Explanations

1. (a) Paschen series of atomic spectrum of hydrogen gas lies in infrared region.

2. (a) The shape of trajectory of the scattered α-particles in α-particle scattering experiment depends only on impact parameter.

3. (b) A positively charged nucleus in an atom was first suggested by Rutherford through his gold foil experiment.

4. (c) Rutherford's atomic model could account for the positive charged central core of an atom. According to him, every atom consists of a central core, called the atomic nucleus in which the entire positive charge and mass of the atom is concentrated.

5. (c) Angular momentum of electron in nth orbit is given by

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

In the lowest energy level, $n = 1$

Then, $$mvr_1 = 1\left(\frac{h}{2\pi}\right) = \frac{h}{2\pi}$$

6. (a) Wavelength of the Balmer series is given by

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

$$\Rightarrow \quad \frac{\nu}{c} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad (\because c = \nu\lambda)$$

$$\Rightarrow \quad \nu = cR\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For second line of Balmer series, $n_1 = 2$, $n_2 = 4$

$$\therefore \quad \nu = 3 \times 10^8 \times 10967800\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

$$= 6.16 \times 10^{14} \text{ Hz}$$

7. (d) Infrared radiation found in Paschen, Brackett and Pfund series and it is obtained when electron transition high energy level to minimum third level.

8. (a) Electron angular momentum (mvr) about the nucleus is an integer multiple of $\frac{h}{2\pi}$, where h is Planck's constant.

Thus, angular momentum,

$$I\omega = mvr = \frac{nh}{2\pi} \qquad \dots \text{(i)}$$

Also, $$\frac{mv^2}{r} = \frac{kZe^2}{r}$$

or $$mv^2 = \frac{Ze^2}{4\pi\varepsilon_0 r} \qquad \dots \text{(ii)}$$

From Eqs. (i) and (ii), we get

$$r \propto n^2$$

9. (a) Wavelength is given by

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

$$\Rightarrow \quad \frac{1}{\lambda} = R\left[\frac{1}{(2)^2} - \frac{1}{(4)^2}\right]$$

$$\Rightarrow \quad \frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{16}\right)$$

$$\Rightarrow \quad \frac{1}{\lambda} = R\left(\frac{4-1}{16}\right)$$

$$\Rightarrow \quad \frac{1}{\lambda} = \frac{3R}{16} \Rightarrow \lambda = \frac{16}{3R}$$

10. (a) We know that, frequency, $\nu = Rc\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

This gives, $$\nu_1 = Rc\left(1 - \frac{1}{\infty}\right) = Rc$$

$$\Rightarrow \quad \nu_2 = Rc\left(1 - \frac{1}{4}\right) = \frac{3}{4}Rc$$

$$\nu_3 = Rc\left(\frac{1}{4} - \frac{1}{\infty}\right) = \frac{Rc}{4}$$

$$\Rightarrow \quad \nu_1 - \nu_2 = \nu_3$$

11. (a) Light emitted from rarefied gases heated in a flame or excited electrically in a glow tube such as the familiar neon or mercury vapour light has only certain discrete wavelengths. The spectrum appears as a series of bright lines.

As, in such gases, the average spacing between atoms is large. Hence, the radiation emitted can be considered due to individual atoms rather than because of interaction between atoms or molecules.

12. (c) Rutherford's experiment suggested the size of the nucleus to be about 10^{-15}m to 10^{-14} m. From kinetic theory, the size of an atom was known to be 10^{-10}m about 10000 to 100000 times larger than the size of the nucleus.

Thus, the electrons would seem to be at a distance from the nucleus about 10,000 to 1,00,000 times the size of the nucleus itself.

Hence, most of an atom is an empty space.

13. (a) In an atom, electron revolves around nucleus, for this required centripetal force is provided by electrostatic force of attraction between negatively charged electron and positive nucleus.

If the electrons were stationary, then the electrostatic force will remain unbalanced, which leads to the electron to fall into the nucleus.

14. (b) $L = n\left(\frac{h}{2\pi}\right)$, i.e. $L \propto n$.

In ground state, $n = 1$, so L = minimum.

15. (d) **For Assertion** It is not essential that all the lines available in the emission spectrum will also be available in the absorption spectrum.

For Reason The spectrum of hydrogen atom may not be absorption spectrum.

16. (b) $mv_2r_2 = 2\left(\frac{h}{2\pi}\right)$

$$\therefore \quad 2\pi r_2 = 2\left(\frac{h}{mv_2}\right) = 2\lambda_2$$

Further, $\lambda = \frac{h}{p}$

Speed of momentum is maximum in ground state. Hence, λ is minimum.

17. (i) (c) $E_n = \frac{-13.6}{n^2}(Z^2)$

In first excited state, $E_{H_2} = 3.4$ eV

and $E_{He} = -13.6$ eV

So, H_2 atom gives excitation energy $(13.6 - 3.4 = 10.2 \text{ eV})$ to helium atom.

Now, energy of He^+ ion

$$= -13.6 + 10.2 = -3.4 \text{ eV}$$

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

$$\Rightarrow -3.4 = \frac{-13.6}{n^2} \times (2)^2 \Rightarrow n = 4$$

(ii) (a) The energy required to excite the H-atom from $n = 2$ to $n = 4$ is given as

$$= E_4 - E_2 = -0.85 - (-3.40)$$
$$= 3.4 - 0.85 = 2.55 \text{ eV}$$

(iii) (a) Kinetic energy, $K \propto \frac{Z^2}{n^2}$

$$\frac{K_{H_2}}{K_{He}} = \left(\frac{Z_{H_2}}{Z_{He}}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

(iv) (b) Radius of the permitted orbit is

$$r = \frac{n^2 h^2 \varepsilon_0}{\pi mZe^2}$$

i.e. $r \propto n^2$

(v) (a) Angular momentum for hydrogen atom,

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

For second excited state, $n = 3 \Rightarrow L = \frac{3h}{2\pi}$

DCAM classes
Dynamic Classes for Academic Mastery