Class :- VIII

Bohr's Theory

Teaching Task

Q1) Ans:- C.

Solution:- $r_n = \frac{Kn^2}{Z}$, $Z=1$ for hydrogen.

$r_1 : r_2 : r_3 = \frac{K \cdot 1^2}{1} : \frac{K \cdot 2^2}{1} : \frac{K \cdot 3^2}{1} = 1:4:9.$

Q2) Ans:- D.

Solution:- $E = \frac{hc}{\lambda}$.

$E = 13.6\, eV$.

$\lambda = \frac{hc}{E} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{13.6 \times 1.6 \times 10^{-19}\, J} = 91.2\, nm$

Q3) Ans:- B.

Solution:- Expression for bohr's radius is given by,

$r = \frac{n^2 h^2}{4\pi^2 m k Ze^2}$, since $n=1$, $Z=1$ for both

hydrogen & deuterium nucleus, the ratio

of the radius is 1:1.

Q4) Ans:- B

Solution:- Potential Energy, $PE = \frac{-KZe^2}{r}$.

$K.E = \frac{1}{2} \times mv^2$

According to Bohr's Model, $\frac{mv^2}{r} = KZe^2/r^2$.

$\therefore \frac{1}{2} \times mv^2 = KZe^2/2r$; $KE = -PE/2$

Total Energy $= -4.9$

K.E + Potential Energy $=$ T.E

$K.E = 4.9\, eV = -$ total Energy $\therefore PE = 2(T.E) = -9.8\, eV.$

Q5) Ans:- B.

Solution:- The energy of electron $\propto \frac{Z^2}{n^2}$

∴ The energy of e^- in 2nd orbit of He^+ is 4 times the energy of e^- in 2nd orbit of hydrogen.

$$(I.E)_{H.like} = \frac{(I.E)_H}{n^2} Z^2$$

For He^+, $Z = 2$, $n = 1$.

$$I.E_{He^+} = \frac{(-3.41)}{1^2}(2)^2 = -13.64$$

Q6) Ans:- D.

Solution:- Energy differce b/w 1st and 2nd Bohr orbit

$$E_2 - E_1 = 13.6 \times (1)^2 \times \left[\frac{1}{1^2} - \frac{1}{2^2}\right] = 13.6 \times \frac{3}{4}.$$

Energy difference b/w 2nd and 3rd Bohr orbit

$$E_3 - E_2 = 13.6 \times 1^2 \times \left[\frac{1}{2^2} - \frac{1}{3^2}\right] = 13.6 \times \frac{5}{36}.$$

$$\frac{E_2 - E_1}{E_3 - E_2} = \frac{\cancel{13.6} \times \frac{3}{\cancel{4}}}{\cancel{13.6} \times \frac{5}{\cancel{36}\,9}} = \frac{3 \times 9}{5} = \frac{27}{5} = \frac{102}{19}.$$

Q7) Ans:- C.

Solution:- $IE = \frac{(I.E)_H}{n^2} . Z^2$

$$-217.6 = -13.6 \times \frac{Z^2}{1} \Rightarrow Z = 4$$

$^{9}_{4}Be^{3+}$, no. of neutrons 'n' $= 9 - 4 = 5$

Q8) Ans:- A.

Solution:- $r \propto \frac{n^2}{Z}$

$r_{n_2} - r_{n_1} = 24 \times r_0$.

$n_2^2 - n_1^2 = 24$.

$n_2 = 7, n_1 = 5$ or $n_2 = 5, n_1 = 1$.

Q9) Ans:- C

Solution:- Time period $\propto (R)^{3/2}$

$$\frac{T_1}{T_2} = \left[\frac{R_1}{R_2}\right]^{3/2} = \left[\frac{1}{4}\right]^{3/2} = \frac{1}{8}.$$

Q10) Ans:- C

Solution:- Emission of photon of 12.1 eV.

$n_1 = 3$ and $n_2 = 1$

Orbital angular momentum $= \frac{nh}{2\pi}$

Change in orbital angular momentum $= \frac{(3-1)h}{2\pi}$

$= \frac{\cancel{2}h}{\cancel{2}\pi} = \frac{h}{\pi}$

Q11) Ans:- A.

Solution:- For He^+, $n=2$, $Z=2$

$$(I.E)_{H\ like} = \frac{(I.E)_H}{n^2} \cdot Z^2 = \frac{-13.6}{4}(2^2)$$

$= -13.6$ eV.

Q12) Ans:- A.

Solution:- Bohr's model postulates that e^- can only occupy specific circular orbits around the nucleus, meaning there is a fixed set of allowed energy levels & orbitals.

Q13) Ans:- B.

Solution:- $V_n \propto \frac{Z}{n}$

Given: $V_1 = x$.

$V_3 = \frac{x}{3}$.

Q14) Ans:- A.

Solution:- With increasing atomic number of a single electron species, the energy difference b/w two orbits increases.

JEE Advanced Level

Q1) Ans:- A, B, C, D

Solution:- Bohr's theory is applicable for single electron atom.

A) $He^+ \rightarrow \bar{e} = 1$, B) $Li^{+2} \rightarrow e^- = 1$, C) $_1H^3$, $e^- = 3$,

D) Be^{+3}, $e^- = 1$

Q2) Ans:- B, D.

Solution:- Bohr's theory applicable for Li^{+2}, H-atom

Q3) Ans:- A.

Solution:- $v^2 = \frac{KZe^2}{r} \Rightarrow v^2 \propto \frac{1}{r}$.

Velocity square of an electron is inversly proportional to the radius of the orbit.

Q4) Ans:- C.

Solution:- Bohr's orbits are called stationary.

→ Electrons in different orbits have fixed energies.

Q5) Ans:- A.

Solution:- $r_n = \frac{n^2h^2}{4\pi^2 m Ze^2}$

For hydrogen atom $Z=1$, first orbit $n=1$.

$r_1 = \frac{h^2}{4\pi r^2 me^2} = 0.592 A^{\circ}$.

Q6) Ans:- A.

Solution:- $r_n = \frac{r_H \cdot n^2}{Z}$

→ The radius of hydrogen $r_H = 0.52 \times 10^{-8}$ cm.

For helium, $Z=2$, 1st orbit $n=1$.

$r_1 = \frac{0.52 \times 10^{-8} \times 1^2}{2} = 0.26 \times 10^{-8}$ cm.

Integer Type

Q7) Ans:- $\frac{9}{16}$.

Solution:- $r_3 = \frac{0.52 \times 10^{-8} \times 3^2}{1}$

$r_4 = \frac{0.52 \times 10^{-8} \times 4^2}{1}$

$\frac{r_3}{r_4} = \frac{3^2}{4^2} = \frac{9}{16} = 0.5625$.

Q8) Ans:- 2

Solution:- $E = \frac{-313.6}{n^2}$ kcal/mol.

$E = -78.4$ kcal/mol.

$\cancel{-}78.4 = \frac{\cancel{-}313.6}{n^2}$

$n^2 = \frac{313.6}{78.4} = 4.$

$n = 2$

Matrix Matching

Q9) Ans:- A) D B) B C) A D) C.

Solution:-

A) Potential Energy of an electron $\propto$ → D) $\frac{z^2}{n^2}$

B). Frequency of revolution of an electron $\propto$ → B) $\frac{z^2}{n^3}$.

C) Coulombic force of attraction $\propto$ → A) $F_c = \frac{1}{4\pi\epsilon_0} \cdot \frac{Ze^2}{r^2}$

D) The velocity of an electron in the nth orbit → C) $V = k\frac{Z}{n}$

$V \propto \frac{Z}{n}$

Learner's Task

Q1) **Ans:-** C.

Solution:- Quantization of angular momentum was one of the key principles in Bohr's model.

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

Q2) **Ans:-** D.

Solution:- Bohr's model explains the hydrogen atomic spectrum

Q3) **Ans:-** C.

Solution:- Heisenberg's uncertainity principle directly contradicts Bohr's model.

Q4) **Ans:-** C.

Solution:- Total Energy = PE + K.E

$$= \frac{-2\pi^2 me^4 z^2}{h^2 n^2}$$

Q5) **Ans:-** A.

Solution:- According to Bohr's theory, when an electron moves from a lower energy orbit to a higher energy orbit, energy is absorbed by the electron

Q6) **Ans:-** B.

Solution:- $E_n = -\frac{13.6 eV}{n^2}$

As n increases (moving away from the nucleus), the energy En becomes less negative, which corresponds to increase in energy.

Q7) Ans:- D.

Solution:- Bohr's angular momentum $= \frac{nh}{2\pi}$

For 5th orbit $n = 5$.

$$L = \frac{5h}{2\pi}$$

Q8) Ans:- B.

Solution:- In order to keep electron in its orbit, these two forces, centripel & centrifugal forces, which act in opposite direction, must balance each other.

$$\frac{-Ze^2}{r} = -\frac{mv^2}{r}.$$

Q9) Ans:- D.

Solution:- As n increase, the energy level becomes less negative and the difference b/w the energy of adjacent orbits becomes smaller.

The Energy difference b/w the 'N & 'O' shells is smaller.

Q10) Ans:- A, B, C.

Solution:- Bohr's model of the atom can successfully explain the spectra of hydrogen like atoms, which are atoms with only one electron.

A) $H \rightarrow 1e^-$ ✓

B) $He^+ \rightarrow 1e^-$ ✓

C) $Li^{++} \rightarrow 1e^-$ ✓

D) $He \rightarrow 2e^-$ ✗

Q11) Ans:- D.

Solution:- $K.E = \frac{Ze^2}{2r}$, $T.E = -\frac{Ze^2}{2r}$.

$$\frac{K.E}{T.E} = \frac{\frac{Ze^2}{2r}}{-\frac{Ze^2}{2r}} = -1.$$

Q12) Ans:- A

Solution:- $E_n = \frac{-13.6}{n^2}$ eV., $n = 1, 2, 3$.

In excited state $E_2 = \frac{-13.6}{4} = -3.4eV$

$E_3 = \frac{-13.6}{9} = -1.51 eV$

JEE Main Level Questions

Q1) Ans:- A

Solution:- Angular momentum $= \frac{nh}{2\pi}$

$$\frac{nh}{2\pi} = \frac{3}{2}\frac{h}{\pi}$$

$$n = 3$$

$\therefore$ The electron is present in third orbit

Q2) Ans:- C

Solution:- $E = -\frac{Ze^2}{2r}$

For hydrogen atom $Z = 1$.

$$E = \frac{-e^2}{2r}.$$

Q3) Ans:- B.

Solution:- The angular momentum of the electron in ground state, $n=1$ is $L = \frac{nh}{2\pi} = \frac{h}{2\pi}$

Q4) Ans:- A

Solution:- The energy level increases, the energy gap decrease progressively. So, the maximum energy for electron transition is required when the electron jumps from $n=1$ to $n=2$

Q5) Ans:- D.

Solution:- The minimum energy required to excite Hydrogen from the ground state is equal to the energy required to excite an electron to the second level.

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

$$E = -13.6\left(\frac{1}{2^2}\right) - \left[-13.6 \times \left(\frac{1}{1^2}\right)\right] = 10.2\,eV.$$

Q6) Ans:- C

Solution:- Hydrogen electron is excited from 1st shell to 2nd shell $K \rightarrow L$

$\square$	$\boxed{\uparrow\downarrow}$	$\boxed{\uparrow\downarrow \mid \uparrow\downarrow \mid \uparrow\downarrow}$
1s	2s	2p

There are 4 orbitals in 2nd shell. So maximum no. of possibilities are 4

Q7) Ans:- B.

Solution:- Energy difference = $E = E_0\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5E_0}{36}$.

$E_0 = 7.2E$.

Ionization potential $= E' = E_0\left[\frac{1}{1^2} - \frac{1}{\infty}\right] = E_0$.

$E' = 7.2E$.

Q8) Ans:- A.

Solution:- $\Delta E = 13.6\,eV \times \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$.

For electron transition from $n=2$ to $n=3$, put

$n_1 = 2$ and $n_2 = 3$

$\Delta E = 13.6\,eV\left[\frac{1}{4} - \frac{1}{9}\right] = 1.89\,eV \approx 1.9\,eV$.

Q9) Ans:- D.

Solution:- Given $I.E_H = 2.18 \times 10^{-18}\,J$.

$$I.E_{H.like} = \frac{[I.E]_H}{n^2} Z^2$$

For hydrogen 2nd orbit, $Z=1, n=2$

$$I.E_{H.like} = \frac{2.18 \times 10^{-18}}{4} \times 1.$$

$= 0.545 \times 10^{-18} = 5.45 \times 10^{-19}\,J$.

Q10) Ans:- A.

Solution:- $V_n = \frac{V_1}{n}$, $V_1 = 2.19 \times 10^6\,m/s$.

$$V_2 = \frac{2.19 \times 10^6}{2} = 1.095 \times 10^6\,m/s.$$

JEE Advanced Level

Q1) Ans:- 2, 3, 4

Solution:-

→ The shape of orbital is given by azimunthal quantum number.

→ Angular momentum of 1S, 2S, 3S are different

→ In an atom, all the electrons travel with different velocities.

Q2) Ans:- D

Solution:- Momentum is the discrete quantity.

Q3) Ans:- A.

Solution:- The dual nature of the electron is an import aspect that Bohr's model ignored and this limitation contributed to its inability to explain the fine details of the hydrogen spectrum observed with high-resolution spectroscopes.

Q4) Ans:- D.

Solution:- → $E = \frac{hc}{\lambda}$ → $E \propto \frac{1}{\lambda}$.

Wavelength increases, Energy decreases.

→ $E = h\nu$

E = Energy of photon

h = Planck's constant ν = Frequency.

Q5) Ans:- A.

Solution:- $L = \frac{nh}{2\pi}$

Bohr's postulate, the angular momentum of an electron in atom is quantized.

Integer Type.

Q6) Ans:- 4.

Solution:- $(n+A)^2 - n^2 = (n-A)^2$

$$\cancel{n^2} + \cancel{A^2} + 2nA - n^2 = \cancel{n^2} + \cancel{A^2} - 2nA$$

$$n^2 = 4nA$$

$$n = 4A$$

Q7) Ans:- 3.

Solution:- Number of waves $= \frac{\text{Circumference}}{\text{wavelength}} = \frac{C_n}{\lambda}$.

$$C_n = 2\pi r_n$$

For $n=3$, the no. of complete waves in 3rd Bohr's orbit is, $N=3$

Q8) Ans:- A, C

Solution:- $\rightarrow$ $I.E_{Li^{+2}} = \frac{-13.6}{n^2} \cdot z^2$ $\rightarrow n=1, n=3$.

$$= \frac{-13.6}{1} \cdot 9 = -122.4\ eV$$

$\rightarrow$ He^+ is $-54.4\,eV$, the ionization energy is +ve value, which is $54.4\,eV$ not $-54.4\,eV$.

Q9) Ans :- B.

Solution :- IE mean the energy required to remove the electron from the ground state, which is exactly the definition of the binding energy.

Matrix Matching

Q8) Ans :- A) B. B) A. C) C D). D.

Solution :-

A) Energy $\rightarrow$ B) $-\frac{2\pi^2 m z^2 e^4}{n^2 h^2}$

B) Velocity $\rightarrow$ A) $\frac{2\pi z e^2}{nh}$.

C) Rydberg Constant $\rightarrow$ C) $\frac{2\pi^2 m z^2 e^4}{h^3 c}$.

D) Radius $\rightarrow$ D) $\frac{n^2 h^2}{4\pi^2 m z e^2}$