

3. ATOMIC STRUCTURE- SUBJECTIVE QUESTIONS

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Rutherford's α -rays (α -particles) Scattering Experiment and Nuclear Model of the Atom

1. Discuss how Rutherford's nuclear model of an atom was introduced based on an alpha particle scattering experiment. Point out its limitations.
2. What are the observations of Rutherford's α -ray scattering experiment? Write down the conclusions about the structure of an atom drawn from it. Point out its drawbacks. 5
3. What are the postulates of the nuclear model of atomic structure according to Rutherford's α - particle scattering experiment? Point out its limitations. 5
4. What experimental evidence led Rutherford to conclude that a) the atom's nucleus contains most of the atomic mass? b) the nucleus of the atom is positively charged? c) The atom consists mostly empty space? 3
5. Rutherford and his coworkers performed an α -particle scattering experiment, leading to the discovery of the nucleus of atoms. 1+1+1+2
 - a. What are the α particles?
 - b. Why was thin gold foil chosen for the experiment?
 - c. Why was ZnS coated on the screen?
 - d. What observations led to the discovery of the nucleus of atoms?

Bohr's Atomic Model

6. Write down the main postulates of Bohr's atomic model. How did it overcome the defects of Rutherford's Model? 5
7. Explain the main postulates of Bohr's theory of the atomic model. How did this theory justify the origin of spectral lines in hydrogen atoms?
8. Describe Bohr's atomic model. Draw a picture, labelling pertinent parts.
9. Describe Bohr's atomic model. How is it applied to explain the origin of the hydrogen spectra? 5
10. How is the nuclear model of the atom improved by Bohr? 3
11. What is meant by quantization of angular momentum? 2

Explanation of Hydrogen Spectra

12. What is meant by atomic spectrum? 2
13. Niels Bohr, a Danish physicist, won a Nobel Prize in 1922 at the age of 37 for his contribution to atomic structure and quantum mechanics. One of the successes of his model of the atom is that it was able to account for the origin of the hydrogen spectra.
 - a. Why does a hydrogen atom produce so many spectral lines even though it contains only one electron?
 - b. Mention the names of five spectral series of hydrogen atoms.
 - c. Draw a well-labelled diagram to show the origin of the above series in hydrogen spectra.
 - d. Which spectral series of Hydrogen is visible? 1+1+2+1
14. Write short notes on Bohr's model and the explanation of the hydrogen spectra. 5
15. Explain the hydrogen spectra in light of Bohr's theory. 4
16. Name the spectral series that appears as a visible part of the electromagnetic spectrum. How does such a series originate? 2
17. How do the Balmer series and Paschen series originate in the Hydrogen spectra? 2

Defects of Bohr's Theory

18. What are the limitations of Bohr's atomic model? 2
19. Mention any two limitations of Bohr's theory. 2
20. How does Bohr's atomic model appear to be defective in light of Heisenberg's uncertainty principle? 2
21. Based upon Plank's quantum theory, Niels Bohr developed an atomic model which overcame the limitations of the nuclear model of atoms.
I. What are the postulates of Bohr's atomic model?
II. How did this model overcome the limitations of Rutherford's atomic model?
III. Mention any three limitations of Bohr's atomic model. 5+1+2

Elementary Idea of Quantum Mechanical Model de-Broglie Equation (Dual nature of matter)

22. What is the conclusion made by de-Broglie? Write its mathematical relationship. 1+1
23. Derive de-Broglie equation. 3
24. Which principle goes against the concept of fixed orbitals? State the principle. 2

Heisenberg's Uncertainty Principle

25. Which principle goes against the concept of fixed orbitals? State the principle. 2

Probability Concept Atomic Orbitals

26. W. K. Heisenberg, a German Physicist, got the Nobel Prize (1932) in physics for 'the creation of quantum mechanics'. He is famous for his uncertainty principle, which led to the introduction of orbitals.
a. What is Heisenberg's Uncertainty principle?
b. Define orbital.
c. Distinguish between orbit and orbital.
d. Draw the shapes of the s and p orbitals. 2+1+2+2

Quantum Numbers

27. Write short notes on quantum numbers. 4
28. Which quantum number specifies the shape of the orbitals? 1
29. Name the quantum number that specifies the orientation of an orbital. 1
30. What information is provided by the magnetic quantum number? 2
31. Quantum numbers are assigned to characterize the electrons in an atom.
a. Define quantum numbers.
b. Name the four quantum numbers.
c. For the identification of orbital, only three quantum numbers are necessary. Which are they?
d. What does the spin quantum number signify?
e. Mention the spin of two electrons in an orbital. 1+1+1+1+1
32. To characterize the electrons in an atom, numbers are assigned, called quantum numbers.
a. Name the four quantum numbers.
b. What does the spin quantum number signify? Mention the spin of two electrons in an orbital.
c. Write the values of n, l, and m for (i) 2p and (ii) 3p_x orbitals. 1+1+2
33. An electron of an atom possesses the quantum numbers n=2, l=0, and m=0. What do they mean? 2
34. Write all the possible values of l and m for n=4. 2
35. An atomic orbital has n=3; what are the possible values of l and m. 2

36. What are the values of n and l for 3d orbitals? 2
37. What are the values of the principal quantum number (n) and the azimuthal quantum number (l) for the following orbital designations
i. 3s ii) 4p iii) 3p_x? 3
38. Write down the value of quantum numbers m and l for electrons for 3d and 3p orbitals. 2
39. What are the values of n , l , and m for 2p_x and 3p_z orbitals? 2
40. Give the value of all four quantum numbers of the 10th electron of Magnesium. (Atomic no. 12) 2
41. Identify the four quantum numbers of the 13th electron of an element having atomic number 30. 2
42. Assign the value of quantum numbers n , l , and m for the outermost electron in Sodium and Potassium atoms. 2
43. Write the electronic configuration for the atom having atomic number 19. What are the values of n and l of its outermost electron? 2
44. The element with atomic number X possesses 19 electrons and contains 20 neutrons in its nucleus.

Pauli's Exclusion Principle

45. State and illustrate Pauli's exclusion principle. 2

Hund's Rule of Maximum Multiplicity

46. What is meant by degenerate orbitals? Give a suitable example. 2
47. What is Hund's rule? 2
48. Write down the orbital electronic configuration of the oxygen atom using a box diagram. 2
49. Write down all 4 sets of quantum numbers for the last two electrons of silicon. Does it comply with Pauli's exclusion principle? 2
50. How many unpaired electrons are present in the atom having the following electronic configuration? $1s^2 2s^2 2p^6 3s^2 3p^2$ 2

Aufbau Principle

51. A scientist investigating the electron structure of the element concluded that the K, L, and M shells were full, and the N shell contained four electrons. What is the atomic number of that element? 2
52. Write down the electronic configuration of i) N ii) S 2
53. Write the electronic configuration of elements with the atomic numbers 18, 19, 23, and 26. Give the names of these elements. 2
54. Write the electronic configuration of cobalt in terms of s, p, d, and f orbitals. 2
55. Write down the ground state electronic configuration of an atom, having mass number 37 and number of neutrons 20. 2
56. Write the electronic configuration of the following atoms: i) Cu ii) Cr 2
57. Write the electronic configuration of the following ions
i) K⁺ ii) Cl⁻ iii) Al³⁺ iv) O²⁻ v) Ca²⁺ 2
58. Calculate the atomic number and number of p electrons of an atom whose valence shell electronic configuration is $3s^2$. 2
59. Calculate the atomic number of the following elements whose outermost electrons are represented by i) $3s^2 3p^2$ 2
60. Write the electronic configuration of elements whose outermost electronic configuration is: a) $3s^2$ and b) $3s^2 3p^6$. 2
61. An element has 2 electrons in the 'K' shell, 8 in the 'L' shell, 9 electrons in the 'M' shell, and 2 in the 'N' shell. Write its electronic configuration and calculate the total number of p-electrons. 2
62. An atom of the element has 24 electrons; what is the total number of s electrons? 1

1. Table 1.1 gives some details of the stable naturally occurring isotopes of rhodium and iridium.
Complete Table 1.1. [3]

isotope	number of protons	number of neutrons	total number of electron shells
$^{103}_{45}\text{Rh}$		58	
$^{191}_{77}\text{Ir}$			6
$^{193}_{77}\text{Ir}$			6

2. An isotope of copper has a relative isotopic mass of 65.

Complete Table 1.2 for an atom of copper-65.

[3]

atomic number	nucleon number	number of neutrons	electronic arrangement
copper-65			

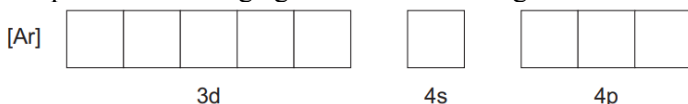
3. State the electronic configuration of a copper atom. [1]
 4. State the **full** electronic configuration of an atom of potassium. [1]
 5. Lithium hydride contains the ions Li^+ and H^- . State the electronic configuration of these two ions. [1]
 6. Give the full electronic configuration of $\text{S}^{2+}(\text{g})$. [1]
 7. P^{3-} , S^{2-} and Cl^- have the same number of electrons. Give the full electronic configuration of P^{3-} . [1]
 8. State the full electronic configuration of Cu^{2+} . [1]
 9. Determine the full electronic configuration of Fe^{3+} . [1]
 10. Cobalt, rhodium, and iridium are metals in the same group of the Periodic Table.
 (a) The shorthand electronic configuration of cobalt is $[\text{Ar}]3\text{d}^74\text{s}^2$.
 (i) Identify what is meant by $[\text{Ar}]$ by giving its full electronic configuration.

11. Electrons in atoms up to ^{36}Kr are distributed in s, p, and d orbitals.

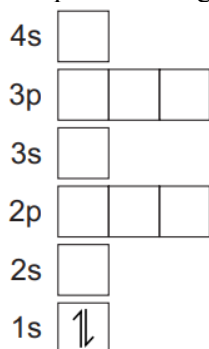
State the number of occupied orbitals in an isolated atom of ^{36}Kr . [3]

type of orbital	s	p	d
number of orbitals			

12. Complete the following figure to show the arrangement of electrons in a bromine atom using the electrons in box notation.



13. Complete the diagram to show the number and relative energies of the electrons in an isolated atom of ^{14}Si .



14. Cobalt, rhodium, and iridium are metals in the same group of the Periodic Table.

The shorthand electronic configuration of cobalt is $[\text{Ar}]3\text{d}^74\text{s}^2$.

Deduce the number of unpaired electrons in a cobalt atom.

[1]

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