

General and Structural Chemistry

Quiz-1

Spring Semester 2025

IIT-Hyderabad

Time: 45 min

Max Marks: 55

Q1. State the following statements as True or False:

[5×2]

- (i) The precise direction of the orbital angular momentum vector is unknown.
- (ii) Quantum numbers n and l determine the energy of an electron in a multielectron atom.
- (iii) The function $\sin e^{ax}$ an eigenfunction of the operator d^2/dx^2 .
- (iv) The basic shapes of orbitals are unchanged by changes in the nuclear charge, although their extensions into space depend inversely on the value of atomic number, Z .
- (v) Particles with half-integer spin are called bosons.

Q2. How can one prove whether the ground state helium atom has parallel or antiparallel spins $\uparrow\downarrow s^2$ electrons?

[2]

Q3. The angular momentum vector \vec{L} makes the largest angle of 135° with the positive z -axis. Determine corresponding possible quantum numbers l and m . What is the degree of degeneracy for the quantum state?

[3,1]

Q4. Write down the quantum numbers n , l , and m values for $2p_x$, $2p_y$ and $2p_z$ orbitals respectively.

[2,2,2]

Q5. Show that the $2p_z$ orbital has a nodal plane in the x - y plane.

[3]

Q6. Draw schematic diagrams for $3d_{xy}$ and $4d_{xy}$ orbitals. Show the phases of the lobes and comment whether these orbitals have gerade or ungerade symmetry with respect to inversion.

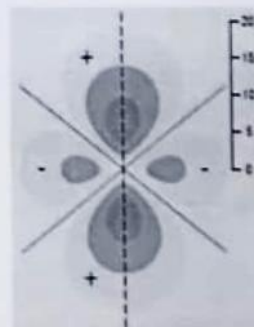
[3+3]

Q7. Identify the following orbitals:

[2+2]

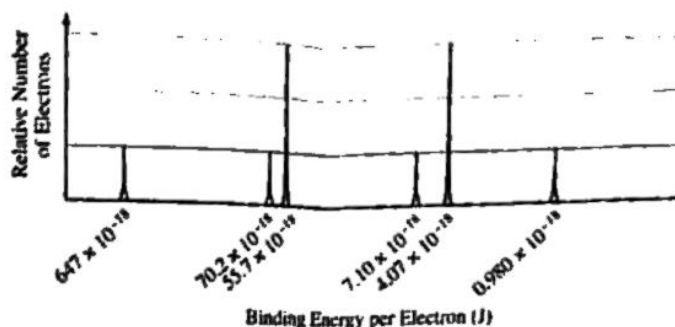


(a)

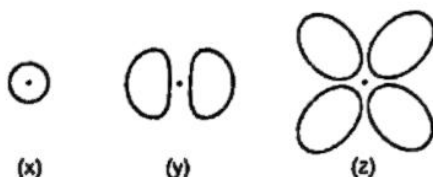


(b)

Q8. The complete photoelectron spectrum of an element in its ground state is represented below. Based on the spectrum, (i) write the ground state electronic configuration of the element, and (ii) identify the element. [3+2]



Q9. Consider the atomic orbitals shown here in the outline.



- What is the maximum number of electrons contained in a sub-shell of orbital of type (y)? [1]
- How many orbitals of type (z) are found in a shell with $n = 4$? [1]
- What is the smallest possible value of n for an orbital of type (x)? Of type (z)? [2]
- What are the possible l and m_l values for an orbital of type (x)? Of type (z)? [2]

Q10. Which ion with a +1 charge has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$? Which ion with a -2 charge has this configuration? Explain how you made your decision. [2+2]

Q11. For a 1s orbital, the radial distribution function is given by $P(r) = \frac{4Z^3}{a_0^3} r^2 e^{-2Zr/a_0}$. Plot the function and justify the nature of the curve. Show the location of the most probable radius. [4+1]

Given:

$$p_z = (3/4\pi)^{1/2} \cos\theta$$

$$\cos(\pi/4) = 1/\sqrt{2}$$