Homework #2 Due: September 15
Name _____ Chemistry 331

1. X-ray photoelectron spectroscopy is a method for detecting the presence of atoms on a surface. In this method a high energy X-ray ionizes the molecule by kicking out a core electron (i.e. an electron from a 1s orbital). Any excess energy leaves with the electron as kinetic energy. Calculate the kinetic energy of an electron ejected from a nitrogen atom using a 100 eV X-ray. (Hint: assume that carbon is just a hydrogen atom with a different nuclear charge)

   The kinetic energy of an ejected electron is _____.

2. What is the concentration of a dye molecule that has $\varepsilon(600\text{ nm}) = 74{,}000\ M^{-1}cm^{-1}$ if it has an absorbance of 0.6 at 600 nm in a 1 cm pathlength cell? What fraction of the incident light makes it through the cuvette?

   The concentration of the dye is _____.

   The fraction of incident light that travels through the cuvette is _____.

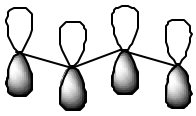
3. What is the force of attraction of an electron with the proton in the nucleus of a hydrogen atom if it is in the second Bohr orbit? What is the gravitational force of the electron at that distance?

   The Coulombic force of attraction is _____.

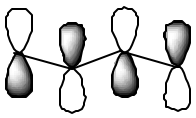
   The Gravitational force of attraction is _____.

4. The figure below represents the pi orbitals of butadiene. Each p orbital, ϕ_i, contributes on electron to the molecular orbital.

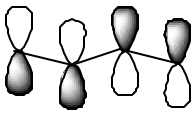
A



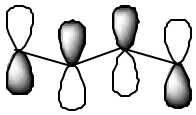
B



C



D



ϕ_1 ϕ_2 ϕ_3 ϕ_4

A. Identify the molecular orbitals below with the appropriate letter corresponding to the figure above.

$\chi_1 = \phi_1 + \phi_2 + \phi_3 + \phi_4$ corresponds to _____.
$\chi_2 = \phi_1 + \phi_2 - \phi_3 - \phi_4$ corresponds to _____.
$\chi_3 = \phi_1 - \phi_2 - \phi_3 + \phi_4$ corresponds to _____.
$\chi_4 = \phi_1 - \phi_2 + \phi_3 - \phi_4$ corresponds to _____.

B. How many nodes does each molecular orbital have in total?

Nodes in χ_1 = _____.
Nodes in χ_2 = _____.
Nodes in χ_3 = _____.
Nodes in χ_4 = _____.

C. Which orbitals are filled (occupied) and which are empty (unoccupied).

χ_1 is _____.
χ_2 is _____.
χ_3 is _____.
χ_4 is _____.

D. Which transitions are allowed? Keep in mind that a transition cannot occur between to filled levels or between two empty levels. Indicate your answer by writing the letter of the lower and upper state in the transition (e.g. X → Y).

Allowed transitions are _____.