PHYSICS OF CLASS XII
CHAPTER – 12 ATOMS

Q.1. Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its

(i) second permitted energy level to the first level and

(ii) the highest permitted energy level to the first permitted level.

Ans. (i) The second permitted energy level to the first level $\Delta E = E_2 - E_1$ = Energy of photon released = (- 3.4 eV) – (- 13.6 eV) = 10.2 eV

(ii) The highest permitted energy level to the first permitted level

$\Delta E = E_\infty - E_1$ = 0 – (- 13.6) = 13.6 eV

Ratio of energies of photon = $\frac{10.2}{13.6} = \frac{3}{4}$ = 3 : 4

Q.2. Why is the classical (Rutherford) model for an atom of electron orbiting around the nucleus not able to explain the atomic structure?

Ans. The classical method could not explain the atomic structure as the electrons revolving around the nucleus are accelerated and emits energy as the result, the radius of the electron circular paths goes on decreasing. Ultimately electrons fall into the nucleus, which is not true for an atom.

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

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Ans. In case hydrogen atom, the kinetic energy is equal to the negative of the total energy and potential energy is equal to twice to the total energy.

Given, total ground state enrgy (TE) = (- 13.6 eV)

Potential energy = 2 (TE)

= 2 × (- 13.6 eV) = - 27.2 ev

Kinetic energy = - TE = 13.6 eV

Q.4. What is the ratio of radii of the orbits corresponding to first excited state and ground state in a hydrogen atoms?

Ans. For first excited state n = 2

Ground state occurs for n = 1

Since, $r_n = r_0 n^2$

Since, $r \propto n^2$

$\Rightarrow \quad \frac{r_2}{r_1} = \left(\frac{n_2}{n_1}\right)^2 = \left(\frac{2}{1}\right)^2$

So, $r_2 : r_1$ = 4 : 1, where r_2 and r_1 are radii corresponding to first excited state and ground state of the atom.

Q.5. The radius of innermost electron orbit of a hydrogen atom is 5.3 × 10^{-11} m. What is the radius of orbit in the second excited state?

Ans. The radius of atom whose principal quantum number in n, is given by

$$r_n = n^2 r_0 = 5.3 \times 10^{-11} \text{ m}$$

where r_0 = radius of innermost electron orbit, for second excited state n = 3

So, $r_3 = 3^3 \times r_0 = 9 \times 5.3 \times 10^{-11}$

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where r_0 = radius of innermost electron orbit, for second excited state n = 3

So, $r_3 = 3^2 \times r_0 = 9 \times 5.3 \times 10^{-11}$

$r_3 = 4.77 \times 10^{-10}$ m

Q.6. Write the expression for Bohr's radius in hydrogen atom.

Ans. Expression for Bohr's radius in hydrogen atom (n = 1)

$$r_n = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)^2 \frac{4\pi\varepsilon_0}{e^2} = \frac{\varepsilon_0 n^2 h^2}{\pi e^2 m} = \frac{\varepsilon_0 h^2}{\pi e^2 m}$$

where n = principal quantum number, m = mass of electron, h = Plank's constant.

Q.7. State Bohr's postulate of quantisation of angular momentum of the orbiting electron in hydrogen atom.

Ans. According to Bohr's quantisation condition, electrons are permitted to revolve in only those orbits in which the angular momentum of electron is an integral multiple of $\frac{h}{2\pi}$. i.e., mvr = $\frac{nh}{2\pi}$ where, n = 1,2,3,….

m, v, r are mass, speed and radius of electron and h being Plank's constant.

Q.8. Suppose you are given a chance to repeat the α-particle scattering experiment using a thin sheet of solid hydrogen in place of the gold foil. (Hydrogen is solid at temperature below 14 K). What result do you expect.

Ans. In the α-particle scattering experiment, if a thin sheet solid hydrogen is used in place of a gold foil. Then the scattering angle would not be large enough. This is because the mass of hydrogen is less than the mass of incident α-particles (6.64 × 10^{-27} kg). Thus, the mass of the scattering particle is more than the target

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nucleus (hydrogen). As a result, the α-particle would not bounce back if solid hydrogen is used in the α-particles scattering experiment.

Q.9. In the Rutherford scattering experiement, the distance of closest approach for an α-particle is d_0. If α-particle is replaced by a proton, how much kinetic energy in comparison to α-particle will be required to have the same distance of closest approach, d_0 ?

Ans. When α-particle is replaced by proton then there will be change change in atomic number and mass of the particle.

∵ For given distance of closest approach

Kinetic energy ∝ Z (atomic number)

⇒ $\frac{K_{proton}}{K_\alpha} = \frac{z_{proton}}{Z_\alpha}$

⇒ $K_{proton} : K_\alpha = 1 : 2$

Q.10. If Bohr's quantisation postulate angular momentum (L = nh/2π) is a basic law of nature, it should be equally valid for the case of planetary motion also. Why them do we never speak of quantisation of orbits of planets around the sun?

Ans. We never speak of quantisation of orbits of planets around the sun because the angular momentum associated with planetary motion is largely relative to the value of Planck's constant (h).

The angular momentum of the earth in its orbit is of the order of 10^{70}. This leads to a very high value of quantum levels n, successive energies and angular

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momenta are relatively very small. Hence, the quantum levels for planetary motion are considered continuous.

Q.11. The energy of the electron in the ground state of hydrogen, is – 13.6 eV. Calculate the energy of the photon that would be emitted if the electron were to make a transition corresponding to the emission of the first line of the

(i) Lyman series

(ii) Balmer series of the hydrogen spectrum

Ans. Given, the energy of the electron, in the ground state of hydrogen is – 13.6 eV.

Since, $E_n = \frac{-13.6}{n^2}$ eV

So, E_1 = - 13.6 eV

For n = 2, E_2 = - 3.4 eV

For n = 3, E_3 = - 1.5 eV

So energy of photon corresponding to the first line of the

(i) Lyman series, ΔE = E_2 - E_1 = 10.2 eV
(ii) Balmer series, ΔE = E_3 - E_2 = 1.9 eV

Q.12. The total energy of an electron in the first excited state of hydrogen atom is about – 3.4 eV.

(i) What is the kinetic energy of the electron in this state?

(ii) What is the potential energy of the electron in this state?

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(iii) Which of the answers above would change if the choice of the zero of potential energy is changed?

Ans. (i) Total energy of the electron, E = - 3.4 eV.

Kinetic energy of the electron is equal to the negative of the total energy.

⇒ K = - E = - (- 3.4) = + 3.4 eV.

Hence, the kinetic energy of the electron in the given state is + 3.4 ev.

(ii) Potential energy (U) of the electron is equal to the negative of twice of its kinetic energy

⇒ U = - 2 K = - 2 × 3.4 = 6.8 EV

Hence, the potential energy of the electron in the given state is – 6.8 ev.

(iii) The potential energy of a system depends on the reference point taken. Here, the potential energy of the reference point is taken as zero. If the reference point is changed then the value of the potential energy of the system also changes. Since, total energy is the sum of kinetic and potential energies, total energy of the system will also change.

Q.13. Poonam's mother is diagnosed cancer. The attending physician told her that she has to undergo radiotherapy. While telling her the side effects of the treatment, the doctor told that her beautiful hair may fall and she may become bald. Poonam's mother refuses to get the treatment.

Read the above passage and answer the following questions

(i) What would you do if you were in Poonam's place?

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(ii) What values of life are associated with your attitude?

(iii) What are types of radioactive radiations? Which one has the maximum penetrating power?

Ans. (i) If I were in Poonam's place, I would tell my mother that treatment of cancer is a must. Hair fall is a temporary effect and the hair would grow slowly after the therapy. Convincing my mother to get the treatment, using all sorts of reasoning will be my top priority.

(ii) Concern for my mother's health is most important. I will not mind taking help from specialists to convince my mother for getting the treatment.

(iii) The three types of radiactive radiations are: α-rays; β-rays. Out of then, γ-rays have maximum penetrating power.

Q.14. Shyam saw his younger brother wondering with a question which deals with emission of light from a vapour lamp. He was anxious to know how different colours were being emitted by different light. He also saw mercury and sodium vapour lamps in the physics lab and was curious to know what is inside the lamps. On seeing his anxiety to know more about it Shyam explained about obsorption of energy and re-emission of photons in the visible region. He also advised him not to touch or break any items in the lab for the knowledge.

(i) What is the moral you derive from Shyam?

(ii) Which series in the hydrogen spectrum is in the visible region?

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Ans. (i) Concern for his brother, care about the school property subject knowledge.

(ii) Balmer

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