EXERCISE - O

1. Anode rays are made up of :

(A) only protons
(B) only nucleus of atom
(C) Positive residue of atoms
(D) only electrons

AS0076

If $H_2(g)$ is filled in the discharge tube then:

$H_2 \rightarrow 2H \longrightarrow 2H^+ + 2e$

$2e \rightarrow$ (cathode rays)

$2H^+ \rightarrow$ Constitute anode rays

If O_2 is filled in the discharge tube then:

$O_2 \rightarrow 2O \longrightarrow 2O^+ + 2e \rightarrow$ Cathode rays.

$2O^+ \rightarrow$ Constitute anode rays.

2. When Lithium $\left({}^{7}_{3}\mathrm{Li}\right)$ vapours were filled in discharge tube for anode ray experiment, the anode rays were found to contain only Li^{+} ions. Thus the anode ray particle contains :

(A) 1 proton only

(B) 3 proton and 4 neutron only

(C) 3 proton, 4 neutron and 2 electrons

(D) 3 proton, 3 neutrons and 3 electrons

AS0077

$Li^{+} \Rightarrow$ 3 Proton, (7-3) = 4 neutron and (3-1) = 2 electron.

3. The specific charge is maximum for

(A) Na^{+} (B) Al^{+3} (C) H^{+} (D) Mg^{+2}

AS0078

Specific charge = $\frac{\text{charge}}{\text{mass}}$.

A) Na^{+}, specific charge = $\frac{1}{23}$

B) Al^{3+}, " " = $\frac{3}{27}$

C) H^{+}, " " = $\frac{1}{1}$

D) Mg^{2+}, " " = $\frac{2}{24}$

4. Which of the following particle is not deflected in the magnetic field

(A) Electron (B) proton (C) Neutron (D) Deuteron

(−)ve (+)ve neutral. (+)ve **AS0079**

Neutral particle will not be deflected in the magnetic field.

Deuteron is the nucleus of $^{2}_{1}H$. It is D^{+}.

5. E/m ratio of a particle of charge 2 unit and mass 4 amu is

(A) 4.8×10^{7} C/kg (B) 0.5 C/kg (C) 4.8×10^{4} C/kg (D) 8×10^{-20} C/kg

AS0080

$$\frac{E}{m} = \frac{2 \times 1.6 \times 10^{-19}\ C}{4 \times 1.67 \times 10^{-27}\ kg} = 0.48 \times 10^{8}\ C/kg = 4.8 \times 10^{7}\ C/kg.$$

6. α-particles are projected towards the nucleus of following metals, with the same kinetic energy. The distance of closest approach will be minimum for which metal?

(A) Cu $Z = 29$ (B) Ag $Z = 47$ (C) Au $Z = 79$ (D) Ca $Z = 20$ **AS0081**

$(KE) = PE$

or, $(KE) = \frac{K(Ze)(2e)}{r}$ α-particle ⇒ charge = 2e.

or, $r = \frac{2KZe^2}{(KE)}$

Clearly $r \propto Z$, r = distance of closest approach.

for r to be min^m, Z should be min^m.

7. Which of the following is not a conclusion of Rutherford's atomic model -

(A) Most of the part inside an atom is empty

(B) Almost all mass of an atom is concentrated in the nucleus.

(C) The size of nucleus is very small in compartison to the size of atom

(D) Electron revolves around the nucleus in definite orbits. → It is the postulate of Bohr model.

(D)

8. In the different experiements, α-particles, proton, deuteron and neutron are projected towards gold nucleus with the same kinetic energy. The distance of closest approach will be minimum for

(A) α-particle $q = 2e$ (B) proton $q = e$ (C) dueteron $q = e$ (D) neutron $q = 0$

$(KE) = PE$

or, $(KE) = \frac{K(Ze) \times q}{r}$ where q = charge on particles.

or, $r = \frac{K(Ze)q}{(KE)}$

Clearly $r \propto q$, for min^m r, q must be min^m.

9 The ratio of the energy of a photon of 2000 Å wavelength radiation to that of 4000 Å radiation is

(A) 1 / 4 (B) 4 (C) 1 / 2 (D) 2

$E = \frac{hc}{\lambda}$ clearly $E \propto \frac{1}{\lambda}$

$\therefore \frac{E_1}{E_2} = \frac{4000}{2000} = \boxed{2}$ Ans.

10. Small packet~~s~~ of light is called

(A) proton (B) quanta (C) photon (D) spectrum

Small packets of light is called quantum or photon.
However word quantum is used for tiniest possible particle of any substance at the subatomic level. Word photon is used only for small packet of light. word quanta is plural of word quantum.

11. Which of the following electromagnetic radiation have greater frequency ?

(A) X - rays (B) Ultraviolet rays (C) Radio waves (D) Visible rays

order of frequency:

Radio < micro < infra < visible < ultraviolet < x-rays < γ rays < cosmic

12. Two electromagnetic radiations have wave numbers in the ratio 2 : 3. Their energies per quanta will be in the ratio

(A) 3 : 2 (B) 9 : 4 (C) 4 : 9 (D) 2 : 3

$E = \frac{hc}{\lambda} = hc\bar{\nu}$ where $\bar{\nu} = \frac{1}{\lambda}$ = wave number.

Clearly, $E \propto \bar{\nu}$

$\therefore \frac{E_1}{E_2} = \frac{\bar{\nu}_1}{\bar{\nu}_2} = \frac{2}{3}$

13. A radio station is emitting the radiations of frequency 2×10^4 Hz. If its frequency is doubled,

(A) wavelength will be doubled
(B) energy per quanta will be doubled
(C) wave number will be halved
(D) all of these

$c = \nu\lambda \Rightarrow \lambda \propto \frac{1}{\nu}$ if ν is doubled $\Rightarrow$ λ is halved.

$E = h\nu \Rightarrow E \propto \nu$ if ν is doubled $\Rightarrow$ energy per quantum is doubled.

14. A photon of 400 nm is absorbed by a gas molecule and then the molecule re-emits two photons. One re-emitted photon has wavelength 500 nm. Assuming that there is no change in the energy of molecule, the wavelength of second re-emitted photon is

(A) 100 nm (B) 2000 nm (C) -100 nm (D) 900 nm

$$E = E_1 + E_2$$

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

or, $\frac{1}{400} = \frac{1}{500} + \frac{1}{\lambda_2}$

or, $\frac{1}{\lambda_2} = \frac{1}{400} - \frac{1}{500} = \frac{500-400}{20,0000} = \frac{100}{200,000} = \frac{1}{2000}$

or, $\boxed{\lambda_2 = 2000\,nm}$ Ans.

15. A green bulb and a red bulb are emitting the radiations with equal power. The correct relation between numbers of photons emitted by the bulbs per second is

(A) $n_g = n_r$ (B) $n_g < n_r$ (C) $n_g > n_r$ (D) unpredictable

Order of frequency:

Violet > Indigo > Blue > green > yellow > orange > red.

$E_g = n_g h \nu_g$ — ①

$E_r = n_r h \nu_r$ — ②

$\because$ Power is same

$\Rightarrow E_g = E_r$

or, $n_g \nu_g = n_r \nu_r$

or, $\frac{n_r}{n_g} = \frac{\nu_g}{\nu_r} > 1$

$\Rightarrow \boxed{n_r > n_g}$

n_g = no. of green photons emitted per sec.

n_r = no. of red photons emitted per sec)

16. The threshold wavelength for ejection of electrons from a metal is 330 nm. The work function for the photoelectric emission from the metal is ($h = 6.6 \times 10^{-34}$ J-s)

(A) 1.2×10^{-18} J (B) 6.0×10^{-19} J (C) 1.2×10^{-20} J (D) 6.0×10^{-12} J

$$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{330 \times 10^{-9}} = \frac{6.6 \times 3}{33} \times 10^{-18} = \boxed{6 \times 10^{-19} J}$$

Ans.

17. In the emission of photoelectrons, the number of photoelectrons emitted per unit time depends upon

(A) energy of the incident radiation
(B) intensity of the incident radiation
(C) frequency of the incident radiation
(D) wavelength of the incident radiation

Number of photoelectrons emitted per unit time depends upon intensity of light.

18. Radiations of frequency, ν, are incident on a photosensitive metal. The maximum kinetic energy of photoelectrons is 'E'. When the frequency of the incident radiations is doubled, what is the maximum kinetic energy of the photoelectrons ?

(A) 2E (B) E/2 (C) E + hv (D) E - hv

$E = \phi + (KE)_{max}$ ϕ = work function.

or, $h\nu = \phi + E$ — ①

when frequency of incident radiations is doubled then

let $(KE)_{max} = E'$

$\therefore$ $2h\nu = \phi + E'$ — ②

② - ① $\Rightarrow$ $h\nu = E' - E$ $\Rightarrow$ $\boxed{E' = h\nu + E}$

D

19. Radiation of $\lambda = 155$ nm was irradiated on Li (work function = 5 eV) plate. The stopping potential (in V) is _____.

(A) 3 V (B) 8 V (C) 9 V (D) 5 V

$E = \phi + (KE)_{max}$

or, $8 = 5 + (KE)_{max}$

or, $(KE)_{max} = 3\ eV$

$E = \frac{1240}{\lambda} = \frac{1240}{155} = 8\ eV.$

$\therefore$ Stopping potential = $\boxed{3 \text{ Volt.}}$

20 Electromagnetic radiations having $\lambda = 310$ Å are subjected to a metal sheet having work function = 12.8 eV. What will be the velocity of photoelectrons with maximum Kinetic Energy..

(A) 0, no emission will occur

(B) 2.18×10^6 m/s

(C) $2.18\sqrt{2} \times 10^6$ m/s

(D) 8.72×10^6 m/s

$$E = \frac{12400}{\lambda} = \frac{1240\cancel{0}}{31\cancel{0}} = 40\,eV.$$

$$E = \phi + (KE)_{max}$$

or, $40 = 12.8 + (KE)_{max} \Rightarrow (KE)_{max} = 27.2\,eV$

or, $\frac{1}{2}mv^2 = 27.2 \times 1.6 \times 10^{-19}\,J$

or, $v = \sqrt{\frac{2 \times 27.2 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}}\,ms^{-1}$

$= 3.09 \times 10^6\,ms^{-1} = \boxed{2.18\sqrt{2} \times 10^6\,ms^{-1}.}$

21. Bohr's model may be applied to

(A) Na^{10+} ion (1e) (B) He atom (2e) (C) Be^{2+} ion (2e) (D) C^{6+} ion (no electron)

Bohr model is applied only to single electron atom/ion.

22. If the radius of 3rd Bohr's orbit of H is x, then radius of 4th orbit of Li^{2+} ion would be :-

(A) $\frac{27}{16}x$ (B) $\frac{16}{27}x$ (C) $\frac{9}{16}$ (D) None of these

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

for 3rd Bohr orbit of H atom, $n=3$, $Z=1$

$$x = \frac{a_0 \times 3^2}{1} \Rightarrow a_0 = \frac{x}{9} \quad \text{— (1)}$$

for 4th orbit of Li^{2+} ion, $n=4$, $Z=3$

$$\therefore r = \frac{a_0 n^2}{Z} = \frac{x}{9} \times \frac{4^2}{3} = \boxed{\frac{16x}{27}}$$ Ans.

23. What would be the approximate quantum number, n, for a circular orbit of hydrogen, 1×10^{-5} cm in diameter ?

(A) 31 (B) 43 (C) 40 (D) 39

$$r = \frac{0.529 n^2}{Z} \text{ Å}$$

or, $$\frac{10^{-5}}{2} = \frac{0.529 \times n^2}{1} \times 10^{-8}$$

or, $$n^2 = \frac{1000}{0.529 \times 2} \Rightarrow \boxed{n = 31}$$

Ans

24. If the mass of electron is doubled, the radius of first orbit of H-atom become about

(A) 0.529 Å (B) 0.265 Å (C) 1.058 Å (D) 0.32 Å

From Bohr's postulate,

$$mvr = \frac{nh}{2\pi} \Rightarrow v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \quad \text{— (1)}$$

Also, $F_{centrifugal} = F_{electrostatic}$

or, $$\frac{mv^2}{r} = \frac{KZe^2}{r^2} \Rightarrow v^2 = \frac{KZe^2}{mr} \quad \text{— (2)}$$

From (1) & (2), $$\frac{n^2h^2}{4\pi^2m^2r^2} = \frac{KZe^2}{mr}$$

or, $$r = \frac{n^2h^2}{4\pi^2KZe^2m}$$ Clearly, $\boxed{r \propto \frac{1}{m}}$

$\therefore$ $r = \frac{0.529}{2} A^0 = \boxed{0.265 A^0}$

25. The speed of electron revolving in the 4th orbit of a hydrogen like atom or ion is 1094 km/s. The atom or ion is

(A) H (B) He^{+} (C) Li^{2+} (D) Be^{3+}

$$v = \frac{2.16 \times 10^{6} \times Z}{n}$$

$$1094 \times 10^{3} = \frac{2.16 \times 10^{6} \times Z}{4} \quad \Big| \because n = 4$$

or, $$Z = \frac{1094 \times 4}{2.16 \times 1000} \simeq 2$$

$\therefore$ ion is $\boxed{He^{+}}$

26. How much distance an electron revolving in 3rd orbit of He^+ ion will travel in one second

(A) 1.458×10^6 m (B) 3.28×10^6 m (C) 4.862×10^5 m (D) 2.917×10^6 m

$n = 3, \quad t = 1$ sec.

$$\text{Distance} = v \times t = v \times 1 = \frac{2.16 \times 10^6 \times Z}{n} \times 1$$

for 3rd orbit of He^+, $n = 3$ and $Z = 2$

$$\therefore \text{Distance} = \frac{2.16 \times 10^6 \times 2}{3} = \boxed{1.45 \times 10^6 \text{ m}}$$ Ans.

27. The ratio of time taken by electron in revolutions round the H-nucleus in 2nd and 3rd orbits, are

(A) 2 : 3 (B) 4 : 8 (C) 8 : 27 (D) 27 : 8

$$\text{time } 't' = \frac{2\pi r}{v} = \frac{2\pi \times a_0 \times n^2}{Z \times v_0 \times \frac{Z}{n}} = \frac{2\pi a_0}{v_0} \times \frac{n^3}{Z^2}$$

Clearly $t \propto n^3$

$$\therefore \frac{t_2}{t_3} = \frac{(2)^3}{(3)^3} = \boxed{\frac{8}{27}}$$

28. Which of the following is not a permissible value of angular momentum of electron in H-atom?

(A) $1.5\ \frac{h}{\pi}$ (B) $0.5\ \frac{h}{\pi}$ (C) $1.25\ \frac{h}{\pi}$ (D) all of these

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

Check for (A) $1.5\frac{h}{\pi} = \frac{nh}{2\pi} \Rightarrow n = 3 \Rightarrow$ Possible.

Check for (B), $0.5\frac{h}{\pi} = \frac{nh}{2\pi} \Rightarrow n = 1 \Rightarrow$ Possible

Check for (C), $1.25\frac{h}{\pi} = \frac{nh}{2\pi} \Rightarrow n = 2.5 \Rightarrow$ not possible

29. Angular momentum for P–shell electron :–

(A) $\frac{3h}{\pi}$ (B) Zero (C) $\frac{\sqrt{2}h}{2\pi}$ (D) None

For P-shell, $n = 6$,

$n =$	1	2	3	4	5	6
shell =	K	L	M	N	O	P

$\therefore$ Angular momentum $= \frac{nh}{2\pi} = \frac{6h}{2\pi} = \frac{3h}{\pi}$

30. Angular momentum in 2nd Bohr orbit of H-atom is x. Then find out angular momentum in Ist excitetd state of Li^{+2} :–

(A) 3x (B) 9x (C) x/2 (D) x

For 2nd Bohr orbit of H-atom, $n=2$

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

or, $x = \frac{2h}{2\pi} \Rightarrow \frac{h}{\pi} = x$ —— (1)

For 1st excited state of Li^{2+}, $n=2$

$\therefore$ Angular momentum $= \frac{nh}{2\pi} = \frac{2h}{2\pi} = \frac{h}{\pi} = \boxed{x}$

31. The orbit from which when electron will jump in other orbit, energy may be absorbed but not emitted out, will be

(A) 1st orbit (B) 2nd orbit (C) 7th orbit (D) infinite orbit

Energy is emitted only when electron jumps from higher energy level to lower energy level. 1st orbit is the lowest energy orbit so energy can't be emitted from this orbit.

32. The potential energy of electron revolving in the ground state of H-atom is

(A) -13.6 eV (B) -6.8 eV (C) -27.2 eV (D) Zero

$\because KE = -TE = -\frac{PE}{2}$ (TE = Total energy)

$\therefore PE = 2(T.E.)$

$= 2 \times (-13.6)$

$= \boxed{-27.2\,eV}$

33. If the potential energy (PE) of hydrogen electron is –3.02eV then in which of the following excited level is electron present :-

(A) 1st (B) 2nd (C) 3rd (D) 4th

$\because PE = 2(TE)$

TE = Total energy = E (say)

or, $-3.02 = 2 \times E$

or, $E = -1.51 eV$.

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

or, $-1.51 = \frac{-13.6}{n^2} \Rightarrow n^2 = \frac{13.6}{1.51} = 9 \Rightarrow \boxed{n=3}$

$\Rightarrow$ 2nd excited level.

34. A single electron is revolving in orbits around a stationary nucleus (z = 5). The energy required to excite the electron from third to fourth Bohr orbit will be :-

(A) 4.5 eV (B) 8.53 eV (C) 25 eV (D) 16.53 eV

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

$$= 13.6 \times 5^2 \left[\frac{1}{3^2} - \frac{1}{4^2} \right]$$

$$= 13.6 \times 25 \left[\frac{7}{9 \times 16} \right] = \boxed{16.53 \text{ eV}}$$

Ans.

35. A photon of energy 12.75 ev is completely absorbed by a hydrogen atom initially in ground state. The principle quantum number of the excited state is

$Z = 1$ $\quad$ $n_1 = 1$

(A) 1 (B) 3 (C) 4 (D) ∞

$$\Delta E = 13.6 \left[\frac{1}{1^2} - \frac{1}{n^2} \right]$$

$$\text{or, } 12.75 = 13.6 \left(1 - \frac{1}{n^2} \right)$$

$$\text{or, } 1 - \frac{1}{n^2} = \frac{12.75}{13.6}$$

$$\text{or, } 1 - \frac{12.75}{13.6} = \frac{1}{n^2}$$

$$\text{or, } \frac{0.85}{13.6} = \frac{1}{n^2} \Rightarrow n^2 = \frac{13.6}{0.85} \simeq 16 \Rightarrow \boxed{n = 4}$$

36. An hydrogen atom (ionisation energy 13.6 eV) jumps from third excited state to first excited state. The energy of photon emitted in the process is

$n=4$ $n=2$

(A) 1.89 eV (B) 2.55 eV (C) 12.09 eV (D) 12.75 eV

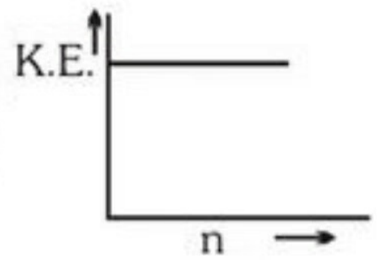
$$\Delta E = 13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$= 13.6\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = 13.6\left[\frac{1}{4} - \frac{1}{16}\right] = 13.6\left[\frac{3}{16}\right]$$

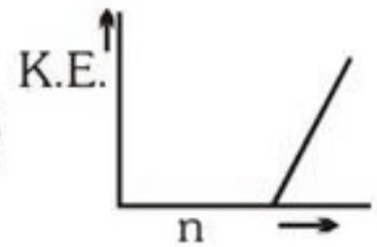
$$= \boxed{2.55\,eV.}$$ Ans.

37. Which is correct graph :-

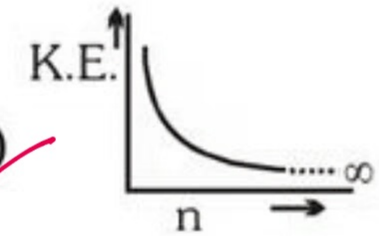
(A) ✗



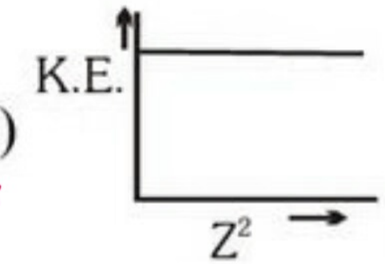
(B) ✗



(C) ✓



(D) ✗



$KE = \frac{1}{2} m v^2 = \frac{1}{2} m \times v_0 \times \frac{Z}{n}$

or, $KE = \frac{K \times Z}{n}$ where $K = \text{Const} = \frac{1}{2} m v_0$

$\Rightarrow$ KE vs n is rectangular hyperbola.

38. The energy required to remove an electron from the surface of sodium metal is 3.3 eV. What is the longest wavelength of radiation with which it can show photoelectric effect?

Use $h = 6.6 \times 10^{-34}$ J.s

(A) 1.75×10^{-7} m (B) 3.75×10^{-5} m (C) 1.75×10^{-5} m (D) 3.75×10^{-7} m

$\phi = 3.3 eV.$ longest $\lambda \Rightarrow$ min^m energy

or, $\frac{hc}{\lambda} = 3.3 \times 1.6 \times 10^{-19}$

or, $\lambda = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{3.3 \times 1.6 \times 10^{-19}} = \frac{6}{1.6} \times 10^{-7} m = \boxed{3.75 \times 10^{-7} m}$

39. Which is correct for any H like species :-

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

(B) $(E_2 - E_1) < (E_3 - E_2) < (E_4 - E_3)$

(C) $(E_2 - E_1) = (E_3 - E_2) = (E_4 - E_3)$

(D) $(E_2 - E_1) = 1/4\ (E_3 - E_2) = 1/9\ (E_4 - E_3)$

As n increases the energy difference between successive energy level decreases.

40. A single electron orbits a stationary nucleus of charge +Ze, where Z is a constant. It requires 47.2 eV to excite electron from second Bohr orbit to third Bohr orbit, find the value of Z :-

(A) 1 (B) 3 (C) 5 (D) 4

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

or, $$47.2 = 13.6 \times Z^2 \left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

or, $$\frac{47.2}{13.6} = Z^2 \left[\frac{5}{36}\right]$$

or, $$Z^2 = \frac{47.2 \times 36}{13.6 \times 5} \simeq 25 \Rightarrow \boxed{Z = 5}$$

41. The energy of H–atom in n^{th} orbit is E_n then energy in n^{th} orbit of singly ionised helium atom will be:

(A) $4E_n$ (B) $E_n/4$ (C) $2E_n$ (D) $E_n/2$

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

for nth orbit of H-atom $(Z=1)$, $E = \frac{-13.6}{n^2} = E_n$

for nth orbit of He^+ ion $(Z=2)$, $E = \frac{-13.6 Z^2}{n^2} = E_n Z^2 = \boxed{4E_n}$

Ans.

42 Which electronic level would allow the hydrogen atom to absorb a photon but not to emit a photon

(A) 3s (B) 2p (C) 2s (D) 1s

When electron will be in its lowest energy state then it will never emit a photon. It can only absorb a photon.

43 The third line in Balmer series corresponds to an electronic transition between which Bohr's orbits in hydrogen

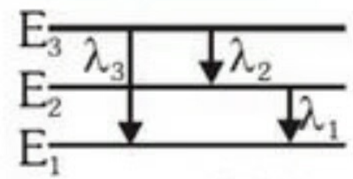
(A) $5 \rightarrow 3$ (B) $5 \rightarrow 2$ (C) $4 \rightarrow 3$ (D) $4 \rightarrow 2$

For Balmer $n_1 = 2$

For 3rd line of Balmer, $n_2 = n_1 + 3 = 2+3 = 5$

$\Rightarrow 5 \rightarrow 2$

44. In the following transition which statement is correct



(A) $E_{3-1} = E_{3-2} - E_{2-1}$

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

(C) $\nu_3 = \nu_2 + \nu_1$

(D) All of these

$E_{3-1} = E_{3-2} + E_{2-1}$ (energy balance)

or, $h\nu_3 = h\nu_2 + h\nu_1$

$\Rightarrow \boxed{\nu_3 = \nu_2 + \nu_1}$

or, $\frac{1}{\lambda_3} = \frac{1}{\lambda_2} + \frac{1}{\lambda_1}$.

45. The first Lyman transition in the hydrogen spectrum has $\Delta E = 10.2$ eV. The same energy change is observed in the second Balmer transition of :-

(A) Li^{2+} (B) Li^{+} (C) He^{+} (D) Be^{3+}

$$\Delta E_{Balmer} = 13.6 Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

For 2nd Balmer transition, $n_1 = 2$, $n_2 = 4$

or, $$10.2 = 13.6 \times Z^2 \left[\frac{1}{2^2} - \frac{1}{4^2}\right]$$

or, $$\frac{10.2}{13.6} = Z^2 \left[\frac{3}{16}\right]$$

or, $$Z^2 = \frac{10.2 \times 16}{13.6 \times 3} = 4 \Rightarrow Z = 2 \Rightarrow He^{+} \text{ ion.}$$

46. In a sample of H–atoms, electron transits from 6th orbit to 2nd orbit in multi step. Then total spectral lines (without Balmer series) will be :–

(A) 6 (B) 10 (C) 4 (D) 0

$n=6$ to $n=2$, no. of spectral lines $= \Sigma(n_2-n_1)$

$= \Sigma(6-2)$

$= \Sigma 4 = 4 + 3 + 2 + 1$ → Pfund.

4 → Balmer, 3 → Paschen, 2 → Brackett

$= 10$ lines.

∴ Total spectral lines without Balmer $= 10-4 = 6$ lines.

47. What is the shortest wavelength in the Pfund series of He^+ ion :-

(A) $\frac{25}{R}$ (B) $\frac{4}{R}$ (C) $\frac{4R}{25}$ (D) $\frac{25}{4R}$

For shortest λ, $n_2 = \infty$

For Pfund line, $n_1 = 5$

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

or, $\frac{1}{\lambda} = R \times 2^2 \left[\frac{1}{5^2} - \frac{1}{\infty}\right]$

or, $\frac{1}{\lambda} = \frac{4R}{25} \Rightarrow \boxed{\lambda = \frac{25}{4R}}$ Ans.

48 The shortest wavelength of He^+ ion in Balmer series is x, then longest wavelength in the Paschene series of Li^{+2} is

(A) $\frac{36x}{5}$ (B) $\frac{16x}{7}$ (C) $\frac{9x}{5}$ (D) $\frac{5x}{9}$

For shortes wavelength of He^+ ion in Balmer series:

$n_1 = 2, \; n_2 = \infty, \; Z = 2$

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

or, $$\frac{1}{x} = R \times 2^2\left[\frac{1}{2^2} - \frac{1}{\infty}\right]$$

or, $$R = \frac{1}{x}$$

For longest wavelength in the Paschen series of Li^{2+}:

$n_1 = 3, \; n_2 = n_1 + 1 = 4, \; Z = 3$

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \frac{1}{\lambda} = \frac{1}{x} \times 3^2\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = \frac{1}{x}\left[1 - \frac{9}{16}\right] = \frac{7}{16x}$$

$$\therefore \boxed{\lambda = 16x/7}$$

49 The ratio of wave length of photon corresponding to the α-line of Lyman series in H-atom and β-line of Balmer series in He^+ is

(A) 1 : 1 (B) 1 : 2 (C) 1 : 4 (D) 3 : 16

α-line means 1st line and β line means 2nd line.

For α-line of Lyman series in H-atom, $Z=1$, $n_1=1$, $n_2=2$

$$\frac{1}{\lambda_1} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\times 1^2\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = \frac{3R}{4} \Rightarrow \lambda_1 = \frac{4}{3R}.$$

For β line of Balmer series in He^+, $Z=2$, $n_1=2$, $n_2=4$

$$\frac{1}{\lambda_2} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right] = R\times 2^2\left[\frac{1}{2^2}-\frac{1}{4^2}\right] = R\left[1-\frac{1}{4}\right] = \frac{3R}{4}$$

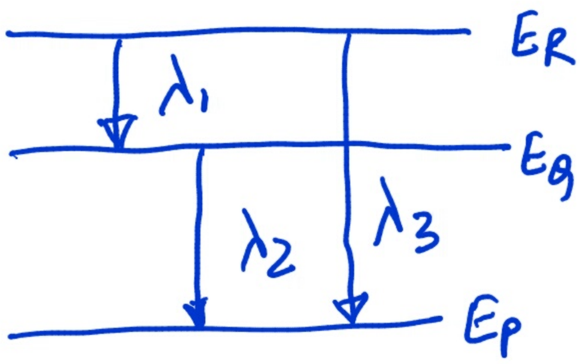
$$\Rightarrow \lambda_2 = \frac{4}{3R}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \boxed{1:1}$$

2

50 Three energy levels P, Q, R of a certain atom are such that $E_P < E_Q < E_R$. If λ_1, λ_2 and λ_3 are the wave length of radiation corresponding to transition $R \rightarrow Q$; $Q \rightarrow P$ and $R \rightarrow P$ respectively. The correct relationship between λ_1, λ_2 and λ_3 is

(A) $\lambda_1 + \lambda_2 = \lambda_3$ (B) $\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$ (C) $\lambda_3 = \sqrt{\lambda_1 \lambda_2}$ (D) $\frac{2}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$



$\because E_P < E_Q < E_R$

Clearly, $E_{RP} = E_{RQ} + E_{QP}$

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

or, $\boxed{\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}}$ Ans.

51. Number of possible spectral lines which may be emitted in bracket series in H atom, if electrons present in 9th excited level returns to ground level, are

(A) 21 (B) 6 (C) 45 (D) 5

9th excited level means $n=10$.

no. of spectral lines $= \Sigma(10-1) = \Sigma 9 = 9+8+7+6+5+4+3+2+1$

Lyman Balmer Paschen Brackett

$\therefore$ no. of Brackett lines $= \boxed{6}$

52. The value of $(n_2 + n_1)$ and $\left(n_2^2 - n_1^2\right)$ for He^+ ion in atomic spectrum are 4 and 8 respectively. The wavelength of emitted photon when electron jump from n_2 to n_1 is

(A) $\frac{32}{9} R_H$ (B) $\frac{9}{32} R_H$ (C) $\frac{9}{32 R_H}$ (D) $\frac{32}{9 R_H}$

$n_1 + n_2 = 4$ — (1)

$n_2^2 - n_1^2 = 8$

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

or, $4(n_2 - n_1) = 8$

or, $n_2 - n_1 = 2$ — (2)

(1) + (2) $\Rightarrow$ $2n_2 = 6 \Rightarrow \boxed{n_2 = 3}$

$\therefore \boxed{n_1 = 1}$

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

or, $\frac{1}{\lambda} = R \times 2^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

or, $\frac{1}{\lambda} = 4R\left[1 - \frac{1}{9}\right] = 4R \times \frac{8}{9}$

or, $\boxed{\lambda = \frac{9}{32R}}$

53 An electron, a proton and an alpha particle have kinetic energies of 16E, 4E and E respectively. What is the qualitative order of their de Broglie wavelengths?

(A) $\lambda_e > \lambda_p = \lambda_\alpha$ (B) $\lambda_p = \lambda_\alpha > \lambda_e$ (C) $\lambda_p > \lambda_e > \lambda_\alpha$ (D) $\lambda_\alpha < \lambda_e \gg \lambda_p$

$$KE = \frac{1}{2} m v^2 \Rightarrow 2mKE = m^2 v^2 \Rightarrow mv = \sqrt{2m(KE)}.$$

$$\lambda = \frac{h}{mv} \quad \text{or,} \quad \lambda = \frac{h}{\sqrt{2m(KE)}}$$

$$\lambda_e = \frac{h}{\sqrt{2m_e \times 16E}} \quad \text{— (1)}$$

$$\lambda_p = \frac{h}{\sqrt{2 \times 1840 m_e \times 4E}} \quad \text{— (2)} \qquad (\because m_p = 1840 m_e)$$

$$\lambda_\alpha = \frac{h}{\sqrt{2 \times 4 \times 1840 \times m_e \times E}} \quad \text{— (3)} \qquad (\because m_\alpha = 4 m_p)$$

Clearly, $\boxed{\lambda_e > \lambda_p = \lambda_\alpha}$

54 The wavelength associated with a golf weighing 200g and moving at a speed of 5m/h is of the order

(A) 10^{-10}m (B) 10^{-20}m (C) 10^{-30}m (D) 10^{-40}m

$$\lambda = \frac{h}{mv} = \frac{6.626\times10^{-34}}{\frac{200}{1000}\times\frac{5}{3600}}$$

$v = 5\,m/hr$

$= \frac{5}{3600}\,ms^{-1}$

or, $\lambda = 36\times6.626\times10^{-32}\,m = 238.5\times10^{-32}\,m$

$= \boxed{2.385\times10^{-30}\,m}$

55. An electron has kinetic energy 2.8×10^{-23} J. de-Broglie wavelength will be nearly :-
($m_e = 9.1 \times 10^{-31}$ kg)

(A) 9.28×10^{-24} m (B) 9.28×10^{-7} m (C) 9.28×10^{-8} m (D) 9.28×10^{-10} m

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2m(KE)}}$$

$\left(\because KE = \frac{1}{2}mv^2 \right.$

or, $2mKE = m^2v^2 \Rightarrow mv = \sqrt{2m(KE)} \Big)$

$$\text{or, } \lambda = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 2.8 \times 10^{-23}}} = \frac{6.626}{\sqrt{2 \times 9.1 \times 2.8}} \times 10^{-7}$$

$$= \boxed{9.28 \times 10^{-8} \text{ m}}$$

56. What will be de-Broglie wavelength of an electron moving with a velocity of $1.2 \times 10^5 \, ms^{-1}$:-

(A) 6.068×10^{-9} m (B) 3.133×10^{-37} m (C) 6.626×10^{-9} m (D) 6.018×10^{-7} m

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.11 \times 10^{-31} \times 1.2 \times 10^{5}} = \frac{6.626}{9.11 \times 1.2} \times 10^{-8}$$

or, $\boxed{\lambda = 6.06 \times 10^{-9} \, m}$

Ans.

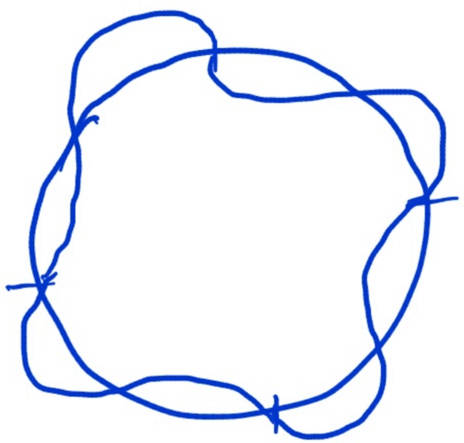
57. For a valid Bohr orbit, its circumfrence should be:

(A) $= n\lambda$ (B) $= (n-1)\lambda$ (C) $> n\lambda$ (D) $< n\lambda$

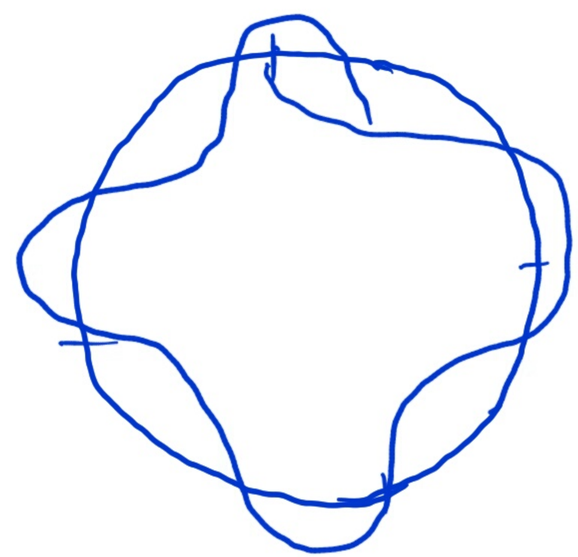
For electron wave in-phase,

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

or, circumference $= n\lambda$.



e-wave in phase



e-wave out of phase.

58. The number of waves made by a Bohr electron in an orbit of maximum magnetic quantum number + 2 :

(A) 3 (B) 4 (C) 2 (D) 1

$m = 2$ (maximum value)

$\therefore l = 2$ and $n = 3$

$$\text{no. of waves} = \frac{2\pi r}{\lambda} = \frac{2\pi r}{(h/mv)} = \frac{2\pi}{h} \times mvr$$

$$= \frac{2\pi}{h} \times \frac{nh}{2\pi} = \boxed{n = 3}$$

59. How fast is an electron moving if it has a wavelength equal to distance travelled in one second -

(A) $\sqrt{\frac{m}{h}}$ (B) $\sqrt{\frac{h}{m}}$ (C) $\sqrt{\frac{h}{p}}$ (D) $\sqrt{\frac{h}{2\times K.E.}}$

$\lambda = v \times 1$ —— (1)

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

or, $v^2 = \frac{h}{m}$ $(\because \lambda = v)$

or, $\boxed{v = \sqrt{\frac{h}{m}}}$

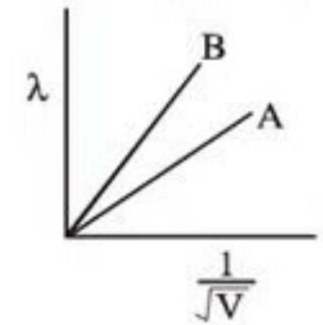
60. De-Broglie wavelength of two particles A & B are plotted against $\left(\frac{1}{\sqrt{V}}\right)$; where V is potential on the particles. Which of the following relation is correct about mass of particle (charge is same)

(A) $M_A = M_B$

(B) $M_A > M_B$

(C) $M_A < M_B$

(D) $M_A \le M_B$



$\lambda = \frac{h}{mv}$ $\quad$ $\left(\because KE = \frac{1}{2}mv^2\right.$

$\Rightarrow mv = \sqrt{2m(KE)}$

or, $\lambda = \frac{h}{\sqrt{2m(KE)}} = \frac{h}{\sqrt{2mqV}}$ $\quad$ $(\because KE = q \times V)$

Clearly $\lambda = \frac{h}{\sqrt{2mq}} \times \frac{1}{\sqrt{V}}$

$y = m \quad x$

from fig:

$\because$ slope of A < slope of B

$\therefore M_A > M_B$

61. An α-particle is accelerated through a potential difference of V volts from rest. The de-Broglie's wave-length associated with it is -

(A) $\sqrt{\frac{150}{V}}\,A^\circ$ (B) $\frac{0.286}{\sqrt{V}}\,A^\circ$ (C) $\frac{0.101}{\sqrt{V}}\,A^\circ$ (D) $\frac{0.983}{\sqrt{V}}\,A^\circ$

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

for electron, $\lambda(\text{in } A^\circ) = \sqrt{\frac{150}{V(\text{in volt})}}$

for α particle, $m = 4 \times 1836\, m_e$

$q = 2 \times e$

$$\therefore \lambda(\text{in } A^\circ) = \sqrt{\frac{150}{4 \times 1836 \times 2\, V(\text{in volt})}} = \frac{0.101}{\sqrt{V(\text{in volt})}}$$

or, $\boxed{\lambda = \frac{0.101}{\sqrt{V}}\,A^\circ}$

62 Which quantum number is not related with Schrodinger equation

(A) Principal (B) Azimuthal (C) Magnetic (D) Spin

ψ is a fn of quantum numbers n, l and m.

So spin quantum number is not used in the solution of Schrödinger eqn.

63. Which is true about ψ :-

(A) ψ represents the probability of finding an electron around the nucleus

(B) ψ represent the amplitude of the electron wave

(C) Both A and B

(D) None of these

ψ = wave function, gives amplitude of e-wave.

ψ^2 = probability density.

64. According to Schrodinger model nature of electron in an atom is as :-

(A) Particles only

(B) Wave only

(C) Both simultaneously

(D) Sometimes waves and sometimes particle

Schrödinger considered electron as a wave as well as a particle.

65. The orbital angular momentum of an electron in 2s orbital is:

(A) $+\frac{1}{2}\cdot\frac{\hbar}{2\pi}$ (B) Zero (C) $\frac{\hbar}{2\pi}$ (D) $\sqrt{2}.\frac{\hbar}{2\pi}$

For 2s orbital, $l = 0$

orbital angular momentum $= \sqrt{l(l+1)}\,\frac{h}{2\pi} = 0$

66. In an excited state, a calcium atom has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 4d^1$. What is the orbital angular momentum for d electron :- $\left(\hbar = \frac{h}{2\pi}\right)$

(A) $\sqrt{4}\hbar$ (B) $\sqrt{16}\hbar$ (C) $\sqrt{6}\hbar$ (D) $\sqrt{10}\hbar$

For 'd' electron, $l = 2$

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

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

$= \sqrt{6}\,\hbar$

67. Which orbitlal has two angular nodal planes :-

(A) s (B) p (C) d (D) f

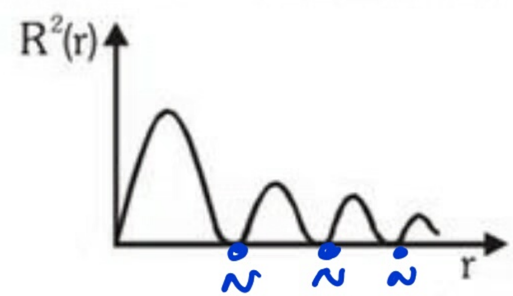
no. of angular nodal plane = l = 2 ⇒ d orbital.

68. From the following observations predict the type of orbital :

Observation 1 : x y plane acts as nodal plane ⇒ either $5P_z$ or $6d_{yz}$

Observation 2 : The angular function of the orbital intersect the three axis at origin only. ⇒ only $6d_{yz}$ because P_z orbital involves $\cos\theta$ only. So angular function can intersect axis at positions other than origin.

Observation 3 : $R^2(r)$ v/s r curve is obtained for the orbital is

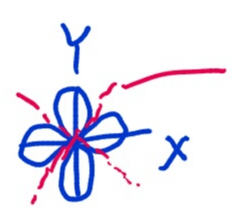


(A) $5p_z$ (B) $6d_{xy}$ (C) $6d_{x^2-y^2}$ (D) $6d_{yz}$ ✓

no. of radial node = $n-l-1 = 3$

$\Rightarrow n-l = 4$.

Orbitals	nodal plane
P_z	XY
d_{XY}	XZ, YZ
$d_{x^2-y^2}$	
d_{YZ}	XY, XZ



nodal plane.