

Atomic Structure and Periodicity

1. Multiple-Choice Question (MCQ)

Which of the following quantum numbers determines the shape of an atomic orbital?

- A) Principal quantum number (n)
- B) Azimuthal quantum number (l)
- C) Magnetic quantum number (m_l)
- D) Spin quantum number (m_s)

Answer: B) Azimuthal quantum number (l)

2. Numerical Answer Type (NAT)

The ionization energy of hydrogen in its ground state is **13.6 eV**. Calculate the wavelength (in nm) of the photon emitted when an electron falls from $n = 3$ to $n = 1$ in a hydrogen atom. (Use $hc = 1240 \text{ eV}\cdot\text{nm}$)

Answer: 102.5 nm

(Solution: Using the Rydberg formula, $1/\lambda = R_H (1/n_1^2 - 1/n_2^2)$, the calculated wavelength is **102.5 nm**.)

3. MCQ

Which of the following elements has the highest **first ionization energy**?

- A) Na
- B) Mg
- C) Al
- D) Cl

Answer: D) Cl

(Explanation: Ionization energy increases across a period, and chlorine, being a halogen, has the highest ionization energy among the given options.)

4. MCQ

The atomic radius generally **decreases** across a period in the periodic table due to:

- A) Decreasing nuclear charge
- B) Increasing electron shielding
- C) Increasing effective nuclear charge
- D) Addition of new electron shells

Answer: C) Increasing effective nuclear charge

5. NAT

The effective nuclear charge (Z_{eff}) experienced by a **3p** electron in **sulfur (S, Z = 16)** can be estimated using Slater's rules. Calculate Z_{eff} for the **3p** electron.

Answer: 5.75

(Solution: Using Slater's rules, the shielding constant S is calculated, and $Z_{\text{eff}} = Z - S = 16 - 10.25 = 5.75$.)

