

Name:

Time allowed: 50 minutes

Total marks: 50

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

1. (Total 10 marks)

(a) (i) Write one set of quantum numbers to describe each of the following orbitals:

3d

5s

(ii) Write two sets of quantum numbers to describe two electrons in the same 2p orbital

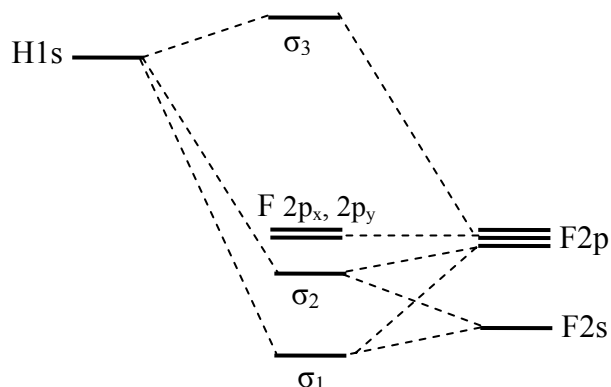
(c) (i) Give an electron configuration for an excited-state chlorine atom (Cl: $Z = 17$).

(ii) Give the electron configurations of two different atoms that belong to the same group in the Periodic Table (it is not necessary to name the atoms).

(d) The atomic unit, a_0 , has a value of 52.918 pm. What is the significance of this quantity to Bohr's model of the hydrogen atom, and to our modern understanding of the hydrogen atom?

2. (Total 20 marks)

A molecular orbital energy level diagram for HF is shown below. Z is the internuclear axis.



- (a) Explain **in detail**, referring to the **basic concepts** of Molecular Orbital (MO) theory, how this diagram was derived. Include comment about: the relative energies of the H and F atomic orbitals, why the F 1s orbitals do not appear on the diagram and why the MOs are all σ type (F: $Z = 9$).

Continue your answer on the following page

(b) What is the **character** of each of the MOs (e.g. mainly H1s, solely F2s etc)? Explain your answer.

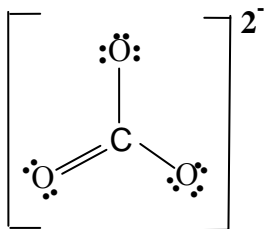
(c) (i) Give the electron configuration of the HF molecule.

(ii) What is the predicted magnetic character of HF?

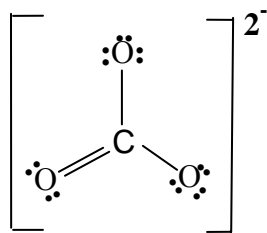
(iii) How does Molecular Orbital theory account for the polarity of the HF molecule?

4. (Total 20 marks)

- (a) A Lewis dot diagram for carbonate, CO_3^{2-} , is shown below. Outline the **basic principles** of Valence Shell Electron Pair Repulsion (VSEPR) theory, and use the theory, **with explanation**, to predict the geometry and bond angles of carbonate. (C: $Z = 6$; O: $Z = 8$)



(b) Describe the bonding in carbonate using Valence Bond Theory. (C: Z = 6; O: Z = 8)



(b) From your general understanding of bonding theories, explain, using carbonate as an example, why MO theory is described as a delocalised bonding theory, and Valence Bond theory as a localised bonding theory.

END OF PAPER