

Worksheet 03: Atomic Models, Wave-Particle Duality and Orbitals

Focus: Bohr and Schrodinger models, probability, uncertainty, s and p orbitals | Suggested time: 50 minutes | Total: 40 marks

| | | | |
|--------------|--|------------|-----------------------------|
| Student name | _____ | Class | _____ |
| Instructions | Answer all questions. Show working for calculations. Use the data booklet values where needed. | Calculator | Permitted where appropriate |

Section A: Multiple choice

Choose the best answer for each question. Each question is worth 1 mark.

1. An atomic orbital is best defined as:

| | |
|--|--|
| A. a fixed circular path followed by an electron | B. a region of high probability of finding an electron |
| C. the exact position of an electron | D. a particle inside the nucleus |

2. The shape of an s orbital is usually described as:

| | |
|--------------------|--------------------|
| A. dumbbell-shaped | B. spherical |
| C. square planar | D. four-lobed only |

3. The three p orbitals in one p sublevel are:

| | |
|---|---|
| A. different in energy and shape | B. equal in energy but oriented differently |
| C. always filled with four electrons each | D. found only in $n = 1$ |

4. Which statement is linked to the Pauli exclusion principle?

| | |
|---|---|
| A. Electrons fill higher-energy orbitals first. | B. An orbital can hold two electrons with opposite spins. |
| C. All p orbitals are spherical. | D. Electrons in atoms have no wave properties. |

5. Electron diffraction provides evidence that electrons can show:

| | |
|-------------------|---------------------------|
| A. wave behaviour | B. only nuclear behaviour |
| C. no momentum | D. chemical colour |

6. A key limitation of the Bohr model is that it:

| | |
|-------------------------------------|--|
| A. explains hydrogen too accurately | B. assumes fixed electron paths |
| C. uses quantized energy levels | D. allows electrons to move to higher levels |

Section B: Short-answer questions

1. State two differences between the Bohr model and the Schrodinger model of the hydrogen atom. [4 marks]

Answer: _____

2. Explain why the exact path of an electron around the nucleus cannot be described in the modern model. [3 marks]

Answer: _____

Answer key and marking guidance

Award marks for scientifically correct alternative wording. Penalize only once for the same repeated error unless it causes a new error in reasoning.

Section A: Multiple choice

| Q | Answer | Brief marking guidance |
|---|--------|--|
| 1 | B | An orbital represents a probability region, not a fixed path. |
| 2 | B | s orbitals are spherical around the nucleus. |
| 3 | B | p orbitals are degenerate in a sublevel and differ by spatial orientation. |
| 4 | B | Pauli exclusion limits an orbital to two electrons of opposite spin. |
| 5 | A | Diffraction is a wave phenomenon. |
| 6 | B | Modern models do not treat electrons as moving in precise fixed paths. |

Section B: Short-answer mark scheme

| Q | Marks | Expected answer / marking points |
|---|-------|---|
| 1 | 4 | Bohr: fixed circular orbits/defined paths (1); Schrodinger: orbitals/probability regions (1); Bohr treats electron more like a particle in orbit (1); Schrodinger uses wave equation/wave nature of electron (1). |
| 2 | 3 | Position and momentum cannot both be known exactly/uncertainty principle (1); measuring position disturbs the electron (1); therefore only probability distribution/orbital can be described (1). |
| 3 | 3 | Dumbbell-shaped/two lobes (1); oriented along the x-axis (1); nucleus lies between the lobes/at the centre (1). |
| 4 | 3 | An orbital can contain maximum two electrons (1); they must have opposite spins (1); opposite spins allow same orbital occupancy according to Pauli exclusion principle (1). |

Section C: Data response / case study mark scheme

| Q | Marks | Expected answer / marking points |
|---|-------|---|
| 1 | 1 | Observation A (1). |
| 2 | 1 | Observation B (1). |
| 3 | 3 | Observation C (1); diffraction is characteristic of waves (1); therefore electrons can behave as waves under suitable conditions (1). |
| 4 | 4 | Different models explain different evidence (1); simple models are easier to use for some predictions (1); more complex models may be needed for finer detail (1); models are judged by agreement with experimental data (1). |

Section D: Extended response mark scheme

Award up to 8 marks: models simplify systems that cannot be directly observed (1); Bohr model explains quantized levels and hydrogen spectra (1); Bohr model is useful for simple electron transitions (1); limitation: fixed paths and poor treatment of multi-electron atoms (1); Schrodinger model uses wave behaviour/probability (1); orbitals describe likely electron locations (1); models change when new evidence appears, such as diffraction/spectra/ionization data (1); includes balanced conclusion about usefulness despite limitations (1).