Chapter 26

Atoms

TYPE A : MULTIPLE CHOICE QUESTIONS

1. If the electron in hydrogen orbit jumps from third orbit to second orbit, the wavelength of the emitted radiation is given by : *[1997]*

(a) $\lambda = \frac{R}{6}$ (b) $\lambda = \frac{5}{R}$

(c) $\lambda = \frac{36}{5R}$ (d) $\lambda = \frac{5R}{36}$

2. The radius of hydrogen atom in the first excited level is : *[1998]*

(a) twice (b) four times

(c) same (d) half

3. In Bohr's theory, relation between principal quantum number n and radius of orbit r is: *[1999]*

(a) $r \propto \frac{1}{n^2}$ (b) $r \propto n$

(c) $r \propto \frac{1}{n}$ (d) $r \propto n^2$

4. For an electron in the second orbit of hydrogen, the moment of momentum as per Bohr's model is *[2000]*

(a) $\frac{h}{\pi}$ (b) $\frac{2h}{\pi}$

(c) $\frac{h}{2\pi}$ (d) $2\pi h$

5. The speed of an electron having a wavelength of 10^{-10}m is *[2002]*

(a) 4.24×10^6 m/s (b) 5.25×10^6 m/s

(c) 6.25×10^6 m/s (d) 7.25×10^6 m/s

6. We wish to seen inside an atom. Assuming the atom to have a diameter of 100 pm, this means that one must be able to resolve a width of say 10 pm. If an electron microscope is used, the minimum electron energy required is about

(a) 1.5 keV (b) 15 keV *[2004]*

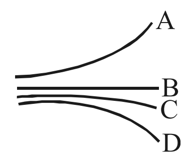
(c) 150 keV (d) 1.5 MeV

7. The ground state energy of hydrogen atom is – 13.6 eV. What is the potential energy of the electron in this state ? *[2005]*

(a) 0 eV (b) –27.2 eV

(c) 1 eV (d) 2 eV

8. In the following diagram, which particle has highest e/m value? *[2007]*



(a) A (b) B

(c) C (d) D

9. What is the energy of He^+ electron in first orbit?

(a) 40.8 eV (b) –27.2 eV *[2007]*

(c) –54.4 eV (d) –13.6 eV

10. What is the energy of photon whose wavelength is 6840 Å? *[2007]*

(a) 1.81 eV (b) 3.6 eV

(c) –13.6 eV (d) 12.1 eV

11. The ratio of the energy of the photon emitted by the k_α line to that of the k_β line is *[2009]*

(a) greater than 1 (b) Less than 1

(c) 1 (d) indeterminate

12. The angular momentum of an electron in the 2^{nd} excited state of a Helium ion (He^+) is *[2009]*

(a) $\frac{h}{2\pi}$ (b) $\frac{2h}{2\pi}$

(c) $\frac{3h}{2\pi}$ (d) $\frac{4h}{2\pi}$

13. What is the wavelength of the least energetic photon emitted in the Lyman series of the hydrogen atom spectrum ? *[2011]*

(a) 150 nm (b) 122 nm

(c) 102 nm (d) 82 nm

14. The energy of electron in the nth orbit of hydrogen atom is expressed as $E_n = \frac{-13.6}{n^2}$ eV. The shortest and longest wavelength of Lyman series will be ***[2013]***

(a) 910 Å, 1213 Å (b) 5463 Å, 7858 Å
(c) 1315 Å, 1530 Å (d) None of these

15. Which of the following statements are true regarding Bohr's model of hydrogen atom? ***[2015]***

(I) Orbiting speed of electron decreases as it shifts to discrete orbits away from the nucleus

(II) Radii of allowed orbits of electron are proportional to the principal quantum number

(III) Frequency with which electrons orbit around the nucleus in discrete orbits is inversely proportional to the cube of principal quantum number

(IV) Binding force with which the electron is bound to the nucleus increases as it shifts to outer orbits

Select correct answer using the codes given below.

Codes :

(a) I and II (b) II and IV
(c) I, II and III (d) II, III and IV

16. The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z of hydrogen like ion is ***[2016]***

(a) 3 (b) 4
(c) 1 (d) 2

17. Which one did Rutherford consider to be supported by the results of experiments in which α-particles were scattered by gold foil? ***[2017]***

(a) The nucleus of an atom is held together by forces which are much stronger than electrical or gravitational forces.

(b) The force of repulsion between an atomic nucleus and an α-particle varies with distance according to inverse square law.

(c) α-particles are nuclei of Helium atoms.

(d) Atoms can exist with a series of discrete energy levels

18. As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion ***[2017]***

(a) kinetic energy decreases, potential energy increases but total energy remains same

(b) kinetic energy and total energy decrease but potential energy increases

(c) its kinetic energy increases but potential energy and total energy decrease

(d) kinetic energy, potential energy and total energy decrease

TYPE B : ASSERTION REASON QUESTIONS

Directions for (Qs. 19-21) : These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following five responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

(e) If the Assertion is incorrect but the Reason is correct.

19. **Assertion:** The specific charge of positive rays is not constant.

Reason: The mass of ions varies with speed. ***[1999]***

20. **Assertion :** Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate.

Reason : According to classical physics all moving electrons radiate. ***[2003]***

21. **Assertion :** Balmer series lies inthe visible region of the electromagnetic spectrum.

Reason : $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$, where n = 3, 4, 5 ***[2008]***

Directions for (Qs. 22-25) : Each of these questions contains an Assertion followed by Reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

22. **Assertion :** In Lyman series, the ratio of minimum and maximum wavelength is $\frac{3}{4}$.

Reason : Lyman series constitute spectral lines corresponding to transition from higher energy to ground state of hydrogen atom. ***[2011]***

23. **Assertion :** Between any two given energy levels, the number of absorption transitions is always less than the number of emission transitions.

Reason : Absorption transitions start from the lowest energy level only and may end at any higher energy level. But emission transitions may start from any higher energy level and end at any energy level below it. ***[2015]***

24. **Assertion :** In Lyman series, the ratio of minimum and maximum wavelength is $\frac{3}{4}$.

Reason : Lyman series constitute spectral lines corresponding to transition from higher energy to ground state of hydrogen atom. ***[2016]***

25. **Assertion :** Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate.

Reason : According to classical physics all moving electrons radiate. ***[2017]***

HINTS & SOLUTIONS

Type A : Multiple Choice Questions

1. **(c)** We know that

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

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \Rightarrow R\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\frac{1}{\lambda} = \left(\frac{9-4}{36}\right)R = \frac{5R}{36} \Rightarrow \lambda = \frac{36}{5R}$$

2. **(b)** Radius of H-atom $\propto n^2$
So for excitation from n = 1 to n = 2, radius becomes 4 times.

3. **(d)** Radius of Bohr's orbit $\propto n^2$, where n is principal quantum no.

4. **(a)** The moment of momentum is also known as angular momentum of electron.
We know from Bohr's theory that in an orbit

angular momentum $= n.\frac{h}{2\pi}$

For second orbit n = 2

So, angular momentum $= 2 \times \frac{h}{2\pi} = \frac{h}{\pi}$ is the answer.

5. **(d)** We know that De-Broglie wavelength is

$$mv = \frac{h}{\lambda} \Rightarrow \lambda = \frac{h}{mv}$$

$$10^{-10} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times v};$$

$$v = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-41}} = 7.25 \times 10^6$$

6. **(b)** From the de-Broglie equation,

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

where l is wavelength, h is plank's constant and p is momentum and v is velocity

$$v = \frac{h}{m\lambda} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^{-11}} = 7.25 \times 10^7 \, m/s$$

$\therefore$ Energy of electron $= \frac{1}{2}mv^2$

$$= \frac{1}{2} \times \frac{9.1 \times 10^{-31} \times (7.25 \times 10^7)^2}{1.6 \times 10^{-19}} = 15\,keV$$

7. **(b)** In case of hydrogen atom
If –E = ground state energy (Total)
E is kinetic energy then –2E is potential energy.
Here E = 13.6 eV $\Rightarrow$ 2E = 27.2 eV
So, potential energy = – 27.2 eV

8. **(d)** The deflection of a particle along y-axis is electricfield is given by $y = \frac{Ex^2}{2mv^2}$

$\Rightarrow y \propto \frac{e}{m}$ for all other values to be constant. Since y is maximum for D, hence it has highest e/m ratio.

9. **(c)** $E = \frac{-13.6Z^2}{n^2}$ eV, for He^+, Z = 2, n = 1 (first orbit)

$$\therefore E = \frac{-13.6 \times 2}{1^2} = -54.4 \text{ eV}$$

10. **(a)** Energy of photon

$$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{6840 \times 10^{-10}}$$

$$= \frac{6.6 \times 3 \times 10^{-26}}{6.84 \times 10^{-7}} J$$

$$= \frac{6.6 \times 3 \times 10^{-26}}{6.84 \times 10^{-7} \times 1.6 \times 10^{-19}} eV = 1.8\,eV$$

11. **(b)** $\Delta E = E_0(Z-1)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

for k_α, $n_1 = 1, n_2 = 2$

for k_β, $n_1 = 1, n_2 = 3$

so energy of the photon corresponding to k_α line is less than that of k_β line.

12. **(c)** Angular momentum in the ground state $= \frac{h}{2\pi}$

Angular momentum in the first excited state $= \frac{2h}{2\pi}$

Angular momentum in the second excited state $= \frac{3h}{2\pi}$

13. **(b)** The least energy is corresponding to longest wavelength, which is $\lambda = 1216$Å.

14. **(a)** $\frac{1}{\lambda_{max}} = R\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right] \Rightarrow \lambda_{max} = \frac{4}{3R} \approx 1213$Å

and $\frac{1}{\lambda_{min}} = R\left[\frac{1}{(1)^2} - \frac{1}{\infty}\right] \Rightarrow \lambda_{min} = \frac{1}{R} \approx 910$Å.

15. **(a)** Orbital speed varies inversely as the radius of the orbit.

$v \propto \frac{1}{n}$

16. **(d)** For first line of Lyman series of hydrogen

$$\frac{hc}{\lambda_1} = Rhc\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

For second line of Balmer series of hydrogen like ion

$$\frac{hc}{\lambda_2} = Z^2 Rhc\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

By question, $\lambda_1 = \lambda_2$

$$\Rightarrow \left(\frac{1}{1} - \frac{1}{2}\right) = Z^2\left(\frac{1}{4} - \frac{1}{16}\right) \text{ or } Z = 2$$

17. **(b)**

18. **(c)** $U = -K\frac{ze^2}{r}$; $T.E = -\frac{k}{2}\frac{ze^2}{r}$

$K.E = \frac{k}{2}\frac{ze^2}{r}$. Here r decreases

Type B : Assertion Reason Questions

19. **(a)** The specific charge $\frac{e}{m}$ of positive ray is not constant because for different velocities the rest mass of particles change i.e. mass of ions varies with speed. So $\frac{e}{m}$ will differ. Hence, Reason and Assertion both are correct and Reason explains Assertion.

20. **(b)** According to classical physics all moving electrons around the nucleus will radiate because an accelerated electron in electric field will radiate e.m. wave. So Reason is correct. But Reason does not explain the Assertion.

Bohr's postulates that the electron in stationary orbits do not radiate. His postulate was based not out of compulsion but on the quantum theory. So Assertion is also correct but Reason does not explain Assertion.

21. **(b)** Wavelength is Balmer series is,

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]; \frac{1}{\lambda_{max}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$\text{or } \lambda_{max} = \frac{36}{5R} = \frac{36}{5 \times 1.097 \times 10^7} = 6563\text{Å}$$

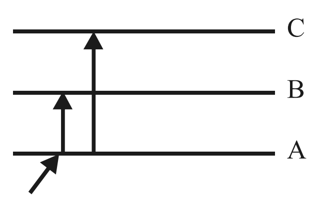
$$1/\lambda_{min} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$$

$$\text{or } \lambda_{min} = \frac{4}{R} = \frac{4}{1.097 \times 10^7} = 3646\text{Å}$$

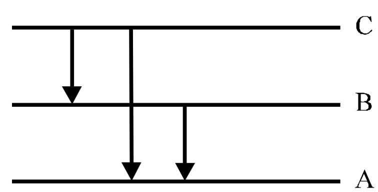
So it lies in the visible region.

22. **(b)**

23. **(a)** Absorption transition



Two possibilities in absorption transition.



Three possibilities in emission transition.
Therefore, absorption transition < emission.

24. **(b)**

25. **(b)** Bohr postulated that electrons in stationary orbits around the nucleus do not radiate. This is the one of Bohr's postulate. According to this the moving electrons radiates only when they go from one orbit to the next lower orbit.