

22.2 Mass spectrometry

Name: _____ Class: _____ Date: _____

Total: 9 marks

Objective

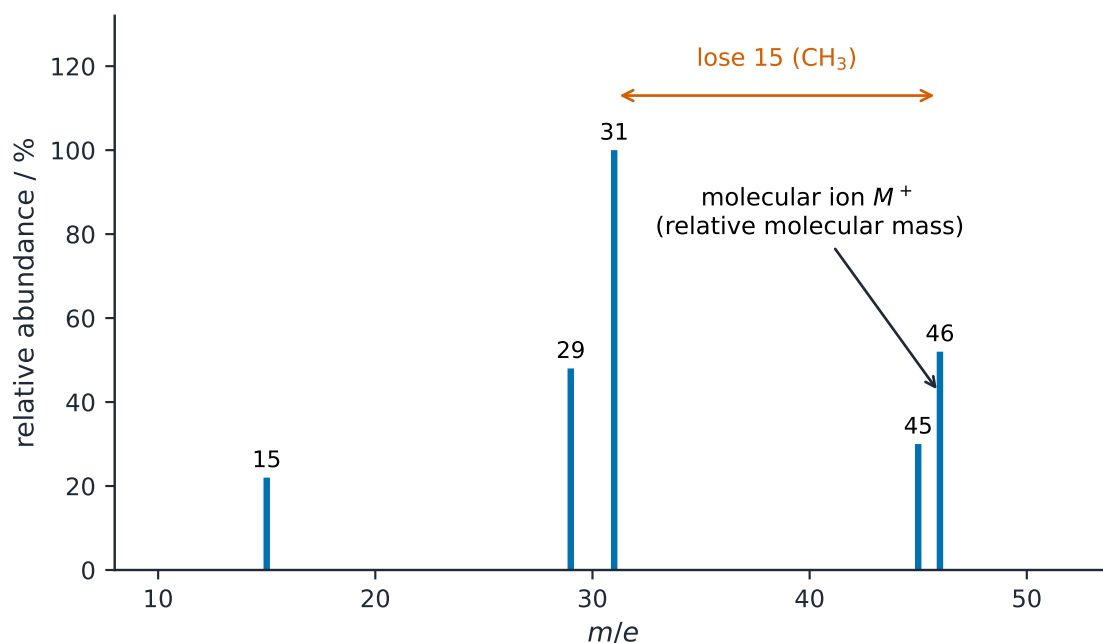
Build the skills to answer exam questions on **mass spectrometry** 质谱—the **molecular ion** 分子离子, **fragmentation** 碎裂, the $[M+1]$ carbon count, and the $[M+2]$ halogen test.

You must be able to:

- calculate relative atomic mass from isotopic abundances or a mass spectrum
- deduce molecular mass from the molecular ion peak and identify fragments
- use the $[M+1]$ peak to find the number of carbons, and $[M+2]$ for Cl/Br

1 Worked examples

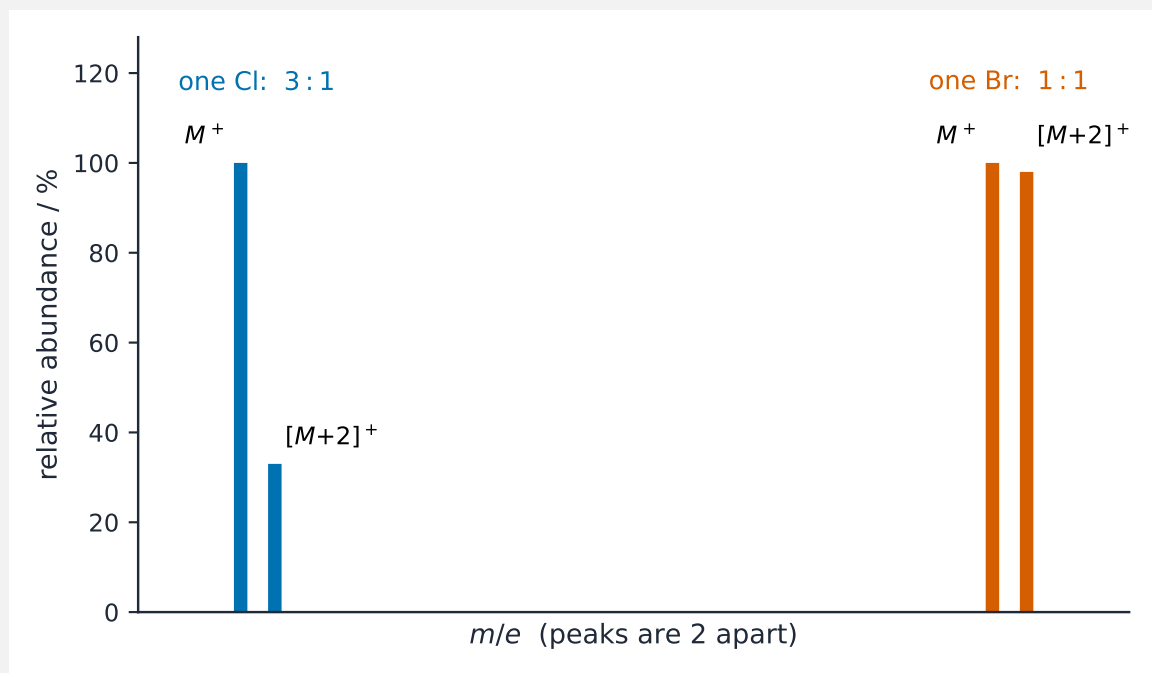
■ Relative atomic mass and the molecular ion



The peaks are at different m/e values; the **molecular ion** M (highest m/e) gives the M_r

$$A_r = \frac{\sum(\text{isotope mass} \times \text{abundance})}{\sum \text{abundance}}$$

■ Fragmentation, $[M+1]$ and $[M+2]$



A small $[M+1]$ peak comes from ^{13}C ; an $[M+2]$ peak shows a Cl or Br atom

- **fragments:** the molecule breaks into smaller ions; the mass lost identifies the group (e.g. loss of 15 = CH).
- **$[M+1]$ carbon count:** $n = \frac{100 \times \text{abundance of } [M+1]}{1.1 \times \text{abundance of } M^+}$.
- **$[M+2]$:** a peak two higher $\rightarrow$ Cl (3:1) or Br (1:1).

2 Practice

2.1 State what the molecular ion peak (highest m/e) tells you about a compound. [1]

2.2 A mass spectrum shows a peak at M and another of nearly equal height at $M+2$. What element is present? [1]

3 Exam-style questions

3.1 Chlorine has isotopes ^{35}Cl (75%) and ^{37}Cl (25%). Its relative atomic mass is: [1]

- A 35.0
- B 35.5
- C 36.0

- **D** 37.0
-

3.2 Loss of a fragment of mass 15 from a molecular ion suggests the loss of: [1]

- **A** OH
 - **B** CH
 - **C** C H
 - **D** Cl
-

3.3 A compound has a molecular ion peak M at $m/e = 88$ (abundance 100) and an $[M+1]$ peak (abundance 4.4).

(a) Use $n = \frac{100 \times \text{abundance of } [M+1]}{1.1 \times \text{abundance of } M^+}$ to find the number of carbon atoms. [2]

(b) The compound is a carboxylic acid of M_r 88. Suggest its molecular formula. [1]

3.4 A mass spectrum has peaks at $m/e = 78$ and 80 in a 1:1 ratio. State, with a reason, which halogen is present. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **22.2 Mass spectrometry** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/21 N25 —Q4 (mass spectrometry, structured)
- 9701/22 N25 —Q4 (analysis, structured)

Solutions

2.1 its molecular mass / M_r (the mass of the whole molecule).

2.2 bromine (Br) —the $\text{Br}/^1\text{Br}$ ratio is about 1:1.

3.1 B. $A_r = \frac{(35 \times 75) + (37 \times 25)}{100} = 35.5$.

3.2 B. A loss of 15 is a CH_3 group.

3.3 (a) $n = \frac{100 \times 4.4}{1.1 \times 100} = 4$.

(b) $\text{C}_4\text{H}_8\text{O}_2$ (e.g. butanoic acid).

3.4 bromine; the two peaks two apart in a ~1:1 ratio match the Br and ^1Br isotopes.