$\frac{0.68\times10^{-19}}{7.83\times10^{-19}}\times100 = 8.68\%$$

46. Energy given to I_2 molecule

$$= \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{4500\times10^{-10}} = 4.417\times 10^{-19}\text{ J}$$

Also energy used for breaking up of I_2 molecule

$$= \frac{240\times10^{3}}{6.023\times10^{23}} = 3.984 \times 10^{-19}\text{ J}$$

$\therefore$ Energy used in imparting kinetic energy to two I atoms

$= [4.417 - 3.984] \times 10^{-19}$ J

$\therefore$ K.E./iodine atom = $[(4.417 - 3.984)/2] \times 10^{-19}$

$= 0.216 \times 10^{-19}$ J

48. $\lambda = \sqrt{\dfrac{150}{10^{3}\times100}} = 3.88 \times 10^{-2}$ Å $= 3.88$ pm

49. $\lambda = \dfrac{6.6\times10^{-34}}{6\times10^{24}\times3\times10^{6}} = \dfrac{1\times1}{3}\times10^{-65} = 3.68 \times 10^{-65}$ m

50. $\Delta V = 30 \times 10^{2}$ cm/sec

$\lambda = 5000$ Å $\qquad$ m = 200 g

$\lambda = \dfrac{h}{mV} \qquad 500 = \dfrac{h}{m\times V}$

$P = mV = \dfrac{500}{6.626\times10^{-26}} = 30 \times 10^{2} \times 200$

$\boxed{=1.75\times10^{-29}}$

51. v = 40 m/sec $\qquad \Delta v = 0.01$

$$\therefore \Delta x = \frac{h}{4\pi\times9.1\times10^{-37}\times99.99\times40}$$

$$= \frac{0.53\times100\times10^{-54}}{40\times99.99\times9.1\times10^{-37}}$$

$$= \frac{0.53\times10^{-3}\times100}{40\times9.1\times99.99} \quad m.\Delta x.\Delta x = \frac{h}{4\pi}$$

$$\Delta x = \frac{5.27\times10^{-34}}{9.1\times10^{-31}\times40\times0.04\times\dfrac{1}{100}} = 1.447\times10^{-3}\times100$$

52. Given that $\lambda_1 = 486.1 \times 10^{-9}$ m

$= 486.1 \times 10^{-7}$ cm

$\lambda_2 = 410.2 \times 10^{-9}$ m $= 410.2 \times 10^{-7}$ cm

and $\bar{v} = \bar{v}_2 - \bar{v}_1 = \left[\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right]$

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

$$v = R_H\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] \qquad \text{........(I)}$$

For line I of Balmer series

$$\frac{1}{\lambda_1} = R_H\left[\frac{1}{2^2}-\frac{1}{n_1^2}\right] = 109678\left[\frac{1}{2^2}-\frac{1}{n_1^2}\right]$$

$$\text{or } \frac{1}{456.1\times10^{-7}} = 109678\left[\frac{1}{2^2}-\frac{1}{n_1^2}\right]$$

$\therefore n_1 = 4$

For line II of Balmer series ;

$$\frac{1}{\lambda_1} = R_H\left[\frac{1}{2^2}-\frac{1}{n_2^2}\right] = 109678\left[\frac{1}{2^2}-\frac{1}{n_2^2}\right]$$

$$\text{or } \frac{1}{410.2\times10^{-7}} = 109678\left[\frac{1}{2^2}-\frac{1}{n_2^2}\right]$$

$\therefore n_2 = 6$

Thus given electronic transition occurs from 6th to 4th shell.

Also by eq. (I)

$$\bar{v} = \frac{1}{\lambda} = 109678\left[\frac{1}{4^2}-\frac{1}{6^2}\right]$$

$\therefore \lambda = 2.63 \times 10^{-4}$ cm

53. $E_{ext} = 2.18\times10^{-19}\left(1-\dfrac{1}{9}\right)\times6.023\times10^{23} = 116.71$ kJ/mol H

D.E. = $116.71 \times 2.67 = 311.62$ kJ/mol H_2

$n = \dfrac{PV}{RT} = \dfrac{1}{0.082\times300} = 0.04$

$\Rightarrow$ T.E. = $0.04 \times 311.62 + 0.08 \times 116.71 = 21.8$kJ

54. $E(ev) = \dfrac{1240}{\lambda(nm)}$

Energy of 1st photon = $\dfrac{1240}{108.5} = 11.428$ eV

Energy of 2st photon = $\frac{1240}{30.4}$ =40.79 eV

En = 52.217– 54.4 = – 2.182 eV (E_1 = –54.4 eV)

$-2.182 = -\frac{13.6 \times 4}{n^2} \Rightarrow n = 5$

55. Since we obtain 6 emission lines, it means electron comes from 4th orbit energy emitted is equal to, less than and more than 2.7 eV. So it can be like this :

$E_4 - E_2 = 2.7$ eV, $E_4 - E_3 < 2.7$ eV,
$E_4 - E_1 > 2.7$ eV

(a) n = 2,
$(E_4 - E_2)^{atom} = (E_4 - E_2)^H \times Z^2$
$2.7 = 2.55 \times Z^2 = 1.029$

(b) $IP = 13.6\,Z^2 = 13.6 \times (1.029)^2 = 14.4$ eV

(c) Maximum energy emitted $= E_4 - E_1 = (E_4 - E_1)^H \times Z^2$
$= 12.75 \times (1.029)^2$
$= 13.5$eV
Minimum energy emitted$= E_4 - E_3 = (E_4 - E_3)^H \times Z^2$
$= .66 \times (1.029)^2 = 0.7$eV

56. $n \rightarrow 2\Delta E = 27.2\text{eV}(17 + 10.2)$

$\left.\begin{array}{l} \\ n \rightarrow 3\Delta E = 10.2\text{eV}(4.25+5.95.2) \end{array}\right\} E_3 - E_2 = 17\text{eV}$

17 eV = $1.89 \times Z^2 \Rightarrow Z = 3$
$E_2 = -3.4 \times 9 = -30.6$ eV
$E_n - E_2 = 27.2$ eV
$E_n = 27.2 + E_2 = -3.4$ eV

$E_n = -3.4 = -\frac{13.6 \times 3^2}{n^2} \Rightarrow n^2 = 36 \Rightarrow n = 6$

57. λ = 975 Å

$E = \frac{\lambda c}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{975 \times 10^{10}} = 2.03 \times 10^{-18}\text{J} = 12.75\text{eV}$

So electron will excite to 4th energy level and when comeback number of emission line will be 6.

minimum energy emitted $= E_4 - E_3 = 0.66$ eV

$\lambda = \frac{hc}{E} = \frac{1.9878 \times 10^{-25}}{.66 \times 1.6 \times 10^{-19}} = 1.882 \times 10^{-6}\text{ m} = 18820$ Å

58. (a) $kE = qV = 2 \times 1.6^{-19} \times 2 \times 10^6 = 6.4 \times 10^{-13}$J

(b) At distance $d = 5 \times 10^{-14}$ m let K.E. is x J and

$PE = \frac{k q_1 q_2}{d} = \frac{9 \times 10^9 \times 2 \times 1.6 \times 10^{-19} \times 47 \times 1.6 \times 10^{-19}}{5 \times 10^{-14}}$

$PE = 4.33 \times 10^{-13}$ J

By energy conservation :
$6.4 \times 10^{-13} = x + 4.33 \times 10^{-13}$
$x = 2.06 \times 10^{-13}$ J, kE = PE

$6.4 \times 10^{-13} = \frac{9 \times 10^9 \times 2 \times 47 \times (1.6 \times 10^{-19})^2}{d}$

$\Rightarrow d = 3.384 \times 10^{-14}$ m

59. $pE = \frac{-ke^2}{3r^3}$, since $F = -\frac{du}{dr} = -\frac{ke^2}{r^4}$

For stable atom $F = \frac{mv^2}{r}$ so $\frac{ke^2}{r^4} = \frac{mv^2}{r}$ ...**(1)**

$mv^2 = \frac{ke^2}{r^3}$ ...**(2)**

$kE = \frac{1}{2}mv^2 = \frac{ke^2}{2r^3}$, $PE = \frac{-ke^2}{3r^3}$

$T.E = \frac{ke^2}{2r^3} - \frac{ke^2}{3r^3} = +\frac{ke^2}{6r^3}$ ...**(3)**

Form bohr's postulate $mvr = \frac{nh}{2\pi} \Rightarrow V = \frac{nh}{2\pi mr}$

putting this in equation **(2)**

$m\left(\frac{nh}{2\pi mr}\right)^2 = \frac{ke^2}{r^3} \Rightarrow m\left\{\frac{n^2h^2}{4\pi^2 m^2 r^2}\right\} = \frac{ke^2}{r^3}$

$r = \frac{4\pi^2 mke^2}{n^2h^2}$

putting this in equation **(3)**

$T.E. = \frac{ke^2}{6\left\{\frac{4\pi^2 m^2 ke^2}{n^2h^2}\right\}^3} = \frac{ke^2}{6\left\{\frac{64\pi^6 m^3k^3e^6}{n^6h^6}\right\}}$

$E = \frac{n^6h^6}{384\, m^3\pi^6k^2e^4}$

60. (a) $(E_3 - E_2) = 68$ eV $= (E_3 - E_2)^H \times Z^2$
$68 = 1.89 \times Z^2$
z = 6

(b) $(kE)_1 = -E_1 = 13.6 \times 36 = 489.6$ eV

(c) Energy required $= -E_1 = 489.6$ eV

$\lambda = \frac{1240}{489.6} = 2.53$ nm

61. E_1 = IP
$= -4\,R = -4 \times 2.18 \times 10^{-18}$ J
$= -8.72 \times 10^{-18}$ J

$E_2 = \frac{E_1}{4} = -2.18 \times 10^{-18}$ J

$\Delta E = E_2 - E_1 = 6.54 \times 10^{-18}\ J = \frac{\lambda c}{\lambda}$

$\lambda = \frac{1.9878 \times 10^{-25}}{6.54 \times 10^{-18}} = 0.3039 \times 10^{-7}\ m = 303.9$ Å

$E_1 = -8.72 \times 10^{-18} = -21.79 \times 10^{-19} \times Z^2 \Rightarrow Z = 2$

(II) $r_1 = \frac{0.529 \times 1}{2}$ A°=0.2645A°= 2.645×10^{-11}m

62. (a) $\lambda = 12.4$ nm, $E\,(ev) = \frac{1240}{12.4} = 100$ eV

$W_0 = 25$ eV

$kE = E - W_0 = 75$ eV $\Rightarrow$ V = 75 volt

(b) $\lambda = \sqrt{\frac{150}{V}}$ A° $= \sqrt{2}$ A° = 1.414 A°

(c) since $p = \frac{h}{\lambda} \Rightarrow dp = \frac{h}{\lambda^2} d\lambda$

$d\lambda = \frac{\lambda^2 dp}{h} = \frac{(1.414 \times 10^{-10})^2 \times 6.62 \times 10^{-28}}{6.626 \times 10^{-34}}$

$d\lambda = 2 \times 10^{-14}$ m

63. Since electron is in some exited state of He^+ so it's energy ≤ 13.6 eV so energy need to exitation is also < 13.6 eV & only for hydrogen $E_3 - E_1 < 13.6$ eV. So Z =1. Now for He^+ this energy is equal to the energy gap of 2nd and 6th orbit so initial state is 2 and final state is 6.

64. $mvr = \frac{nh}{2\pi} \Rightarrow 3.1652 \times 10^{-34} = n \left\{\frac{6.626 \times 10^{-34}}{2 \times 3.14}\right\}$

n = 3

$\bar{v} = R\left[\frac{1}{1} - \frac{1}{3^2}\right] = \left(\frac{8R}{9}\right)$

EXERCISE - 5

Part # I : AIEEE/JEE-MAIN

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

$\therefore$ $\lambda = 91 \times 10^{-9}$ m = 91 m.

2. For 4*f* 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.

3. ${}_{24}Cr \rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$ (we know for p, $\ell = 1$ and for d, $\ell = 2$).

$\ell = 1, \ell = 1, \ell = 2$

For $\ell = 1$, total number of electrons = 12

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

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

5. 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.

6. According to Heisenberg's uncertainty principle

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

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

here $\Delta v = \frac{0.001}{100} \times 300 = 3 \times 10^{-3}\ ms^{-1}$

$\therefore$ $\Delta x = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 3 \times 10^{-3}} = 1.29 \times 10^{-2}$m.

7. Angular momentum of the electron, $mvr = \frac{nh}{2\pi}$

where n = 5 (given)

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

8. ${}_{28}Ni \rightarrow [Ar]3d^8\,4s^2$

3d: $\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$ 4s: $\boxed{\uparrow\downarrow}$ 4p: $\boxed{\ }\boxed{\ }\boxed{\ }$

Number of unpaired electrons (n) = 2

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

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

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

(C) ${}^{A}_{Z}X \xrightarrow{-{}^{1}_{0}n} {}^{A-1}_{Z}Y$ X **(D)** ${}^{A}_{Z}X \xrightarrow{-\beta+} {}^{A}_{Z-1}Y$

10. I.E. = 1.312×10^6 J mol^{-1}
The energy required to excite the electron in the atom from $n_1 = 1$ to $n = 2$.

$$= 1.312 \times 10^6 \left[1 - \frac{1}{4}\right]$$

$$= 1.312 \times 10^6 \times \frac{3}{4}$$

$$= 9.84 \times 10^5 \text{ J mol}^{-1}$$

11. 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)
$n + l = 4 + 0 = 4$

12. $Cl–Cl(g) \longrightarrow 2Cl(g)$; $\Delta H = 242$ KJ mol

$$= \frac{242 \times 10^3}{6.02 \times 10^{23}} \text{ J molecule}^{-1}$$

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

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

$$\lambda = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{242 \times 10^{-23} \times 10^3} = \frac{6.6 \times 3 \times 6.02}{242} \times 10^{-6}$$

$$= 0.494 \times 10^{-6}$$

$$= 494 \times 10^{-9} \text{ m} = 494 \text{ nm}$$

13. I.E. of $He^+ = 19.6 \times 10^{-18}$ J atom^{-1}
I.E. $= -E_1$
E_1 for He^+ is $= -19.6 \times 10^{-18}$ J atom^{-1}

$$\frac{(E_1)_{He^+}}{(E_1)_{Li^{3+}}} = \frac{(Z_{He^+})^2}{(Z_{Li^{2+}})^2}$$

$$\frac{-19.6 \times 10^{-18}}{(E_1)_{LI^{2+}}} = \frac{4}{9}$$

$$E_1(Li^{2+}) = \frac{-19.6 \times 9 \times 10^{-18}}{4} = -44.1 \times 10^{-18}$$

$$= -4.41 \times 10^{-17} \text{ J atom}^{-1}$$

14. $E = E_1 + E_2$

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

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

$$\frac{1}{355} = \frac{1}{680} + \frac{1}{\lambda_2}$$

$\lambda_2 = 742.76$ nm.

15. $h\nu = \Delta E = 13.6\, z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$\nu_{He+} = \nu_H \times z^2 \left(\frac{1}{\left(\frac{n_1}{2}\right)^2} - \frac{1}{\left(\frac{n_2}{2}\right)^2}\right)$$

$$= \nu_H \left(\frac{1}{\left(\frac{2}{2}\right)^2} - \frac{1}{\left(\frac{4}{2}\right)^2}\right)$$

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

16. **(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)

17. $_{37}Rb = [Kr]\, 5s^1$

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

18. $-\frac{13.6z^2}{n^2} \Rightarrow$ for hydrogen ; z = 1 $\Rightarrow -\frac{13.6}{n^2}$

Possible is –13.6, –3.4, –1.5 etc.

19. $\Delta KE = -q.\, \Delta v = e.v$

$$\therefore \frac{\ln}{\lambda} = \sqrt{2.m(\Delta KE)}$$

$$= \sqrt{2mev}$$

21. Radius of nth Bohr orbit in H-atom = 0.53 n^{2}Å
Radius of II Bohr orbit = $0.53 \times (2)^2 = 2.12$ Å

Part # II : IIT-JEE ADVANCED

1. $r_n = 0.529 \dfrac{n^2}{Z} \overset{\circ}{A}$

For hydrogen, n = 1 and Z = 1 ; $\therefore$ $r_H = 0.529$
For Be^{3+}, n = 2 and Z = 4 ;

$$\therefore \quad r_{Be^{3+}} = \frac{0.529 \times 2^2}{4} = 0.529$$

Therefore, **(D)** is correct option.

2. ψ^2_{2s} = probability of finding electron with in 2s orbital
$\psi^2_{\text{at node}}$ = 0 (probability of finding an electron is zero at node)

For node at $r = r_0$, $\psi^2 = 0$

$$\text{So,} \quad \psi^2 = 0 = \frac{1}{4\sqrt{2\pi}}\left[\frac{1}{a_0}\right]^3\left[2 - \frac{r_0}{a_0}\right] \times e^{r_0/2a_0}$$

$$\Rightarrow \left[2 - \frac{r_0}{a_0}\right] = 0 \text{ or } 2 = \frac{r}{a_0}$$

$\Rightarrow$ $r = 2a_0$

(b) The wavelength can be calculated with the help of de-Broglie's formula i.e.,

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{100 \times 100 \times 10^{-3}} = \frac{6.626 \times 10^{-34}}{10{,}000 \times 10^{-3}}$$

$$= 6.626 \times 10^{-35} \text{ m} \quad \text{or} \quad 6.626 \times 10^{-25} \text{ Å}$$

(c) **(I)** The atomic mass of an element reduces by 4 and atomic number by 2 on emission of an α-particle.

(II) The atomic mass of an element remains unchanged and atomic number increses by 1 on emission of a β-particle.

Thus change in atomic mass on emission of 8α–particles will be $8 \times 4 = 32$

New atomic mass = old atomic mass $- 32 = 238 - 32 = 206$

Similarly change in atomic number on emission of 8α-particle will be : $8 \times 2 = 16$

i.e., New atomic number = old atomic number $- 16 = 92 - 16 = 76$

On emission of 6β-particles the atomic mass remains unchanged thus, atomic mass of the new element will be 206.

The atomic number increases by 6 unit thus new atomic nubmer will be $76 + 6 = 82$

Thus, the equation looks like :

$$_{92}X^{238} \xrightarrow[-6\beta]{-8\alpha} {}_{82}Y^{206}$$

3. **(a)** For hydrogen atom, Z = 1, n = 1

$$v = 2.18 \times 10^6 \times \frac{Z}{n} \text{ ms}^{-1} = 2.18 \times 10^6 \text{ ms}^{-1}$$

$$\text{de Broglie wavelength, } \lambda = \frac{h}{mv}$$

$$= \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.18 \times 10^6} = \mathbf{3.32 \times 10{-}10\ m} = 3.3 \text{ Å}$$

(b) For 2p, $\ell = 1$

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

$$= \sqrt{2} \cdot \frac{h}{2\pi}.$$

4.
$$\left.\begin{aligned} K_n &= \frac{KZe^2}{2r} \\ V_n &= -\frac{KZe^2}{r} \\ E_n &= -\frac{KZe^2}{2r} \end{aligned}\right\} \text{ so, } \frac{V_n}{K_n} = -2 \text{ and } E_n \propto \frac{1}{r}.$$

5. For lower state (S_1)
No. of radial node = 1 = $n - \ell - 1$
Put n = 2 and ℓ = 0 (as higher state S_2 has n = 3)
So, it would be 2s (for S_1 state)

6. Energy of state $S_1 = -13.6\left(\dfrac{3^2}{2^2}\right)$ eV/atom

$$= \frac{9}{4}\text{(energy of H-atom in ground state)}$$

= 2.25 (energy of H-atom in ground state).

7. For state S_2
No. of radial node = 1 = $n - \ell - 1$ .... (eq.-1)
Energy of S_2 state = energy of e^- in lowest state of H-atom
$= -13.6$ eV/atom

$$= -13.6\left(\frac{3^2}{n^2}\right) \text{ eV/atom}$$

n = 3.

put in equation **(1)** $\ell = 1$

so, orbital $\Rightarrow$ 3p (for S_2 state).

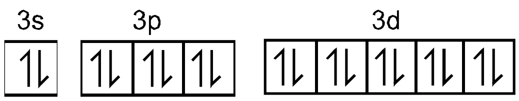
8. $E_{photon} = \frac{12400}{3000} = 4.13$ ev

Photoelectric effect can take place only if $E_{photon} \geq \phi$

Thus,

Li, Na, K, Mg can show photoectric effect.

9.



So, electrons with spin quantum number $= -\frac{1}{2}$ will be

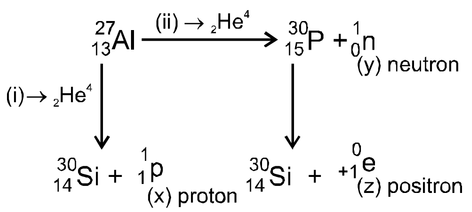
$1 + 3 + 5 = 9$.

10. $mv\,(4a_0) = \frac{h}{\pi}$

so, $v = \frac{h}{4m\pi a_0}$

so $KE = \frac{1}{2}mv^2 = \frac{1}{2}m.\frac{h^2}{16m^2\pi^2a_0^2} = \frac{h^2}{32m\pi^2a_0^2}$

11.



12. $^{63}_{29}Cu + ^1_1H \rightarrow 6^1_0n + ^4_2\alpha + 2^1_1H + X$

$64 = 6 + 4 + 2 + A \quad \Rightarrow \quad A = 52$

$29 + 1 = 30 = 0 + 2 + 2 + z \quad \Rightarrow \quad z = 26$

Element X should be iron in group 8.

13. n = 4, $m_\ell = 1, -1$

Hence ℓ can be $= 3, 2, 1$

i.e. H_f ; 2 orbitals

H_d ; 2 orbitals

H_p ; 2 orbitals

Hence total of 6 orbitals, and we want $m_s = -\frac{1}{2}$, that is only one kind of spin. So, 6 electrons.

14. For multielectron system (n + l) rule is valid

energy

3s < 3p < 3d.

Maximum degenerating in d orbital and hence = 5

15. **C**

16. **A**

$$\frac{27}{3} \times 13.6 \times 2^2\left\{\frac{1}{4} - \frac{1}{36}\right\} = 13.6 \times \left\{\frac{1}{4} - \frac{1}{16}\right\}$$

$$\frac{27}{32} \times \frac{8}{36} = \frac{3}{16}$$

17. **D**

MOCK TEST

1. In the given figure if line 'E' is in visible region then line belongig to ultraviolet region will have moe energy than 'E' i.e. line A

2. Let n be the number of Photons emitted

$\Rightarrow \frac{12400}{6000} \times 1.6 \times 10^{-19} \times n = 60 \times 10 \times 60 \times 60$

$\Rightarrow n = 6.5 \times 10^{24}$

3. $\frac{f_1}{f_2} = \frac{z_1^2}{n_1^3} \times \frac{n_2^3}{z_2^2}$

$\Rightarrow n_1 = 3, n_2 = 3, z_1 = 2, z_2 = 1$

$\therefore$ putting these values in the equation we get

$$\frac{2^2}{3^3} \times \frac{2^3}{1} = \frac{32}{27}$$

4. $\lambda = \frac{h}{\sqrt{2m_peV}}$ $\quad \lambda_\alpha = \frac{h}{\sqrt{2m_\alpha(2e)V\alpha}} = 2m_p eV$

$= 2 \times 4 \times m_p \times 2eV\alpha$

$\Rightarrow V_\alpha = \frac{V}{8}$

5. $\bar{v} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$x = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\bar{\nu}_1 = R \times 2^2\left(1-\frac{1}{2^2}\right) = 3R = \frac{36}{5}x \times 3 = \frac{108x}{5}$$

6. $\ell = 1$ for p and $\ell = 2$ for d.
Now $_{24}Cr$ hs configuration
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$
Hence there are 12, p-electrons and 5, d-electrons.

7. Energy of one photon $= \dfrac{12400}{4000}$

$= 3.1$ ev

Energy supplied by one mole photon in KJ/mole $= 3.1 \times 1.6 \times 10^{-19} \times 6 \times 10^{23} \times 10^{-3} \approx 297\ kJmol^{-1}$

$\therefore$ % of energy converted to K.E. $= \dfrac{297-246.5}{297} \simeq 17\%$

8. $r_3 = r_1\dfrac{3^2}{3}$

$\Rightarrow\ r_1 = \dfrac{r_3}{3} = \dfrac{x}{3}$ cm

$\therefore$ De-broglies wavelength $= \dfrac{2\pi x}{3}$

9. $\nu \propto \dfrac{1}{n^2} - \dfrac{1}{(n+1)^2}$

$$\propto \frac{(n+1)^2 - n^2}{(n+1)^2 n^2} \qquad \propto \frac{n}{n^4} \propto n^{-3}$$

10. $\Delta P \cdot \Delta x \geq \dfrac{h}{4\pi}$

$\because\ 2\Delta x = \Delta P$ (given)

$\therefore\ \dfrac{\Delta P^2}{2} \geq \dfrac{h}{4\pi}$

$\therefore\ m^2(\Delta V)^2 \geq \dfrac{h}{2\pi} \qquad \{\because \Delta P = m\Delta V\}$

$\Delta V \geq \sqrt{\dfrac{h}{2m^2\pi}}$

$\therefore\ \Delta V \geq \dfrac{1}{m}\sqrt{\dfrac{h}{2\pi}} \qquad$ or $\qquad \Delta V \geq \dfrac{1}{m}\sqrt{\hbar}$

11. $\bar{\nu} = RZ^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

$$x = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\bar{\nu}_1 = R \times 2^2\left(1-\frac{1}{2^2}\right) = 3R = \frac{36}{5}x \times 3 = \frac{108x}{5}$$

12. 3s orbital has two radial node at the values of radius given by solutions of $\left(6 - \dfrac{4Zr}{a_0} + \dfrac{4}{9}\cdot\dfrac{Z^2r^2}{a_0^2}\right) = 0$

$3p_z$ orbital has on radial nodal surface at $\left(4 - \dfrac{2Zr}{3a_0}\right) = 0$

& one angular node at $\theta = \pi/2$
for $3p_z$, at $r = 0$ $\quad \psi = 0$ while for
$3s$ at $r = 0$ $\quad \psi =$ maximum so, 3s has greater penetrating power than $3p_z$ orbital

13. Since it absorbes 'n' photons and it also emits exctly n-photns therefore transition must have taken place from 1 to 2.
$\therefore$ Energy of photon $= 10.2\ Z^2$
where $Z = 1, 2, 3, 4$

14. 'He' has highest first ionisation energy therefore assertion is wrong and also additio of extra electron to the outer most shell of fully filed orbitals absorbes energy. Hence reason is also wrong.

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

$\Rightarrow\ \Delta v = \dfrac{6.62\times10^{-34}}{9.1\times10^{-31}\times4\times3.14\times10^{-11}}$

$\simeq 6 \times 10^6$ m/s
as uncertainty in velocity is very high so we cannot define the trajectroy of an electron.

16. 2nd excitation energy $= 108.9$ eV
$\Rightarrow\ 108.9 = 12.1Z^2 \Rightarrow Z = 3$
Sample is Li^{++}
$\therefore$ Series limit of paschen is last lineof paschen series

$$= \frac{RZ^2}{n^2} = R \times \frac{3^2}{3^2}$$

17. Since if is a single isolated atom therefore maximum number of spectral line observed will be

18. $\frac{1}{\lambda} = R\left(1-\frac{1}{3^2}\right) = \frac{8}{9}R \quad \Rightarrow \quad \lambda = \frac{9}{8}R$

Last line of Brackett series

$\frac{1}{\lambda} = R\left(\frac{1}{4^2}\right) \Rightarrow \lambda = \frac{16}{R} \quad \Rightarrow \quad \frac{16}{R} - \frac{9}{8R} = \frac{119}{8R}$

19. Let n_1 and n_2 are the two states

$n_1 + n_2 = 4$ and $n_1 - n_2 = 2$

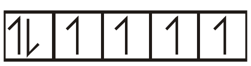
$\Rightarrow$ $n_1 = 3$ and $n_2 = 1$ $\quad \Rightarrow \quad$ wave number

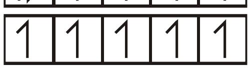
$= \frac{1}{\lambda} = R \times 3^2\left(1-\frac{1}{3^2}\right) = 8R$

20. Given $h\,v_1 = 13.6$ eV, $h\,v_2 = 10.2$ eV

$h\,v_3 = 3.4$ eV

clearly $v_1 - v_2 = v_3$

21. Fe^{2+} – [Ar] $3d^6$ 

Mn^{2+} – [Ar] $3d^5$ 

Cr^{3+} – [Ar] $3d^4$

V^{3+} [Ar] $3d^1$

clearly Mn^{2+} has maximum number of unpaired electrons therefore it has highest magnetic moment.

22. Magnetic moment $= \sqrt{n(n+2)} = 3.873$

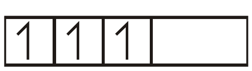
$\Rightarrow$ number of unpaired electron n = 3

$\therefore$ $_{25}Mn$ – [Ar] $3d^5\ 4s^2$

 therefore Mn should be in + 4

$3d^2$ $\quad$ 4s

23. There is two unpaired electron in Ti^{2+}

24. Mn^{4+} – [Ar] $3d^3$ 

25. **(A)** $T_n = -\frac{kze^2}{2r} \quad \Rightarrow \quad T_n \propto r^{-1}$

(B) $T_n = \frac{P_n}{2} \quad \Rightarrow \quad \frac{T_n}{P_n} = 1/2$

(C) $\frac{1}{f_n^{-x}} \propto z \quad \Rightarrow \quad f_n^{x} \propto z$

$f_n \propto z^2 \quad \Rightarrow \quad x = 1/2$

(D) $T_n \times V_n = \frac{2\pi}{v_n} r \times v_n \quad \Rightarrow \quad t = 1$

26. **(A)** $6 \rightarrow 3 \quad \Delta n = 3$

$\therefore$ no. of lines $= \frac{3(3+1)}{2} = 6$

All lines are in infrared region

(B) $7 \rightarrow 3 \quad \Delta n = 4$

$\therefore$ no. of lines $= \frac{4(4+1)}{2} = 10$

All lines are in infrared region

(C) $5 \rightarrow 2 \quad \Delta n = 3$

All lines are in visible region

(D) $6 \rightarrow 2 \quad \Delta n = 4$

All lines are in visible region

27. For the positive particle, applying energy conservation initially and at a point A.

$K.E._i + P.E._i = K.E._f + P.E._f$

$\Rightarrow$ $4eV + (+4e)(0V) = 0 + (+4e)(x\text{ volt})$ $\quad$ {x = potential at point A}

$\Rightarrow$ x = 1 volt

Now applying energy conservation for the negative particle at point 'A' and initially

$\Rightarrow$ $K.E._i + (-2e)(4V) = 0 + (-2e)(1\text{ volt})$

$K.E._i - 8\text{ eV} = -2\text{ ev}$

$\Rightarrow$ $K.E._i = 6$ eV.

28. From Bohr model $\quad mvr = \frac{nh}{2\pi} \quad mv = \frac{nh}{2\pi r}$

De broglie wavelength $\lambda = \frac{h}{mv} \Rightarrow \lambda = \frac{h}{\frac{nh}{2\pi r}}$

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

$\therefore$ number of waves made in one revolution

$= \frac{2\pi r}{\lambda} = \frac{2\pi r}{\frac{2\pi r}{n}} = n = \text{Orbit number} = 3$

29. **(a)** $mur = \frac{nh}{2\pi}$

$$u = \frac{nh}{2\pi mr} = \frac{1\times 6.626\times 10^{-34}}{2\times 3.14\times 9.108\times 10^{-31}\times 0.529\times 10^{-10}}$$

$$= 2.19\times 10^{6}\ m/s$$

$$\lambda = \frac{h}{mu} = \frac{6.626\times 10^{-34}}{9.108\times 10^{-31}\times 2.19\times 10^{6}}$$

$$= 3.32\times 10^{-10} m = 3.32 Å$$

(b) Orbital angular momentum for 2p-orbital ($\ell = 1$)

$$= \sqrt{\ell(\ell+1)}\cdot\frac{h}{2\pi} = \frac{h}{2\pi}\sqrt{1(1+1)} = \sqrt{2}\left[\frac{h}{2\pi}\right]$$

$$= \frac{h}{\sqrt{2}\pi} = \sqrt{2}\hbar \quad (\hbar = h/2\pi)$$

30. **(a)** $(\psi)_{2s} = \frac{1}{2\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{1/2}\left(2-\frac{r}{a_0}\right)e^{-r/2a_0}$

For radical node at $r = r_0$, $\psi_{2s}^2 = 0$. this is possible only

when $\left(2-\frac{r}{a_0}\right) = 0$

or $2 = \frac{r_0}{a_0}$

$\therefore\ r_0 = 2a_0$

(b) Given : $m = 100$, $g = 0.1$ kg ; $u = 100\ ms^{-1}$

wavelength $\lambda = \frac{h}{mu} = \frac{6.626\times 10^{-34}}{0.1\times 100} = 6.626\times 10^{-35}$ m

31. We have

$$\Delta E = \frac{3}{4}\times 0.85 eV$$

as energy = 0.6375 the photon will belong to brackett series (as for brackett $0.31 \le E \le 0.85$)

$$0.85\times\left(1-\frac{1}{4}\right) = 13.6\left(\frac{1}{4^2}-\frac{1}{n^2}\right)$$

$$0.85\left(1-\frac{1}{4}\right) = \frac{13.6}{16}\left[1-\left(\frac{4}{n}\right)^2\right] \qquad \therefore\ \frac{4}{n} = \frac{1}{2}$$

$\Rightarrow\ n = 8$

Hence $x = 8$.

32.

$$\frac{X}{2}\longrightarrow\frac{X^+}{2}+e \qquad \frac{1}{2}\text{I.E.} \qquad ....\text{(I)}$$

$$e+\frac{X}{2}\longrightarrow\frac{X^-}{2} \qquad \frac{1}{2}\text{E.A.}(-ve) \qquad ....\text{(II)}$$

(I) + (II)

$$X\longrightarrow\frac{1}{2}x^+ + \frac{1}{2}X^- \qquad \frac{1}{2}(\text{I.E.} - \text{E.A.}) = 410 kJ$$

$$\text{I.E.} - \text{E.A.} = 820 J$$

Now $\frac{1}{2}X^- \longrightarrow \frac{1}{2}X^+ + 2e^-$ ....**(III)** $\Delta H = 735$

Now evaluation **(III)** can be achieved by **(I)** + reverse **(II)** and we will get

$\frac{1}{2}$I.E. + $\frac{1}{2}$E.A. = 735

I.E. + E.A. = 1470 ....**(IV)**

2 E.A. = 650

E.A. = 325 kJ/mol.

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