

Name:

Time allowed: 50 minutes

Total marks: 50

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

1. (10 marks)

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

3s

4d

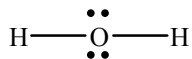
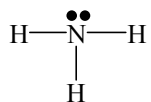
(b) Explain, with reference to quantum numbers, why an atom with the following electron configuration cannot exist (in the ground state or an excited state): $1s^1 2s^3$

(c) In Bohr's model of the hydrogen atom, the electron revolves around the nucleus in circular orbits of certain fixed radii.

Briefly explain how this aspect of Bohr's model is different to our modern understanding of the hydrogen atom.

2. (18 marks)

- (a) A Lewis dot diagram for ammonia, NH_3 , is shown below. Use Valence Shell Electron Pair Repulsion (VSEPR) theory, with explanation, to predict the shape and bond angles of ammonia in as much detail as possible (H: $Z = 1$; N: $Z = 7$). Predict, with brief explanation, whether the water molecule, (Lewis dot diagram shown below), has a larger or smaller bond angle than ammonia.



- (b) Answer the following questions about the ammonia molecule based on Valence Bond Theory:

- (i) what is the hybridisation of N?
- (ii) which H orbitals overlap with N orbitals to form the N-H bonds?
- (iii) are the N-H bonds σ or π bonds?

3. (22 marks)

- (a) **Starting from basic principles**, use Molecular Orbital (MO) theory to describe the bonding in O₂ (O: Z = 8). Your answer should include the following terms and a labelled **MO**

Energy Level Diagram:

linear combination of atomic orbitals (LCAO);

bonding molecular orbital; antibonding molecular orbital;

σ molecular orbital, π molecular orbital;

electron configuration (how it is determined) and

bond order (how it is calculated and its value for O₂).

Question 3 continued on following page

- (b) Show the electron configuration of the O₂ molecule on your MO Energy Level diagram in part (a). Briefly comment on the important properties of O₂ that are predicted by the MO description of the bonding.

END OF PAPER