AP CHEMISTRY • EXERCISE SHEET

1.6 Photoelectron Spectroscopy

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

KEY WORDS binding energy 结合能 • photoelectron spectroscopy 光电子能谱 • electron configuration 电子排布 • nucleus 原子核

Objective

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

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

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]

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

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

3 Exam-style questions

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

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** $1s^6\ 2s^2\ 2p^2$

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]

Solutions

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.