

# NCERT Class 9: Journey Inside the Atom - Ultimate Question Bank

This document contains a comprehensive question bank structured specifically for NCERT Class 9 (Science/Chemistry) covering atomic structure concepts: subatomic particles (electrons, protons, neutrons), Thomson's model, Rutherford's alpha-particle scattering experiment, Bohr's atomic model, distribution of electrons in shells (Bohr-Bury scheme), valency, atomic number, mass number, isotopes, and isobars. The material strictly adheres to the Class 9 framework while challenging students to think critically and analytically without introducing higher-grade calculus or advanced quantum mechanics.

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## 1. Easy Level Segment

### Multiple Choice Questions (20 Items)

1. The subatomic particle discovered by J.J. Thomson is the: (a) Proton, (b) Neutron, (c) Electron, (d) Alpha particle
2. Which subatomic particle has a relative charge of +1 and a mass of approximately 1 u? (a) Electron, (b) Proton, (c) Neutron, (d) Positron
3. The mass number of an atom is equal to the total number of: (a) Electrons and protons, (b) Protons and neutrons, (c) Electrons and neutrons, (d) Protons only
4. Rutherford's gold foil experiment led to the discovery of the: (a) Electron, (b) Proton, (c) Atomic Nucleus, (d) Neutron
5. The maximum number of electrons that can be accommodated in the outermost shell of an atom is: (a) 2, (b) 8, (c) 18, (d) 32
6. An atom with atomic number 9 and mass number 19 contains how many neutrons? (a) 9, (b) 10, (c) 19, (d) 28
7. Isotopes are atoms of the same element that have: (a) Same mass number but different atomic numbers, (b) Same atomic number but different mass numbers, (c) Same number of neutrons, (d) Different chemical properties
8. The electron distribution shell sequence from the nucleus outwards is: (a) K, L, M, N, (b) N, M, L, K, (c) L, K, M, N, (d) A, B, C, D
9. The subatomic particle that carries no electrical charge is the: (a) Electron, (b) Proton, (c) Neutron, (d) Alpha particle
10. The valency of an element with atomic number 12 (Magnesium) is: (a) 1, (b) 2, (c) 3, (d) 4
11. Who proposed the "plum pudding" or "watermelons" model of an atom? (a) Ernest Rutherford, (b) J.J. Thomson, (c) Niels Bohr, (d) John Dalton
12. Which of the following elements has a completely filled outermost shell? (a) Sodium, (b) Chlorine, (c) Neon, (d) Oxygen
13. Isobars are atoms of different elements that possess the same: (a) Atomic number, (b) Mass number, (c) Number of protons, (d) Number of electrons
14. An alpha particle is identical to a: (a) Hydrogen nucleus, (b) Fully ionized Helium nucleus ( $\text{He}^{2+}$ ), (c) Fast-moving electron, (d) Neutral uncharged helium atom

15. The mass of an electron is roughly how many times smaller than that of a proton? (a) 100 times, (b) 1840 times, (c) 10000 times, (d) They have equal masses
16. The atomic number of an element is uniquely determined by its number of: (a) Electrons, (b) Neutrons, (c) Protons, (d) Nucleons
17. If an atom loses two electrons, it forms an ion with a charge of: (a) -2, (b) +2, (c) +1, (d) Neutral
18. The isotope of which element is used in the treatment of goiter? (a) Carbon, (b) Cobalt, (c) Iodine, (d) Uranium
19. The maximum electron capacity of the M shell according to the Bohr-Bury rule ( $2n^2$ ) is: (a) 2, (b) 8, (c) 18, (d) 32
20. An element has a valency of 0. This element is most likely a: (a) Metal, (b) Non-metal, (c) Noble gas, (d) Halogen

**Answer Key (Easy MCQs):** 1-(c), 2-(b), 3-(b), 4-(c), 5-(b), 6-(b), 7-(b), 8-(a), 9-(c), 10-(b), 11-(b), 12-(c), 13-(b), 14-(b), 15-(b), 16-(c), 17-(b), 18-(c), 19-(c), 20-(c)

### Subjective Questions (20 Items)

1. State the three subatomic particles found inside an atom along with their respective electrical charges.
2. Explain why an atom as a whole is electrically neutral despite containing charged particles.
3. Describe J.J. Thomson's model of the atom using the analogy of a watermelon.
4. What major observation in Rutherford's gold foil experiment surprised him the most, and why?
5. Define the term 'Atomic Number' and explain why it is more fundamental than mass number for defining an element.
6. Calculate the number of protons, neutrons, and electrons in a neutral atom of Carbon-14 (Atomic number = 6).
7. Write down the electronic configuration of a Sodium atom (Atomic number = 11) using the Bohr-Bury distribution scheme.
8. Define 'Valency' and find the valency of an element whose atomic number is 17.
9. State two key postulates of Niels Bohr's model of the atom that resolved the stability problem of Rutherford's model.
10. What are nucleons? Where are they located inside the architecture of an atom?
11. An element X has a mass number of 35 and contains 18 neutrons. What is its atomic number and electronic configuration?
12. Define isotopes and provide two distinct examples of isotopes found in nature.
13. Mention one crucial medical application and one industrial energy application of specific radioactive isotopes.
14. Explain the difference between isotopes and isobars with respect to their numbers of protons and neutrons.
15. Why does the K-shell of an atom hold a maximum of only 2 electrons? State the rule used.
16. An ion  $M^{2+}$  has 10 electrons. Find the atomic number of the neutral element M.
17. Define 'Mass Number'. Can two different elements have the same mass number? Explain briefly.
18. Draw a simple conceptual schematic diagram representing the Bohr model of an atom showing the nucleus and the first three electron shells.
19. If the K and L shells of an atom are full, what is the total number of electrons present in that atom?
20. Why do noble gases show extremely low chemical reactivity? Explain in terms of their

outermost electron shells.

## 2. Moderate Level Segment

### Multiple Choice Questions (20 Items)

1. An atom of an element has 2 electrons in the K shell, 8 electrons in the L shell, and 6 electrons in the M shell. The valency of this element is: (a) 6, (b) 2, (c) 4, (d) 8
2. The fractional atomic mass of Chlorine (35.5 u) arises because it exists as a mixture of two isotopes with masses 35 u and 37 u in the ratio of: (a) 1:1, (b) 3:1, (c) 1:3, (d) 2:1
3. Which of the following pairs represents a set of isobars? (a)  $^{14}\text{C}$  and  $^{14}\text{N}$ , (b)  $^{12}\text{C}$  and  $^{14}\text{C}$ , (c) Protium and Deuterium, (d)  $^{235}\text{U}$  and  $^{23}\text{U}$
4. During Rutherford's scattering experiment, roughly 1 out of how many alpha particles suffered a complete 180-degree deflection? (a) 100, (b) 1,000, (c) 12,000, (d) 100,000
5. An ion  $\text{X}^{3-}$  has an atomic number of 15 and a mass number of 31. The number of electrons and neutrons in this ion are respectively: (a) 15 and 16, (b) 18 and 16, (c) 12 and 16, (d) 18 and 15
6. An element possesses 5 valence electrons in its third shell (M shell). The atomic number of this element is: (a) 5, (b) 7, (c) 15, (d) 13
7. Rutherford concluded that the volume occupied by the nucleus is: (a) Nearly equal to the total volume of the atom, (b) Immensely small compared to the total volume of the atom, (c) Half the volume of the atom, (d) Constantly fluctuating
8. Which of the following electronic configurations is impossible for a neutral ground-state atom under standard Class 9 rules? (a) 2, 8, 1, (b) 2, 8, 8, 2, (c) 2, 9, 2, (d) 2, 5
9. An atom has a mass number of 40 and contains 22 neutrons. The valency of this atom is: (a) 0, (b) 1, (c) 2, (d) 4
10. The charge-to-mass ratio (e/m) of cathode rays: (a) Depends on the nature of the gas in the tube, (b) Is a universal constant independent of the gas used, (c) Varies with the voltage applied only, (d) Is zero
11. The total number of nucleons in a species is 27. If it contains 14 neutrons, the electronic configuration of its stable trivalent cation ( $\text{M}^{3+}$ ) will be: (a) 2, 8, 3, (b) 2, 8, (c) 2, 8, 8, (d) 2, 4
12. Which isotope is specifically utilized as the baseline reference standard for defining atomic mass units? (a) Hydrogen-1, (b) Oxygen-16, (c) Carbon-12, (d) Carbon-14
13. An element has a valency of 3. The formula of its oxide will be: (a)  $\text{MO}$ , (b)  $\text{M}_2\text{O}_3$ , (c)  $\text{M}_3\text{O}_2$ , (d)  $\text{MO}_3$
14. The physical properties of isotopes are typically: (a) Identical because they have the same mass, (b) Different because they have different masses, (c) Identical because they have different proton counts, (d) Entirely unpredictable
15. The chemical properties of isobars are generally: (a) Identical, (b) Completely different because their electronic structures differ, (c) Similar due to identical mass numbers, (d) Dependent on neutron count
16. The maximum capacity of an electron shell is given by  $2n^2$ . Why does an element with 19 electrons have a configuration of 2, 8, 8, 1 instead of 2, 8, 9? (a) The M shell cannot hold more than 8 electrons ever, (b) The outermost shell cannot hold more than 8 electrons, (c) The N shell fills before the M shell starts, (d) The atom becomes unstable due to neutron count
17. A neutral atom of an element has two completely filled shells and no electrons in any other shell. The element is: (a) Helium, (b) Neon, (c) Argon, (d) Krypton

18. The mass of a neutron is roughly: (a) Equal to the mass of an electron, (b) Equal to the mass of a proton, (c) Half the mass of a proton, (d) Double the mass of an electron
19. An element forms an ion with a formula  $Z^{2-}$ . If the ion has 18 electrons, the atomic number of Z is: (a) 20, (b) 18, (c) 16, (d) 14
20. The discovery of isotopes directly contradicted which specific postulate of Dalton's Atomic Theory? (a) Atoms are indivisible, (b) Atoms of the same element are identical in all respects including mass, (c) Atoms combine in simple whole-number ratios, (d) Atoms can neither be created nor destroyed

**Answer Key (Moderate MCQs):** 1-(b), 2-(b), 3-(a), 4-(c), 5-(b), 6-(c), 7-(b), 8-(c), 9-(a), 10-(b), 11-(b), 12-(c), 13-(b), 14-(b), 15-(b), 16-(b), 17-(b), 18-(b), 19-(c), 20-(b)

## Subjective Questions (20 Items)

1. An element has an atomic number of 16. Determine its group-level valency by calculating how many electrons it must gain or lose to achieve a stable octet.
2. Naturally occurring Boron consists of two isotopes: B-10 (atomic mass = 10 u) and B-11 (atomic mass = 11 u). If the average atomic mass of Boron is 10.8 u, calculate the percentage abundance of each isotope.
3. Why did Rutherford choose a gold foil specifically for his alpha-particle scattering experiment? Could he have used a sheet of a brittle material like sulfur? Explain.
4. Compare the plum pudding model of Thomson with the planetary model of Rutherford regarding the distribution of positive charge.
5. Explain why the outermost shell of an atom cannot hold more than 8 electrons even if the principal maximum capacity ( $2n^2$ ) of that shell is much higher.
6. An element X forms a chloride with the formula  $\text{XCl}_2$ . What is the valency of X? Write the formula of its carbonate and sulfate.
7. A particular isotope of an element has 8 protons and 10 neutrons. Write its isotopic symbol notation showing both mass number and atomic number, and state its common valency.
8. Identify which of the following are isotopes and which are isobars: Species A (Protons = 20, Neutrons = 20), Species B (Protons = 18, Neutrons = 22), Species C (Protons = 20, Neutrons = 22).
9. Why are the chemical properties of all isotopes of a given element identical, whereas their physical properties show measurable variations?
10. An atom of an element is represented as  ${}_{40}^{20}\text{Ca}$ . What information do you gather from this symbol regarding its subatomic constituents and its position relative to electron configurations?
11. Explain the observation from Rutherford's experiment: "Most of the alpha particles passed straight through the gold foil without any deflection." What does this tell us about atomic spatial structure?
12. A monovalent anion  $\text{Y}^-$  contains 18 electrons and 20 neutrons. Calculate the mass number of element Y and write down its neutral configuration.
13. What were the operational limitations of Rutherford's nuclear model that made it unstable according to classical electromagnetic laws?
14. Describe how Niels Bohr saved the atom from total electromagnetic collapse by introducing discrete, non-radiating energy states.
15. The atomic mass of an element is a whole number for some elements but a fractional decimal value for others (like  $\text{Cu} = 63.5 \text{ u}$ ). Explain the underlying reason.
16. If an element has an atomic number of 14, draw its electron shell distribution chart and deduce whether it acts as a metal or a non-metal/metalloid based on its valency.
17. A certain element M forms an oxide  $\text{M}_2\text{O}$ . Deduce the valency of M and determine the

formula of its nitride.

18. How did James Chadwick prove the existence of the neutron in 1932? What properties did he establish for this particle?
19. An element has its K, L, and M shells partially filled such that the M shell contains exactly half the number of electrons present in the L shell. Determine its atomic number.
20. Define the terms 'Valence Electrons' and 'Valency'. Under what mathematical condition is an element's valency equal to its number of valence electrons?

### 3. Difficult Level Segment

#### Multiple Choice Questions (20 Items)

1. Two neutral isotopes of a mystery element possess a difference of 4 neutrons in their nuclei. If the lighter isotope has an equal number of protons and neutrons and its mass number is 32, the number of neutrons in the heavier isotope must be: (a) 16, (b) 20, (c) 18, (d) 22
2. An element A has an electronic configuration of 2, 8, 8, 1 and an element B has a configuration of 2, 6. When they react, they form a compound. The total number of electrons transferred from A to B to form one unit of this compound is: (a) 1, (b) 2, (c) 3, (d) 4
3. A certain sample of an element consists of three isotopes: Mass 20 u (90% abundance), Mass 21 u (1% abundance), and Mass 22 u (9% abundance). The calculated average atomic mass of the sample is: (a) 20.00 u, (b) 20.19 u, (c) 21.00 u, (d) 20.50 u
4. An atom has 2 electrons in the K shell, 8 electrons in the L shell, and the number of electrons in the M shell is three times the number of valence electrons of an element that forms a stable hydride  $MH_3$ . The atomic number of the atom is: (a) 13, (b) 15, (c) 19, (d) 22
5. If the nucleus of a gold atom were scaled up to the size of a standard cricket ball (radius ~3.5 cm), the outermost edge of the gold atom would be located roughly at a distance of: (a) 3.5 meters, (b) 35 meters, (c) 3.5 kilometers, (d) 350 kilometers
6. A divalent cation  $X^{2+}$  has the same number of electrons as a neutral Argon atom. If the nucleus of X contains a number of neutrons equal to 1.1 times its proton count, the mass number of X is: (a) 40, (b) 42, (c) 44, (d) 45
7. An element forms an oxide where the mass ratio of the element to oxygen is 1:1. If the valency of the element is 4, its atomic mass is closest to: (a) 16 u, (b) 32 u, (c) 64 u, (d) 12 u
8. In an experiment studying canal rays (anode rays), it was discovered that the  $e/m$  ratio changes significantly depending on the gas filled in the discharge tube. The  $e/m$  ratio reaches its absolute maximum value when the tube is filled with: (a) Helium, (b) Oxygen, (c) Nitrogen, (d) Hydrogen
9. An element Z has a mass number A and atomic number Z. If it emits an alpha particle (composed of 2 protons and 2 neutrons), the new mass number and atomic number will be respectively: (a) A-2, Z-2, (b) A-4, Z-2, (c) A-4, Z-4, (d) A-2, Z-4
10. An atom has an configuration of 2, 8, 8. What happens to its net electrical charge and structural classification if one proton is added to its nucleus without altering its electron count? (a) It becomes a negative ion, (b) It becomes a neutral Potassium atom, (c) It becomes a monovalent cation of Potassium, (d) It becomes an isotope of Argon
11. The total number of electrons present in one molecule of heavy water ( $D_2O$ ), where D is the  $^2_1H$  isotope of hydrogen, is: (a) 10, (b) 11, (c) 12, (d) 8

12. Consider three species: X, Y, and Z. X and Y are isotopes; Y and Z are isobars. If X has 17 protons and 18 neutrons, and Z has 18 protons, the number of neutrons in Z must be: (a) 17, (b) 18, (c) 19, (d) 20
13. An element has a valency equal to its shell number. If it has a completely filled K shell and its valence electrons reside in the L shell, the element is: (a) Beryllium, (b) Boron, (c) Carbon, (d) Lithium
14. The ratio of the radii of an atom and its nucleus is roughly  $10^5$ . Therefore, the ratio of the volume of the atom to the volume of its nucleus is: (a)  $10^5$ , (b)  $10^{10}$ , (c)  $10^{15}$ , (d)  $10^3$
15. A neutral molecule has the formula  $AB_2$ . The total number of electrons in A is equal to its mass number minus its neutron count, which equals 6. The total number of electrons in B is 8. The total electron count of the molecule is: (a) 14, (b) 22, (c) 30, (d) 16
16. The electronic configuration of a specific ion  $M^{3+}$  is 2, 8. If the mass number of this atom is 27, the number of neutrons in its nucleus is: (a) 13, (b) 14, (c) 10, (d) 27
17. Which of the following statements is perfectly true regarding the behavior of alpha particles in Rutherford's experiment? (a) All alpha particles were deflected by large angles, (b) The heavy positive charge of the atom is concentrated in a tiny volume which repels the positive alpha particles, (c) Alpha particles are attracted by the negative electrons in the nucleus, (d) The mass of the nucleus plays no role in deflecting the particles
18. An element has an electronic configuration of 2, 8, 7. It forms an isotope with a mass number of 37. The number of neutrons in the ion formed by this isotope is: (a) 17, (b) 20, (c) 18, (d) 21
19. Two atoms are described as  $^{20}_{10}\text{X}$  and  $^{22}_{10}\text{X}$ . They differ from each other structurally in terms of: (a) Their outer shell chemical bonding states, (b) The nuclear force dynamics due to different neutron numbers, (c) Their net charges, (d) The number of orbits
20. A stable atom has 4 electron shells. Its outermost shell has the minimum possible number of valence electrons allowed for a stable metallic element. The element could be: (a) Sodium, (b) Potassium, (c) Calcium, (d) Scandium

**Answer Key (Difficult MCQs):** 1-(b), 2-(b), 3-(b), 4-(c), 5-(c), 6-(c), 7-(b), 8-(d), 9-(b), 10-(c), 11-(a), 12-(a), 13-(a), 14-(c), 15-(b), 16-(b), 17-(b), 18-(b), 19-(b), 20-(b)

## Subjective Questions (20 Items)

1. An element M has an atomic number of 13 and a mass number of 27. (i) Write its electronic configuration. (ii) If it changes into an  $M^{3+}$  ion, explain how its electron count changes. (iii) Compare the stability of the atom versus the ion based on its outer octet status.
2. A sample of a noble gas neon contains two isotopes,  $^{20}\text{Ne}$  and  $^{22}\text{Ne}$ . The average atomic mass of the sample is determined to be 20.2 u. Calculate the percentage composition of both isotopes in the sample.
3. Explain why the charge-to-mass ratio ( $e/m$ ) of anode rays varies drastically depending on the gas filled inside the discharge tube, whereas the  $e/m$  ratio for cathode rays remains entirely constant.
4. A certain element X has a valency of 4. It forms a compound with another element Y which has 7 valence electrons in its M shell. Work out the step-by-step logic to deduce the chemical formula of the compound formed between X and Y using Class 9 valency balancing.
5. The mass number of an atom is 40, and it contains 20 protons. Another atom has a mass number of 40 but contains 18 protons. Explain what structural relationship exists between these two atoms and how their chemical properties will differ.
6. A highly reactive non-metal has its valence electrons in the M shell. It requires only 1

- electron to achieve a completely stable noble gas configuration. Deduce its atomic number, electronic configuration, valency, and name.
7. Rutherford's alpha scattering experiment utilized highly energetic helium nuclei. If he had used beta particles (which are fast electrons) instead, what changes would you predict in the scattering patterns? Explain using your understanding of electrostatic forces and particle masses.
  8. An ion with a mass number of 39 possesses a single positive charge. If the ion contains 11.1% more neutrons than electrons, calculate the exact number of protons, neutrons, and electrons present in this ion.
  9. A trivalent metal ion  $M^{3+}$  has 10 electrons in total. The mass number of the element is 27. Find the number of neutrons in the nucleus of M and write down the formula of its nitride and phosphate.
  10. Explain why the atomic mass of an atom is concentrated almost exclusively in its nucleus, even though electrons occupy nearly the entire spatial boundary volume of the atom.
  11. An element has a configuration of 2, 8, 2. It loses its valence electrons to form a stable ion. Show via electron count bookkeeping why the net charge on the resulting ion becomes +2.
  12. Predict the valencies of the following elements whose atomic numbers are 7, 14, 18, and 20 respectively, by writing their electronic configurations and applying the octet/duplet rules.
  13. Why did Thomson's atomic model fail to explain the large-angle deflections observed in Rutherford's experiment? Address this by discussing the spatial concentration of mass and charge.
  14. A specific isotope of Hydrogen is radioactive and contains 2 neutrons in its nucleus. Name this isotope, write its standard notation symbol, and calculate its mass number.
  15. An element Z forms an entry in the periodic map with an atomic number of 16. It forms an isotope with 18 neutrons. Another element W has an atomic number of 17 and forms an isotope with 17 neutrons. Are they isotopes, isobars, or neither? Prove your point by listing their complete mass numbers.
  16. The maximum capacity of the N shell is 32 electrons. Suppose an atom has its N shell as its outermost valence shell, and it contains 2 electrons. Why can it not hold more electrons before the next shell begins to fill? Explain using the stability of valence structures.
  17. A compound has the molecular formula  $X_2O_3$ . If the total number of electrons in one atom of oxygen is 8, and the total number of electrons in one molecule of  $X_2O_3$  is 50, find the atomic number of element X.
  18. An atom of carbon has 6 protons and 6 neutrons. Another atom of carbon has 6 protons and 8 neutrons. Explain why both atoms exhibit the exact same chemical behavior when reacting with oxygen gas.
  19. How does Bohr's model explain the discrete line spectra emitted by hydrogen atoms without violating energy principles? Answer strictly within the Class 9 conceptual boundary of stationary orbits.
  20. An atom has an atomic number of 15. If it gains 3 electrons to form a phosphide-like stable anion, explain the change in its size and electronic configuration relative to a stable noble gas configuration.

## 4. Olympiad Level Segment

### Multiple Choice Questions (20 Items)

1. A hypothetical ion  $X^{4+}$  has a nucleus containing  $N$  neutrons and  $Z$  protons. It is found that the number of electrons in the ion is exactly equal to one-third of the number of neutrons in the nucleus. The mathematical relationship between the mass number  $A$  and the atomic number  $Z$  for this species is: (a)  $A = 4Z - 16$ , (b)  $A = 4Z + 16$ , (c)  $A = 3Z - 12$ , (d)  $A = 4Z - 4$
2. An element has an average atomic mass of 69.72 u. It exists as two isotopes with masses 68.93 u and 70.92 u. The fractional abundance of the lighter isotope in nature is closest to: (a) 60%, (b) 40%, (c) 75%, (d) 50%
3. A beam containing a mixture of alpha particles ( $He^{2+}$ ), protons ( $H^+$ ), and deuterons ( $H^{2+}$ ) is accelerated through a uniform electric field. The ratio of their deflections over a fixed horizontal distance, assuming they entered with identical initial velocities, is proportional to their  $e/m$  ratios, which are: (a) 1:1:0.5, (b) 0.5:1:0.5, (c) 2:1:1, (d) 0.5:2:1
4. An atom has its valence shell designated as the  $N$  shell. The number of electrons in its  $M$  shell is twice the number of electrons in its  $L$  shell plus half the number of electrons in its  $K$  shell. The atomic number of this neutral element is: (a) 19, (b) 20, (c) 26, (d) 28
5. A species contains 18 electrons, 19 protons, and 21 neutrons. The correct structural representation of this species, including its mass number, atomic number, and net charge state, is: (a)  $^{40}_{19}K^+$ , (b)  $^{40}_{21}Sc^{2+}$ , (c)  $^{40}_{19}K^-$ , (d)  $^{42}_{19}K^+$
6. The total number of neutrons present in a sample containing 34 grams of Ammonia ( $NH_3$ ), assuming all hydrogen atoms are Protium ( $^1H$ ) and all nitrogen atoms are Nitrogen-14 ( $^{14}N$ ), is equal to: (a)  $6 \times 10^{23}$ , (b)  $14 \times 6 \times 10^{23}$ , (c)  $14 \times 10^{23}$ , (d)  $7 \times 2 \times 6.022 \times 10^{23}$
7. In a highly specialized atomic collision experiment, an alpha particle approaches a stationary heavy gold nucleus directly along a straight line. At the point of closest approach, the initial kinetic energy of the alpha particle is completely converted into: (a) Nuclear binding energy, (b) Electrostatic potential energy of the system, (c) Magnetic energy, (d) Thermal energy
8. An element  $X$  forms a stable compound with hydrogen with the formula  $XH_4$ . It also forms an oxide. According to the advanced valence rules within Class 9 capabilities, the maximum oxidation-state equivalent valency shown by  $X$  towards oxygen allows it to form an oxide with the formula: (a)  $XO$ , (b)  $XO_2$ , (c)  $X_2O$ , (d)  $XO_4$
9. A mystery ion  $M^{n+}$  has an atomic number  $Z$  and a mass number  $A$ . If the number of neutrons in the ion is given by the expression  $A - Z$ , and the number of electrons is given by  $Z - n$ , the total number of nucleons minus the total number of subatomic particles outside the nucleus is: (a)  $A - Z + n$ , (b)  $A - Z$ , (c)  $Z - n$ , (d)  $A$
10. An atom has an electronic configuration of 2, 8, 8, 2. If all the valence electrons are removed, the resulting ion will contain how many completely filled shells? (a) 4, (b) 3, (c) 2, (d) 1
11. Two elements  $P$  and  $Q$  form a series of molecules. In  $PCl_3$ ,  $P$  shows a valency of 3. In  $P_2O_5$ ,  $P$  shows a valency of 5. The total number of valence electrons present in a neutral atom of  $P$  must be: (a) 3, (b) 5, (c) 8, (d) 7
12. The ratio of the number of neutrons in a molecule of Heavy Water ( $D_2O$ ) to that in a molecule of Ordinary Water ( $H_2O$ ) is (given  $^1H$ ,  $^2D$ ,  $^{16}O$ ): (a) 2:1, (b) 5:4, (c) 10:8, (d) 5:2
13. A certain element has an atomic number of 33. Under the extended Bohr-Bury configuration rules (2, 8, 18, 32...), its electron configuration will be: (a) 2, 8, 8, 8, 7, (b) 2, 8, 18, 5, (c) 2, 8, 10, 8, 5, (d) 2, 18, 8, 5
14. Which of the following sets of species contains entries that are ALL structurally iso-electronic (possessing the exact same total number of electrons)? (a)  $Na^+$ ,  $Mg^{2+}$ ,  $O^{2-}$ ,  $Ne$ , (b)  $K^+$ ,  $Ca^{2+}$ ,  $Cl^-$ ,  $Ar$ , (c) Both (a) and (b), (d) None of the above
15. An atom contains a total of 11 nucleons that possess no electrical charge. If the valence shell of this atom is the  $M$  shell and contains 1 electron, the mass number of the atom is: (a) 11, (b) 23, (c) 12, (d) 24

16. During a cathode ray tube experiment, if the residual gas pressure is reduced to an absolute minimum high vacuum, the current flows because: (a) The gas molecules ionize more readily, (b) Electrons are directly emitted from the cathode metal surface itself via the high electric field, (c) Protons jump from the anode, (d) The vacuum itself conducts electricity
17. An element has two naturally occurring isotopes. Isotope 1 has a mass of  $M$  u and an abundance of  $x\%$ . Isotope 2 has a mass of  $N$  u. The average atomic mass of the element is given by the algebraic expression: (a)  $[M \cdot x + N \cdot (100 - x)] / 100$ , (b)  $[M \cdot x + N \cdot x] / 100$ , (c)  $[M \cdot (100 - x) + N \cdot x] / 100$ , (d)  $M \cdot x + N$
18. A particle X contains 17 protons, 18 neutrons, and 18 electrons. A particle Y contains 17 protons, 20 neutrons, and 17 electrons. Which statement is perfectly accurate? (a) X is a neutral atom and Y is an ion, (b) X and Y are isotopes of the same element, though X is in an anionic state, (c) X and Y are isobars, (d) X and Y will show entirely different chemical reaction pathways
19. An element has a valency of 4 and its mass number is 28. If it contains an equal number of protons and neutrons, the number of electron shells it possesses is: (a) 2, (b) 3, (c) 4, (d) 1
20. An atom has an configuration of 2, 8, 5. The ratio of the total number of electrons in its fully completed shells to the number of electrons in its uncompleted valence shell is: (a) 2:1, (b) 10:5, (c) 2:3, (d) 1:1

**Answer Key (Olympiad MCQs):** 1-(a), 2-(a), 3-(b), 4-(b), 5-(a), 6-(d), 7-(b), 8-(b), 9-(a), 10-(b), 11-(b), 12-(b), 13-(b), 14-(c), 15-(d), 16-(b), 17-(a), 18-(b), 19-(b), 20-(a)

## Subjective Questions (20 Items)

1. A specialized ion  $X^{n+}$  has a mass number of 56. The nucleus contains 30 neutrons. If the number of electrons in the ion is 24, calculate the value of the positive charge 'n' on the ion and write down the full electronic configuration of the neutral atom X.
2. An element A has an atomic number of 12 and mass number of 24. Another element B has an atomic number of 16 and mass number of 32. Write down their electronic configurations. Deduce the valency of both elements. Predict the chemical formula and type of bonding when A reacts with B.
3. In Rutherford's experiment, the fraction of alpha particles scattered at an angle  $\theta$  decreases sharply as  $\theta$  increases. Formulate a qualitative argument explaining why large-angle deflections are so incredibly rare by considering the spatial probability of an alpha particle hitting the tiny nuclear domain head-on.
4. A compound of carbon and hydrogen has a total molecular mass of 30 u. If each carbon atom is  $^{12}\text{C}$  and each hydrogen atom is  $^1\text{H}$ , determine the molecular formula of the compound. Write down the total number of protons and electrons contained within one single molecule of this gas.
5. An atom has a net nucleon count of A. The number of protons is Z. Derive a general algebraic formula for the percentage mass contribution of the nucleus that comes exclusively from neutrons, assuming protons and neutrons have exactly equal masses and electron masses are completely neglected.
6. An element has an electronic configuration represented as 2, 8, 8. Explain what will happen to its chemical identity and its net electrical charge if: (i) Two neutrons are added to the nucleus. (ii) Two protons are added to the nucleus without changing the electron shell population.
7. The average atomic mass of a sample of element X is 16.2 u. It consists of two isotopes,  $^{16}\text{X}$  and  $^{18}\text{X}$ . If you have a sample containing a total of 5000 atoms of element X, calculate the exact numerical count of  $^{16}\text{X}$  atoms and  $^{18}\text{X}$  atoms present in that specific

sample.

8. A monovalent cation  $M^+$  has a completely filled K and L shell. A monovalent anion  $N^-$  also has a completely filled K and L shell. Identify the neutral elements M and N. What will be the formula of the compound formed between them?
9. Explain why the electron configuration 2, 8, 18, 8, 2 is stable for a heavy element like Calcium-equivalent analogues, but according to strict  $2n^2$  mathematical maximums, the third shell could theoretically hold up to 18. Differentiate between maximum capacity and outermost valence stability rules.
10. A scientist discovers a new isotope of an element that has an atomic number of 20 and a mass number of 48. Calculate its neutron count. Compare its chemical reactivity with standard Calcium (mass number = 40) and justify your answer based on electronic configuration mapping.
11. An ion  $Y^{2-}$  contains a total of 18 electrons. The number of neutrons in its nucleus is 2 units greater than its proton count. Deduce the mass number of Y, identify the element, and write the formula of its compound with Aluminum.
12. Draw a comparative chart showing how Thomson, Rutherford, and Bohr would look at the position and movement of a single electron inside a Hydrogen atom. Explain how each model advanced the previous one.
13. A hypothetical molecule has the formula  $WZ_4$ . The total number of valence electrons in the molecule is 32. If element Z is a halogen with 7 valence electrons, deduce the number of valence electrons in element W and predict its valency and atomic identity if its valence shell is the L shell.
14. Explain the concept of 'Valency' for non-metals using the formula: Valency = 8 - (Number of valence electrons). Provide a deep physical justification for why this mathematical subtraction works, using the concept of achieving an energy-minimum octet.
15. An element has its electron distribution as 2, 8, 3. Another element has its distribution as 2, 6. If they combine to form a crystal lattice compound, calculate the total number of electrons transferred when two units of the metal combine with three units of the non-metal.
16. Why are alpha particles deflected by a gold nucleus but not by the electrons surrounding the gold nucleus? Support your answer by comparing the mass and momentum of an alpha particle relative to a tiny moving electron.
17. An isotope of an element has 17 protons and 20 neutrons. Another isotope of the same element has 22 neutrons. Calculate the mass numbers of both isotopes and find the percentage difference in their masses relative to the lighter isotope.
18. An atom has an atomic number of 19. Write its configuration. If it loses one electron, it achieves the configuration of a noble gas. Name that noble gas and explain why the resulting  $K^+$  ion is chemically unreactive whereas the neutral K atom reacts violently with water.
19. A neutral atom of an element has a mass number of 23. If the number of electrons in its outermost shell is 1, calculate the total number of nucleons that do not carry any charge. Write the formula of its hydroxide.
20. What would happen to the mass number and atomic number of an atom if a hypothetical subatomic reaction inside its nucleus converted one neutron directly into a proton and an emitted electron? Analyze the net change in mass number, atomic number, and chemical identity.