

Exercise walk-through

# 1.2.1

## Mass spectra, orbitals and ionisation evidence

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Pearson Edexcel · International A-Level · Chemistry

## What does a jump establish?

### Your turn

Three successive ionisation energies are close; the fourth is much larger. What follows from the jump alone?

- A. Three outer electrons; period still unknown
- B. Period 3; group still unknown
- C. Four outer electrons
- D. The atom has four occupied shells

## Compare fuels using their whole pathway

- 1** Cracking makes smaller hydrocarbons including alkenes; balance atoms in proposed products.
- 2** CO reduces oxygen transport; nitrogen/sulfur oxides can contribute to acid pollution.
- 3** Bioethanol growth can absorb  $\text{CO}_2$ , but processing and transport still emit. Hydrogen production also matters.

## Final transfer: a biased measurement

### Your turn

A 0.480 g sample produces 0.240 dm<sup>3</sup> of gas in a 1:1 reaction. Use  $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ . A leak makes gas volume too low. What happens to inferred sample molar mass?

- A. It is too high
- B. It is too low
- C. It stays correct
- D. It becomes negative

## Exercises 2.1·2.3

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**2.1** An atom has  $Z = 16$  and  $A = 34$ . State its proton, neutron and electron counts, then give the electron count of its  $2-$  ion. [3]

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**2.2** A sample gives two ion peaks:  $m/z = 20$  and  $40$ . Explain why these peaks alone do not prove that the sample contains two isotopes. Give one alternative interpretation and one further observation needed. [3]

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**2.3** Give the numbers of orbitals and maximum electrons in an s, a p and a d subshell. State the maximum total electrons in quantum shell  $n = 3$ . [4]

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**2.1** 16 protons and 18 neutrons, 16 electrons in the neutral atom, 18 electrons in the  $2-$  ion. The nucleus is unchanged by electron gain.

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**2.2** The instrument separates  $m/z$ , not mass alone. A single mass-40 isotope could form both  $1+$  and  $2+$  ions. Determine the ion charges independently, or obtain a charge-resolved spectrum before assigning two isotope masses. The peak pair alone cannot distinguish these possibilities.

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**2.3** Give the numbers of orbitals and maximum electrons in an s, a p and a d subshell. State the maximum total electrons in quantum shell  $n = 3$ . [4]

**2.3** s: one orbital/two electrons; p: three/six; d: five/ten. Shell  $n = 3$  contains 3s, 3p and 3d, with maximum  $2 + 6 + 10 = 18$  electrons. A single d orbital holds two, not ten.

## Exercises 3.1·3.3

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**3.1** Write electron configurations for K, Br and  $\text{Cu}^+$ , using the atomic numbers 19, 35 and 29. Explain why forming  $\text{Cu}^+$  does not leave a 4s electron. [4]

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**3.2** An element has successive ionisation energies whose  $\log_{10}$  values rise from 3.0 to 4.2 between the second and third removals. Calculate the energy ratio and infer the outer-electron count. Write the third-ionisation equation and state its energy sign. [5]

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**3.3** Two successive elements in Period 3 have outer configurations  $3s^2$  and  $3s^23p^1$ . Explain

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**3.1** K:  $[\text{Ar}]4s^1$ ; Br:  $[\text{Ar}]3d^{10}4s^24p^5$ ;  $\text{Cu}^+$ :  $[\text{Ar}]3d^{10}$ . Neutral copper is  $[\text{Ar}]3d^{10}4s^1$ ; its 4s electron is removed first when the positive ion forms.

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**3.2** Difference in logarithms  $= 4.2 - 3.0 = 1.2$ , so energy ratio  $= 10^{1.2} = 15.8$ . A large

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**3.3** The 3p electron is higher in energy and more easily removed than a 3s electron; this outweighs the increase in nuclear charge across Mg to Al. For P to S, removal remains from 3p; sulfur has the first paired 3p electrons, whose repulsion makes one easier to remove despite the greater nuclear charge. An extra inner shell is not added in either comparison.

## Exercise 3.4

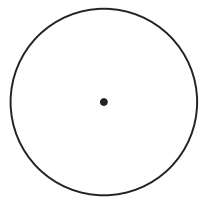
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**3.4** Draw the shapes of an s and a p orbital, indicating the nucleus. State the maximum number of electrons in either orbital. [3]

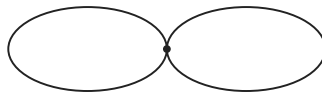
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**3.4**



s orbital: spherical



one p orbital: two lobes

P: [Ne]3s<sup>2</sup>3p<sup>3</sup>



3s

three 3p orbitals

S adds ↓ to one 3p box.

Spherical s region; two-lobed p region about the nucleus; either orbital holds up to two electrons with opposite spins. The electron-box panel is additional occupancy teaching, not a third spatial orbital.

## Exercises 3.5·3.6

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**3.5** Sodium and potassium have outer configurations  $3s^1$  and  $4s^1$ . Explain their similar

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**3.6** A molecular ion of charge  $2+$  gives  $m/z = 29$ . Which formula fits its mass:  $C_3H_6O$ ,  $C_2H_6O$  or  $C_4H_{10}O$ ? Use  $C = 12$ ,  $H = 1$ ,  $O = 16$ . Explain why this evidence does not identify one unique structure. [3]

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**3.5** Both have one outer electron and tend to form  $1+$  ions, giving similar chemical behaviour. Potassium's outer electron is further from the nucleus with greater shielding by occupied inner shells; these outweigh its higher nuclear charge, so it is more easily removed.

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**3.6** Relative molecular mass  $= 29 \times 2 = 58$ .  $C_3H_6O$  has mass  $3 \times 12 + 6 + 16 = 58$ ; the other candidates are 46 and 74. Structural isomers such as propanal and propanone share  $C_3H_6O$  and the same molecular mass, so further structural evidence is needed.

## Exercise 3.7

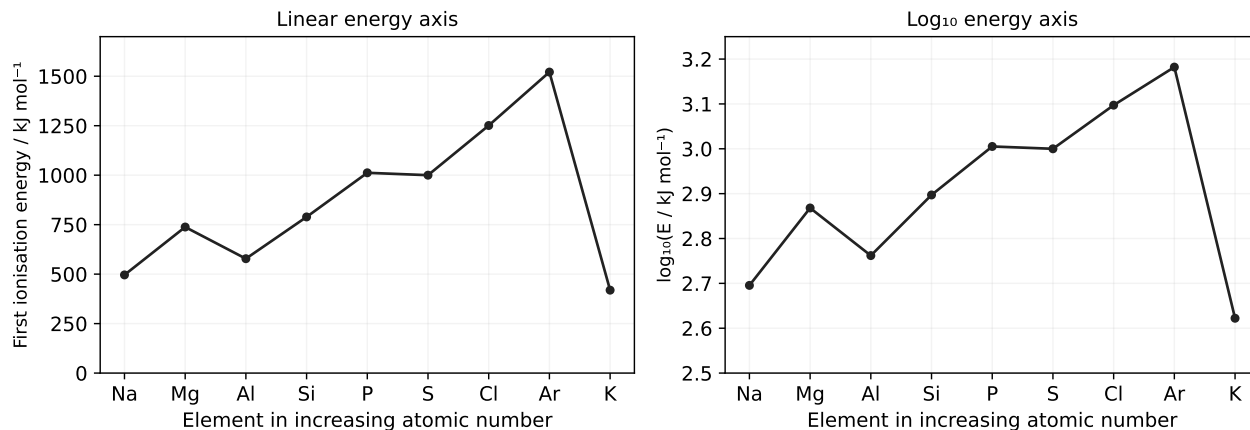
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**3.7** The first ionisation energies in  $\text{kJ mol}^{-1}$  are Na 496, Mg 738, Al 578, Si 789, P 1012,

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Award labelled axes/consistent scales, correct linear points, and correct logarithmic points. K begins a new occupied outer shell, increasing distance and shielding relative to Ar; the large decrease after a noble-gas maximum is part of the repeating periodic pattern. A logarithmic axis preserves order but compresses large values.