

Name: _____

Please answer any 6 questions, showing all calculations - 25 points each, 150 total.

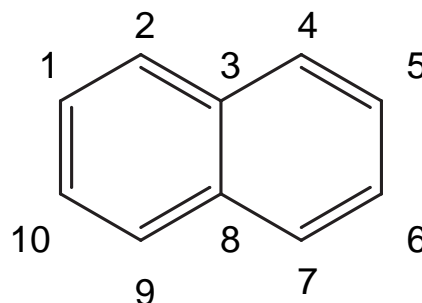
Single electron atom: $E_n = -h c Z^2 R_J / n^2$ $R_J = (\mu_J/m_e) R$ $R = m_e e^4 / 8 \epsilon^2 h^3 c$

Answer both questions, showing all calculations, 15 pts each.

- Which of the following term symbols describes an atomic wavefunction which may be the final state in an allowed transition from an atomic wavefunction in a ${}^2D_{3/2}$ state?
 A) ${}^2P_{3/2}$ B) ${}^3P_{3/2}$ C) ${}^2D_{3/2}$ D) ${}^3D_{3/2}$ E) ${}^2S_{1/2}$
- What is the term symbol for a helium atom with the electron configuration $1s^1 3d^1$?
 A) 2P_3 B) 3P_2 C) 2D_3 D) 3D_2 E) 1P_1

Problems - Answer any 4 questions, showing all calculations 30 pts each

- Describe the differences and similarities between the energy, atomic radius and angular momentum of the ground state of a hydrogen atom as described by the Bohr model and the quantum mechanical model.
- Write out the Hückel matrix for the π electrons in naphthalene (as numbered to the right) and describe how this would be used to determine the energies of the π molecular orbitals.
- What is the orbital angular momentum of an electron in the orbitals (A) 2p, (b) 4f, (c) 4s? Give the numbers of angular and radial nodes in each case.
- What is the most probable point (not radius) for a $2p_z$ electron to be found in a hydrogen atom.



$$\Psi_{2p_z} = \frac{1}{4\sqrt{6}} \left(\frac{Z}{a_0} \right)^3 \left(\frac{2Zr}{a_0} \right) e^{-\frac{2Zr}{4a_0}} \cos\theta$$

- Briefly describe the Born-Oppenheimer approximation and its application to molecules.
- Write the Slater determinant for the lowest energy excited state wavefunction of a beryllium ion (Be^+ , 3 electrons). Use the notation $1s_A \alpha_A$, $2s_B \beta_B$, $3p_C \alpha_C$, etc. for the electrons labeled A through C, where α and β are the spin portion of the wavefunction for each electron. Explain how this determinant relates to the Pauli principle and anti-symmetry of the wavefunction.
- Describe why the bond length of a C—C single bond is longer than that of a C=C double bond. Use valence bond theory and include the role of orbital overlap.