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GCSE | A-LEVEL

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AQA 7405

Atomic Structure I

Specification-led notes



SPEC →



CRACK IT →



TEST IT →



DONE

EVERY SPECIFICATION POINT. EXPLAINED. PRACTISED. CHECKED OFF.



SPECIFICATION COVERAGE

3.1.1.1		Fundamental particles and the evolving atomic model
3.1.1.2		Mass number, isotopes, TOF mass spectrometry and mass spectra
3.1.2.1		Relative atomic, molecular and formula mass

Written by an experienced AQA examiner and chemistry teacher

Mapped to AQA Chemistry 7405, version 1.2 (July 2026)



The big picture

THE PROMISE This booklet turns every Atomic Structure I requirement into something you can explain, calculate or interpret in an exam.

SPEC	CRACK IT	TEST IT	DONE
This is your target	Unlock what it actually means	Prove you can do it	Mastered

BOUNDARY Electron configurations and ionisation energies are deliberately saved for Atomic Structure II. Relative mass definitions from 3.1.2.1 are included here because they complete the mass-spectrometry story.

1. How the atomic model changed

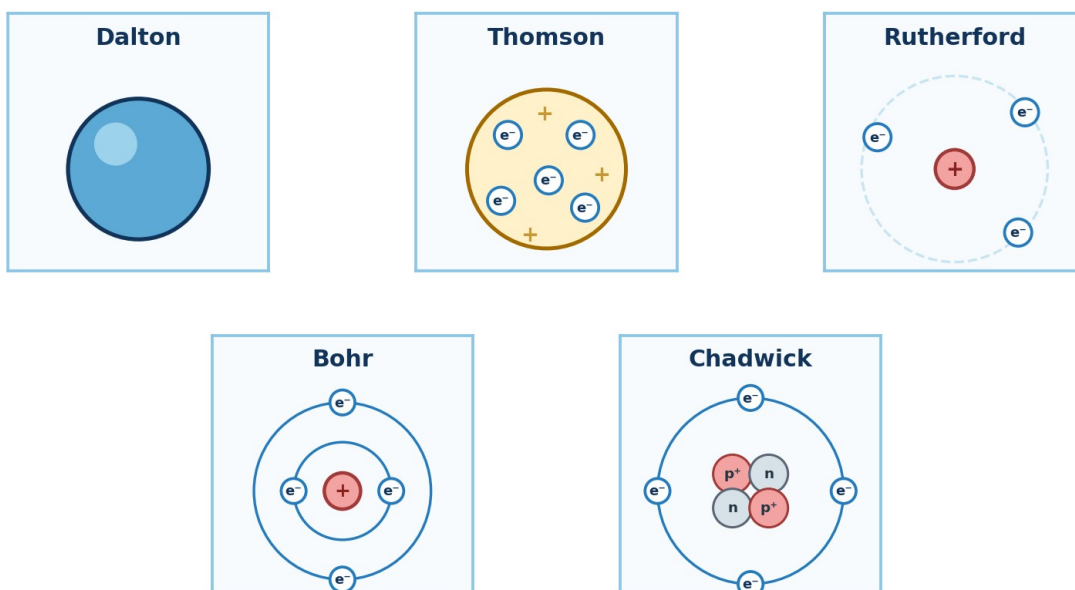
**SPEC 3.1.1.1**

Appreciate that knowledge and understanding of atomic structure has evolved over time.

**CRACK IT**

A scientific model changes when new evidence cannot be explained by the old model. In an exam, link each observation to the conclusion it supports.

The atomic model changed when new evidence appeared



The atomic model changed when new evidence appeared.

Dalton Atoms were pictured as tiny, solid, indivisible spheres.	Thomson The electron showed that atoms were divisible. Electrons were placed in diffuse positive charge.
Rutherford Alpha scattering showed a tiny, dense, positive nucleus and that most of the atom is empty space.	Bohr Electrons were placed in fixed energy levels around the nucleus.

Chadwick

The neutron completed the nuclear model and helped explain isotope masses.

EXAM TRAP Do not merely list the models. State the evidence, then state what that evidence showed.

WORKED EXAMPLE Alpha scattering: observation → inference

QUESTION During Rutherford's alpha-scattering experiment, most alpha particles passed straight through, some were deflected through large angles and a very small number rebounded. State what these observations showed about the atom.

ANSWER

1. Most alpha particles passed straight through → most of the atom is empty space.
2. Some were deflected through large angles and a very small number rebounded → positive charge and most mass are concentrated in a tiny, dense nucleus that is much smaller than the atom.

**TEST IT 1 · QUICK CHECK**

Explain how two observations from alpha scattering changed the model of the atom. [4]



DONE WHEN: You can connect Dalton → Thomson → Rutherford → Bohr → Chadwick using evidence, not just names.

2. Fundamental particles and the atom

**SPEC 3.1.1.1**

Protons, neutrons and electrons: relative charge and relative mass. An atom consists of a nucleus containing protons and neutrons surrounded by electrons.

**CRACK IT**

Particle	Relative charge	Relative mass	Location
Proton	+1	1	Nucleus
Neutron	0	1	Nucleus
Electron	-1	approximately 1/1840	Energy levels / orbitals outside the nucleus

- Almost all atomic mass is concentrated in the nucleus.
- The nucleus is tiny compared with the whole atom.
- A neutral atom has equal numbers of protons and electrons.

MEMORY HOOK Protons are positive. Neutrons are neutral. Electrons are negative and have negligible relative mass.

**TEST IT 2 · QUICK CHECK**

State the relative charge and relative mass of all three particles. Then state where each is found. [6]



DONE WHEN: You can reproduce the particle table from memory and describe the structure of an atom.

3. Mass number, atomic number and ions



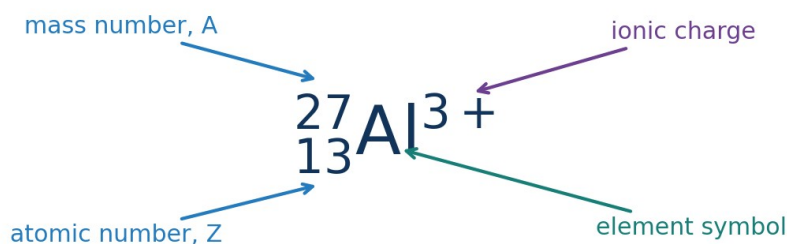
SPEC 3.1.1.2

Mass number (A) and atomic (proton) number (Z). Students should be able to determine the number of fundamental particles in atoms and ions using mass number, atomic number and charge.



CRACK IT

Atomic number, Z	The number of protons in the nucleus. It identifies the element.
Mass number, A	The total number of protons and neutrons in one atom of a particular isotope. It is a whole number.



Reading nuclide notation: mass number, atomic number, symbol and ionic charge.

$$A = Z + \text{number of neutrons}$$

A and Z are whole numbers and have no units. Therefore: neutrons = $A - Z$.

CALCULATING NUMBERS OF SUBATOMIC PARTICLES IN IONS

1. First find the neutral atom: protons = Z; electrons = Z; neutrons = $A - Z$.
2. Positive ion: electrons have been lost, so subtract the charge from Z.
3. Negative ion: electrons have been gained, so add the size of the charge to Z.
4. Only the electron number changes when an ion forms.

WORKED EXAMPLE Finding particle numbers in an ion

QUESTION State the number of protons, neutrons and electrons in $^{56}\text{Fe}^{2+}$. The atomic number of iron is 26.

1. Iron has $Z = 26$, so it contains 26 protons.
2. Neutrons = $56 - 26 = 30$.
3. Start with 26 electrons, then subtract 2 because the ion is $2+$.

ANSWER 26 protons, 30 neutrons and 24 electrons.

EXAM TRAP Work out the neutral atom first. Then subtract electrons for a positive ion or add electrons for a negative ion. This is easy to reverse under pressure.



TEST IT 3 · QUICK CHECK

An ion contains 17 protons, 18 neutrons and 18 electrons. Give its element, mass number and charge.
[3]



DONE WHEN: You can move both ways: notation → particle numbers and particle numbers → notation.

4. Isotopes



SPEC 3.1.1.2

Students should be able to explain the existence of isotopes.



CRACK IT

Isotopes

Atoms of the same element with the same number of protons but different numbers of neutrons.

- Same element means the same atomic number and therefore the same number of protons.
- Different neutron numbers give different mass numbers.
- Neutral atoms of the isotopes have the same number of electrons and the same electron configuration, so they react in the same way.
- Their masses differ, so mass-dependent physical properties can differ.

WORKED EXAMPLE Comparing isotopes

QUESTION Compare neutral atoms of ^{35}Cl and ^{37}Cl . State their numbers of protons, neutrons and electrons, then explain why they have the same chemical properties but different masses. The atomic number of chlorine is 17.

1. ^{35}Cl and ^{37}Cl both contain 17 protons.
2. ^{35}Cl contains 18 neutrons; ^{37}Cl contains 20 neutrons.
3. Both neutral atoms contain 17 electrons and have the same electron configuration, so they react in the same way.

ANSWER Both have 17 protons and 17 electrons; ^{35}Cl has 18 neutrons and ^{37}Cl has 20. Their identical electron configurations make them react in the same way, while their different neutron numbers give them different masses.

DO NOT MIX THESE UP Mass number describes one isotope and is a whole number. Relative atomic mass is a weighted mean for the element and is often not a whole number.



TEST IT 4 · QUICK CHECK

Explain why ^{35}Cl and ^{37}Cl have the same chemical properties but different masses. [3]



DONE WHEN: You can define isotopes and explain both their similarities and their differences.

5. The simple TOF mass spectrometer



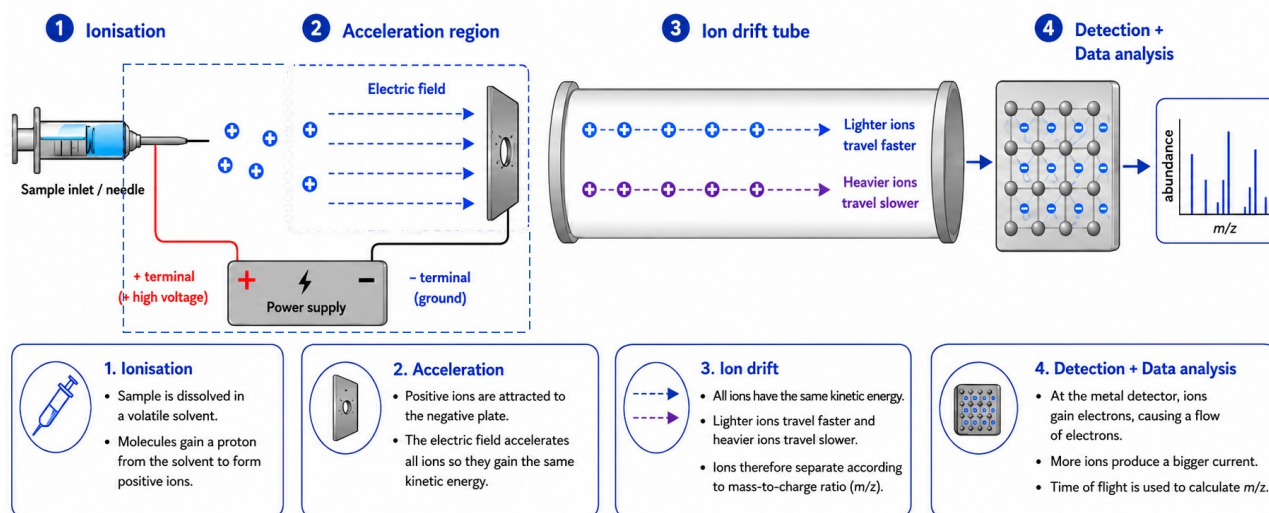
SPEC 3.1.1.2

The principles of a simple time of flight (TOF) mass spectrometer, limited to ionisation, acceleration to give all ions constant kinetic energy, ion drift, ion detection, data analysis.



CRACK IT

Simple TOF Mass Spectrometer



Simple TOF mass spectrometer. The diagram is not to scale.

1 Ionisation Atoms or molecules are converted into positive ions so an electric field can act on them.	2 Acceleration An electric field accelerates the ions so they enter the drift region with constant kinetic energy.
3 Ion drift Ions travel through a field-free tube and separate according to m/z .	4 Detection Positive ions gain electrons at the metal detector. Electron flow produces a current; more ions give a larger current.
5 Data analysis Flight time gives m/z ; current size gives relative abundance. The computer produces a mass spectrum.	

CURRENT AQA FOCUS Learn the five-stage principle and the outcome of each stage. Acceleration is by an electric field, not a magnetic field. Examiners use that distinction to catch students out. The key outcome is constant kinetic energy.

Ionisation context for molecular-mass questions

EXAM-PROOF IONISATION CONTEXT

The specification does not name a particular ionisation technique, but these common ion forms help you interpret molecular-mass questions.

Method	Typical sample	What happens	Common ion
Electrospray	Large or thermally unstable molecules in solution	The molecule gains a proton as solvent evaporates.	$[MH]^+$
Electron impact	Small volatile molecules in the gas phase	A high-energy electron removes an electron from the molecule.	M^+
$M(g) + H^+(g) \rightarrow [MH]^+(g)$			
Electrospray: protonated molecular ion			

$M(g) + e^- \rightarrow M^+(g) + 2e^-$			
Electron impact: molecular ion after one electron is removed			



TEST IT 5 · QUICK CHECK

Put the five TOF stages in order and state what happens at the detector. [4]



DONE WHEN: You can describe the full five-stage TOF sequence and connect flight time/current to the spectrum.

6. Why lower- m/z ions arrive first



SPEC 3.1.1.2

Acceleration gives the ions constant kinetic energy; during ion drift they separate before ion detection and data analysis.



CRACK IT

$$KE = \frac{1}{2}mv^2$$

KE in J; m in kg; v in $m\ s^{-1}$

- If kinetic energy is the same, a lower-mass ion must have a higher velocity.
- Across the same flight distance, the faster ion reaches the detector sooner.
- For ions with equal charge, lower mass means lower m/z . More generally, TOF separates ions according to m/z .
- A $2+$ ion has half the m/z of a $1+$ ion with the same mass.

KEY CHAIN Same kinetic energy + lower m/z → higher speed → shorter flight time.



TEST IT 6 · QUICK CHECK

Two singly charged ions have the same kinetic energy. Explain why the lighter ion reaches the detector first. [3]



DONE WHEN: You can explain arrival order using constant kinetic energy, mass, velocity and flight time.

7. TOF calculations: the calculation toolkit



SPEC 3.1.1.2 + MS 1.1

Students report calculations to an appropriate number of significant figures. The TOF principles link kinetic energy, ion velocity and flight time.

THE ROUTE THROUGH THE CALCULATION There is no single fixed TOF route. Start with the quantity the question asks for and work backwards: target → equation → missing value → next equation.

UNIT-PREFIX REMINDER

WATCH YOUR UNITS TOF equations use SI units: mass in kg, distance in m and time in s. Common conversions: $1\ \mu\text{s} = 1 \times 10^{-6}\ \text{s}$ and $1\ \text{cm} = 1 \times 10^{-2}\ \text{m}$.

Prefix	Symbol	Multiplier
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

EQUATIONS AND UNITS

NON-NEGOTIABLE Learn to rearrange every equation below. If you cannot make each variable the subject before substituting numbers, you will lose TOF calculation marks.

$$KE = \frac{1}{2}mv^2 \rightarrow 2KE = mv^2$$

Multiply both sides by 2 first: $m = 2KE/v^2$ and $v = \sqrt{(2KE/m)}$.

$$v = d/t \quad \text{and} \quad t = d/v$$

v in m s^{-1} ; d in m; t in s

$$\text{mass of one ion, } m = (\text{relative mass} \times 10^{-3}) / N_A$$

m in kg. Use the value of N_A supplied in the question.

$$\text{relative mass} = m \times N_a \times 1000$$

Relative mass has no units. For a singly charged mononuclear ion, this is numerically equal to m/z .

BUILD THE ROUTE FROM THE TARGET

1. Scan the question and identify exactly what is wanted: mass, velocity, time, distance or m/z .
2. Choose an equation containing that unknown and only one other unknown. Rearrange before inserting numbers.
3. Convert every value to SI units: kg, m and s.
4. Use $v = d/t$ first when distance and time are both known. This removes an unknown before you use $KE = \frac{1}{2}mv^2$.
5. If relative mass is given, turn its numerical value into kg mol^{-1} by multiplying by 10^{-3} , then divide by N_a .
6. For a reverse calculation, find the mass of one ion, multiply by N_a and then by 1000.
7. Round only at the end and match the significant figures in the data.

CALCULATOR HABIT Do not start with an equation containing more than one unknown: use the data to remove one unknown first. Keep unrounded values in your calculator and round only the final answer.

Worked TOF calculations

WORKED EXAMPLE Forward calculation: relative mass $\rightarrow$ flight time

QUESTION A singly charged $^{40}\text{Ar}^+$ ion has relative mass 40.0 and kinetic energy $6.00 \times 10^{-16} \text{ J}$. It travels 1.50 m through the flight tube. Using $N_a = 6.022 \times 10^{23} \text{ mol}^{-1}$, calculate its flight time in seconds and microseconds.

1. For Ar^+ with relative mass 40.0: molar mass = $40.0 \text{ g mol}^{-1} = 0.0400 \text{ kg mol}^{-1}$.
2. $m = 0.0400 / (6.022 \times 10^{23}) = 6.642 \times 10^{-26} \text{ kg}$.
3. $v = \sqrt{(2 \times 6.00 \times 10^{-16}) / (6.642 \times 10^{-26})} = 1.34 \times 10^5 \text{ m s}^{-1}$.
4. $t = 1.50 / (1.34 \times 10^5) = 1.12 \times 10^{-5} \text{ s}$.

ANSWER $t = 1.12 \times 10^{-5} \text{ s} = 11.2 \mu\text{s}$

WORKED EXAMPLE Reverse calculation: flight time $\rightarrow$ mass and m/z

QUESTION A singly charged ion has kinetic energy $5.00 \times 10^{-16} \text{ J}$ and travels 1.60 m in $13.0 \mu\text{s}$. Using $N_a = 6.022 \times 10^{23} \text{ mol}^{-1}$, calculate the mass of one ion in kg and hence its m/z .

1. Convert first: $t = 13.0 \times 10^{-6} \text{ s}$ and $d = 1.60 \text{ m}$.
2. $v = d/t = 1.60 / (13.0 \times 10^{-6}) = 1.23 \times 10^5 \text{ m s}^{-1}$.
3. Multiply $KE = \frac{1}{2}mv^2$ by 2, then rearrange: $m = 2KE/v^2 = 6.60 \times 10^{-26} \text{ kg}$.
4. Relative mass = $6.60 \times 10^{-26} \times 6.022 \times 10^{23} \times 1000 = 39.8$.
5. The ion is singly charged, so $m/z = 39.8$.

ANSWER mass of one ion = $6.60 \times 10^{-26} \text{ kg}$; $m/z = 39.8$

TWO-ION SHORTCUT: SEE EXACTLY WHAT CANCELS

SPOT THE TRIGGER Two ions mentioned? Think ratio. Use the shortcut only when the ions have the same kinetic energy and travel the same distance; for a direct m/z comparison, their charges must also be equal. Set the kinetic energies equal, then cancel only quantities that are genuinely the same, such as d^2 . Do not cancel masses, speeds or times.

WORKED EXAMPLE Deriving the two-ion shortcut

QUESTION Two singly charged ions have the same kinetic energy and travel the same distance. Starting from $KE = \frac{1}{2}mv^2$ and $v = d/t$, derive an expression for t_2/t_1 in terms of m_2 and m_1 . State clearly what cancels and what does not.

1. Set the kinetic energies equal: $\frac{1}{2}m_1v_1^2 = \frac{1}{2}m_2v_2^2$.
2. Multiply both sides by 2. The halves vanish: $m_1v_1^2 = m_2v_2^2$.
3. Substitute $v = d/t$: $m_1(d/t_1)^2 = m_2(d/t_2)^2$.
4. The distance is the same, so d^2 cancels: $m_1/t_1^2 = m_2/t_2^2$.
5. The masses and speeds are different, so they cannot be cancelled.
6. Cross-multiply and rearrange: $t_2^2/t_1^2 = m_2/m_1$.
7. Take the positive square root because flight times are positive.

ANSWER $t_2/t_1 = \sqrt{(m_2/m_1)}$

WHY NOT CALCULATE BOTH SPEEDS SEPARATELY? Unless kinetic energy or one speed is known, there is more than one unknown. The ratio method compares the ions without pretending those missing values are known.

WORKED EXAMPLE Comparing $^{24}\text{Mg}^+$ and $^{26}\text{Mg}^+$

QUESTION Singly charged $^{24}\text{Mg}^+$ and $^{26}\text{Mg}^+$ ions have the same kinetic energy and travel the same distance. Which ion reaches the detector first, and what is the ratio $t(^{26}\text{Mg}^+)/t(^{24}\text{Mg}^+)$?

1. Let ion 1 be $^{24}\text{Mg}^+$ and ion 2 be $^{26}\text{Mg}^+$.
2. $t_2/t_1 = \sqrt{(26/24)} = 1.0408$.
3. The heavier ion takes longer, so $^{24}\text{Mg}^+$ arrives first.

ANSWER $t(^{26}\text{Mg}^+)/t(^{24}\text{Mg}^+) = 1.041$; about 4.1% longer

**TEST IT 7 · QUICK CHECK**

A singly charged ion takes 13.0 μs to travel 160 cm with $KE = 5.00 \times 10^{-16}$ J. Calculate m/z . Use $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$. [7]



DONE WHEN: You can choose the method, convert units, complete forward/reverse calculations and justify the two-ion shortcut.

8. Reading elemental mass spectra

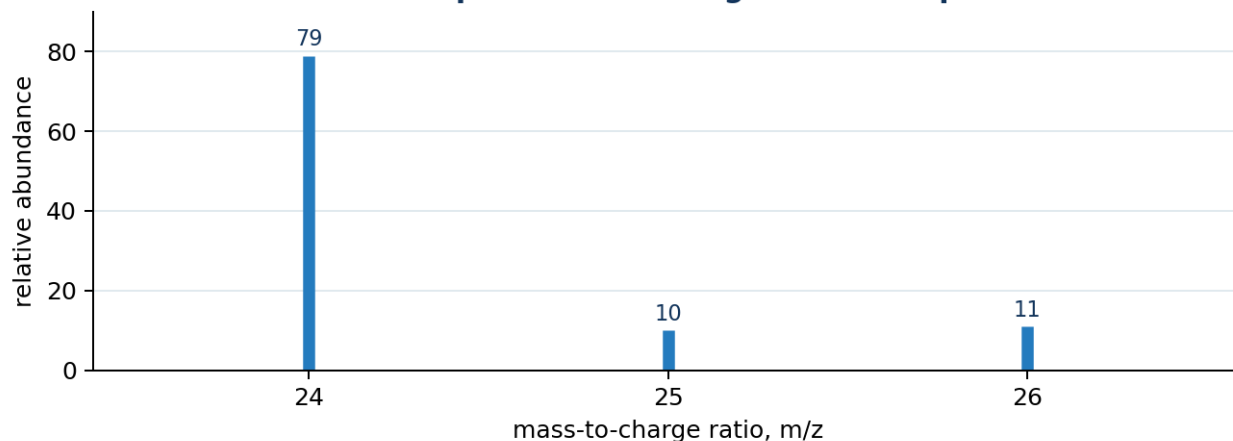
**SPEC 3.1.1.2**

The mass spectrometer gives accurate information about relative isotopic mass and relative abundance. Mass spectrometry can identify elements. Students should be able to interpret simple mass spectra of elements.

**CRACK IT**

- x-axis: mass-to-charge ratio, m/z .
- y-axis: relative abundance.
- Peak position tells you the m/z of an ion.
- Peak height or intensity tells you its relative abundance.
- For singly charged mononuclear ions, m/z is numerically equal to relative isotopic mass.

Mass spectrum of a magnesium sample



Example elemental mass spectrum: peak position gives m/z; peak height gives relative abundance.

IDENTIFY THE ELEMENT Use the isotope pattern and the calculated A_r . The weighted mean should match the element's periodic-table value.



TEST IT 8 • QUICK CHECK

A spectrum has peaks at m/z 24, 25 and 26 with relative abundances 79, 10 and 11. Calculate A_r and identify the element. [4]



DONE WHEN: You can read both axes, interpret peak positions/heights and use a spectrum to identify an element.

9. Calculating relative atomic mass



SPEC 3.1.1.2 + MS 1.2

Students calculate weighted means and calculate relative atomic mass from isotopic abundance, limited to mononuclear ions.



CRACK IT

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

A_r has no units. If abundances are percentages, the denominator is 100.

WORKED EXAMPLE Type 1: every mass and abundance is known

QUESTION An element has isotopes of relative isotopic mass 28, 29 and 30 with relative abundances 92%, 5% and 3% respectively. Calculate its relative atomic mass, A_r .

1. Multiply each isotopic mass by its abundance.
2. Add the products and divide by the total abundance.
3. For masses 28, 29, 30 with 92%, 5%, 3%: $[(28 \times 92) + (29 \times 5) + (30 \times 3)]/100$.

ANSWER $A_r = 28.11$

WORKED EXAMPLE Type 2: one isotope mass is unknown

QUESTION An element has two isotopes. The isotope of mass number 63 has an abundance of 69%; the other isotope has an abundance of 31%. The element has $A_r = 63.62$. Calculate the mass number of the second isotope.

1. Write $63.62 = [63(69) + 31x]/100$.
2. Multiply by 100: $6362 = 4347 + 31x$.
3. Rearrange: $x = 65$.

ANSWER The second isotope has mass number 65.

WORKED EXAMPLE Type 3: two abundances are unknown

QUESTION An element has isotopes of mass number 24, 25 and 26. The mass-24 isotope has an abundance of 79.0% and the element has $A_r = 24.32$. Calculate the abundances of the mass-25 and mass-26 isotopes.

1. Mass 24 has abundance 79%. Let mass 25 have abundance $x\%$.
2. Mass 26 must have abundance $100 - 79 - x = 21 - x$.
3. $24.32 = [24(79) + 25x + 26(21 - x)]/100$.
4. $2432 = 2442 - x$, so $x = 10$.

ANSWER Mass 25 = 10%; mass 26 = 11%.

SENSE CHECK A weighted mean must lie between the lightest and heaviest isotope masses and should sit closest to the most abundant isotope.

EXAM TRAP For three isotopes, the final abundance is $100 - \text{known abundance} - x$. Do not use $100 - x$ because the known abundance has already been counted.

**TEST IT 9 · QUICK CHECK**

An element has isotopes 24, 25 and 26. Mass 24 is 79.0% and $A_r = 24.32$. Find the other two abundances. [5]



DONE WHEN: You can solve all three A_r question types and check that the answer is chemically sensible.

10. Relative molecular mass from mass spectra

**SPEC 3.1.1.2**

Mass spectrometry can be used to determine relative molecular mass.

**CRACK IT**

Molecular-ion peak, M^+	The peak from the intact molecule after one electron has been removed. For a singly charged ion, its m/z gives M_r .
Base peak	The tallest peak. It represents the most abundant ion and is not automatically the molecular ion.

electron impact: $M_r = m/z$ of M^+

The intact molecular ion is singly charged.

electrospray: $M_r = m/z$ of $[MH]^+ - 1$

The protonated molecule is singly charged.

EXAM TRAP Do not choose the tallest peak just because it is tallest. Use the peak identified as the intact molecular or protonated molecular ion.



TEST IT 10 · QUICK CHECK

A molecule gives $[MH]^+$ at m/z 151. Find M_r . A different spectrum has a base peak at 43 and M^+ at 72. Find M_r . [4]



DONE WHEN: You can distinguish the base peak from the molecular-ion peak and extract M_r from M^+ or $[MH]^+$.

11. Relative masses: the definitions and the language



SPEC 3.1.2.1

Relative atomic mass and relative molecular mass in terms of ^{12}C . The term relative formula mass will be used for ionic compounds. Students should be able to define relative atomic mass (A_r) and relative molecular mass (M_r).



CRACK IT

Relative isotopic mass	The mass of an atom of one isotope compared with one-twelfth of the mass of a carbon-12 atom. No units.
Relative atomic mass, A_r	The weighted mean mass of an atom of an element compared with one-twelfth of the mass of a carbon-12 atom. No units.
Relative molecular mass, M_r	The mean mass of a molecule compared with one-twelfth of the mass of a carbon-12 atom. No units.
Relative formula mass	The sum of the A_r values in one formula unit. AQA uses this term for ionic compounds. No units.

$$M_r \text{ or relative formula mass} = \Sigma(A_r \times \text{number of each atom})$$

Use M_r for molecules and relative formula mass for ionic compounds. Do not attach units.

WORKED EXAMPLE Choosing M_r or relative formula mass

QUESTION Calculate M_r for CO_2 and the relative formula mass of NaCl using A_r values $\text{C} = 12.0$, $\text{O} = 16.0$, $\text{Na} = 23.0$ and $\text{Cl} = 35.5$. State which term applies to each substance and whether either answer has units.

- CO_2 consists of molecules: $M_r = 12.0 + 2(16.0) = 44.0$.
- NaCl is ionic: relative formula mass = $23.0 + 35.5 = 58.5$.
- Neither relative value has units.

ANSWER $M_r(\text{CO}_2) = 44.0$; relative formula mass(NaCl) = 58.5

DEFINITION PRECISION For A_r , include weighted mean. For both definitions, compare with one-twelfth of the mass of a carbon-12 atom.



TEST IT 11 · QUICK CHECK

Define A_r and M_r exactly, then calculate the relative formula mass of MgCl_2 using $\text{Mg} = 24.3$ and $\text{Cl} = 35.5$. [6]



DONE WHEN: You can define A_r and M_r precisely, choose M_r versus relative formula mass and calculate either without adding units.



Final mastery check

THE RULE Tick a statement only when you can do it without looking back at the notes.

☐	Explain how evidence changed the atomic model.
☐	State the relative charges, relative masses and locations of protons, neutrons and electrons.
☐	Use A, Z and charge to calculate particle numbers in atoms and ions.
☐	Define isotopes and explain their chemical and physical similarities/differences.
☐	Describe all five TOF stages and explain the detector current.
☐	Explain why lower- m/z ions arrive first.
☐	Choose equations and complete forward, reverse and two-ion TOF calculations in SI units.
☐	Interpret simple elemental spectra and identify an element.
☐	Solve all three A_r calculation types.
☐	Determine M_r from M^+ or $[MH]^+$ and distinguish the molecular ion from the base peak.
☐	Define relative isotopic mass, A_r and M_r and use relative formula mass correctly.



TEST IT answers

USE THESE PROPERLY Attempt each TEST IT question first. Then compare your answer with the chemistry below and return to the exact specification point if anything is missing.

TEST IT	CHECK ANSWER
1	Most alpha particles passed straight through, so most of the atom is empty space. Some were deflected through large angles and a very small number rebounded, so positive charge and most mass are concentrated in a tiny, dense nucleus.
2	Proton: charge +1, relative mass 1, nucleus. Neutron: charge 0, relative mass 1, nucleus. Electron: charge -1, relative mass approximately 1/1840, in energy levels / orbitals outside the nucleus.
3	17 protons identifies chlorine. Mass number = 17 + 18 = 35. There is one more electron than proton, so the charge is -1: $^{35}\text{Cl}^-$.
4	Both neutral atoms have 17 electrons and the same electron configuration, so they react in the same way. They have different neutron numbers, so their masses differ.
5	Ionisation → acceleration → ion drift → detection → data analysis. At the detector, positive ions gain electrons. The resulting electron flow produces a current; more ions produce a larger current.
6	At the same kinetic energy, the lighter ion must travel faster because $\text{KE} = \frac{1}{2}mv^2$. Across the same distance, the faster ion has the shorter flight time and reaches the detector first.
7	$t = 13.0 \times 10^{-6} \text{ s}$; $d = 1.60 \text{ m}$; $v = d/t = 1.23 \times 10^5 \text{ m s}^{-1}$; $m = 2\text{KE}/v^2 = 6.60 \times 10^{-26} \text{ kg}$; relative mass = $m \times N_A \times 1000 = 39.8$. For a singly charged ion, $m/z = 39.8$.
8	$A_r = [24(79) + 25(10) + 26(11)]/100 = 24.32$. The element is magnesium.
9	Let the abundance of mass 25 be $x\%$. The abundance of mass 26 is $(21 - x)\%$. Solving $24.32 = [24(79) + 25x + 26(21 - x)]/100$ gives mass 25 = 10.0% and mass 26 = 11.0%.
10	For $[\text{MH}]^+$ at m/z 151, $M_r = 151 - 1 = 150$. For M^+ at m/z 72, $M_r = 72$; the base peak at 43 is irrelevant to M_r .
11	A_r is the weighted mean mass of an atom of an element compared with one-twelfth of the mass of a carbon-12 atom. M_r is the mean mass of a molecule on the same scale. Relative formula mass(MgCl_2) = $24.3 + 2(35.5) = 95.3$. Relative masses have no units.