ATOMS

PART-I (SINGLE CORRECT MCQS)

PHYSICS

1. **In the Bohr's model of hydrogen-like atom the force between the nucleus and the electron is modified as** $F = \frac{e^2}{4\pi\varepsilon_0}\left(\frac{1}{r^2}+\frac{\beta}{r^3}\right)$ **where is β constant. For this atom, the radius of the nth orbit in terms of the Bohr radius** $\left(a_0 = \frac{\epsilon_0 h^2}{m\pi e^2}\right)$ **is**

1) $r_n = a_0 n - \beta$ 2) $r_n = a_0 n^2 + \beta$ 3) $r_n = a_0 n^2 - \beta$ 4) $r_n = a_0 n + \beta$

2. **In the Bohr model an electron moves in a circular orbit around the proton. Considering the orbiting electron to be a circular current loop, the magnetic moment of the hydrogen atom, when the electron is in** n^{th} **excited state, is:**

1) $\left(\frac{e}{2m}\frac{n^2 h}{2\pi}\right)$ 2) $\left(\frac{e}{m}\right)\frac{nh}{2\pi}$ 3) $\left(\frac{e}{2m}\right)\frac{nh}{2\pi}$ 4) $\left(\frac{e}{m}\right)\frac{n^2 h}{2\pi}$

3. **In Ruther ford scattering experiment, the number of α -particles scattered at** 60^0 **is** 5×10^6 **. The number of α - particles scattered at 120^0 will be**

1) 15×10^6 2) $\frac{3}{5}\times10^6$ 3) $\frac{5}{9}\times10^6$ 4) none of these

4. **Electrons in a certain energy level n=n$_1$, can emit 3 spectral lines. When they are in another energy level, n=n$_2$. They can emit 6 spectral lines. The orbital speed of the electrons in the two orbits are in the ratio 8.**

1)4:3 2)3:4 3)2:1 4)1:2

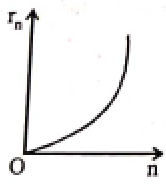
5. **Energy of an electron in an excited hydrogen atom is -3.4 V . Its angular momentum will be**

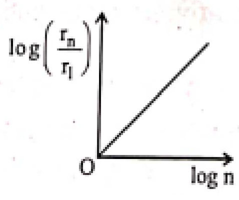
1) $3.72\times10^{-34}\,Js$ 2) $2.10\times10^{-34}\,Js$ 3) $1.51\times10^{-34}\,Js$ 4) $4.20\times10^{-34}\,Js$

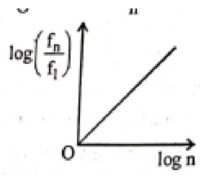
6. **The radiation corresponding to 3 →2 transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of** 3×10^{-4}**. If the radius of the largest circular path followed by these electrons is 10.0mm, the work function of the metal is close to:**

1)1.8eV 2) 1.1eV 3) 0.8eV 4) 1.6eV

7. **If in hydrogen atom, radius of nth Bohr orbit is r$_n$, frequency of revolution of electron in nth orbit** n^{th} **is f$_n$, choose the correct option.**

1) 

2) 

3) 

4) Both (a) and (b)

8. **A 12.5 eV electron beam is used to bombard hydrogen at room temperature. It will emit:**

1) 2 lines in the Lyman series and 1 line in the Balmer series
2) 3 lines in the Lyman series
3) 1 line in the Lyman series and 2 lines in the Balmer series
4) 3 lines in the Balmer series

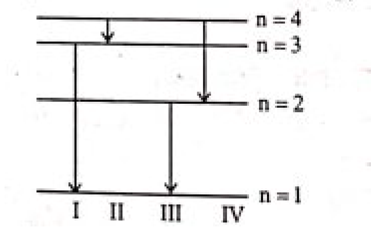
9. **The electric potential between a proton and an electron is given by** $V = V_0\, in\frac{r}{r_0}$ **, where r$_0$ is a constant. Assuming Bohr's model to be applicable, write variation of r$_n$ with n, n being the principal quantum number?**

1) $r_n \propto n$ 2) $r_n \propto 1/n$ 3) $r_n \propto n^2$ 4) $r_n \propto 1/n^2$

10. **Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited state. The ratio of the wavelength** $\lambda_1 : \lambda_2$ **emitted in the two cases is**

1) 7/5 2) 27/20 3) 27/5 4) 20/7

11. **The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?**



1) IV 2) III 3) II 4)I

12. **Consider 3^{rd} orbit of He^+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given constant $K = 9\times10^9$, Z=2 and h (Plank's Constant). =6.6 $\times10^{-34}\,Js$**

1) $1.46\times10^6 m/s$ 2) $0.73\times10^6 m/s$ 3) $3.0\times10^8 m/s$ 4) $2.92\times10^6 m/s$

13. **An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be: (m is the of the electron, R, Rydberg constant and h Planck's mass constant)**

1) $\frac{24hR}{25m}$ 2) $\frac{25hR}{24m}$ 3) $\frac{25m}{24hR}$ 4) $\frac{24m}{25hR}$

14. **If v_1 is the frequency of the series limit of Lyman series, v_2 is the frequency of the first line of Lyman series and v_3 is the frequency of the series limit of the Balmer series. then**

1) $v_1 - v_2 = v_3$ 2) $v_1 = v_2 - v_3$ 3) $\frac{1}{v_2} = \frac{1}{v_1} + \frac{1}{v_3}$ 4) $\frac{1}{v_1} = \frac{1}{v_2} + \frac{1}{v_3}$

15. **Hydrogen $({}_1H^1)$ Deuterium $({}_1H^2)$, single ionised Helium $({}_2He^4)^+$ and doubly ionized lithium $({}_3Li^6)^{++}$ all have one electron around the nucleus. Consider an electron transition from n=2 ton=1. If the wavelengths of emitted radiation are $\lambda_1, \lambda_2, \lambda_3$ and λ_4 respectively then approximately which one of the following is correct?**

1) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$ 2) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$ 3) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$ 4) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

16. **If the atom ${}_{100}Fm^{257}$ follows the Bohr model and the radius of ${}_{100}Fm^{257}$ is n times the Bohr radius, then find n.**

1) 100 2) 200 3) 4 4) 1/4

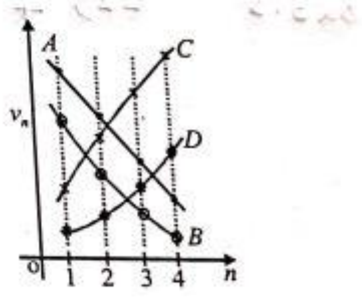
17. **The ionization potential of H-atom is 13.6V. When it is excited from ground state by monochromatic radiations of 970.6 A, the number of emission lines will be (according to Bohr's theory)**

1) 10 2) 8 3) 6 4) 4

18. **The energy of He^+ in the ground state is -54.4 eV, then the energy of Li^{++} in the first excited state will be**

1)-30.6 eV 2) 27.2 eV 3) -13.6 eV 4) -27.2 eV

19. **Which of the plots shown in the figure represents speed (v_n) of the electron in a hydrogen atom as a function of the principal quantum number (n) ?**



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

20. Suppose an electron is attracted towards the origin by a force k/r where 'K' is a constant and 'r' is the distance of the electron from the origin. By applying Bohr model to this system, the radius of the n^{th} orbital of the electron is found to be 'r_n' and the Kinetic energy of the electron to be 'T_n' . Then which of the following is true?

1) $T_n \ \alpha \ \frac{1}{n^2}, r_n \ \alpha \ n^2$ 2) T_n independent of n,$r_n \propto n$ 3) $T_n \propto 1/n, r_n \propto n$ 4) $T_n \ \alpha \ \frac{1}{n}, r_n \ \alpha \ n^2$

PART-II
(NUMERIC/INTEGER TYPE QUESTIONS)

21. The largest wavelength in the ultraviolet region of the hydrogen spectrum is122 nm. The smallest wavelength (in nm) in the infrared region of the hydrogen spectrum is

22. An electron in the hydrogen atom jumps from excited state n to the ground state. The wavelength so emitted illuminates a photosensitive material having work function 2.75 eV. If the stopping potential of the photoelectron is 10 V, the value of n is

23. Ionization potential of hydrogen atom is 13.6eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

24. One of the lines in the emission spectrum of Li^{2+} has the same wavelength as that of the 2^{nd} line of Balmer series in hydrogen spectrum. The electronic transition corresponding to this line is n=12 ⟶n=x. Find the value of x.

25. An energy of 24.6eV is required to remove one of the electrons from a neutral helium atom. The energy (in eV) required to remove both the electrons from a neutral helium atom is

KEY SHEET

PHYSICS

1) **3**	2) **3**	3) **3**	4) **1**	5) **2**	6) **2**	7) **4**	8) **1**	9) **1**	10) **3**
11) **2**	12) **1**	13) **1**	14) **1**	15) **3**	16) **4**	17) **3**	18) **1**	19) **1**	20) **2**
21) 823.5	22) 4	23) **3**	**24)** 6	24) 79					

1. In a Geiger-marsden experiment what is the distance of closest approach to the nucleus of a 5.6 MeV $\alpha -$particle before it comes momentarily to rest and reverses its direction?

Ans: 3.9×10^{-14}

Sol: $K.E = 5.6MeV \quad z = 79$

$$K.E = 9\times10^{9}\times\frac{2ze^{2}}{d}$$

$$d = \frac{9\times10^{9}\times2\times79\times\left(1.6\times10^{-19}\right)^{2}}{5.6\times10^{6}\left(1.6\times10^{-19}\right)}$$

$$d = \frac{18\times79\times1.6\times10^{-19}\times10^{9}}{5.6\times10^{6}}$$

$$d = \frac{18\times76\times1.6\times10^{-10}}{5.6}$$

$$d = 3.90.85\times10^{-16}$$

$$d = 3.9\times10^{-14}$$

2. The total energy of an electron in the first excited state of the hydrogen atom is -3.4eV. What is the potential energy of the electron in this sate?

Ans: -6.8Ev

Sol: $E = +3.4eV$

$$P.E\ V = -2E$$

$$V = -2\times3.4$$

$$V = -6.8eV$$

3. The ground state energy of hydronge atom is -13.6eV. What are the kinetic and potential energies of the electron in this state?

Ans: 13.6eV, -27.2eV

Sol: $KE = TE$

$= \pm 13.6eV$

$P.E = 2T.E$

$= 2(-13.6)$

$P.E = -27.2eV$

4. The radius of the innermost electron orbit of a hydroghe atom is $5.3\times10^{11}m$. What are the radii of the n=2 and n=3 orbits?

Ans: $2.12\times0^{-10}m; 4.77\times10^{-10}m$

Sol: $r_n = \frac{lE_0h^2}{\pi ye^2}\left(\frac{n^2}{z}\right)$

$n=1 \qquad m=1$

$r_1 = 5.3\times10^{-11}$

$r_2 = 5.3\times10^{-11}\left[\frac{n^2}{z}\right]$

If $n=2$

$r_2 = 5.3\times2^2\times10^{-11} = 10.6\times10^{-11}\times2$

$=1.06\times10^{-10}\times2$

If $n=3$

$= 2.12\times10^{-10}$

$r_3 = 5.3\times3^2\times10^{-11}$

$= 5.3\times9\times10^{-11} \Rightarrow 47.7\times10^{-11}$

$r_3 = 4.77\times10^{-10}$

5. In accordance with the Bohr's model. Find the quantum numbers that character rises the earth's revolution around the sun in an orbit of radius $1.5\times10^{11}m$ with orbital speed $3\times10^4 m/s$ (mass of earth$= 6.0\times10^{24}kg$)

Ans: 2.6×10^{74}

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

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

$$n = \frac{2\times 3.14\times 6\times 10^{24}\times 3\times 10^{4}\times 1.5\times 10^{11}}{6.6\times 10^{-34}}$$

$$n = \frac{2\times 3.14\times 3\times 1.5\times 10^{39}\times 10^{34}}{1.1}$$

$$n = \frac{28.26}{1.1}\times 10^{73}$$

$$n = 25.69\times 10^{73}$$

$$n = 2.569\times 10^{74}$$

$$n = 2.6\times 10^{74}$$

6. The total energy of an electron in the first excited state of the hydrogen atom is about -3.4eV. What is the potential energy of the electron in this state

Ans: $V = -2T, P.E = -6.8eV$

7. Obtain the first Bohr's radius and the ground state energy of a muonic hydrogen atom [i.e., an atom in which a negatively charged muon(μ)) of mass about $20\,m_e$ orbits around a proton]

Ans: $2.56\times 10^{-13} m; = 2.8keV$

Ans: $r\alpha \frac{1}{m} \quad E\alpha m$

$$r_\mu = \frac{r_e m_e}{m_\mu} = \frac{0.53\times 10^{13}}{207} = 2.56\times 10_7^{-13}$$

$$E_\mu = \frac{m_\mu E_e}{m_e} = -13.6\times 207eV$$

$$-2.8keV$$

8. Hydrogen atom from excited state comes to the ground state by emitting a photon of wavelength λ. If R is the rRydberg constant, then the principal quantum number n of the excited state is

Ans: $\sqrt{\frac{\lambda R}{\lambda R-1}}$

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

If $n_1=1 \qquad n_2=2$

$\lambda_1=\lambda$

If $n_1=1 \qquad n_2=n$

$\lambda_2=?$

9. Taking the wavelength of first Balmer line in hydrogen spectrum (n=3 to n=2) as 660nm, the wavelength of the 2nd Balmer line (n=4 to n=2) will be

Ans: 488.9nm

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

$n_1=2 \qquad n_2=3\rightarrow$ first with

$n_1=2 \qquad n_2=4\rightarrow$ second with

$$\frac{\lambda_2}{\lambda_1}=\frac{\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)}{\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)_2}$$

$$\frac{\lambda_2}{\lambda_1}=\frac{\frac{1}{4}-\frac{1}{4}}{\frac{1}{4}-\frac{1}{16}}=\frac{9-4}{(16-4)}\times\frac{64}{36}$$

10. An excited He^+ ion emits two photons in succession, with wavelengths 108.5nm and 30.4nm, in making a transition to ground state. The quantum number n,

corresponding to its initial excited state is (for photo of wavelength λ energy

$$E = \frac{12400eV}{\lambda\left(A^0\right)}$$

Ans: $n = 5$

Sol: $E_2 - E_1 = 136\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]eV$