Quantum number-2 (solution)
Atomic Structure -15 (Shapes & Nodes)

Every wrong answer brings you one step closer to the right one. Never fear mistakes.

Quick Facts: Total nodes $= n-1$; Angular nodes $= \ell$; Radial nodes $= n-\ell-1$.
Shapes: s spherical, p dumbbell (2 lobes), d usually clover; d_{z^2} = dumbbell + doughnut; f complex.
Nodal planes (angular nodes): $p_x \to yz$; $p_y \to xz$; $p_z \to xy$; $d_{xy} \to xz, yz$; $d_{xz} \to xy, yz$; $d_{yz} \to xy, xz$; d_{z^2} has conical angular nodes.

Q1. The number of radial nodes in a $3p$ orbital is:

Conceptual Approach : Radial nodes $= n-\ell-1$. $3p \Rightarrow n=3, \ell=1$.

Steps: $n-\ell-1 = 3-1-1 = 1$.
Final Answer: (B) 1.

Q2. For a given orbital, the total number of nodes is given by:

Conceptual Approach : Total nodes $= n-1$ (independent of ℓ split).

Final Answer: (A) $n-1$.

Q3. Which of the following orbitals has spherical shape?

Conceptual Approach : Spherical shape only for s orbitals ($\ell = 0$).

Final Answer: (C) $4s$.

Q4. Number of angular nodes in $4d$ orbital is:

Conceptual Approach : Angular nodes $= \ell$. For d, $\ell = 2$.

Final Answer: (C) 2.

Q5. The dumbbell-shaped orbitals are:

Conceptual Approach : All p orbitals are dumbbell-shaped with two lobes.

Final Answer: (B) p.

Q6. Total number of nodes in $4f$ orbital is:

Conceptual Approach : Total nodes $= n-1$. $4f \Rightarrow n=4$.

Final Answer: (B) 3.

Q7. Radial nodes are absent in:

Conceptual Approach : Radial nodes $= n-\ell-1$. Absent $\Rightarrow n-\ell-1=0 \Rightarrow \ell = n-1$.

Steps: $1s : (1-0-1) = 0$ (absent); $3d : (3-2-1) = 0$ (absent).
Note: Dono (A) & (D) me radial nodes absent hain; single-answer format me ambiguity/typo.
Final Answer: **Ambiguous.** Mathematically: $1s$ *and* $3d$ have 0 radial nodes.

Q8. The number of lobes in a p-orbital is:

Conceptual Approach : Each p orbital has two opposite lobes.

Final Answer: (B) 2.

Q9. The number of nodal planes in d_{xy} orbital is:

Conceptual Approach : d_{xy} lies between x and y axes; nodal planes: xz and yz.

Final Answer: (C) 2.

Q10. The number of angular nodes in $5p$ orbital is:

Conceptual Approach : Angular nodes $= \ell$; for p, $\ell = 1$.

Final Answer: (B) 1.

Q11. Which orbital has 2 radial nodes and 2 angular nodes?

Conceptual Approach : Need $n - \ell - 1 = 2$ and $\ell = 2 \Rightarrow n = 5$. That is a $5d$ orbital.

Final Answer: (D) $5d$.

Q12. Shape of d_{z^2} orbital is often described as:

Conceptual Approach : d_{z^2}: dumbbell along z with a torus ("doughnut") around the middle.

Final Answer: (C) Dumbbell with doughnut.

Q13. For $2s$ orbital, the number of radial nodes is:

Conceptual Approach : $2s$: $n - \ell - 1 = 2 - 0 - 1 = 1$.

Final Answer: (B) 1.

Q14. Which orbital has 3 angular nodes?

Conceptual Approach : Angular nodes $= \ell$. $\ell = 3 \Rightarrow f$ orbital (e.g., $5f$).

Final Answer: (C) $5f$.

Q15. The angular node depends upon:

Conceptual Approach : Angular part of wavefunction $\rightarrow \ell$.

Final Answer: (B) ℓ.

Q16. The shape of f-orbitals is:

Conceptual Approach : f orbitals have complex shapes (not simple spheres/dumbbells).

Final Answer: (C) Complex.

Q17. Which orbital will have highest number of radial nodes?

Conceptual Approach : Radial nodes $= n - \ell - 1$; compare each: $3p(1)$, $4s(3)$, $5d(2)$, $6f(2)$.

Final Answer: (B) $4s$.

Q18. Which orbital has no node at all?

> **Conceptual Approach :** Total nodes $= n - 1 = 0 \Rightarrow n = 1$; only $1s$ has zero total nodes.

Final Answer: (A) $1s$.

Q19. The nodal plane in p_x orbital lies in:

> **Conceptual Approach :** p_x has density along $\pm x$; node is plane perpendicular to x-axis $\Rightarrow yz$-plane.

Final Answer: (A) yz-plane.

Q20. For a $4p$ orbital, total nodes? If one is angular, find radial nodes.

> **Conceptual Approach :** Total $= n - 1 = 3$; for p, angular $= 1$. So radial $= 3 - 1 = 2$.

Final Answer: (A) 2 radial, 1 angular.

Q21. Among $3d$, $4p$, $5s$ — maximum total nodes?

> **Conceptual Approach :** Total nodes $= n - 1$: $3d\,(2)$, $4p\,(3)$, $5s\,(4)$.

Final Answer: (C) $5s$.

Q22. For H atom, ratio of radial to angular nodes in $5f$:

> **Conceptual Approach :** $5f$: radial $= 5 - 3 - 1 = 1$; angular $= \ell = 3$.

Final Answer: (A) $1 : 3$.

Q23. Consider $2p$ and $3s$. Which is true?

> **Conceptual Approach :** $2p$: radial $= 0$, angular $= 1$; $3s$: radial $= 2$, angular $= 0$.

Final Answer: (C) $2p$ has 1 more angular node than $3s$.

Q24. For $n = 6$, how many orbitals have exactly 2 radial nodes?

> **Conceptual Approach :** Set $n - \ell - 1 = 2 \Rightarrow \ell = 3$ (f). Number of orbitals in an f subshell $= 2\ell + 1 = 7$.

Note: Options (A–D) me 7 nahi hai — likely typo.

Final Answer: **Correct count:** 7 orbitals (all $6f$ orbitals).

Q25. Probability density at $r = 0$ is zero for:

> **Conceptual Approach :** At nucleus $r = 0$, only s-orbitals have nonzero value; for $\ell \neq 0$, wavefunction $\to 0$.

Final Answer: (C) All orbitals with $\ell \neq 0$.

Q26. Number of nodal planes for d_{xz}:

> **Conceptual Approach :** d_{xz} lies between x and z axes; nodal planes: xy and yz.

Final Answer: (C) 2.

Q27. Among $2s, 2p, 3s, 3p$, largest number of radial nodes?

> **Conceptual Approach :** Radial nodes: $2s(1)$, $2p(0)$, $3s(2)$, $3p(1)$.

Final Answer: (B) $3s$.

Q28. Which orbital has no angular nodes but two radial nodes?

> **Conceptual Approach :** No angular nodes $\Rightarrow \ell = 0$ (s). Two radial nodes: $n - \ell - 1 = 2 \Rightarrow n = 3$.

Final Answer: (B) $3s$.

Q29. The angular node for d_{z^2} corresponds to:

> **Conceptual Approach :** d_{z^2} has cone-shaped angular nodes (not flat planes).

Final Answer: (C) Cone-shaped surfaces.

Q30. If $n = 5$, maximum number of nodes in any orbital:

> **Conceptual Approach :** Maximum total nodes in shell $= n - 1 = 4$.

Final Answer: (B) 4.

Q31. H atom in $3p$: number of angular and radial nodes?

> **Conceptual Approach :** $3p$: angular $= \ell = 1$; radial $= n - \ell - 1 = 3 - 1 - 1 = 1$.

Final Answer: (A) 1, 1.

Q32. Which orbital has the same number of radial and angular nodes?

> **Conceptual Approach :** Condition: $n - \ell - 1 = \ell \Rightarrow n = 2\ell + 1$. Smallest example: $3p$ $(n = 3, \ell = 1) \Rightarrow 1 = 1$.

Note: Given options (3d, 4p, 4d, 5f) me koi match nahi karta. True example: $3p$.

Final Answer: **None among options.** (*Question options inconsistent.*)

Q33. If an orbital has 3 total nodes and 2 angular nodes, then (n, ℓ) are:

> **Conceptual Approach :** Total $= n - 1 = 3 \Rightarrow n = 4$; angular $= \ell = 2$.

Final Answer: (B) $(4, 2)$.

Errata/Notes for student clarity:

- **Q7:** Radial nodes absent for both $1s$ and $3d$ ($n - \ell - 1 = 0$). Single-answer options make it ambiguous.
- **Q24:** Correct count is **7** orbitals ($6f$ subshell has $2\ell + 1 = 7$), but options do not include 7.
- **Q32:** Condition $n = 2\ell + 1$; none of the given options satisfy. True example: $3p$.