QB365 Question Bank Software

12th Physics Case study Questions Atoms For - 2024

12th Standard

Physics

SECTION - A 2 x 4 = 8

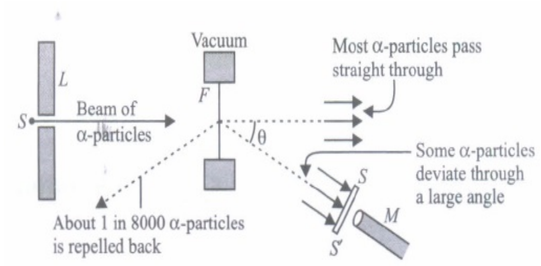
1) In 1911, Rutherford, along with his assistants, H. Geiger and E. Marsden, performed the alpha particle scattering experiment. H. Geiger and E. Marsden took radioactive source $\left({}^{214}_{83}\mathrm{Bi}\right)$ for a-particles. A collimated beam of a-particles of energy 5.5 MeV was allowed to fall on 2.1 x 10^{-7} m thick gold foil. The a-particles were observed through a rotatable detector consisting of a Zinc sulphide screen and microscope. It was found that a-particles got scattered. These scattered a-particles produced scintillations on the zinc sulphide screen. Observations of this experiment are as follows.

(I) Most of the a-particles passed through the foil without deflection.

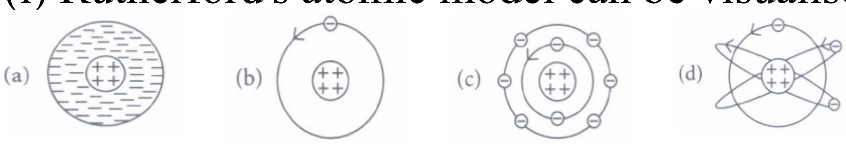
(II) Only about 0.14% of the incident a-particles scattered by more than 1°.

(III) Only about one a-particle in every 8000 a-particles deflected by more than 90°.

These observations led to many arguments and conclusions which laid down the structure of the nuclear model of an atom.



(i) Rutherford's atomic model can be visualised as



(ii) Gold foil used in Geiger-Marsden experiment is about 10^{-8} m thick. This ensures

(a) gold foil's gravitational pull is small or possible

(b) gold foil is deflected when a-particle stream is not incident centrally over it

(c) gold foil provides no resistance to passage of a-particles

(d) most a-particle will not suffer more than 1° scattering during passage through gold foil

(iii) In Geiger-Marsden scattering experiment, the trajectory traced by an a-particle depends on

(a) number of collision **(b) number of scattered a-particles**

(c) impact parameter **(d) none of these**

(iv) In the Geiger-Marsden scatteririg experiment, in case of head-on collision, the impact parameter should be

(a) maximum **(b) minimum**

(c) infinite **(d) zero**

(v) The fact only a small fraction of the number of incident particles rebound back in Rutherford scattering indicates that

(a) number of a-particles undergoing head-on-collision is small

(b) mass of the atom is concentrated in a small volume

(c) mass of the atom is concentrated in a large volume
(d) both (a) and (b).

Answer : (i) (d) : Rutherford's atom had a positively charged centre and electrons were revolving outside it.It is also called the planetary model of the atom as in option (d).
(ii) (d): As the gold foil is very thin, it can be assumed that a-particles will suffer not more than one scattering during their passage through it. Therefore, computation of the trajectory of an a-particle scattered by a single nucleus is enough.
(iii) (c) : Trajectory of a-particles depends on impact parameter which is the perpendicular distance of the initial velocity vector of the a particles from the centre of the nucleus. For small impact parameter a particle close to the nucleus suffers larger scattering.
(iv) (b): At minimum impact parameter, a particles rebound back ($\theta = \pi$) and suffers large scattering.
(v) (d): In case of head-on-collision, the impact parameter is minimum and the a-particle rebounds back. So, the fact that only a small fraction of the number of incident particles rebound back indicates that the number of a-particles undergoing head-on collision is small. This in turn implies that the mass of the atom is concentrated in a small volume. Hence, option (a) and (b) are correct.

2) The spectral series of hydrogen atom were accounted for by Bohr using the relation

$$\bar{v} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right),$$

where R = Rydberg constant = 1.097 x 10^7 m.
Lyman series is obtained when an electron jumps to first orbit from any subsequent orbit. Similarly, Balmer series is obtained when an electron jumps to 2nd orbit from any subsequent orbit, Paschen series is obtained when an electron jumps to 3rd orbit from any subsequent orbit. Whereas Lyman series lies in U.V. region, Balmer series is in visible region and Paschen series lies in infrared region. Series limit is obtained when $n_2 = \infty$

(i) The wavelength of first spectral line of Lyman series is
(a) 1215.4 $\dot{A}$ (b) 1215.4 crn (c) 1215.4 m (d) 1215.4 mm

(ii) The wavelength limit of Lyman series is
(a) 1215.4 $\dot{A}$ (b) 511.9 $\dot{A}$ (c) 951.6 $\dot{A}$ (d) 911.6 $\dot{A}$

(iii) The frequency of first spectral line of Balmer series is
(a) 1.097 x 10^7 Hz (b) 4.57 x 10^{14} Hz (c) 4.57 x 10^{15} Hz (d) 4.57 x 10^{16} Hz

(iv) Which of the following transitions in hydrogen atoms emit photons of highest frequency?
(a) n = 1 to n = 2 (b) n = 2 to n = 6 (c) n = 6 to n = 2 (d) n = 2 to n = 1

(v) The ratio of minimum to maximum wavelength in Balmer series is
(a) 5:9 (b) 5:36 (c) 1:4 (d) 3: 4

Answer : (i) (a) : From, $\bar{v} - \frac{1}{\lambda} - R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$n_1 = 1$, $n_2 = 2$ for first spectral line of Lyman series,

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3 \times 1.097 \times 10^7}{4} \text{ m}^{-1}$$

$$\lambda = \frac{4 \times 10^{-7} \text{ m}}{3 \times 1.097} = \frac{4000}{3 \times 1.097} \dot{A} = 1215.4 \dot{A}$$

(ii) (d): For wavelength limit, we put $n_2 = \infty$

$$\therefore \quad \frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{1^2} - \frac{1}{\infty}\right)$$

$$\lambda = \frac{1}{1.097 \times 10^7} \text{ m} = \frac{1000}{1.097} \dot{A} = 911.6 \dot{A}$$

(iii) (b): For first line of Balmer series, $n_1 = 2$, $n_2 = 3$

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

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

$$= 1.097 \times 10^7 \times 3 \times 10^8 \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 1.097 \times 3 \times 10^{15} \times \frac{5}{36} = 4.57 \times 10^{14} \text{ Hz}$$