CHAPTER 12

Atoms

NCERT FOCUS

ANSWERS

Topic 1

1. (a) not different from
(b) Thomson's model, Rutherford's model
(c) Rutherford's model
(d) Thomson's model, Rutherford's model
(e) both the models

2. The nucleus of a hydrogen atom is a proton. The mass of a proton is 1.67×10^{-27} kg, whereas the mass of an incident α-particle is 6.64×10^{-27} kg. Because the incident α-particles are more massive than the target nuclei (protons), the α-particle won't bounce back even in a head on collision. It is similar to a football colliding with a tennis ball at rest. Thus, there would be no appreciable scattering.

Topic 2

1. Here $E = 2.3$ eV $= 2.3 \times 1.6 \times 10^{-19}$ J
As $E = h\upsilon$
$\therefore$ Frequency,
$$\upsilon = \frac{E}{h} = \frac{2.3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 5.6 \times 10^{14} \text{ Hz.}$$

2. Total energy, $E = -13.6$ eV
K.E. $= -E = -(-13.6) = 13.6$ eV
P.E. $= -2$K.E. $= -2 \times 13.6 = -27.2$ eV.

3. Energy of an electron in the n^{th} orbit of H-atom, $E_n = -\frac{13.6}{n^2}$ eV
Energy in the ground ($n = 1$) level,
$$E_1 = -\frac{13.6}{1^2} = -13.6 \text{ eV}$$
Energy in the fourth ($n = 4$) level,
$$E_4 = -\frac{13.6}{4^2} = -0.85 \text{ eV}$$
Energy radiated during emission
$\Delta E = E_4 - E_1 = -0.85 - (-13.6) = 12.75$ eV
As $h\upsilon = \Delta E$
$$\therefore \text{ Frequency, } \upsilon = \frac{\Delta E}{h} = \frac{12.75 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$
$= 3.078 \times 10^{15}$ Hz
$$\text{Wavelength, } \lambda = \frac{c}{\upsilon} = \frac{3 \times 10^8}{3.078 \times 10^{15}}$$
$= 0.9744 \times 10^{-7}$ m $= 974.4$ Å

4. (a) Speed of the electron in Bohr's n^{th} orbit is
$$v = \frac{e^2}{2nh\varepsilon_0} = \alpha \frac{c}{n}$$
Speed of the electron in Bohr's first ($n = 1$) orbit is
$$v_1 = \frac{1}{137} \times \frac{3 \times 10^8}{1} = 2.186 \times 10^6 \text{ m s}^{-1}$$
$= 2.186 \times 10^6$ m s^{-1}
$$v_2 = \frac{v_1}{2} = 1.093 \times 10^6 \text{ m s}^{-1},$$
$$v_3 = \frac{v_1}{3} = 0.729 \times 10^6 \text{ m s}^{-1}.$$
(b) Orbital period of electron in Bohr's first orbit is
$$T_1 = \frac{2\pi r_1}{v_1} = \frac{2 \times 3.14 \times 0.53 \times 10^{-10}}{2.186 \times 10^6} \text{ s}$$
$= 1.52 \times 10^{-16}$ s
As $T_n = n^3 T_1$
$\therefore$ $T_2 = (2)^3 \times 1.52 \times 10^{-16} = 12.16 \times 10^{-16}$
$= 1.22 \times 10^{-15}$ s
$T_3 = (3)^3 \times 1.52 \times 10^{-16} = 41.04 \times 10^{-16}$
$= 4.10 \times 10^{-15}$ s.

5. Radius of innermost electron, $r = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2}$
For $n = 1$, $r_1 = \frac{h^2 \varepsilon_0}{\pi m e^2} = 5.3 \times 10^{-11}$ m
For $n = 2$, $r_2 = (2)^2 r_1 = 2.12 \times 10^{-10}$ m
For $n = 3$, $r_3 = (3)^2 r_1 = 4.77 \times 10^{-10}$ m.

6. In ground state, energy of gaseous hydrogen at room temperature $= -13.6$ eV. When it is bombarded with 12.5 eV electron beam, the energy becomes $-13.6 + 12.5 = -1.1$ eV. The electron would jump from n = 1 to $n = 3$, where $E_3 = -\frac{13.6}{3^2} = -1.5$ eV. On de-excitation the electron may jump from $n = 3$ to $n = 2$ giving rise to Balmer series. It may also jump from $n = 3$ to $n = 1$, giving rise to Lyman series.

7. According to Bohr's quantization condition of angular momentum,

Angular momentum of the earth around the sun,

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

$$\therefore \quad n = \frac{2\pi mvr}{h}$$

$$= \frac{2 \times 3.14 \times 6.0 \times 10^{24} \times 1.5 \times 10^{11} \times 3 \times 10^{4}}{6.6 \times 10^{-34}}$$

$$= 2.57 \times 10^{74}$$