# Exercise-1

**Marked Questions may have for Revision Questions.**

## OBJECTIVE QUESTIONS

### Section (A) : Calculation related to nucleus

**A-1. Sol.** Volume of nucleus $= \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (10^{-13})^3$ cm$^3$

Volume of atom $= \frac{4}{3}\pi (10^{-8})^3$ cm$^3$

$\frac{V_N}{V_{Atom}} = \frac{10^{-39}}{10^{-24}} = 10^{-15}$

$V_{Nucleus} = 10^{-15} \times V_{Atom}$

**A-2. Sol.** Average atomic mass of Cl is 35.5. Due to isotopes.

**A-3. Sol.** Net charge is –1. (17 e+ 18 p)

**A-4. Sol.** Isoelectronic species should have same number of electrons.

**A-9. Sol.** Cathode rays are made up of negatively charged particles (electrons, $e^-$).

**A-10. Sol.** It is fact.

**A-11. Sol.** It is fact.

**A-12. Sol.** It is fact.

**A-13. Sol.** $\frac{(e/m)_e}{(e/m)_\alpha} = \frac{e/m_e}{2e/4 \times 1836 \quad m_e} = \frac{3672}{1}$

**A-14. Sol.** It is fact.

**A-15. Sol.** It is fact.

**A-16. Sol.** It is fact.

**A-17. Sol.** It is fact.

**A-18. Sol.** It is fact.

### Section (B) : Quantum theory of light and photoelectric Effect

**B-1. Sol.** Given $\lambda = 219$ m Thus, $\nu = \frac{c}{\lambda}$

or $\nu = \frac{3.0 \times 10^8}{219}$ = **$1.3 \times 10^6$ Hz**

**B-2. Sol.** $E = \frac{nhc}{\lambda} \Rightarrow n = 28$

**B-3. Sol.** $E = \frac{hc}{\lambda} \Rightarrow E \propto 1/\lambda$

$\lambda = \frac{h}{p} \Rightarrow p \propto 1/\lambda$

**B-4. Sol.** For photoelectric effect to take place, $E_{light} \geq W$ $\therefore$ $\frac{hc}{\lambda} \geq \frac{hc}{\lambda_0}$ or $\lambda \leq \lambda_0$.

**B-5. Sol.** More energy means less wavelength.

**B-6. Sol.** Power = $\frac{nhC}{\lambda \times t}$ $40 \times \frac{80}{100} = \frac{n \times 6.62 \times 10^{-34} \times 3 \times 10^8}{620 \times 10^{-9} \times 20}$ $\Rightarrow$ $n = 2 \times 10^{21}$

**B-8. Sol.** $f = \frac{c}{\lambda} = 7.5 \times 10^{14}\ s^{-1}$

**B-9. Sol.** $\lambda = \frac{hc}{E} = 6.204 \times 10^{-7}$ m

**B-10. Sol.** Ionisation enthalpy decreases down the group.

**B-11. Sol.** $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{400 \times 10^6} = 0.75$ m

**B-12. Sol.** Violet colour has minimum wavelength so maximum energy.

## Section (C) : Bohr Model

**C-1. Sol.** $E_1$ for $Li^{+2}$ = $E_1$ for H × $Z^2$ = $E_1$ for H × 9

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

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

**C-2. Sol.** $E_n = \frac{-13.6 Z^2}{n^2}$

$E_1 = -13.6Z^2 = 100$ unit

$E_2 = \frac{-13.6\ Z^2}{4} = 25$ unit

**C-3. Sol.** $E_1$ for $Li^{+2}$ = $E_1$ for H × $Z^2$ [for Li, Z = 3]

= 13.6 × 9 = **122.4 eV**

**C-4. Sol.** Largest amount of energy is required in n = ∞ to n = 1.

**C-5. Sol.** Radius = $0.529 \frac{n^2}{Z}$ Å = $10 \times 10^{-9}$ m

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

**C-6. Sol.** $V = 2.188 \times 10^6 \frac{Z}{n}$ m/s

Now, $V \propto \frac{Z}{n}$ so, $\frac{V_{Li^{2+}}}{V_H} = -\frac{Z_1/H_1}{Z_2/H_2} = \frac{3/3}{1/1} = 1$ or, $V_{Li^{2+}} = V_H$

**C-7. Sol.** (1) Energy of ground state of $He^+$ $= -13.6 \times 2^2 = -54.4$ eV (iv)

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

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

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

**C-10. Sol.** $r \propto n^2$

**C-12. Sol.** $\Delta E = E_3 - E_2 = 13.6 \left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = 1.9\,eV$

**C-13. Sol.** It is fact.

## Section (D) : Spectrum

**D-1. Sol.** $\frac{1}{\lambda_{lyman}} = R_H\left(\frac{1}{1}\right)$

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

**D-2. Sol.** For Lymen series $n_1 = 1$

For shortest '$\ell$' or Lymen series the energy difference in two levels showing transition should be maximum

(i.e. $n_2 = \infty$) $\frac{1}{\lambda} = R_H \left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = 109678 = 911.7 \times 10^{-8} =$ **911.7 Å**

**D-3. Sol.** mvr = $\frac{nh}{2\pi} = \frac{5h}{2\pi} = 2.5\,\frac{h}{\pi}$

**D-4. Sol.** When transition is from higher to lower level emission spectrum results.

**D-6. Sol.** $r_n = r_0 \times \frac{n^2}{Z}$

$r_{Li^{2+}} = \frac{r_H}{3} = \frac{0.53}{3} = 0.17$

**D-7. Sol.** $E_{min} = E_2 - E_1 = -3.4 + 13.6 = 10.2$ eV

**D-8. Sol.** $E_n = \frac{-13.6Z^2}{n^2}$ ;

**–1.51 =** $\frac{-13.6Z^2}{9}$ ; $E_2 = \frac{-13.6Z^2}{4} = \frac{-1.51 \times 9}{4} = -3.4$ eV

**D-9. Sol.** $\lambda = \frac{hc}{\Delta E} \;\therefore\; \lambda \alpha \frac{1}{\Delta E}$

**D-10. Sol.** 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 $6\to1, 5\to1, 4\to1, 3\to1, 2\to1$)

**D-11. Sol.** For third line of Bracket series ($4 \to 7$)

$\frac{1}{\lambda} = R\left(\frac{1}{16} - \frac{1}{49}\right) \Rightarrow \lambda = \frac{784}{33R}$

**D-12. Sol.** Balmer series of hydrogen atom spectrum is 'n' to second Bohr orbit.

**D-13 . Sol.** Paschen series of hydrogen atom spectrum is 'n' to third Bohr orbit. $n_1 = 3$ and $n_2 = 4, 5, 6$

**D-14. Sol.** For 1st line of Balmer series (3 → 2)

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

**D-15. Sol.** They lies in ultra violet region.

**D-16. Sol.** $n_1$ = lyman series i.e. transition of the electron in hydrogen atom from the fourth to first energy shell emits a spectral line which falls in lyman series.

**D-18. Sol.** When electronic transition in H–atom takes place from higher level ($n_2$ = 3, 4, 5......∞) to second level ($n_1$ = 2), then obtained spectral lines are called Balmer–series.

## Section (E) : De broglie wavelength & Uncertainity principle

**E-1. Sol.** $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{200}{50}} = \frac{2}{1}$.

**E-2. Sol.** $\lambda = \frac{h}{mv} = 1.33 \times 10^{-3}$ Å

**E-3. Sol.** For an α particle, $\lambda = \frac{0.101}{\sqrt{V}}$ Å.

**E-4. Sol.** $\Delta X . \Delta P \frac{h}{4\pi}$

$m(\Delta X . \Delta V) = \frac{h}{4\pi} \Rightarrow m = 0.099$ Kg

**E-5. Sol.** $\Delta X . \Delta P \geq \frac{h}{4\pi}$

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

**E-6. Sol.** An electron has particle and wave nature both.

**E-7. Sol.** $\Delta p . \Delta x = \frac{h}{4\pi} \Rightarrow \Delta x = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 1 \times 10^{-5}} = 5.27 \times 10^{-30}$ m.

**E-8. Sol.** $\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{m}$

**E-9. Sol.** $\lambda = \frac{h}{mv} = 0.416$ nm

**E-10. Sol.** $r_1 = 0.529$ Å

$r_3 = 0.529 \times (3)^2$ Å $= 9x$

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

**E-11.** **Sol.** For a charged particle $\lambda = \frac{h}{\sqrt{2mqV}}$, $\therefore$ $\lambda \propto \frac{1}{\sqrt{V}}$.

**E-12.** **Sol.** $\lambda = \frac{h}{mv} = 0.4 \times 10^{-33}$ cm

**E-13.** **Sol.** $\Delta x \cdot \Delta p \simeq \frac{h}{4\pi} \Rightarrow \Delta v = 3.499 \times 10^{-24}\ ms^{-1}$

**E-14.** **Sol.** All the material object in motion.

**E-15.** **Sol.** According to $\Delta x \times \Delta p = \frac{h}{4\pi}$

$$\Delta x = \frac{h}{\Delta p \times 4\pi} = \frac{6.62 \times 10^{-34}}{1 \times 10^{-5} \times 4 \times 3.14} = 5.27 \times 10^{-30}\ m$$

## Section (F) : Quantum numbers & Electronic configuration

**F-1.** **Sol.** Orbital angular momentun = $\frac{h}{2\pi}\sqrt{\ell(\ell+1)}$

For 2s-orbital = 0 ⇒ Orbital angular momentun = 0

**F-2.** **Sol.** (1) This set of quantum number is permitted.

(2) This set of quantum number is not permitted as value of 's' cannot be zero.

(3) This set of quantum number is not permitted as the value of '$l$' cannot be equal to 'n'.

(4) This set of quantum number is not permitted as the value of 'm' cannot be greater than '$l$'.

**F-6.** **Sol.** $n = 4, \ell = 2, s = -\frac{1}{2}$ or $+\frac{1}{2}$

**F-7.** **Sol.** Any orbital can accommodate only 2 electrons with opposite spins.

**F-9.** **Sol.** Maximum no. of electrons in a subshell = $2(2\ell + 1) = 4 + 2$.

**F-10.** **Sol.** Two electrons in K shell will differ in spin quantum number $s = +\frac{1}{2}$ or $-\frac{1}{2}$.

**F-11.** **Sol.** 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.

**F-12.** **Sol.** Number of radial nodes = $n - \ell - 1 = 1$, n = 3. $\therefore$ $\ell = 1$.

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

**F-15.** **Sol.** The electronic configuration must be $1s^2\ 2s^1$. .Hence, the element is lithium (z = 3).

**F-16.** **Sol.** An element has the electronic configuration $1s^2, 2s^2\ 2p^6, 3s^2\ 3p^2$ (Si). It's valency electrons are four.

**F-17. Sol.** It has 3 orbitals $p_x$, $p_y$, $p_z$.

**F-18. Sol.** 2s orbital have minimum energy and generally electron filling increases order of energy according to the Aufbau's principle.

**F-19. Sol.** No two electrons in an atom can have identical set of all the four quantum numbers.

## Exercise-2

**Marked Questions may have for Revision Questions.**

**2. Sol.** $Na^+$ has 10 electron and $Li^+$ has 2 electron so these are different number of electron from each other.

**3. Sol.** $-CONH_2 = 6 + 8 + 7 + 2 + 1 = 24$.

**4. Sol.** Mass number ≈ At. Wt.
Mass no. = no. of protons + no. of neutrons
At. no. = no. of protons.

**5. Sol.** $E_{absorbed} = E_{emitted}$

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

∴ $\lambda = 759$ nm.

**6. Sol.** $E_2 - E_1 = 1312 - 1312/4 = 984$ kJ/mol

**7. Sol.** $E_n = -13.6 \frac{z^2}{n^2}$

**8. Sol.** $v = \frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 109678\left[\frac{1}{1} - \frac{1}{4}\right] = 82258.5$

$\lambda = 1.21567 \times 10^{-5}$ cm or $\lambda = 12.1567 \times 10^{-6}$ cm
$= 12.1567 \times 10^{-8}$ m

$$v = \frac{c}{\lambda} = \frac{3 \times 10^8}{12.567 \times 10^{-8}} = 24.66 \times 10^{14} \text{Hz}$$

**9. Sol.** For 1st line of Balmer series

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

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

For last line of Pachen series

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

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

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

**11. Sol.** Visible lines ⇒ Balmer series ⇒ 3 lines. ($5 \to 2$, $4 \to 2$, $3 \to 2$).

**12. Sol.** Shortest wave length of Lyman series of H-atom

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

For Balmes series

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

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

**13.** ***Sol.*** *According to energy,* $E_{4 \to 1} > E_{3 \to 1} > E_{2 \to 1} > E_{3 \to 2}$.

According to energy, Violet > Blue > Green > Red.

∴ Red line ⇒ $3 \to 2$ transition.

**14. Sol.** $\lambda = v$

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

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

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

**17. Sol.** $v = 2.18 \times 10^{-6}\,\frac{z}{n}$ m/s

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

**18. Sol.** $\Delta x = 2\Delta p$

$\Delta x\,.\,\Delta p\,.\,m = \frac{\hbar}{2} = \frac{h}{4\pi}$ ⇒ $2\Delta p\,.\,m\Delta V = \frac{\hbar}{2}$ ⇒ $(\Delta V)^2 = \frac{\hbar}{4m^2}$

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

**19. Sol.** s orbital is spherical so non-directional.

**20. Sol.** Total number of electrons in an orbital = $2\,(2\ell + 1)$.

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

**21. Sol.** After np orbital, (n + 1) s orbital is filled.

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

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

**III** : $Mn_{25}$ = [Ar] $3d^5\ 4s^2$. ∴ 5 unpaired electrons. ∴ Total spin = $\pm\frac{5}{2}$ (False).
**IV** : Inert gases have no unpaired electrons. ∴ spin magnetic moment = 0 (True).

**23.** **Sol.** 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.

**24.** **Sol.** Number of values of $\ell$ = total number of subshells = n.

Value of $\ell$ = 0,1,2........(n – 1).

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

m = + $\ell$ to – $\ell$ through zero.

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

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

# Exercise-3

## PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

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

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

**3.** **Sol.** $\Delta x.\ \Delta v = \frac{h}{4\pi m}$ $\Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 25 \times 10^{-5}}$ ∴ $\Delta v = 2.1 \times 10^{-18}\ ms^{-1}$.

**4.** **Sol.** $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \times 1000}{60 \times 10}$ = $11.05 \times 10^{-34}$ = $1.105 \times 10^{-33}$ metres.

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

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

**7.** **Sol.** The value of $\ell$ (azimuthal quantum number) for s -electron is equal to zero.

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

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

**8.** **Sol.** Number of electrons in $N^{3-}$ = 7 + 3 = 10.

Number of electrons in $F^-$ = 9 + 1 = 10
Number of electrons in $Na^+$ = 11 – 1 = 10.

**9.** **Sol.** $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ $\frac{1}{\lambda} = 1.097 \times 10^7\ m^{-1}$ $\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$ ∴ $\lambda = 91 \times 10^{-9}$ m = 91 m.

**10.** **Sol.** For 4ƒ 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.

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

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

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

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

**13.** **Sol.** 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.

**14.** **Sol.** According to Heisenberg's uncertainity principle

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

$\Delta x \times (m.\Delta v) = \frac{h}{4\pi} \Rightarrow \Delta x = \frac{h}{4\pi m.\Delta v}$ $\Delta v = \frac{0.001}{100} \times 300 = 3 \times 10^{-3}\ ms^{-1}$

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

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

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

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


Number of unpaired electrons (n) = 2

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

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

$^{A}_{Z}X \xrightarrow{-\alpha} {}^{A-\Delta}_{Z-2}Y$ ; $^{A}_{Z}X \xrightarrow{-\beta} {}^{Ay}_{Z+1}$ $^{A}_{Z}X \xrightarrow{-^1_0 n} {}^{A-1}_{Z}X$ ; $^{A}_{Z}X \xrightarrow{-\beta+} {}^{A}_{Z-1}Y$

**18.** **Sol.** The electron have n + l higher value have hegher energy.
n + l = 3 + 0 = 3
n + l = 3 + 1 = 4
n + l = 3 + 2 = 5 (highest energy)

n + l = 4 + 0 = 4

**19.** **Sol.** I.E. = $1.312 \times 10^6$ J mol$^{-1}$

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

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

**20.** **Sol.** Isoelectronic : which have same no. of electrons.

| Species : | $NO^+$, | $C_2^{2-}$, | $CN^-$, | $N_2$, | $O_2^{2-}$, | $O_2^-$, | CO | NO |
|---|---|---|---|---|---|---|---|---|
| No. of e.s: | 14 | 14 | 14 | 14 | 18 | 17 | 14 | 15 |

**21.** **Sol.** As $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 1 \times 10^3}$ = $3.97 \times 10^{-10}$ M = $0.397 \times 10^{-9}$ M = ~ 0.40 nm.

**22.** **Sol.** $\Delta x \times \Delta P = \frac{h}{4\pi}$

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

$\Delta v = \frac{600 \times 0.005}{100} = 0.03$

So $\Delta x\, [9.1 \times 10^{-31} \times 0.03] = \frac{6.6 \times 10^{-34}}{4 \times 3.14}$

$\Delta x = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 0.03 \times 10^{-31}} = 1.92 \times 10^{-3}$M.

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

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

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

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

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

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

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

**24.** **Sol.** 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$^{-1}$

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

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

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

**25. Sol.** $E = E_1 + E_2$

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

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

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

$\lambda_2 = 742.76$ nm.

**26. Sol.** $h\nu = \Delta E = 13.6\, z^2 \left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

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

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

For H-atom

$n_1 = 1, \quad n_2 = 2$

**27. Sol.** (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)

**28. Sol.** $\Delta E = 2.178 \times 10^{-18} \left(\dfrac{1}{1^2} - \dfrac{1}{2^2}\right) = \dfrac{hC}{\lambda}$

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

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

**29. Sol.** Z = 37.

Rb is in fifth period.

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

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

**30. Sol.** $(E_n)_H = -13.6 \dfrac{1^2}{n^2}$ eV

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

**31. Sol.** K.E. = eV

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

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

**32. Sol.** $R = 0.529 \frac{n^2}{z} \mathring{A}$

$= 0.529 \frac{2^2}{1} \mathring{A}$

$= 2.12 \mathring{A}$

## ONLINE JEE-MAIN

**8. Sol.** Following Aufbau principle for filling electrons.

**9. Sol.** De-broglie wavelength (for particles) = $\frac{h}{\sqrt{2m\,KE}}$

As temperature is same, KE is same. So, $\lambda \propto \frac{1}{\sqrt{m}}$.

Hence $\lambda_{db}$ (electron) > $\lambda_{db}$ (neutron)

**10. Sol.** n = 5

Possible subshell are

⇒ 5s, 5p, 5d, 5f, 5g

∴ Total number of orbital = 1 + 3 + 5 + 7 + 9 = 25

**11. Sol.** NaF: $Na^+ = 1s^2 2s^2 2p^6$

$F^- = 1s^2 2s^2 2p^6$

**12. Sol.** For shortest 'λ' of hydrogen

$n_1 = 1$ & $n_2 = \infty$

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

$\frac{1}{A} = R(1)^2 \left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) \Rightarrow R = \frac{1}{A}$

for longest 'λ' of $He^+$ $n_1 = 3$ $n_2 = 4$

$\frac{1}{\lambda} = \frac{1}{A}(2)^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{1}{A} \times \frac{7}{36}$ or $\lambda = \frac{36A}{7}$

**13. Sol.** $r_n = 52.9\left(\frac{n^2}{1}\right)$ pm = 211.6 pm (for H-atom)

∴ n = 2

Higher orbit to n = 2 ⇒ Balmer series

## PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

**1.** **Sol.** Because Rutherford used α-particles and α-particle is represented as nucleus of helium with 2 protons and 2 neutrons.

**2.** **Sol.** On the basis of Pauli's exclusion principle, not more than two electrons can enter in a orbital. Hence seven electrons (as $1s^7$) in an orbital violates Pauli's exclusion principle.

**3.** **Sol.** $r_n = 0.529 \frac{n^2}{Z} \overset{\circ}{A}$

For hydrogen, n = 1 and Z = 1 ; ∴ $r_H = 0.529$

For $Be^{3+}$, n = 2 and Z = 4 ; ∴ $r_{Be^{3+}} = \frac{0.529 \times 2^2}{4} = 0.529$

Therefore, (D) is correct option.

**4.** **Sol.** No. of radial nodes = n – $\ell$ – 1

For 3s, no. of radial nodes = 3 – 0 – 1 = 2

For 2p, no. of radial nodes = 2 – 1 – 1 = 0

**5.** **Sol.** For lower state ($S_1$)

No. of radial node = 1 = n – $\ell$ – 1

Put n = 2 and $\ell$ = 0 (as higher state $S_2$ has n = 3)

So, it would be 2s (for $S_1$ state)

**6.** **Sol.** Energy of state $S_1$ = – 13.6 $\left(\frac{3^2}{2^2}\right)$ eV/atom

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

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

**7.** **Sol.** 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

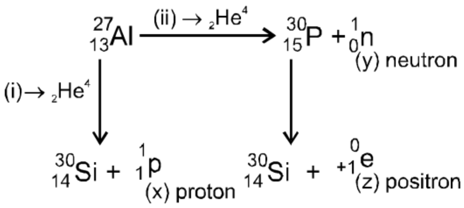
= – 13.6 $\left(\frac{3^2}{n^2}\right)$ eV/atom

n = 3.

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

so, orbital ⇒ 3p (for $S_2$ state).

**8.** **Sol.**

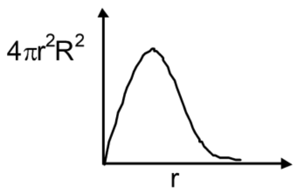



**9.** **Sol.** $mv\,(4a_0) = \frac{h}{\pi}$

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

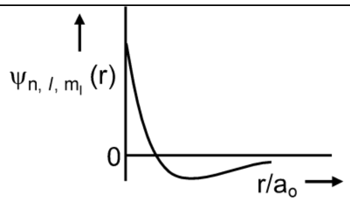
so $KE = \frac{1}{2}mv^2 = \frac{1}{2}m.\frac{h^2}{16m^2\pi^2\ a_0^2} = \frac{h^2}{32m\pi^2\ a_0^2}$

**10.** **Sol.** For 1s electron in H-atom, plot of radial probability function ($4\pi r^2R^2$) V/s r is as shown :



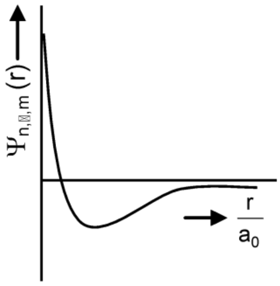

**Answer Q.11, Q.12 and Q.13 by appropriately matching the information given in the three columns of the following table.**

The wave function, $\psi_{n,\,l,\,m_l}$ is a mathematical function whose value depends upon spherical polar coordinates (r, θ, φ) of the electron and characterized by the quantum numbers *n*, *l* and $m_l$. Here r is distance from nucleus, θ is colatitude and φ is azimuth. In the mathematical functions given in the Table, Z is atomic number and $a_o$ is Bohr radius.

| Column 1 | Column 2 | Column 3 |
|---|---|---|
| (I) 1s orbital | (i) $\psi_{n,\,l,\,m_l} \propto \left(\frac{Z}{a_o}\right)^{\frac{3}{2}} e^{-\left(\frac{Zr}{a_o}\right)}$ | (P)  |
| (II) 2s orbital | (ii) One radial node | (Q) Probability density at nucleus $\propto \frac{1}{a_o^3}$ |
| (III) $2p_z$ orbital | (iii) $\psi_{n,\,l,\,m_l} \propto \left(\frac{Z}{a_o}\right)^{\frac{5}{2}} re^{-\left(\frac{Zr}{2a_o}\right)} \cos\theta$ | (R) Probability density is maximum at nucleus |
| (IV) $3d_{z^2}$ orbital | (iv) xy-plane is a nodal plane | (S) Energy needed to excite electron from n = 2 state to n = 4 state is $\frac{27}{32}$ times the energy needed to excite electron from n = 2 state to n = 6 state |

**11.** **Sol.** s-orbital is non directional so wave function will be independent of cos θ.

**12.** **Sol.** For 2s orbital no. of radial nodes = n – $\ell$ – 1 = 1




**13.** **Sol.** For 1s orbital Ψ should be independent of θ, also it does not contain any radial node.

$$\frac{E_4 - E_2}{E_6 - E_2} = \frac{\frac{E_1}{16} - \frac{E_1}{4}}{\frac{E_1}{36} - \frac{E_1}{4}} = \frac{-\frac{3E_1}{16}}{-\frac{8E_1}{36}} = \frac{3 \times 36}{8 \times 16} = \frac{27}{32}$$