CHEM 221

Class Examination — Wednesday 27 April 2005

Name:

Time allowed: 50 minutes **Total marks:** 50

Instructions: Answer **ALL** questions. Use the back of sheets if required.

---

1. (Total 5 marks)

   (a) Briefly explain (in one sentence each) **TWO** important ways in which Bohr's model of the hydrogen atom differs from our modern understanding of the hydrogen atom.

   (b) Write one set of four quantum numbers to describe an electron in each of the following orbitals:

      (i) 4f

      (ii) 3s

2. (Total 8 marks)

   (a) State Hund's Rule, and explain how it is used to derive the ground-state electron configuration of P (Z = 15).

   (b) Give three sets of quantum numbers which could describe the 3p electrons of a ground-state P atom.

   (c) Give an electron configuration of an excited-state phosphorous atom.

3. (Total 19 marks)

(a) Starting from basic principles, use Molecular Orbital (MO) theory to describe the bonding in N_2 (N: Z = 7). Your answer should include a labelled **MO Energy Level Diagram**, an **explanation of the molecular orbital labels on your diagram**, and the following terms:

linear combination of atomic orbitals (LCAO); bonding molecular orbital; antibonding molecular orbital; character of the molecular orbital; electron configuration, and **bond order**.

(b) From your answer to part (a), predict the following for N_2^+:

(i) electron configuration

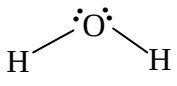
(ii) magnetic character

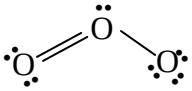
(iii) bond order

(iv) bond length relative to N_2.

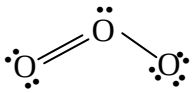
4. (Total 18 marks)

(a) A Lewis dot diagram for water, H_2O, is shown below. Water is a bent (or angular) molecule with a bond angle of 104.5°. Outline the basic principles of Valence Shell Electron Pair Repulsion (VSEPR) theory, and use the theory to account for the geometry and bond angle of water (H: Z = 1; O: Z = 8). Predict, with brief explanation, whether ozone, O_3, also a bent molecule, has a larger or smaller bond angle than water.





(b) Describe the bonding in ozone, O_3, using Valence Bond Theory (O: Z = 8).



(c) From your general knowledge of Molecular Orbital Theory, briefly describe (in one or two sentences) ONE important difference between the Molecular Orbital and Valence Bond descriptions of the bonding in ozone.

END OF PAPER