Atomic Structure

EXERCISE - 1 [A]

1. **(A)**

$_{3}Li^{6} + ? \longrightarrow {}_{2}He^{4} + {}_{1}H^{3}$

By law of conservation of mass and change the missing particle in neutron $\left({}_{0}^{1}n\right)$

2. **(D)**

$\frac{q}{M}$ ratio lies in the sequence $n < \alpha < p < e$

Particle	Charge	Mass
$\propto$	+ 2e	+ 4u
n	0	+ 1u
p	+ 1e	+ 1u
e	– 1e	$= \frac{1}{1837}u$

$\left(\frac{q}{m}\right)$ order $\longrightarrow$ $n < \alpha < p < e$

3. **(D)**

Atomic Number = No. of protons in atom
By equation of charge
$-1\times56 + 1\times x = -2$
$\Rightarrow$ x = 54

4. **(D)**

Same number of neutrons hence, Isotones.

5. **(B)**

Cathode Ray are made of electrons hence, same charge/mass ratio as of β particle.

6. **(B)**

From Muliken's oil drop experiment, it was found that change on oil droplets is quantified.
Hence,
q = ne, where $e = 1.6\times10^{-19}$, n = 1, 2, 3…
$\therefore$ (B)

7. **(B)**

$$f = \frac{1}{T} \Rightarrow f = \frac{1}{1/2} = 2\,Hz$$

8. **(D)**

$$VIBGYOR^{\text{highest wavelength}}_{\text{lowest frequency}}$$

$Energy \propto freq.$

$\therefore$ (D) red

9. **(C)**

Rutherford's experiment showed first time that atom has nucleus.

10. **(C)**

Wave number $\Rightarrow \bar{\upsilon} = \frac{1}{\lambda}$

$$\Rightarrow \quad \frac{1}{500 \times 10^{-9}} \quad \Rightarrow \quad \frac{\overset{2}{\cancel{1000}} \times 10^{6}}{\cancel{500}}$$

11. **(C)**

$$E = \frac{hc}{\lambda},\ \frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = 2$$

12. **(B)**

$$\text{Frequency} = \frac{\text{velocity}}{\text{wavelength}} = \frac{3 \times 10^{8}}{5090 \times 10^{3}}$$

13. **(B)**

$E = nh\nu$

$$n = \frac{E}{h\nu}$$

$$= \frac{10^{3}}{6.626 \times 10^{-34} \times 880 \times 10^{3}} = 1.72 \times 10^{30}$$

14. **(C)**

$$E_{photon} = \frac{12400}{\lambda\left(inA^{0}\right)} = \frac{12400}{8900} = 1.393\,eV$$

$$1.393 \times 1.6 \times 10^{-19} \times x = 3.15 \times 10^{-14}$$

$$x = \frac{3.15}{1.393 \times 1.6} \times 10^{5} \qquad x = 1.41 \times 10^{5}$$

$\therefore \quad (c)$

15. **(A)**

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

$$\frac{hc}{\lambda_{absorbed}} \times n_1 \times \frac{50}{100} = n_2 \times \frac{hc}{\lambda_{emitted}}$$

$$\frac{n_2}{n_1} = \frac{50}{100} \times \frac{\lambda_{emitted}}{\lambda_{absorbed}} = \frac{50}{100} \times \frac{5000}{4500} = \frac{5}{9} = 0.55$$

16. **(A)**

As PE = - 2 KE

PE will change from - 2x to $-\frac{2x}{4}$

$$= -\frac{x}{2} + 2x = +\frac{3}{2}x$$

17. **(A)**

$TE = \frac{PE}{2}$, so first excited state

18. **(D)**

$$TE = \frac{-13.6\ Z^2}{n^2} = \frac{-13.6 \times 16}{16} = -13.6 \text{ and } TE = \frac{PE}{2}$$

$\Rightarrow$ PE = - 27.2 eV

19. **(B)**

$$TE = \frac{-13.6\ Z^2}{n^2} = \frac{-13.6 \times 1}{9} = -1.511$$

$TE = \frac{PE}{2} \Rightarrow PE = -3.02eV$ $\quad$ $TE = -KE \Rightarrow KE = 1.51eV$

20. **(C)**

$$r = \frac{0.529n^2}{Z}\ \text{Å}$$

$r_{3rd} = \frac{0.529 \times 9}{2} = 2.3805\ \text{Å}$ $\quad$ $r_{4th} = \frac{0.529 \times 16}{2} = 4.232\ \text{Å}$

21. **(D)**

$r_x = \frac{0.529\ n^2}{Z}$, n = 4

$r_H = \frac{0.529n^2}{Z}$, n = 1, z = 1

$\Rightarrow \quad \frac{0.529 \times 16}{Z} < 0.529 \quad \Rightarrow Z > 16$

$R_x < r_H$

22. **(B)**

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

$$v \propto \frac{Z}{n} \qquad \frac{v_1}{v_2} = \frac{n_2}{n_1} = \frac{5}{3}$$

$\therefore$ (B)

23. **(D)**

$$r_2 = \frac{a_0 \times 4}{Z} = R \Rightarrow \frac{a_0}{Z} = \frac{R}{4} \qquad r_3 = \frac{a_0 \times 9}{Z} = \frac{R}{4} \times 9$$

$$\Rightarrow \quad r_3 = \frac{9R}{4}$$

24. **(B)**

Ground state of hydrogen atom = 0.529 Å

$$r = \frac{0.529 \times n^2}{z} = \frac{0.529 \times (n)^2}{4} = 0.529 \qquad \Rightarrow \quad n = 2$$

25. **(D)**

$$V = \frac{2.18 \times 10^6 Z}{n}, \ v \ \alpha \ z, \ v \ \alpha \ \frac{1}{n}$$

26. **(D)**

$$\nu = \frac{V}{2\pi r} = \frac{2.18 \times 10^6 \times \frac{1}{2}}{2\pi \times 4 \times 0.529 \times 10^{-10}} = 8.13 \times 10^{14} \ s^{-1}$$

27. **(C)**

$$E = \frac{nhC}{\lambda} = nhc\bar{\upsilon}$$

$$10 = nhcx \qquad n = \frac{10}{hcx}$$

28. **(C)**

$$E = \frac{13.6 Z^2}{n^2} = \frac{13.6 \times 1}{4} = 3.4$$

29. **(D)**

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

$$r = \frac{0.529 n^2}{Z} \qquad mvr \ \alpha \ \sqrt{r}$$

Angular momentum $\alpha \sqrt{r}$

30. **(B)**

$$\nu = \frac{V}{2\pi r} \propto \frac{Z^2}{n^3}$$

$$\frac{\nu_{He^+}}{\nu_H} = \frac{\frac{2^2}{2^3}}{\frac{1^2}{3^3}} \Rightarrow \frac{\nu_{He^+}}{\delta} = \frac{27}{2} \Rightarrow \nu_{He^+} = \frac{27}{2}\delta$$

31. **(A)**

$$E = -KE$$

$$E \propto \frac{Z^2}{n^2}$$

$$\frac{E_{1,\,Li^{2+}}}{E_{4,\,H}} = \frac{\frac{3^2}{1^2}}{\frac{1^2}{4^2}} \Rightarrow \frac{E_{1,\,Li^{2+}}}{-€} = \frac{144}{1} \Rightarrow E_{1,\,Li^{2+}} = -144\ €$$

32. **(B)**

$$R_{\not{H}} \times 1^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = R_{\not{H}} \times 2^2\left(\frac{1}{n_1^{12}} - \frac{1}{n_2^{12}}\right)$$

$$\Rightarrow \quad 1\times\left(\frac{1}{1} - \frac{1}{25}\right) = 4\times\left(\frac{1}{1} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow \quad \frac{\not{24}^{\,6}}{25} = \not{4}\times\frac{n_2^2 - 1}{n_2^2} \qquad \Rightarrow \quad 6n_2^2 = 25n_2^2 - 25$$

$$\Rightarrow \quad 19n_2^2 = 25 \qquad \Rightarrow \quad n_2^2 = \frac{25}{15} = 1$$

$\therefore$ (b)

33. **(D)**

$$f = \frac{KZe^2}{r^2}$$

$$= \frac{KZe^2}{\left(\frac{0.529n^2}{Z}\right)^2} \propto \frac{Z^3}{n^4}$$

$$\frac{f_{1,\,H}}{f_{2,\,Li^{2+}}} = \frac{\frac{1^3}{1^4}}{\frac{3^3}{2^4}} \Rightarrow \frac{f_{1,\,H}}{f} = \frac{16}{27} \Rightarrow f_{1,\,H} = \frac{16}{27}f$$

34. **(C)**

$$a = \frac{V^2}{r}$$

$$= \frac{\frac{(2.18 \times 10^6)^2 Z^2}{n^2}}{\frac{0.529n^2}{Z}} \qquad \propto \frac{z^3}{n^4}$$

$$\frac{a_{2,\,Be^{3+}}}{a_{1,\,He^+}} = \frac{\frac{4^3}{2^4}}{\frac{2^3}{1^4}} \Rightarrow \frac{a_{2,\,Be^{3+}}}{\zeta} = \frac{64}{128} \Rightarrow a_{2,\,Be^{3+}} = \frac{1}{2}\zeta$$

35. **(D)**

Follow the expression

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

$\Rightarrow$ (D)

36. **(A)**

Follow the expression

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

$\Rightarrow$ (A)

37. **(B)**

Transition of an electron from n = 2 to n = 1 is in *UV* spectrum.

38. **(A)**

$2n_2 + 3n_1 = 18$

$2n_2 - 3n_1 = 6$

Solve this and we get

$n_1 = 2,\ n_2 = 6$

So, $\frac{(6-2)(6-2+1)}{2} = 10$

39. **(B)**

$n_1 + n_2 = 4$

$n_2 - n_1 = 2$

$\Rightarrow\ n_2 = 3,\ n_1 = 1$

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

$$= R_H \times 4\left(\frac{8}{9}\right)$$

40. **(A)**

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

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

$$\nu = \frac{c}{\lambda} = cR_H Z^2\left(\frac{1}{n^2} - \frac{1}{(n+1)^2}\right) = cR_H Z^2\left(\frac{2n+1}{n^2(n+1)^2}\right)$$

When n >>> 1 then (n +1) $\approx$ n and (2n + 1) $\approx$ 2n

$$\nu = 2cR_H Z^2 \frac{n}{n^4} = \frac{2cR_H Z^2}{n^3}$$

41. **(C)**

$$\frac{1}{\lambda_{min}} = 3^2 \times R\left(\frac{1}{3^2} - 0\right) = R$$

$$\Rightarrow \lambda_{min} = \frac{1}{R}$$

42. **(B)**

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

$$\frac{1}{\lambda_{max}} = R_H \times 4\left(\frac{1}{1} - \frac{1}{4}\right) \qquad \Rightarrow \lambda_{max} = \frac{1}{3R_H}$$

43. **(B)**

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

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

44. **(B)**

$E = E_1 + E_2$

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

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

45. **(C)**

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

$$\frac{1}{2170 \times 10^{-9}} = R_H\left(\frac{1}{n^2} - \frac{1}{7^2}\right) \qquad \Rightarrow n = 4$$

46. **(A)**

$$\frac{n(n-1)}{2} = 15$$

n = 6

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

$$\frac{1}{\lambda} = 109677\left(\frac{1}{1^2} - \frac{1}{6^2}\right)$$

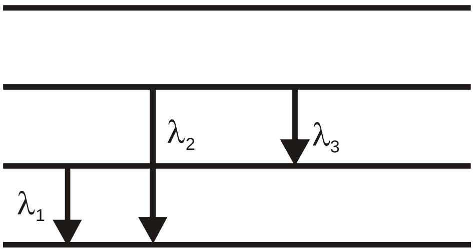
= 937.3 Å

47. **(A)**

$$\frac{n(n-1)}{2} = 6$$

n = 4, so excited state is 3rd

48. **(B)**



$1/\lambda_2 = 1/\lambda_1 + 1/\lambda_3$

$\lambda_2 = \lambda_1\lambda_3/(\lambda_1 + \lambda_3)$

49. **(A)**

$$\frac{1}{\lambda_L} = R_H\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) \Rightarrow \frac{1}{x} = R_H$$

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

$$\frac{1}{\lambda_B} = \frac{1}{x} \times \frac{5}{9}$$

50. **(C)**

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

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

$$\Delta x = \Delta p$$

$$(\Delta p)^2 = \frac{h}{4\pi}, \; \Delta p = \sqrt{\frac{h}{4\pi}}$$

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

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

51. **(C)**

Mass = 100 × 10^3 kg

V = 23.76 km s/hr = $23.76 \times \frac{5}{18}$ m/s

h = 6. 6 × 10^{-34}

$$\lambda = \frac{h}{mV} = \frac{6.626 \times 10^{-34}}{100 \times 10^3 \times 23.76 \times \frac{5}{18}} \simeq 10^{-39} m$$

52. **(C)**

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{h}{m\lambda}\right)^2 \begin{pmatrix} \lambda = \frac{h}{mv} \\ v = \frac{h}{m\lambda} \end{pmatrix}$$

$$= \frac{1}{2}\frac{mh^2}{m^2\lambda^2} = \frac{1}{2}\frac{h^2}{m\lambda^2}$$

$$KE \ \alpha \ \frac{1}{m}$$

53. **(B)**

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

$$\lambda = \frac{2\pi r}{n} \qquad \Rightarrow \lambda = \frac{2\pi \times 3^2 x}{3} = 6\pi x$$

54. **(C)**

Uncertainty principle has significance only on microscopic particles.

55. **(A)**

$\nu = 3.5 \times 10^{15}$ Hz

$\nu_0 = 1.5 \times 10^{15}$Hz

h = 6.6 × 10^{-34}

KE = $h\nu - h\nu_0$

KE = 6.6 × 10^{-34}(3.5 × 10^{15} – 1.5 × 10^{15}) $= 1.32 \times 10^{-18}$ J

56. **(C)**

KE = $h\nu - h\nu_0$

$$\frac{1}{2}mv^2 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$$v^2 = \frac{2hc}{m}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$$v = \sqrt{\frac{2hc}{m}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)}$$

$$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$$

57. **(A)**

WF = $E_p - K_{max}$

$$= 4 \times 10^{-20} - \frac{(6.626 \times 10^{-34})^2}{2 \times 9.11 \times 10^{-31} \times (59 \times 10^{-10})^2}$$

$= 3.313 \times 10^{-20}$J

58. **(B)**

$$KE_1 = h\nu_1 - h\nu_0$$

$$KE_2 = h\nu_2 - h\nu_0$$

$$\frac{1}{k} = \frac{\nu_1 - \nu_0}{\nu_2 - \nu_0}$$

$$\nu_0 = \frac{k\nu_1 - \nu_2}{k - 1}$$

59. **(A)**

Number of nodal planes = l

60. **(A)**

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

61. **(A)**

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

62. **(C)**

For 3f orbital n = 3, l = 3, which is not possible because l can lie between 0 to n – 1.

63. **(D)**

Schrodinger equation gives n, l, m_l

64. **(B)**

$$\sqrt{l(l+1)}\,\frac{h}{2\pi}$$

65. **(B)**

Shape is decided by Azimuthal quantum number l.

66. **(A)**

Number of radial nodes = n – l – 1

67. **(D)**

Number of electrons in any orbit $= \sum_{\ell=0}^{\ell=n-1} 2(2\ell+1)$

68. **(D)**
Plank theory explains dual nature of photon.

69. **(C)**
Orbital is a region where probability of finding electron is very high (90-95%).

70. **(D)**
de-Broglie concept, Heisenberg's principle and Schrodinger wave equation all are based on wave nature on electron.

71. **(B)**
p-orbital contain maximum 2 electrons.

72. **(C)**
Magnetic quantum number decide orientation of orbital in space.

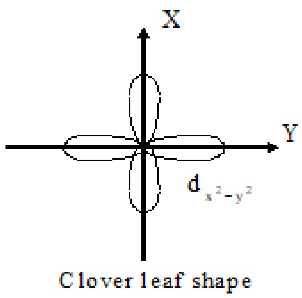
73. **(A)**
Principal quantum number n decide location and energy of electron.

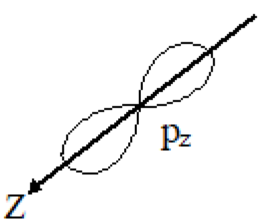
74. **(A)**
m_l can have values between $-l$ to $+l$.

75. **(D)**
n = 3, l = 3, m = 0, s = –1/2
Which is not possible because l can lie between 0 to n – 1.

76. **(C)**
Follow n + l rule

77. **(D)**





78. **(A)**
Follow n + l rule

79. **(D)**
A g subshell will have 9 orbitals so there will be 18 electrons

80. **(C)**
Angular part cannot be 0 so no angular node, Hence s orbital. Two radial node means 3s

81. **(D)**
4d atomic orbitals have one radical node, so graph will have two maxima.

82. **(C)**
n = 5

83. **(C)**
See the graph of 3s, 3p and 3d.

84. **(D)**
Number of local maxima = n – *l*

85. **(C)**
Increasing Z will decrease radius

86. **(C)**
Fe_{26} : [Ar] $4s^2$ $3d^6$

87. **(D)**
(D) is not possible because ‘p’ sub shell cannot have more than 6 electrons.

88. **(A)**
$Mn = 3d^5\ 4s^2$

$Ti = 3d^2\ 4s^2$

$V = 3d^3\ 4s^2$

$Al = 3s^2\ 3p^1$

89. **(A)**
$Fe : 3d^6\ 4s^2$

$Fe^{2+} : 3d^6\ 4s^0$

n = 4

$\mu = \sqrt{4(4+2)} = 2\sqrt{6}\,BM$

90. **(C)**
$s = \pm\frac{1}{2}\times 5 = \frac{5}{2}$

91. **(A)**
Next element is copper.

$Cu - [Ar]3d^{10}\ 4s^1$ (Exception)

92. **(D)**

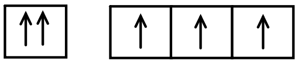
$Mg^{2+}:[Ne] \Rightarrow n=0$

$Ti^{3+}:[Ar]\,3d^1\,4s^0 \Rightarrow n=1$

$V^{3+}:[Ar]\,3d^2\,4s^0 \Rightarrow n=2$

$Fe^{2+}:[Ar]\,3d^6\,4s^0 \Rightarrow n=4$

93. **(C)**



Both electrons in s-orbital have same spin in this configuration.
Hence, their all quantum numbers are same so Pauli principle is violated.

94. **(B)**

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

$2.83=\sqrt{n(n+2)} \Rightarrow n=2$

$Fe^{2+}:[Ar]\,3d^6\,4s^0 \Rightarrow n=4$

$Ni^{2+}:[Ar]\,3d^8\,4s^0 \Rightarrow n=2$

$Mn^{2+}:[Ar]\,3d^5\,4s^0 \Rightarrow n=5$

$Co^{3+}:[Ar]\,3d^6\,4s^0 \Rightarrow n=4$

95. **(C)**

$3.873=\sqrt{n(n+2)} \Rightarrow n=3$

$Mn^{2+}:[Ar]\,3d^5\,4s^0 \Rightarrow n=5$

$Mn^{3+}:[Ar]\,3d^4\,4s^0 \Rightarrow n=4$

$Mn^{4+}:[Ar]\,3d^3\,4s^0 \Rightarrow n=3$

$Mn^{5+}:[Ar]\,3d^2\,4s^0 \Rightarrow n=2$

96. **(D)**

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

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

N = 1

97. **(B)**

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

$Fe^{3+}:[Ar]\,3d^5\,4s^0 \Rightarrow n=5$

$Co^{2+}:[Ar]\,3d^7\,4s^0 \Rightarrow n=3$

$$\frac{\mu_{Fe^{3+}}}{\mu_{Co^{2+}}}=\frac{\sqrt{5(5+2)}}{\sqrt{3(3+2)}}=\frac{\sqrt{35}}{\sqrt{15}}$$

EXERCISE - 1 [B]

1. (A)
Hydrogen nucleus has only one proton & no neutron.

2. (A)
Cathode rays are electrons, hence mass of cathode rays same for all gases.

3. (D)
For electron
$$\frac{e}{m}=\frac{1.6\times10^{-19}}{9.1\times10^{-31}}\ C/kg$$
For α particle
$$\frac{e}{m}=\frac{2\times1.6\times10^{-19}}{4\times1.67\times10^{-27}}C/kg$$

4. (A)
Radius of nucleus is of order 10^{-15} m while radius of atom is of order 10^{-10} m.

5. (C)
$$\text{Radius of nucleus } =1.3\times10^{-15}(M)^{1/3}$$
$$=1.3\times10^{-15}(64)^{1/3}$$
$$=5.2\times10^{-15}m$$
$$=5.2\,fm$$

6. (C)
Cathode rays are electron & hence their speed is less than light.

7. (B)
$$-6.4\times10^{-19}=n\times\left(-1.6\times10^{-19}\right)\Rightarrow n=4$$

8. (D)
Rutherford experiment proved that positive charge of atom is concentrated in central region called nucleus which is almost stationary.

9. (D)
$$\text{Energy } =40\times20$$
$$=800J$$
$$800\times\frac{80}{100}=n\times\frac{6.626\times10^{-34}\times3\times10^{8}}{620\times10^{-9}}$$
$$n=2\times10^{21}$$

10. (B)

$$\frac{1}{500}=\frac{1}{800}+\frac{1}{\lambda}\Rightarrow\lambda=\frac{500\times800}{800-500}=\frac{4000}{3}=1333\,\text{nm}$$

11. (D)

$$r_{3,\,Li^{2+}}=\frac{3^2}{3}\times r_{1,\,H}=3\times r_{1,\,H}$$

12. **(C)**

$$E_{3,Li^{2+}}=-\left(\frac{9}{9}\right)\times\left(\frac{E_{1,He^+}}{4}\right)=\frac{1}{4}\times19.6\times10^{-18}=-4.9\times10^{-18}\text{ J / atom}$$

13. **(D)**

$n\ell:\ 1s^2 2s^2 2p^6 3s^2 3p^1$

$\Rightarrow$ outermost $e^-: n=3,\ \ell=1$

14. **(B)**

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

$\ell=1\Rightarrow$ p subshell $\Rightarrow 12\,e^-$

$\ell=2\Rightarrow$ d subshell $\Rightarrow 10e^-$

15. **(D)**

Orbital angular momentum $\alpha\sqrt{\ell(\ell+1)}$

$\Rightarrow$ same ℓ value has same orbital angular momentum.

16. **(B)**

By $(n+\ell)$ rule

17. **(B)**

$$r_{3,\,He^+}=\frac{n^2}{Z}a_0=\frac{3^2}{2}a_0=4.5\,a_0$$

18. **(C)**

$$\nu=\frac{C}{\lambda}=\frac{3\times10^8}{500\times10^{-9}}=6\times10^{14}\text{ Hz}$$

19. **(D)**

$$\frac{1}{\lambda}=9\times15200=136800$$

20. **(D)**

In a given shell, l = 2, m = +2, denotes one particular orbital which can contain only one electron with spin value = $\frac{1}{2}$.

21. (A)

Atomic no. $=25 \quad \Rightarrow$ Mn

22. (C)

2^{nd} series $\Rightarrow$Balmer

4^{th} Line in Balmer $\Rightarrow 6 \rightarrow 2$

23. (A)

Paschan Lines : $5 \rightarrow 3$

$4 \rightarrow 3$

24. (B)

Splitting of spectral lines in electric field is called as stark effect.

25. (A)

$$E = \frac{1240}{242} \times 1.6 \times 10^{-19} \times 6.022 \times 10^{23} \times \frac{1}{1000}$$

26. (C)

m cannot be greater then ℓ

27. (A)

$Co : [Ar] 4s^2\ 3d^7$

$Co^{3+} : [Ar]\ 4s^0\ 3d^6$

28. (D)

$Cr : [Ar] 4s^1\ 3d^5$

29. (A)

$$\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$$

30. (D)

$$r = \frac{n^2}{Z} a_0$$

31. (A)

$1s^2 2s^2 2p^4$

No. of unpaired electron $= 2$

$\Rightarrow$ total spin $= 1$

Magnetic moment $= \sqrt{2 \times 4} = \sqrt{8}$

32. (B)

No. of angular nodes $= 2$

33. **(A)**

$$E = x\left(\frac{1}{4}-\frac{1}{9}\right)=\frac{5x}{36}$$

34. **(B)**

XZ-plane is the nodal plane for p_y orbital.

35. **(C)**

Orbital angular momentum $=\sqrt{2\times 3}\,\frac{\pi}{2\pi}=\sqrt{6}\,\frac{h}{2\pi}$

36. **(B)**

No. of radical nodes $= n-\ell-1$

$= 2-1-1=0$

37. **(B)**

$$p=\frac{6.6\times 10^{-34}}{0.1\times 10^{-9}}=66\times 10^{-25}$$

38. **(D)**

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

39. **(D)**

$$\frac{nh}{2\pi}=\frac{2h}{\pi}=n=4$$

$$\frac{1}{\lambda}=R\left(\frac{1}{9}-\frac{1}{16}\right)$$

$$\lambda=\frac{144}{7R}$$

40. **(B)**

Min. $\lambda \Rightarrow \text{Max. } E$

41. **(C)**

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

$$\lambda=\frac{4n^2}{R\left(n^2-4\right)}\Rightarrow k=\frac{4}{R}$$

42. **(A)**

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

$$=\frac{1240}{364.6}+\frac{1240}{121.5}\ \text{eV}$$

$= 3.4 + 10.2 = 13.6\,eV$

$= 13.6 = \frac{1240}{\lambda} \Rightarrow \lambda = 91.17\,nm$

43. (A)

Minimum $= 1$ $\quad 4 \rightarrow 1$

Maximum $= 4$ $\quad 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$ & $4 \rightarrow 1$

$\frac{\Delta n(\Delta n + 1)}{2} \rightarrow$ only if sufficiently large number of atoms are present

44. (D)

Shortest wavelength implies maximum energy

$\therefore \frac{n(n-1)}{2} = 15$

$\Rightarrow \frac{1}{\lambda_{6\rightarrow 1}} = R_H (1)^2 \left(\frac{1}{1} - \frac{1}{36}\right)$

$\frac{1}{\lambda} = \frac{35R}{36} \qquad \therefore \lambda = \frac{36}{35R}$

45. (C)

Total orbitals $= 3\ell + 1 = 3 \times 2 + 1 = 7$

e^- in 1 orbital still $= 2$

Since it has only 2 types of spin

46. (B)

$L = \frac{nh}{2\lambda}$

47. (B)

4 $235 + 1 = 146 + x + 3$

$\Rightarrow x = 90 - 3 = 87$

48. (C)

Radial node (spherical) = 3 – 1 –1 = 1

Angular node (non-spherical) = 1

49. (A)

$S \rightarrow$ spherical (non-directional)

50. (D)

$E_{111\rightarrow 1} = 2E - E = \frac{hc}{\lambda}$

$E_{11\rightarrow 1} = \frac{4E}{3} - E = \frac{hc}{\lambda'}$

$\Rightarrow \frac{E}{3} = \frac{hc}{\lambda'} \qquad \Rightarrow \lambda' = 3\lambda$

1. **(A)**

$Mn^{2+} = [Ar]3d^5$

$n = 5 \Rightarrow \mu = \sqrt{5(5+2)} = -\sqrt{35}$ B.M.

$Fe^{2+} = [Ar]\,3d^6$, n = 4

$Ti^{2+} = [Ar]\,3d^2,\ n = 2$

$Cr^{2+} = [Ar]3d^4,\ n = 4$

2. **(D)**

Angular momentum in an orbit $= \frac{nh}{2\pi}$

$= \frac{5h}{2\pi}$

3. **(C)**

$\Delta V = \frac{0.001}{100} \times 300 = 3 \times 10^{-3}$ m/s

$\Delta X \geq \frac{h}{4\pi m \Delta V} = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 3 \times 10^{-3}}$

$= 19.3 \times 10^{-3}$ m

4. **(C)**

For 4f, n = 4, $\ell = 3, m = -3$ to +3 & $\ell = \pm\frac{1}{2}$

5. **(C)**

$(n+\ell)\uparrow$, higher energy

For $(n+\ell)$ having same value, n should be higher.

6. **(A)**

Ionisation enthalpy $= 1.312 \times 10^{16}$ J/mol

$= \frac{1.312 \times 10^6}{60.2 \times 10^{23}}$ J/atom

Energy required $= \frac{1.312 \times 10^6}{6.02 \times 10^{23}}\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$= \frac{1.312 \times 10^6}{6.02 \times 10^{23}} \times \frac{3}{4} = 0.16 \times 10^{-17}$ J/atom

$= 9.84 \times 10^5$ J/mol

7. **(C)**

$$\Delta V = \frac{0.005}{100}\times 600 = 3\times 10^{-2}\ \text{m/s}$$

$$\Delta X = \frac{6.62\times 10^{-34}}{4\times 3.14\times 9.1\times 10^{-31}\times 3\times 10^{-2}} = 1.92\times 10^{-3}\ \text{m}$$

8. **(B)**

$$\lambda = \frac{6.63\times 10^{-34}}{1.67\times 10^{-27}\times 10^{3}} = 3.97\times 10^{-10}\ \text{m}$$

$$= 0.397\ \text{nm}$$

9. **(D)**

$$\text{Energy} = \frac{242\times 10^{3}}{6.02\times 10^{23}}\ \text{J/atom}$$

$$E = \frac{hC}{\lambda} \Rightarrow \lambda = \frac{hC}{E} = \frac{2\times 10^{-25}\times 6.02\times 10^{23}}{242\times 10^{3}}$$

$$\lambda = 4.9\times 10^{-7}\,\text{m} = 490\ \text{nm}$$

10. **(B)**

$$\text{I.E.} \propto \frac{z^2}{n^2}$$

$$\frac{\text{I.E. of } Li^{2+}}{\text{I.E. of } He^{+}} = \frac{9}{4} \Rightarrow \text{I.E. of } Li^{2+} = 4.41\times 10^{-17}\ \text{J/atom}$$

Energy of first orbit of $Li^{2+} = -\text{I.E. of } Li^{2+}$

11. **(C)**

$$\underset{64}{Gd} \rightarrow [Xe]4f^{7}\,5d^{1}\,6s^{2}$$

12. **(B)**

$$\frac{1}{\lambda} + \frac{1}{680} = \frac{1}{355} \Rightarrow \frac{1}{\lambda} = \frac{1}{355} - \frac{1}{680}$$

$$\lambda = \frac{355\times 680}{(680-355)} = 742.76\ \text{nm}$$

13. **(B)**

$(n+\ell)\uparrow$ energy$\uparrow$

For same $(n+\ell)$, n$\uparrow$energy$\uparrow$

14. **(B)**

$$\lambda = \frac{6.63\times 10^{-34}}{1000\times 36\times \frac{5}{18}}$$

$$\lambda = 6.63\times 10^{-38}\,\text{m}$$

15. **(B)**

$n = 5, \; m = +1 \qquad (4 \text{ orbitals} = 8 \text{ electrons})$

$n = 2, \ell = 1, m = -1, s = -\frac{1}{2} \quad$ (1 electron of 2p)

16. **(A)**

$$\bar{\upsilon} = \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5}{36}R$$

17. **(C)**

$n = 3, \; \ell = 2, m = +2 \quad$ (1 orbitals of 3d)

18. **(D)**

$$E = -2.178 \times 10^{-18} \times \frac{z^2}{n^2} J$$

$$\Delta E = \frac{2 \times 10^{-25}}{\lambda} = 2.178 \times 10^{-18} \times \left[\frac{1}{1} - \frac{1}{4}\right]$$

$$\lambda = \frac{2 \times 10^{-25} \times 4}{3 \times 2.178 \times 10^{-18}} = 1.22 \times 10^{-7} \text{ m}$$

19. **(C)**

Energy of $Li^{2+} = -13.6 \times \frac{9}{n^2} eV$

If $n = 2$ then

$$\text{Energy} = -13.6 \times \frac{9}{4} eV$$

$$= -30.6 \, eV$$

20. **(C)**

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$v^2 = \frac{2hc}{m}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$$

21. **(A)**

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

$$\lambda = \frac{6.63 \times 10^{-34}}{6.63 \times 10^{-3} \times 100}$$

$$\lambda = 10^{-33} \text{ m}$$

22. **(D)**

$\text{Energy} = 495.5\ \text{KJ/mol}$

$$= \frac{495.5 \times 10^3}{6.022 \times 10^{23}}\ \text{J/atom}$$

$$\upsilon = \frac{E}{h} = \frac{495.5 \times 10^3}{6.022 \times 10^{23} \times 6.626 \times 10^{-34}}$$

$\upsilon = 1.24 \times 10^{15}\ s^{-1}$

23. **(D)**

$Rb = [Kr]5s^1$

$n = 5, \ell = 0, m = 0, s = \pm\frac{1}{2}$

24. **(C)**

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

If n = 2 then

$E = -3.4\ eV$

25. **(B)**

$ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np$

Sequence of filling of electrons.

26. **(C)**

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

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

27. **(D)**

No. of orbital $= n^2 = 25$

28. (B)

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

$r_3 = 0.529 \times \frac{3^2}{1} \Rightarrow r_4 = 0.529 \times \frac{4^2}{1}$

$\frac{r_4}{r_3} = \frac{4^2}{3^2} = \frac{16}{9} \Rightarrow r_4 = \frac{16r_3}{9}$

29. (C)

$W = h\nu = 6.6 \times 10^{-34} \times 1.3 \times 10^{15} = 8.58 \times 10^{-19}\ J$

30. (C)

$r = \frac{a_0 n^2}{Z}$

For $Li^{2+}, r = \frac{a_0 (2)^2}{3} = \frac{4a_0}{3}$

31. (A)

For determined shortest wavelength, $n_2 = \infty$

For Lyman series, $\bar{\nu}_L = \frac{1}{\lambda_L} = R\left[\frac{1}{(1)^2} - \frac{1}{\infty^2}\right]$

For Paschen series, $\bar{\nu}_P = \frac{1}{\lambda_P} = R\left[\frac{1}{(3)^2} - \frac{1}{\infty^2}\right]$

$\frac{\bar{\nu}_L}{\bar{\nu}_P} = \frac{\lambda_P}{\lambda_L} = 9$

32. (C)

According to Bohr's model energy in n^{th} state

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

For second excited state, of $He^+, n = 3$

$\therefore\ E_3(He^+) = -13.6 \times \frac{2^2}{3^2} eV = -6.04 eV$

33. (C)

$\lambda = 250 nm$

$E = \frac{hc}{\lambda} = \frac{1240 eV.nm}{250 nm} = 4.96 eV$

KE= stopping potential $= 0.5 eV$

$E = W_0 + K.E.$

$4.96 = W_0 + 0.5$

$W_0 = 4.46 \approx 4.5 eV$

34. (B)

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

$r = 211.6 pm = 2.11 \mathring{A} \Rightarrow 0.529 \times \frac{n^2}{1} = 2.11 \mathring{A} [Z = 1]$

$n = 2$ (Balmer series)

35. (C)

According to Bohr's model $v \propto \frac{Z}{n}$

$Z =$ Atomic no. (corresponding to $+ve$ charge)

$n =$ Principal quantum no.

This relation suggest that when the Z increases, the velocity will also increase, so statement I is wrong and as 'n' decreases, velocity will also increase. So statement II is correct.

36. (C)

Energy of one mole of photons $=\frac{hc}{\lambda}\times N_A$

$=\frac{6.63\times10^{-34}\times3\times10^{8}}{300\times10^{-9}}\times6.02\times10^{23}$

$=399.13\times10^{3}$ Joule/mole=399 kJ/mole

37. (D)

$2\pi r=n\lambda$

$r=\frac{n^2a_0}{Z}$

$2\pi\times\frac{4^2}{1}a_0=4\lambda\Rightarrow\lambda=2\pi\times\frac{4}{1}a_0\Rightarrow\lambda=8\pi a_0$

38. (D)

Given $\lambda=1.5\pi a_0$ …….(i)

Radii of stationary states (r) is expressed as:

$r=a_0\frac{n^2}{Z}$ ………(ii)

From equation (i) and (ii)

$n\lambda=\frac{2\pi a_0 n^2}{Z};\lambda=\frac{2\pi a_0 n}{Z}$

$1.5\pi a_0=2\pi a_0\frac{n}{Z}\Rightarrow\frac{n}{Z}=\frac{1.5}{2}=0.75$

39. (D)

According to de-Broglie wavelength equation,

$\lambda=\frac{h}{mv}\Rightarrow\lambda\propto\frac{1}{v}$

According to photoelectric effect.

$h\nu-h\nu_0=\frac{1}{2}mv^2;\nu-\nu_0=\frac{1}{2}\times\frac{mv^2}{h}$

$\nu-\nu_0\propto v^2\Rightarrow v\propto\nu-\nu_0{}^{1/2}$

$\therefore\lambda\propto\frac{1}{(\nu-\nu_0)^{1/2}}$

40. (B)

First Bohr orbit of H atom has radius $r=0.529\,\mathring{A}$. Also, the angular momentum is quantised.

$mvr=\frac{h}{2\pi}\Rightarrow2\pi r=\frac{h}{mv}=\lambda$

$\therefore\lambda=2\pi\times0.529\,\mathring{A}$

41. (B)

Lower the value of $(n+l)$ for an orbital, lower is its energy. If two orbitals have same value of $(n+l)$ then lower value of n will have the lower energy

$A\Rightarrow3d\Rightarrow n+l=3+2=5$

$B\Rightarrow4p\Rightarrow n+l=4+1=5$

$C \Rightarrow 4d \Rightarrow n + l = 4 + 2 = 6$
$D \Rightarrow 3s \Rightarrow n + l = 3 + 0 = 3$
Order is $D < A < B < C$

42. (A)
(A) $n + l = 3 + 0 = 3$
(B) $n + l = 4 + 0 = 4$
(C) $n + l = 3 + 1 = 4$
(D) $n + l = 3 + 2 = 5$
Higher $(n + l)$ value, higher the energy ; if same $(n + l)$ value, then higher n value, higher the energy.
Thus: $D > B > C > A$

43. (C)

Orbit	Angular nodes (ℓ)	Radial nodes $(n - \ell - 1)$
2p	$\ell = 1$	$2 - 1 - 1 = 0$
3p	$\ell = 1$	$3 - 1 - 1 = 1$
3s	$\ell = 0$	$3 - 0 - 1 = 2$
2s	$\ell = 0$	$2 - 0 - 1 = 1$

3s orbital has no angular nodes and two radial nodes.

44. (C)
Number of radical nodes $= n - l - 1$
Number of angular nodes $= l$
For $5d; n = 5, l = 2$
5d orbital has two radial nodes and two angular nodes.

45. (D)
Atomic orbital is characterised by *n*, *l*, *m*.

46. (D)
Isotopes have same atomic number but different mass number. They have different number of neutrons which results in different mass number.

47. (D)
As in Thomson model, protons are diffused (charged is not centered) α-particles deviate by small angles and due to repulsion from protons, their speed decreases.

48. (B)
In the Balmer series of H–atom, the transition takes place from the higher orbital to $n = 2$. Therefore, the longest wavelength corresponds to $n_1 = 2$ and $n_2 = 3$. As wavelength decreases, energy increase or we can say that n_2 increases. The energy difference between two consecutive lines decreases or the line slowly converge. Hence, statement I, II, III are the correct statements among the given options.

49. (C)

For emission spectrum,

$$\bar{v} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) \Rightarrow \bar{v} = R_H\left(\frac{1}{n^2} - \frac{1}{8^2}\right)$$

$$\Rightarrow \bar{v} = \frac{R_H}{n^2} - \frac{R_H}{64}$$

Comparing to $y = mx + c$, we get

$x = \frac{1}{n^2}$ and $m = +R_H$ (slope)

50. (B)

When temperature is increased, black body emits high energy radiation from higher wavelength to lower wavelength.

51. (D)

(a), (b) and (c) are according to quantum theory but (d) is statement of kinetic theory of gases.

52. (A)

Under the given situation,

$n = 1, l = 0, 1, 2$

$n = 2, l = 0, 1, 2, 3$

$n = 3, l = 0, 1, 2, 3, 4$

According to (n + l) rule, order of filling of subshells will be:

1s, 1p, 2s, 1d, 2p, …..

Atomic number 6	$1s^2\ 1p^4$
Atomic number 9	$1s^2\ 1p^6\ 2s^1$
Atomic number 8	$1s^2\ 1p^6$
Atomic number 13	$1s^2\ 1p^6\ 2s^2\ 1d^3$

Therefore option (a) is correct.

53. (A)

As the value of Z (atomic number) increase, energy orbitals decreases (becomes more –ve value).

$\therefore$ order of energy of 2s orbital is H > Li > Na > K.

54. (C)

	$n+\ell$
(I) $n = 4\ \ \ell = 2\ \ \ 4d$	6
(II) $n = 3\ \ \ell = 2\ \ \ 3d$	5
(III) $n = 4\ \ \ell = 1\ \ \ 4p$	5
(IV) $n = 3\ \ell = 1\ \ \ 3p$	4

The energy of an atomic orbital increases with increasing $n+\ell$. For identical values of $n+\ell$, energy increases with increasing value of *n*. Therefore the correct order of energy is:

$$\underset{\text{IV}}{3p} < \underset{\text{II}}{3d} < \underset{\text{III}}{4p} < \underset{\text{I}}{4d}$$

55. (492)

$$\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{3^2}\right)$$

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

$$\frac{\lambda_2}{720} = \frac{\frac{7}{16\times9}}{\frac{16}{25\times9}} = \frac{7}{16}\times\frac{25}{16}$$

$$\lambda = 492$$

56. (50)

Power of infrared range = 1 mW = 10^{-3} W or 10^{-3} Js^{-1}

$\therefore$ In 0.1 second the energy emitted = 10^{-4} J

$$\because\ E = nh\nu = nh\frac{c}{\lambda} \Rightarrow \text{ then; } 10^{-4} = n\times\frac{hc}{\lambda}$$

$$\Rightarrow 10^{-4} = \frac{n\times6.63\times10^{-34}\times3\times10^{8}}{1000\times10^{-9}}$$

$$\Rightarrow n = 5.02\times10^{14} = 50.2\times10^{13}$$

57. (548)

$$\Delta x\times\Delta p_x \geq \frac{h}{4\pi}$$

$$\Rightarrow 2a_0\times m\Delta \mathrm{v}_x = \frac{h}{4\pi} \text{ (for minimum uncertainty)}$$

$$\Rightarrow \Delta \mathrm{v}_x = \frac{h}{4\pi}\times\frac{1}{2a_0}\times\frac{1}{m}$$

$$= \frac{6.63\times10^{-34}}{4\times3.14\times2\times52.9\times10^{-12}\times9.1\times10^{-31}}$$

$$= 548273 \text{ ms}^{-1} = 548.273 \text{ km s}^{-1}$$

58. (58)

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

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

$$\Delta \mathrm{v} = 5\times10^{6}\times\frac{0.02}{100}$$

$$\Delta \mathrm{v} = 10^{3} \text{ m/s}$$

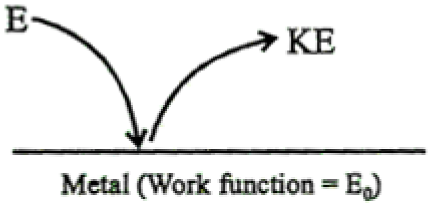
$$\Delta x=\frac{h}{4\pi\times m\cdot\Delta v}=\frac{6.63\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times10^{3}}$$
$$=5.8\times10^{-8}\text{ m}$$
$$=58\times10^{-9}\text{ m}$$

59. (2)
$$\lambda=\frac{h}{\sqrt{2m(K.E.)}};K.E.=\frac{h^2}{2m\lambda^2}$$
$$K.E.=\frac{h^2}{2m\lambda^2}=\frac{43.9\times10^{-68}}{2\times9.1\times10^{-31}\times10.89\times10^{-20}}$$
$$K.E.=2.215\times10^{-18}$$
$$E_{abs}=E_{req}+K.E.$$
$$\frac{E_{abs}}{E_{req}}=1+\frac{K.E.}{E_{req}}=1+\frac{2.215\times10^{-18}}{13.6\times1.602\times10^{-19}}=2.0166$$

60. (4)
No. of neutrons $=26$; No. of electrons $=25$
% of extra neutrons than electrons $=\frac{26-25}{25}\times100=4$

61. (10)
Maximum number of spectral lines
$$=\frac{n(n-1)}{2}=\frac{5\times4}{2}=10$$

62. (2)
Total energy per sec. $=50\text{J}$
$$\because E=nh\nu=\frac{nhc}{\lambda}$$
$$50=\frac{n\times6.63\times10^{-34}\times3\times10^{8}}{795\times10^{-9}}$$
$$n=2\times10^{20}$$

63. (222)


$$E=E_0+(KE)_{max}$$
$$\frac{hc}{\lambda}=4.41\times10^{-19}+KE$$
$$\frac{6.63\times10^{-34}\times3\times10^{8}}{300\times10^{-9}}=4.41\times10^{-19}+KE$$
So, $(KE)_{max}=6.63\times10^{-19}-4.41\times10^{-19}$
$$=2.22\times10^{-19}\text{J}=222\times10^{-21}\text{J}$$

64. (1758)

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

$\frac{h}{9.1\times10^{-31}\times x\, v_{neutron}} = \frac{h}{1.6\times10^{-27}\times v_{neutron}}$

$x = 1758$

65. (22)

$m\times2.4\times10^{-26}\times10^{-7} = \frac{6.626\times10^{-34}}{4\pi}$

$m = 22gm$

66. (6)

d-Broglie wave-length of electron:

$\lambda_e = \frac{h}{\sqrt{2m(KE)}} \left\{ \begin{array}{l} \because e^- \text{is acceleated} \\ \text{from rest} \\ \Rightarrow KE = q\times v \end{array} \right\}$

$\lambda = \frac{h}{\sqrt{2mqV}} = \frac{6.63\times10^{-34}}{\sqrt{2\times1.6\times10^{-19}\times9.1\times10^{-31}\times40\times10^3}}$

$= 0.614\times10^{-11}m = 6.14\times10^{-12}m$

67. (9)

Incident energy of photon = Work function of metal +K.E. of photoelectron

$h\nu = h\nu_0 + KE$ ……(i)

Incident energy of photon

$= \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^8}{248\times10^{-9}\times1.6\times10^{-19}} eV = 5eV$

Now using equation (i),

$5 = 3 + KE$

$KE = 2.0eV$

Now, $\lambda = \frac{h}{\sqrt{2m\,KE}} = \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times2\times1.6\times10^{-19}}}$

$= 8.68\times10^{-10}m \approx 9\,\mathring{A}$

68. (2)

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

$\frac{\lambda_{Li}}{\lambda_P} = \sqrt{\frac{m_P(e)V}{m_{Li}(3e)(V)}}$ $m_{Li} = 8.3m_P$

$\frac{\lambda_{Li}}{\lambda_P} = \sqrt{\frac{1}{8.3\times3}} = \frac{1}{5} = 0.2 = 2\times10^{-1}$

69. (2)

For a given value of n, l ranges from 0 to $n-1$

For given l, m_l ranges from $-l$ to $+l$

Quantum number of set (B) and (C) can be correct (A) and (D) are wrong as $n = l$ is not possible.

70. (0)

$Zn^{+} \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

Outermost electron is in 4 s subshell, so $m = 0$

71. (0)

$Ga^{+} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$

The azimuthal quantum number for the valence electron (4s-subshell) of Ga^{+} ion is zero(0).

72. (0)

Given: $n = 4$ and $m_l = 3$

Hence, l value must be 3.

$\therefore$ Number of radial nodes $= n - l - 1$

$= 4 - 3 - 1 = 0$

EXERCISE - 2 [A]

1. **(D)**

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

$$\frac{1}{\lambda} = \frac{1}{912\ \text{Å}} \times 4 \left(\frac{1}{3^2} - \frac{1}{\infty^2} \right)$$

$$\lambda = \boxed{2052\ \text{Å}}$$

2. **(B)**

$$T = \frac{2\pi r}{V} = 2\pi \times \frac{\frac{0.529n^2}{Z}}{\frac{2.18 \times 10^6 Z}{n}}$$

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

3. **(C)**

$\frac{-13.6}{16}$ ____________________ 4

$\frac{-13.6}{9}$ ____________________ 3

$\frac{-13.6}{4}$ ____________________ 2

-13.6 ____________________ 1

$E_4 - E_2 = 2.55$eV

4. **(A)**

4p has 2 radial nodes & 1 angular node.

3s has 2 radial nodes & 0 angular node.

Orbital angular momentum for s electron is 0.

5. **(A)**

Energy absorbed by electron $=13.6\times 1.5\,\text{eV}$

Energy used in coming out of atom = 13.6 eV

So, KE of emitted electron = 6.8 eV

$$\lambda=\sqrt{\frac{150}{6.8}}\ \text{Å}=4.7\ \text{Å}$$

6. **(D)**

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

$$\Delta P=\frac{h}{4\pi\Delta x}=\frac{6.626\times 10^{-34}}{4\times 3.14\times 1\times 10^{-9}}$$

$= 0.527\times 10^{-25}$

$= \boxed{5.2\times 10^{-26}}$

7. **(C)**

$$\frac{1}{\lambda}=R_H Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right),\ \frac{1}{\lambda}=\frac{1}{912\ \text{Å}}\times 4\left(\frac{1}{2^2}-\frac{1}{\infty}\right)$$

$\lambda=912\ \text{Å}$

$$\lambda=\frac{h}{mc}=\frac{6.626\times 10^{-34}}{3\times 10^{8}\times 912\times 10^{-10}}=2.42\times 10^{-35}\ \text{kg}$$

8. **(D)**

By looking at wavelength increasing for can say it belongs to visible range

$$E_p=\frac{1242}{486.4}=2.55\ \text{eV}\Rightarrow\ 4^{th}\ \text{orbit to}\ 2^{nd}\ \text{orbit}$$

9. **(B)**

$$r=\frac{0.529\times 4}{Z}$$

$$=\frac{0.529\times 4}{3}=0.705\text{Å}$$

10. **(D)**

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

$$\frac{\lambda_A}{\lambda_B}=\frac{v_B}{v_A}$$

When $\lambda_B=2\lambda_A$, then $V_A = 2V_B$

$$KE=\frac{1}{2}mv^2$$

$$\frac{T_A}{T_B} = \frac{V_A^2}{V_B^2}$$

$$\frac{T_A}{T_B} = \frac{4}{1}$$

Also $T_A - T_B = 1.50$

$\therefore \quad T_B = 0.50$

$T_A = T_B + 1.5$

$= 0.50 + 1.50$

$= 2$

Also, $4.25 = W_A + T_A$

$4.20 = W_B + T_B$

$W_A = 4.25 - 2 = 2.25$

$W_B = 4.20 - 0.50 = 3.70$

11. **(C)**

$$\frac{hc}{\lambda} = \frac{hc}{8208} - \frac{hc}{22800}$$

$\lambda = 12825\text{Å}$

12. **(C)**

$$\lambda_1 = \sqrt{\frac{150}{100}}\text{Å} \qquad \ldots(1)$$

$$\lambda_2 = \sqrt{\frac{150}{81}}\text{Å} \qquad \ldots(2)$$

$$\lambda_3 = \sqrt{\frac{150}{49}}\text{Å} \qquad \ldots(3)$$

From (1), (2) and (3)

$$\frac{\lambda_3 - \lambda_2}{\lambda_1} = \frac{20}{63}$$

13. **(A)**

No. of radial node = 1

14. **(D)**

Probability of finding electron at nucleus is 0.

15. **(B)**

$$R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R \times 2^2\left[\frac{1}{4^2} - \frac{1}{6^2}\right]$$

$$\bar{\upsilon}_{He^+}(6 \to 4) = \bar{\upsilon}_H(3 \to 2)$$

16. **(A)**

P.E. = - 2 K.E.

$\Rightarrow \quad \text{P.E.} = -mv^2$

17. **(B)**

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

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

$$\lambda = \frac{6.6\times 10^{-34}}{\sqrt{2\times 9.1\times 10^{-31}\times 4.55\times 10^{-25}}} = 7.27\times 10^{-7}\,m$$

18. **(C)**

Type of orbitals filled in 4[th] period $= 4s, 3d, 4p$

Total no. of orbitals possible = 1 + 5 + 3 = 9

Total no. of elements = 9 × 3 = 27

19. **(C)**

No. of orbitals $= 2l + 1$

20. **(A)**

$$\frac{E_{1H}}{E_{2Be}} = \frac{1/1}{(4)^2/(2)^2} = \frac{4}{16} = 1:4$$

21. **(D)**

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

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

$$\frac{1}{\lambda} = R_H \times 16\left(\frac{1}{1^2} - \frac{1}{2^2}\right)\frac{R_H \times 16 \times 3}{4} = R_H \times 12$$

(D) (Be^{3+})

22. **(B)**

$$K_A = E_A - 2 \quad K_B = E_B - 4$$

$$\lambda_A = \frac{h}{\sqrt{2m K_A}},\ \lambda_B = \frac{h}{\sqrt{2m K_B}}$$

$$\frac{\cancel{h}}{\sqrt{\cancel{2m}\,K_B}} = 2\frac{\cancel{h}}{\sqrt{\cancel{2m}\,K_A}}$$

$$\frac{1}{K_B} = \frac{4}{K_A}$$

$$E_A - 2 = 4E_B - 16 \qquad E_A - 2 = 4E_A + 2 - 16$$

$$3E_A = 12 \Rightarrow E_A = 4$$

$$\Rightarrow \qquad E_B = 4.5$$

23. **(D)**
$(n + 1)^2 – (n)^2 = (n – 1)^2$
$2n + 1 = n^2 – 2n + 1$
$n^2 – 4n = 0 \Rightarrow n = 4$

24. **(D)**
Acceleration $\propto \frac{z^3}{n^4}$

$$\frac{\text{initial acceleration}}{\text{final acceleration}} = \frac{z_1^3}{z_2^3} \times \frac{n_2^4}{n_1^4}$$
$$= \frac{2^4}{3^4} = \frac{16}{81}$$

25. **(A)**
The probability on the surface of sphere is same.

26. **(D)**
$$\Delta x\ \Delta p \geq \frac{h}{4\pi}$$
$$\Delta x \geq \frac{h}{4\pi\Delta p} = \frac{6.62\times10^{-34}}{4\times3.14\times10^{-20}}$$
$$= 5.27\times10^{-15}\,\text{m}$$

27. **(B)**
Energy is required to separate particles which attract each other.

28. **(A)**
No. of waves = orbit no.

29. **(B)**
n decides size of orbital.
l decides shape of orbital.
m decides orientation of orbital.

30. **(C)**
$\Delta n = 5 - 1 = 4$
No. of spectral line $= \frac{\Delta n(\Delta n + 1)}{2}$
$$= \frac{4\times5}{2} = 10$$

31. **(D)**
On increasing no. of photons, no. of photo electrons increase but K.E. remains same.

32. **(A)**
$U = 2\times \text{Total Energy}$

33. **(A)**

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

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{q_2}{q_1}} = \sqrt{\frac{2}{1}}$$

$$\lambda_1 > \lambda_2$$

34. **(C)**

$$\Psi_{3s} = \frac{1}{9\sqrt{3}}\left(\frac{1}{a_0}\right)^{3/2}(6 - 6\sigma + \sigma^2)e^{-\frac{\sigma}{2}}\text{; where } r = \frac{2r.Z}{3a_0}$$

The maximum distance of node from nucleus will be $r = \frac{3}{2}\frac{(\sqrt{3} + 3)}{Z}a_0$

Radial node occurs where probability of finding e^- = 0

$\therefore$ $\Psi^2 = 0$ or $\Psi = 0$

$\therefore$ $6 - 6\sigma + \sigma^2 = 0$ or $\sigma = 3 \pm \sqrt{3} = \frac{2rZ}{3a_0} \Rightarrow r = \frac{3}{2}\frac{3+\sqrt{3}}{z}a_0$

35. **(C)**

Probability of finding e^- is zero implies mat $\Psi^2 = 0$ or $\Psi = 0$

$(\sigma - 1) = 0,\ \sigma = 1 \Rightarrow r = \frac{a_0}{2z}$

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

$(\sigma - 6)(\sigma - 2) = 0$

$\sigma = 6,\ \Rightarrow\ r = \frac{6a_0}{2Z} = \frac{3a_0}{Z}$

R = 2, $\Rightarrow r = \frac{a_0}{Z}$

EXERCISE - 2 [B]

1. **(C)**

Most of the α-particle go straight, because most part of atom is empty.

2. (**ABC)**

Rutherford’s experiment conclusion:

Atom has large empty space, the centre of the atom has positively charged nucleus and size of nucleus is very small as compared to atom.

3. (**ABD)**

Probability of electron in P_x orbital is along x-axis, zero at nucleus and maximum on two opposite sides of the nucleus along x-axis.

4. **(AB)**
Electron in motion behave as waves and orbital is non directional.

5. **(BCD)**
Bohr's model does not predicts that probability of electron near nucleus.

6. **(ABD)**
If $\ell = 2$ then $m = -2, -1, 0, 1, 2$

7. **(BC)**
It is applicable for moving microscopic particles.

8. **(C)**
Both are same one of them in ground state & other in excited state.

9. **(AD)**
2^{nd} orbit have 2 sub energy level (S & P)
M energy level (3^{rd} orbit) can accommodate 18 electron only.

10. **(ABD)**
If m = –2, then it should be d orbital or f orbital.

11. **(ABC)**
All statement are correct.

12. **(ABC)**
All statement are correct.

13. **(A)**
For 3d, n = 3, $\ell = 2$, m = –2 to +2, $s = \pm\frac{1}{2}$

14. **(BC)**
Attraction between electron and nucleus is electrostatic.
Penetration of nucleus by s-electron is more than p-electron.

15. **(ABCD)**
All statement are correct.

16. **(AB)**

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

$$\Delta x\left(F\Delta t\right) \geq \frac{h}{4\pi}$$

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

17. **(ABD)**

Velocity $\propto \frac{Z}{n}$

Frequency $\propto \frac{Z^2}{n^3}$

Radius $\propto \frac{n^2}{Z}$

Force $\propto \frac{Z^3}{n^4}$

18. **(BCD)**

Photon doesn't carry any charge.

19. **(ABC)**

Shielding effect is not possible in H atom because it is unielectronic.

20. **(AD)**

White light can't be deflected by magnet & it consist different wavelength photons.

21. **(ABC)**

Number of spectral pines $= \frac{(n-1)n}{2}$

22. **(ABC)**

Photoelectric effect supports quantum nature of light because, minimum frequency required for emission of photoelectrons & maximum K.E. depends only on frequency.

23. **(AC)**

$\ell = 0$, it is s-shubshell.
Shape is decided by ℓ.
Orbital angular momentum of 1s, 2s, 3s electrons are equal.

24. (B,C)

25. (B,C,D)

Energy depends only on n in case of hydrogen & hydrogen like atoms. The difference in potential energies of any two energy levels is always more than the difference in K.E.
$\text{P.E.} = -2\text{K.E.}$

❖ COMPREHENSION TYPE

Comprehension – 1

1. **(B)**

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

$$= \sqrt{1(1+1)}\frac{h}{2\pi} = \frac{h}{\sqrt{2}\pi}$$

2. **(A)**

$$\frac{\text{Volume of Nucleus}}{\text{Volume of atoms}} \approx 10^{-15}$$

3. **(A)**

s orbitals are non-directional.

4. **(D)**

No. of protons = 6
No. of electrons = 6
No. of neutrons = 14 – 6 = 8

5. **(D)**

As $n\uparrow$ energy difference between consecutive orbit decreases.

6. **(A)**

No. of drops $= \dfrac{6.4\times10^{-19}}{1.6\times10^{-19}} = 4$

Comprehension – 2

7. **(C)**

No. of waves in one revolution = orbit no.

8. **(D)**

Circumference $= 2\pi r$

$$= 2\times3.14\times0.529\times10^{-10}\times\frac{3^2}{1}$$

$$= 3\times10^{-9}\,m$$

9. **(A)**

$$\lambda = \frac{2\pi r}{n} = \frac{3\times10^{-9}}{3} = 10^{-9}\,m$$

10. **(B)**

$$E = -21.8\times10^{-19}\times\frac{z^2}{n^2}\,J$$

$$E = -21.8\times10^{-12}\times\frac{z^2}{n^2}\,erg$$

$$E = -21.8\times10^{-12}\times\frac{1}{9}\,erg$$

$$E = -2.42\times10^{-12}\,erg$$

$$P.E. = 2\times \text{total energy}$$

$$= -4.84\times10^{-12}\,erg$$

11. **(A)**

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

$$mv = \frac{nh}{2\pi r} = \frac{3\times6.62\times10^{-34}}{3\times10^{-9}} = 6.62\times10^{-25}$$

Comprehension – 3

12. **(B)**

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

$$v = \frac{6.62\times10^{-34}}{9.1\times10^{-31}\times5200\times10^{-10}} = 1400\ m/s$$

13. **(A)**

$$\lambda = \sqrt{\frac{150}{V}} \Rightarrow V = \frac{150}{\lambda^2} = \frac{150}{(1.54)^2} = 63.3\ V$$

14. **(B)**

$$\text{Binding energy} = 250\ KJ/mol$$

$$= \frac{250\times10^3}{6.02\times10^{23}}\ J/atom$$

$$v_0 = \frac{B.E.}{h} = \frac{250\times10^3}{6.02\times10^{23}\times6.62\times10^{-34}} = 6\times10^{14}\ sec^{-1}$$

15. **(D)**

$$\Delta X\,\Delta P \ge \frac{h}{4\pi}$$

$$(\Delta X)^2 \ge \frac{h}{4\pi} \qquad (\Delta X = \Delta P)$$

$$\Delta X = \Delta P \ge \sqrt{\frac{h}{4\pi}}$$

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

$$\frac{h}{m} = \lambda V$$

$$\Delta V = \sqrt{\frac{\lambda V}{4\pi m}}$$

$$\hbar = \sqrt{\frac{\hbar}{2\pi}}$$

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

16. **(C)**
Cs have lowest ionisation energy, so it is commonly used in photoelectric cell.

17. **(C)**

$$\lambda = \frac{6.62\times 0^{-34}\times 3600}{0.2\times 5} = 2.38\times 10^{-30}\,m$$

Comprehension – 4

18. **(C)**
No. of electrons in $P^{3-} = 15+3 = 18$
No. of electrons in $Cl^{-} = 17+1 = 18$

19. **(D)**

	3d						4s
$Cr = [Ar]$	↑	↑	↑	↑	↑		↑

20. **(B)**
For Al, no. of S electrons = 2 + 2 +2 = 6
No. of P electrons = 6 +1 = 7
For Mg, no. of S electrons = 6 = no. of P electrons

21. **(B)**

	4s		3d				
Ni^{2+} = Ar			↑↓	↑↓	↑↓	↑	↑

n = 2

$$\mu = \sqrt{2(2+2)} = \sqrt{8}\text{ B.M.}$$

22. **(D)**
No. of radial nodes in 2P = 0
No. of angular nodes in 2P = 1

23. **(D)**

$\Delta n = 5 - 2 = 3$

Max. no. of spectral line $= \frac{3(3+1)}{2} = 6$

24. **(A)**

For H atoms, energy only depends upon n.

25. **(B)**

No. of valence electron in $NH_4^+ = 5 - 1 + 4 = 8$

❖ **MATRIX MATCH**

1. **(A) $\rightarrow$ Q; (B) $\rightarrow$ S; (C) $\rightarrow$ R; (D) $\rightarrow$ P**

$$\frac{U_{1,2}}{K_{1,1}} = \frac{-2 \times 13.6 \times \frac{z^2}{n^2}}{13.6 \times \frac{z^2}{n^2}} = \frac{-2 \times 13.6 \times \frac{4}{1}}{13.6 \times 1} = -\frac{8}{1}$$

$$\frac{r_{2,1}}{r_{1,2}} = \frac{0.529 \times \frac{4}{1}}{0.529 \times \frac{1}{2}} = \frac{8}{1}$$

$$\frac{V_{1,2}}{V_{2,4}} = \frac{2.18 \times 10^8 \times \frac{2}{1}}{2.18 \times 10^8 \times \frac{4}{2}} = 1$$

$$\frac{T_{1,2}}{T_{2,2}} = \frac{\frac{1^3}{2^2}}{\frac{2^3}{2^2}} = \frac{1}{8}$$

2. **(A) $\rightarrow$ Q; (B) $\rightarrow$ R; (C) $\rightarrow$ S; (D) $\rightarrow$ P**

No. of radial node of 5s = 5 – 1 = 4

No. of angular node of $3d_{yz} = 2$

No. of angular node of $4d_{xy} = 2$

No. of radial node of $4d_{xy} = 1$

No. of angular node of $3p = 1$

3. **(A) $\rightarrow$ S; (B) $\rightarrow$ R; (C) $\rightarrow$ P; (D) $\rightarrow$ Q**

Orbital angular momentum of an electron = $\sqrt{l(l+1)}\frac{h}{2\pi}$

Angular momentum of an electron in an orbit = $\frac{nh}{2\pi}$

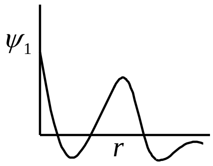
Spin angular momentum of an electron = $\sqrt{s(s+1)}\frac{h}{2\pi}$

Magnetic moment of atom (in B.M.) = $\sqrt{n(n+2)}$

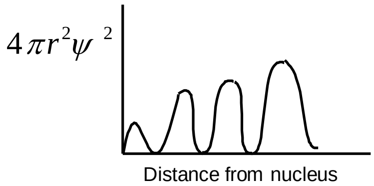
4. **(A) $\rightarrow$ S; (B) $\rightarrow$ P; (C) $\rightarrow$ Q; (D) $\rightarrow$ R**

No. of orbitals in the n^{th} shell = n^2
Max. no. of electrons in a subshell = $2(2l + 1)$
No. of subshells in n^{th} shell = n
No. of orbitals in a subshell = $2l + 1$

5. **(A) $\rightarrow$ P; (B) $\rightarrow$ P, Q, S; (C) $\rightarrow$ Q, S; (D) $\rightarrow$ P, R**

(A) 

= $4s$

(B) 

= $4s$, $5p_x$, $6d_{xy}$

(C) Angular probability is dependent on θ and ϕ = $5p_x$, $6d_{xy}$

(D) No angular node is present = $4s$, $3s$

6. **(A) $\rightarrow$ P, Q, R; (B) $\rightarrow$ R; (C) $\rightarrow$ P, R, S; (D) $\rightarrow$ P, Q, R**

m = –1 can be for p, d & f
$\ell = 2$ only for d
$n = 3$ has s, d & f
s subshell doesn't have angular nodes

7. **(A) $\rightarrow$ P, S; (B) $\rightarrow$ P, R; (C) $\rightarrow$ Q, R; (D) $\rightarrow$ S**

Velocity $\propto \frac{Z}{n}$

Frequency $\propto \frac{Z^2}{n^3}$

Energy $\propto \frac{Z^2}{n^2}$

Force $\propto \frac{Z^3}{n^4}$

EXERCISE - 2 [C]

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

$600 = \frac{6.626\times10^{-34}\times3\times10^{8}\times2\times10^{22}}{\lambda}$

$600 = \frac{39.759\times10^{-4}}{\lambda}$

$\lambda = 6630\,\text{nm}$

2. $75\times0.2 = n\times\frac{19.878\times10^{-26}}{500\times10^{-9}}$

$n = 3.75\times10^{19}$

3. (a) $0.376 = n\times\frac{19.878\times10^{-26}}{633\times10^{-9}}$

$n = 1.2\times10^{18}$

(b) Power = $\frac{0.376}{10^{-9}} = 3.76\times10^{8}$ W

4. Energy given to I_2 molecule $= \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{4500\times10^{-10}}$

$= 4.417\times10^{-19}$ J

Also energy used for breaking up of I_2 molecules

$= \frac{240\times10^{3}}{6.022\times10^{23}} = 3.948\times10^{-19}$ J

∴ Energy used in importing KE to two I atoms = [4.417 – 3.984]

$\text{KE}/\text{Iodine atom} = \left[4.417 - \frac{3.984}{2}\right]\times10^{-19}$

$= 0.216\times10^{-19}$ J

5. (a) $\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 109677\left(\frac{1}{4} - \frac{1}{9}\right)\text{cm}^{-1}$

$\frac{1}{\lambda} = \frac{109677\times5}{36}\text{cm}^{-1} \Rightarrow \lambda = 6564\overset{0}{A}$

(b) $\frac{1}{\lambda} = R_H\left(\frac{1}{4^2} - \frac{1}{5^2}\right) = 109677\left(\frac{1}{16} - \frac{1}{25}\right)\text{cm}^{-1}$

$\frac{1}{\lambda} = \frac{109677\times9}{400}\text{cm}^{-1} \Rightarrow \lambda = 40523\overset{0}{A}$

(c) $\frac{1}{\lambda} = R_H\left(\frac{1}{9^2} - \frac{1}{10^2}\right) = 109677\left(\frac{1}{81} - \frac{1}{100}\right)\text{cm}^{-1}$

$\frac{1}{\lambda} = \frac{109677\times19}{8100}\text{cm}^{-1} \Rightarrow \lambda = 388701\overset{0}{A}$

6. **Lyman Series**

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

$$\frac{1}{\lambda} = \frac{109678 \times 3}{4} cm^{-1}$$

$$\lambda = 1215 \overset{0}{A}$$

Balmer Series

$$\frac{1}{\lambda} = 109678\left(\frac{1}{2^2} - \frac{1}{3^2}\right) cm^{-1}$$

$$= 109678\left(\frac{1}{4} - \frac{1}{9}\right) cm^{-1}$$

$$= \frac{109678 \times 5}{36} cm^{-1}$$

$$\lambda = 6564 \overset{0}{A}$$

Paschen Series

$$\frac{1}{\lambda} = 109078\left(\frac{1}{3^2} - \frac{1}{4^2}\right) cm^{-1}$$

$$\frac{1}{\lambda} = \frac{109678 \times 7}{144} cm^{-1} \Rightarrow \lambda = 18756 \overset{0}{A}$$

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

$$\frac{1}{\lambda} = 109678 \times 3^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right) cm^{-1}$$

$$= 109678 \times 9\left(\frac{1}{1} - \frac{1}{9}\right) cm^{-1}$$

$$\frac{1}{\lambda} = \frac{109678 \times 9 \times 8}{9} cm^{-1} \Rightarrow \lambda = 113.9 \overset{0}{A} \text{ or } 11.39 \text{ nm}$$

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

$$\frac{1}{2170 \times 10^9} = 1.09677 \times 10^7\left(\frac{1}{n_1^2} - \frac{1}{7^2}\right)$$

Solve $n_1 = 4$

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

$$\frac{1}{\lambda} = 109678\left(\frac{1}{1^2} - \frac{1}{2^2}\right) cm^{-1}$$

$$= \frac{109678 \times 3}{4} cm^{-1}$$

$\lambda = 1215\,\overset{0}{A}$

10. Energy given to H atom = $\dfrac{6.626\times10^{-34}\times3\times10^{8}}{1028\times10^{-10}}$

$=1.933\times10^{-18}\,J = 12.07\,eV$

$\therefore$ Energy of the H atom offer excitation = – 13.6 + 12.07

$\therefore$ $E_n = \dfrac{E_1}{n^2}$

$n^2 = \dfrac{-13.6}{-1.53} \approx 9$ n = 3

Thus electron in H atom is excited to 3rd orbit

I induced $\lambda_1 = \dfrac{hc}{E_3 - E_1}$

$E_1 = -13.6\,eV$, $E_3 = -1.53\,eV$

$$\lambda_1 = \frac{6.026\times10^{-34}\times3\times10^{8}}{(-1.53+13.6)\times1.602\times10^{-19}} = 1028\times10^{-10}\,m = 1028\,\overset{0}{A}$$

$\therefore$ II Induced $\lambda_2 = \dfrac{hc}{E_2 - E_1}$

$E_1 = -13.6\,eV$ $E_2 = \dfrac{-13.6}{4}\,eV$

$$\lambda_2 = \frac{6.626\times10^{-34}\times3\times10^{8}}{\left(\frac{-13.6}{4}+13.6\right)\times1.602\times10^{-19}} = 1216\times10^{-10}\,m = 1216\,\overset{0}{A}$$

$\therefore$ III Induced $\lambda_3 = \dfrac{hc}{E_3 - E_2}$

$E_1 = -13.6\,eV$, $E_2 = \dfrac{-13.6}{4}\,eV$, $E_3 = \dfrac{-13.6}{9}\,eV$

$$\lambda_3 = \frac{6.626\times10^{-34}\times3\times10^{8}}{\left(\frac{-13.6}{9}+\frac{13.6}{4}\right)\times1.662\times10^{-19}}$$

$= 6568\times10^{10}\,m = 6568\,\overset{0}{A}$

11. For visible line spectrum, i.e. Balmer series $n_1 = 2$

Also for minimum energy transition. $n_2 = 3$

$E_{Photon} = E_3 - E_2 = (-1.51) - (-3.4) = 1.89\ eV$

$E_{total} = 1.89\times1.6\times10^{-19}\times6.022\times10^{23} = 182.5\ kJ$

12. $\dfrac{1}{\lambda} = R_H\left(\dfrac{1}{1^2} - \dfrac{1}{6^2}\right)$

$\dfrac{1}{\lambda} = \dfrac{109677\times35}{36}\,cm^{-1}$

$\lambda = 937.8\overset{0}{A}$

13. Threshold wavelength $\left(\lambda^0 = 230\text{nm} = 230\times10^{-9}\text{m}\right)$

$$E_\rho = 13.6\left(1-\frac{1}{9}\right) = 12.09\,\text{eV}$$

$$KE_{max} = 12.09\times1.6\times10^{-19} - \frac{6.626\times10^{-34}\times3\times10^8}{230\times10^{-9}}$$

$$= 1.07\times10^{-18}\,\text{J}$$

14. $\bar{\upsilon} = 1.096\times10^7\left[1-n^{-2}\right]$ where n = 2

Maximum wavelength means. Minimum Energy

$\bar{\upsilon} = 1.096\times10^7\left(1-2^{-2}\right]$

Maximum wavelength = $1215\overset{0}{A}$ or 1.216×10^{-7} meters

Minimum wavelength means maximum energy

$\bar{\upsilon} = 1.096\times10^7\left(1-\infty^{-2}\right]$

0.912×10^{-7} meter

Series will be ultraviolet region

15. for He^+, $\frac{1}{\lambda} = R_H Z^2\left[\frac{1}{2^2}-\frac{1}{4^2}\right]$

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

Since λ is same

$$z^2\left[\frac{1}{2^2}-\frac{1}{4^2}\right] = \left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$$

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

$n_1 = 1$ and $n_2 = 2$

16. Shortest wavelength [largest energy] max transition

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

$$\frac{1}{\lambda} = 109677/4\ \text{cm}^{-1} = 27419\,\text{cm}^{-1}$$

17. $V = \frac{2.18\times10^6 Z}{n}$

$V \propto \frac{1}{n}$ $V = \frac{2.18\times10^6\times1}{2} = 1.09\times10^6\,\text{m/sec}$

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

18. i) $E = \frac{-13.6\,Z^2}{n^2} = -\frac{13.6\times1}{9} = -1.51\,eV$

ii) $r = \frac{0.529\ n^2}{z} = 0.529\times9 = 4.761\overset{0}{A}$

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

$\frac{1}{\lambda} = 109677\times1\left(\frac{8}{9}\right)$

$= 1025\overset{0}{A}$ or 1.032×10^{-7} m

iv) $v = \frac{C}{\lambda} = \frac{3\times10^8}{1.032\times10^{-7}} = 2.90\times10^{15}\,Hz$

19. $r = \frac{0.529\,n^2}{Z}$

$r_I = 0.529\overset{0}{A}$

$r_{II} = 0.529\times4 = 2.116\overset{0}{A}$

$r_{III} = 0.529\times9 = 4.761\overset{0}{A}$

$r_I\ He^+ = \frac{0.529\times1}{2} = 0.2645\overset{0}{A}$

$r_{II}\ He^+ = \frac{0.529\times4}{2} = 1.058\overset{0}{A}$

$r_{III}\ He^+ = \frac{0.529\times9}{2} = 2.38\overset{0}{A}$

20. $E = \frac{313.6\times Z^2}{n^2} = \frac{313\times1}{16} = 19.6\,Kcal$

21. $\frac{-13.6}{16}$ ______________ 4

$\frac{-13.6}{9}$ ______________ 3

$\frac{-13.6}{4}$ ______________ 2

-13.6 ______________ 1

$E_3 - E_1 = -1.51 - (-13.6)$ = 12.09 eV

22. $E_n = \frac{-21.7\times10^{-12}}{n^2}\,erg$

$E_2 = -\frac{21.7\times10^{-12}}{4} = -5.425\times10^{-12}\ erg$

For removal of electron $E_2 = \frac{hc}{\lambda}$ E_2 should be given to remove electron i.e. + ve

$$\lambda = \frac{6.626\times10^{-27}\times3\times10^{10}}{5.425\times10^{-12}} = 3663.6\times10^{-8}\ \text{cm}$$

23. E_1 for $Li^{2+} = \frac{E_1 \text{ for H} \times Z^2}{n^2} = \frac{-13.6\times9}{4} = -30.6\,\text{eV}$

E_1 for $Be^{3+} = \frac{E_1 \text{ for H} \times Z^2}{n^2} = \frac{-13.6\times16}{4} = -54.4\,\text{eV}$

24. Energy of one photon = $\frac{hc}{\lambda}$

$= \frac{6.626\times10^{-34}\times3\times10^{8}}{4500\times10^{-10}}\ \text{J}$

$= 4.42\times10^{-19}\ \text{J}$

Energy emitted by bulb $= 150\times\frac{8}{100}\ \text{J}/\text{sec}\left(\text{watt} = \frac{\text{J}}{\text{sec}}\right)$

$\therefore \quad n\times4.42\times10^{-19} = 150\times\frac{8}{100}$

$n = 27.2\times10^{18}$

25. E_3 for H = -2.41×10^{-12} erg

E_2 for H = -5.42×10^{-12} erg

$\therefore$ for a jump from III to II shell

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

$\lambda = \frac{hc}{E_3 - E_2} = \frac{6.626\times10^{-27}\times3\times10^{10}}{-2.41\times10^{-12}+5.42\times10^{-12}}$

$= 6602.9\times10^{-8}\ \text{cm} = 6603\ \overset{0}{\text{A}}$

26. (a) $V = \frac{2.18\times10^{6}\times Z}{n} = \frac{2.18\times10^{6}}{3}$

$= 0.726\times10^{6}$

(b) Number of revolution $= \frac{V}{2\pi r} = \frac{0.726\times10^{6}}{2\times3.14\times9\times0.529\times10^{-9}} = 2.43\times10^{-14}$

27. $\nu = \frac{V}{2\pi r} = \frac{2.18\times10^{6}}{2\times2\times3.14\times0.529\times4\times10^{-10}} = 0.0819\times10^{16}$

Number of revolution $= 0.0819\times10^{16}\times10^{-8} = 0.0819\times10^{8}$

28. E_1 for H = – 13 .6 eV

E_2 for H = $-\frac{13.6}{22} = -\frac{13.6}{4} = -3.4\,\text{eV}$

$E_1 - E_2 = -3.4 - (-13.6) = +10.2\,\text{eV}$

Difference in two level = 10.2 eV

Also for transition of H like atom

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

$$\therefore \quad \frac{1}{3\times10^{-8}} = 109677\times10^2\times2^2\left(\frac{3}{4}\right)$$

$Z^2 = 4$ Z = 2 He^+

29. The no of waves made by a Bohr is equal to orbit no.

30. (a) $E = hv$

$$3.97\times10^{-19} = hv$$

$$v = \frac{3.97\times10^{-19}}{6.626\times10^{-34}} \qquad v = 0.599\times10^{15}$$

(b) $E = \frac{6.626\times10^{-34}\times3\times10^8}{450\times10^{-9}} = 4.4\times10^{-19}$ J

31. Copper surface $W_f = 4.5\,\text{eV} = \frac{hc}{\lambda_0} \Rightarrow 4.5\times1.6\times10^{-19} = \frac{6.626\times10^{-34}\times3\times10^8}{\lambda_0}$

$$7.2\times10^{-19} = \frac{19.878\times10^{-26}}{\lambda_0} \Rightarrow \lambda_0 = 2.76\times10^{-7}\text{ m}$$

Similarly for sodium and cerium surface.

32. Energy of photon = work function + KE

Energy of photon = work function + eV_0

e = electronic charge V_0 = slopping potential

eV_0 = energy required to stop the ejection to electron

$$E_{photon} = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^8}{253.7\times10^{-9}} = 7.834\times10^{-19}$$

$$= \frac{7.834\times10^{-19}}{1.602\times10^{-19}}\text{eV} = 4.89\,\text{eV}$$

Work function = 4.89 – 0.24 = 4.65 eV

33. Binding energy of electron = $180.69\,\text{kJ mol}^{-1}$

Binding energy of one electron = $\frac{180.69\times10^3}{6.022\times10^{23}}$ J

$$= 30.00\ 49\times10^{-20}\text{ J}$$

Binding energy $= h\nu_0$

$$\nu_0 = \frac{30.0049\times10^{-20}}{6.626\times10^{-34}} = 4.52\times10^{14}\text{ sec}^{-1}$$

34. $K.E._{min} = 2eV \qquad (\text{When } \lambda = \lambda_0)$

$$K.E._{max} = 2 + \frac{12400}{\lambda(\overset{o}{A})} - \frac{12400}{\lambda_0(\overset{o}{A})} eV \qquad (\text{if } \lambda < \lambda_0)$$

$$K.E._{max} = 2 + \frac{1240}{400} - \frac{1240}{660}$$

$$= 2 + \frac{1240 \times 260}{400 \times 660}$$

$$= 2 + 1.22$$

$$K.E._{max} = 3.22 \text{ eV}$$

35. Energy of photon liberated from He^+ during emission of first line of lyman series.

$$E = 13.6 \times 2^2\left(\frac{1}{n_1^2} - \frac{1}{n_n^2}\right) = 13.6 \times 4\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$= \frac{13.6 \times 4 \times 3}{4} = 40.8 eV$$

This energy is used in liberating electron from H atom from ground state.
Therefore,

$$40.8 eV = E_1 \text{ of } H + KE$$

$$40.8 eV = 13.6 + KE$$

KE = 40.8 – 13.6 = 27.2 eV

$$\frac{1}{2}mV^2 = 27.2 \times 1.6 \times 10^{-19} \Rightarrow V = 3.09 \times 10^6 \text{ m/sec}$$

36. $E_{photon} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{360 \times 10^{-10}}$

$$= 5.52 \times 10^{-18} \text{ Joules}$$

$$KE = h\nu - WF$$

$$= 5.52 \times 10^{-18} - 7.52 \times 10^{-19}$$

$$= 47.68 \times 10^{-19} \text{ Joules}$$

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

$$= \frac{6.626 \times 10^{-34}}{\frac{100}{1000} \times 100} = 0.6626 \times 10^{-34} = 6.626 \times 10^{-35} m$$

38. $\lambda = \frac{h}{\sqrt{2mK}} = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.11 \times 10^{-31} \times 4.55 \times 10^{-25}}} = 7.27 \times 10^{-7} \text{ m}$

39. $\lambda = \sqrt{\frac{150}{V_{acc.}}} \text{ Å} = \sqrt{\frac{150}{100}} \text{ Å} = 1.227 \text{ Å}$

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

$= \frac{6.626\times10^{-34}}{9.108\times10^{-31}\times\frac{3\times10^{8}\times1}{20}}$

$= 4.899\times10^{-11}$ m

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

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

$= \frac{6.626\times10^{-34}}{4\times3.14\times9.108\times10^{-31}\times10^{-10}}$

$= 5.8\times10^{5}\ \text{m sec}^{-1}$

42. $\Delta v = 3\times10^{7}\times0.02 = 6\times10^{5}$

$\Delta x = \frac{6.6\times10^{-34}}{4\times3.14\times1.67\times10^{-27}\times6\times10^{5}} = 0.525\times10^{-13}$ m

43. $\lambda = \sqrt{\frac{150}{V_{acc.}}} \Rightarrow V_{acc.} = \frac{150}{(1.54)^2} = 63.3\ \text{V}$

44. Due to Hund's Rule

45. A d subshell can have maximum 10 electrons

46.

$\left.\begin{aligned}&S^{-2} = \text{diamagnetic}\\&\quad = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\end{aligned}\right]$ magnetic moment = 0

Co^{3+} = Paramagnetic

$1s^2\ 2s^2\ 2p^6\ 3s^6\ 4s^0\ 3d^6$

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

$\sqrt{4(4+2)}$ = 4.89 BM

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

AT $r = r_0$, radial node is formed

For radial node at $r = r_0$, $\psi_{2s}^2 = 0$ this is possible only when $\left[2-\frac{r}{a_0}\right] = 0$

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

❖ **Objective Questions – I (Only One Option Correct Type)**

1. **(C)**
Nucleus is discovered by Rutherford.

2. **(D)**
Maximum 2 electrons of opposite spin are occupied by an orbital.

3. **(A)**
Principal quantum number is related to size of orbital.

4. **(A)**
Nucleus is discovered by Rutherford.

5. **(D)**
$\frac{e}{m}$ will be lowest for neutron & maximum for electron. $\frac{e}{m}$ value of α is half time $\frac{e}{m}$ value of proton.
$\frac{e}{m} : n < \alpha < p < e$

6. **(A)**
$[Kr]5s^1$
$n = 5,\ \ell = 0,\ m = 0,\ s = \pm\frac{1}{2}$

7. **(D)**
If electron is present in 1s then it can jumps to higher orbits by absorb photon of appropriate energy.

8. **(B)**
Bohr's model can explain spectrum of an atom or ion containing one electron only.

9. **(B)**
The radius of an atomic nucleus is of the order of 10^{-13}cm.

10. **(B)**
Electromagnetic radiation with maximum wavelength is radio wave.

11. **(B)**
Rutherford's alpha particle scattering experiment eventually let to the electrons occupy space around the nucleus.

12. **(C)**
$m = -\ell \text{ to } +\ell$

if $\ell = 2$ then $m = -2$ to $+2$

13. **(D)**

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

$$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = \frac{4000}{2000} = \frac{2}{1}$$

14. **(C)**

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

15. **(B)**

Aufbau Principle: This principle states that the electrons are added one by one to the various orbitals in order of their increasing energy starting with the orbital of lowest energy.

16. **(C)**

$F = 1s^2 2s^2 2p^5$

17. **(A)**

$[Ar] 4s^1 3d^5$

18. **(C)**

$[Ne] 3s^2 3p^5$

$n = 3, \ \ell = 1, \ m = \pm 1, 0$

19. **(C)**

X – rays is not deflected by electric and magnetic fields.

20. **(D)**

E = hv

21. **(B)**

$\ell = 0$

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

22. **(D)**

$Mg^{2+} = [Ne]$

$Ti^{3+} = [Ar] 3d^1$, $V^{3+} = [Ar] 3d^2$, $Fe^{2+} = [Ar] 3d^5$

23. **(B)**

Bohr

24. **(A)**

For a orbital, $\ell = 2$

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

$$=\frac{\sqrt{6}h}{2\pi}$$

25. **(A)**

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

$n=2$

$E=-13.6\times\frac{1}{4}=-3.4\,eV$

26. **(A)**

As $(n+\ell)\uparrow$, energy $\uparrow$

For same n, $\ell\uparrow$, energy $\uparrow$

27. **(B)**

It is configuration of Cr.

28. **(A)**

No. of nodal plane $=\ell=1$

29. **(C)**

$\lambda=\frac{h}{m\upsilon}=\frac{6.62\times10^{-34}\times3600}{0.2\times5}$

$\lambda\approx10^{-30}$ m

30. **(D)**

two quantum mechanical spin states which have no classical analogue

31. **(C)**

Pauli exclusion principle

32. **(D)**

helium nuclei which impinged on metal foil and got scattered

33. **(B)**

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

$\frac{n^2}{z}=1\Rightarrow n^2=z$

34. **(A)**

No. of radial nodes in $3s=n-\ell-1$

$$=3-0-1=2$$

No. of radial nodes in $2p=2-1-1=0$

35. **(C)**

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

$$mvr = \frac{nh}{2\pi} \Rightarrow mv = \frac{nh}{2\pi r} = P$$

$$K.E. = \frac{n^2h^2}{2m\left(4\pi^2r^2\right)} = \frac{4h^2}{2m\left(4\pi^2a_0^2 \times 16\right)}$$

$$K.E. = \frac{h^2}{32\pi^2ma_0^2}$$

36. **(B)**

$$\left[Ar\right]4s^2 3d^{10} 4p^6 5s^1$$

$$n = 5, \ell = 0, m = 0, s = \pm\frac{1}{2}$$

37. (D)

$$r \propto \frac{n^2}{Z} \text{ or } r = 0.529 \times \frac{n^2}{Z};(I),(T)$$

$$|L| \propto n \text{ or } mvr = \frac{nh}{2\pi};(II),(S)$$

❖ Objective Questions – II (More than One Option Correct Type)

1. **(BD)**
Isotope have same atomic number but different mass number.
Isotone have same no. of neutrons
$_{32}Ge^{76}$: no. of neutrons = 76 – 32 = 44
$_{33}As^{77}$: 77 – 33 = 44
$_{34}Se^{78}$: 78 – 34 = 44

2. **(AC)**
Many elements have non-integral atomic masses because they have isotopes.

3. **(C)**
most part of the atom is empty space.

4. **(BD)**
No. of neutron & proton in $_1H^2 = 1 + 1 = 2$
No. of neutron & proton in $_1H^3 = 1 + 2 = 3$

5. **(AB)**
Nucleus contains protons & neutrons.

6. **(A)**

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

7. **(ABC)**

(A) The electronic configuration of Cr is [Ar] $3d^5\ 4s^1$. (Atomic number of Cr=24).

(B) The magnetic quantum number may have a negative value

(C) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type. (Atomic number of Ag = 47)

8. **(AD)**

↑↓	↑↓	↑	↑	↑

↑↓	↑↓	↓	↓	↓

9. (A,C)

Given, azimuthal quantum no. $(l)=2(\text{d}-\text{subshell})$ Magnetic quantum no $(\text{m})=0(\text{zero})$, which is for d_{z^2} orbital.

$$E=-13.6\frac{z^2}{n^2}\Rightarrow -13.6\times\frac{2^2}{n^2}=-3.4$$

$$13.6\times\frac{2^2}{n^2}=3.4$$

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

Radial node $=n-l=4-2-1=1$

Angular node $=l=2$

Wave function corresponds to $\Psi_{4,2,0^+}$. It represents $4d_{z^2}$ – orbital which has only one radial node and two angular nodes. It experiences nuclear charge of 2e units.

❖ Comprehension Based Questions

Passage 1

1. **(B)**

Li^{2+} is in a spherically symmetric state, i.e. in s orbital. It has one radial node hence it should be in 2s.

2. **(C)**

$$E_{2,Li^{2+}}=-13.6\times\frac{9}{4}=2.25\ E_{1,H}$$

3. **(B)**

S_2 is in 3rd orbit.

Now no. of radial nodes = 1

Hence it should be 3P.

Orbital angular momentum quantum number is 1.

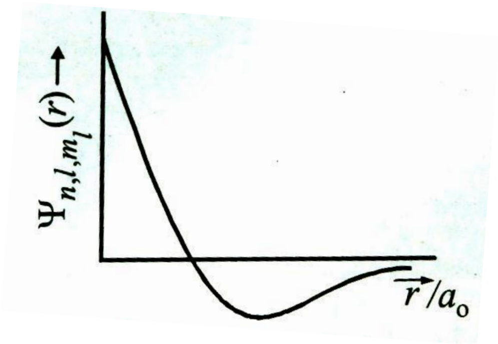
Passage 2

4. (C)

No. of radial nodes $=n-l-1$. For 2s orbital, $n=2, l=0$

$\therefore$ No.of radial nodes $=2-0-1=1$

The potential graph is correct for 2s– orbital, as wave function changes its sign at node.



5. (A)

E.C. of H: $1s^1$; for 1s orbital

$$\psi_{n.l,m} \propto \left(\frac{Z}{a_0}\right)^{3/2} e^{-(Zr/a_0)}$$

For s- orbital , θ and ϕ cannot be a part of wave function expression. Hence, this is correct.

For 1 s orbital of hydrogen like species:

$$E \propto -\frac{1}{n^2}$$

Then, $E_4 - E_2 = \left(\left(\frac{1}{2}\right)^2 - \left(\frac{1}{4}\right)^2\right) E_{1,H} = \frac{3}{16} \quad E_{1,H}$

$$E_6 - E_2 = \left(\left(\frac{1}{2}\right)^2 - \left(\frac{1}{6}\right)^2\right) E_{1,H} = \frac{8}{36} E_{1,H}$$

$$\therefore (E_4 - E_2) = \frac{27}{32} \times (E_6 - E_2)$$

6. (C)

In the wave function (ψ) expression for 1s-orbital of He^+, there should be no angular part (θ)

❖ Match the Columns

1. **(A)$\rightarrow$r; (B)$\rightarrow$q; (C)$\rightarrow$p; (D)$\rightarrow$s**

$$\frac{V_n}{K_n} = -2$$

$$r \propto \frac{n^2}{z}, \; E \propto \frac{z^2}{n^2}$$

$r \propto E^{-1}$ for same z

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

$$\frac{1}{r} \propto \frac{z}{n^2} \Rightarrow \frac{1}{r} \propto z'$$

2. **(A)$\rightarrow$q; (B) $\rightarrow$ p, q, r, s; (C)$\rightarrow$p, q, r; (D)$\rightarrow$p, q, r**

Refer theory

❖ Integer Type Questions

1. **(9)**

$n = 3,\ m_s = -\frac{1}{2}$

3rd orbit has 3s, 3p & 3d

Total no. of electron with $\left(S = -\frac{1}{2}\right) =$ number of orbital = 9

2. **(4)**

Energy given $= \frac{1240}{300} = 4.1\,\text{eV}$

If energy given > work function
Then photoelectric effect occurs.

3. **(6)**

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

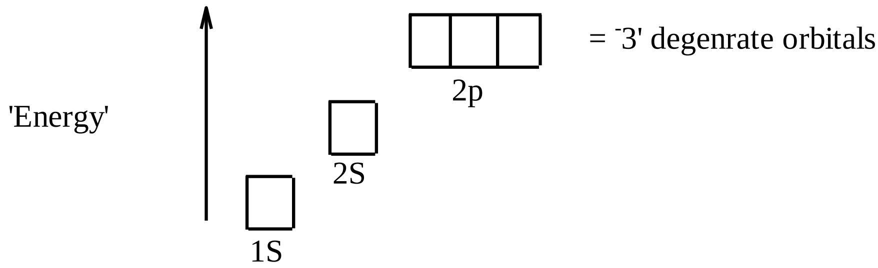
2 orbitals of p, 2 orbitals of d & 2 orbitals of f
= 6 orbitals

Total no. of electron with $-\frac{1}{2}$ spin quantum no. n these orbitals

$=$ no. of orbitals = 6

4. **(3)**

For H^- (Multielectron)



5. (30)

$p = \frac{h}{\lambda} \Rightarrow \frac{6.6 \times 10^{-34}\,\text{kgm}^2/\text{s}^2}{330 \times 10^{-9}\,\text{m}}$

$= \frac{4 \times 10^{-3}\,\text{kg mol}^{-1}}{6 \times 10^{23}\,\text{mol}^{-1}} \times v\,(p = m \times v)$

$v = 0.3\,\text{m/s} = 30\,\text{cm/s}$