

Atomic Structure



Problems Based on Bohr's Energy of Electron in the n -th Orbit

1. Problem 1: Energy of Electron in the First Orbit

- Calculate the energy of an electron in the first orbit ($n = 1$) of a hydrogen atom.

2. Problem 2: Energy of Electron in the Second Orbit

- Determine the energy of an electron in the second orbit ($n = 2$) of a hydrogen atom.

3. Problem 3: Energy of Electron in the Third Orbit of a Hydrogen-like Ion

- Find the energy of an electron in the third orbit ($n = 3$) of a hydrogen-like ion with atomic number $Z = 2$ (e.g., He^+).

4. Problem 4: Energy Comparison Between Orbits

- Compare the energy of an electron in the fourth orbit ($n = 4$) with that in the first orbit ($n = 1$) of a hydrogen atom. What is the ratio of their energies?

5. Problem 5: Energy of Electron in the Fifth Orbit of a Lithium Ion

- Calculate the energy of an electron in the fifth orbit ($n = 5$) of a hydrogen-like lithium ion (Li^{2+}) with $Z = 3$.

6. Problem 6: General Expression for Energy in the n -th Orbit

- Derive the general expression for the energy of an electron in the n -th orbit of a hydrogen-like ion with atomic number Z . Calculate the energy of an electron in the $n = 2$ orbit for a singly ionized helium ion (He^+).

Answer Key (Next Page)

1. Problem 1:

- Energy of the first orbit for hydrogen: $E_1 = -\frac{13.6 \text{ eV}}{n^2} = -13.6 \text{ eV}$.

2. Problem 2:

- Energy of the second orbit for hydrogen: $E_2 = -\frac{13.6 \text{ eV}}{2^2} = -\frac{13.6}{4} \text{ eV} = -3.4 \text{ eV}$.

3. Problem 3:

- Energy of the third orbit for $Z = 2$: $E_3 = -\frac{13.6 \times Z^2}{3^2} = -\frac{13.6 \times 2^2}{3^2} \text{ eV} = -\frac{13.6 \times 4}{9} \text{ eV} = -6.04 \text{ eV}$.

4. Problem 4:

- Energy of the fourth orbit for hydrogen: $E_4 = -\frac{13.6 \text{ eV}}{4^2} = -\frac{13.6}{16} \text{ eV} = -0.85 \text{ eV}$.
- Ratio $E_1 : E_4 = -13.6 : -0.85 = 16 : 1$.

5. Problem 5:

- Energy of the fifth orbit for $Z = 3$: $E_5 = -\frac{13.6 \times Z^2}{5^2} = -\frac{13.6 \times 3^2}{5^2} \text{ eV} = -\frac{13.6 \times 9}{25} \text{ eV} = -4.896 \text{ eV}$.

6. Problem 6:

- General expression: $E_n = -\frac{13.6 \times Z^2}{n^2} \text{ eV}$.
- Energy of the $n = 2$ orbit for $Z = 2$: $E_2 = -\frac{13.6 \times 2^2}{2^2} = -13.6 \text{ eV}$.