

# 1.6 Photoelectron Spectroscopy

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 12 marks

## Objective

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Build the skills to answer exam questions on **photoelectron spectroscopy (PES)**.

You must be able to:

- describe how **photoelectron spectroscopy** 光电子能谱 ejects electrons and measures their **binding energy** 结合能
- interpret a PES spectrum (one peak per subshell)
- read peak position (binding energy) and peak height (number of electrons)
- match a spectrum to an electron configuration

## 1 Worked examples

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Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

### ■ One peak per subshell

Each peak corresponds to one subshell. Its position gives the binding energy; its height is proportional to the number of electrons in that subshell.

### ■ Higher binding energy is closer in

Electrons closer to the nucleus are held more tightly, so they have a higher binding energy. The  $1s$  peak is always at the highest binding energy.

### ■ Reading a ratio

Neon's PES has peaks in the ratio  $2 : 2 : 6$ , matching  $1s^2 2s^2 2p^6$ . A filled  $2p$  peak is three times taller than a filled  $2s$ .

## 2 Practice

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Now apply the methods above.

**2.1** State what the height of a PES peak is proportional to.

[1]

**2.2** Which electrons have the highest binding energy —those closest to or farthest from

the nucleus? [1]

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**2.3** Neon's PES shows peaks in the height ratio 2 : 2 : 6. Identify the subshells. [2]

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**2.4** How many times taller is a filled  $2p$  peak than a filled  $2s$  peak? [1]

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### 3 Exam-style questions

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**3.1** In PES, a higher binding energy means the electron is [1]

- **A** farther from the nucleus
  - **B** closer to the nucleus
  - **C** more numerous
  - **D** at a lower energy shell that is easier to remove
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**3.2** A PES spectrum with three peaks of relative height 2 : 2 : 6 belongs to an atom with configuration [1]

- **A**  $1s^2 2s^2 2p^6$
  - **B**  $1s^2 2s^2 2p^4$
  - **C**  $1s^2 2p^6 3s^2$
  - **D**  $1s^6 2s^2 2p^2$
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**3.3** Sodium's PES has peaks in the ratio 2 : 2 : 6 : 1.

(a) Write the electron configuration this represents. [2]

(b) State which peak is at the highest binding energy. [1]

**3.4** A PES spectrum has a small peak and a larger peak, with the small peak at a higher binding energy.

(a) State which peak is closer to the nucleus. [1]

(b) Explain what a taller peak tells you. [1]

## 4 Go further

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You are ready for more on this subtopic:

- work through the interactive **1.6 Photoelectron Spectroscopy** lesson on the **Learn** page;
- read the **Atomic Structure and Properties** section of the AP Chemistry handout on the **Know** page for the full explanation and worked diagrams.

## Solutions

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**2.1** The number of electrons in that subshell.

**2.2** Those closest to the nucleus.

**2.3**  $1s$ ,  $2s$ , and  $2p$ .

**2.4** Three times ( $2p$  holds 6,  $2s$  holds 2).

**3.1 B** —a higher binding energy means closer to the nucleus.

**3.2 A** — $2 : 2 : 6$  matches  $1s^2 2s^2 2p^6$ .

**3.3** (a)  $1s^2 2s^2 2p^6 3s^1$ . (b) The  $1s$  peak.

**3.4** (a) The small peak (higher binding energy). (b) It has more electrons in that subshell.