

Exercise walk-through

Photoelectron Spectroscopy ■ 1.6

eXercise

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

Method — 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.

Method — 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.

Method — 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 $2s$.

Practice 2.1 ■ 1 mark

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

Solution 2.1

Method: One peak per subshell

Worked steps

The number of electrons in that subshell **B1**.

Practice 2.2 ■ 1 mark

Which electrons have the highest binding energy — those closest to or farthest from the nucleus?

Solution 2.2

Method: Higher binding energy is closer in

Worked steps

Those closest to the nucleus **B1**.

Practice 2.3 ■ 2 marks

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

Solution 2.3

Method: Reading a ratio

Worked steps

1s, 2s, and 2p **M1** **A1**.

Practice 2.4 ■ 1 mark

How many times taller is a filled $2p$ peak than a filled $2s$ peak?

Solution 2.4

Method: Reading a ratio

Worked steps

Three times ($2p$ holds 6, $2s$ holds 2) **B1**.

Exam-style 3.1 ■ 1 mark

In PES, a higher binding energy means the electron is

- A** farther from the nucleus
- B** closer to the nucleus
- C** more numerous
- D** at a lower energy shell that is easier to remove

Solution 3.1

Method: Higher binding energy is closer in

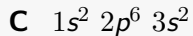
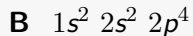
- A farther from the nucleus
- B closer to the nucleus** 
- C more numerous
- D at a lower energy shell that is easier to remove

Worked steps

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

Exam-style 3.2 ■ 1 mark

A PES spectrum with three peaks of relative height 2 : 2 : 6 belongs to an atom with configuration



Solution 3.2

Method: Reading a ratio

A $1s^2 2s^2 2p^6$



B $1s^2 2s^2 2p^4$

C $1s^2 2p^6 3s^2$

D $1s^6 2s^2 2p^2$

Worked steps

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

Exam-style 3.3 ■ 2 marks

Sodium's PES has peaks in the ratio 2 : 2 : 6 : 1.

- (a) Write the electron configuration this represents.
- (b) State which peak is at the highest binding energy.

Solution 3.3

Method: Higher binding energy is closer in

Worked steps

(a) $1s^2 2s^2 2p^6 3s^1$ **M1** **A1**. (b) The 1s peak **B1**.

Exam-style 3.4 ■ 1 mark

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.
- (b) Explain what a taller peak tells you.

Solution 3.4

Method: Higher binding energy is closer in

Worked steps

(a) The small peak (higher binding energy) **B1**. (b) It has more electrons in that subshell **B1**.