Exercise walk-through

1.1
Atoms, elements, compounds and mixtures (4.1.1.1–4.1.1.4)

AQA · GCSE · Chemistry

How evidence changed the model of the atom

- **Around 1800**, John Dalton described atoms as tiny spheres that could not be divided.
- **In 1897**, J. J. Thomson discovered the **electron**, a tiny negative particle inside atoms. So atoms must have parts. He proposed the **plum pudding model** : a ball of positive charge with negative electrons scattered through it.
- **In 1909**, Hans Geiger and Ernest Marsden, working for Ernest Rutherford in Manchester, fired positive alpha particles at a sheet of gold foil only a few hundred atoms thick.

Building the periodic table; metals and non-metals

- In the early 1800s, chemists arranged the elements in order of atomic weight, since protons were not yet known.
- These early tables put some elements next to others with very different properties.
- **Mendeleev** solved this in two ways: he left gaps for elements not yet discovered, and in a few places he changed the order to keep elements with similar properties in the same **group**.
- When gallium (1875) and germanium (1886) were found with the properties he had predicted, scientists accepted his table.

Groups 0, 1 and 7

- **Group 0.** Each **noble gas** , such as helium, neon or argon, is very unreactive because its outer shell is full.
- The noble gases exist as single atoms.
- Their boiling points increase down the **group** as the **relative atomic mass** increases.
- **Group 1.** Each **alkali metal** has one outer **electron** and forms a $+1$ ion.

$4\mathrm{Li} + \mathrm{O_2} \rightarrow 2\mathrm{Li_2O}$ $2\mathrm{Na} + \mathrm{Cl_2} \rightarrow 2\mathrm{NaCl}$ $2\mathrm{K} + 2\mathrm{H_2O} \rightarrow 2\mathrm{KOH} + \mathrm{H_2}$

Exercises 2.1·2.2

2.1 An atom has atomic number 17 and mass number 37. Give the numbers of protons, neutrons and electrons. [3]

$^{37}_{17}\mathrm{Cl}$

2.2 Name the separation method for: (a) sand from water; (b) ethanol from water. [2]



(a) sand + water (b) ethanol + water

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2.1 17 protons; $37 - 17 = 20$ neutrons; 17 electrons.

2.2 Name the separation method for: (a) sand from water; (b) ethanol from water. [2]

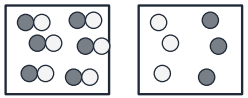


(a) sand + water (b) ethanol + water

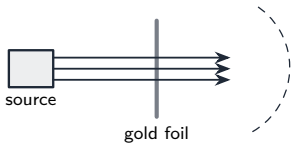
2.2 (a) Filtration; (b) fractional distillation – different boiling points.

Exercises 2.3·3.1

2.3 State two differences between a compound and a mixture. [2]

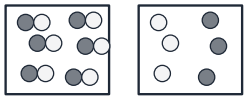


3.1 Describe how the model of the atom changed after the alpha particle scattering experiment, and give two conclusions from that experiment. [5]



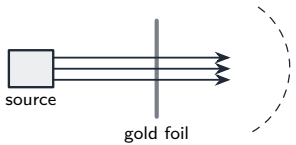
Exercises 2.3·3.1

2.3 State two differences between a compound and a mixture. [2]



2.3 A compound has its elements chemically combined in fixed proportions; a mixture's substances are not combined and keep their own properties. A compound needs a chemical reaction to separate; a mixture separates by physical processes.

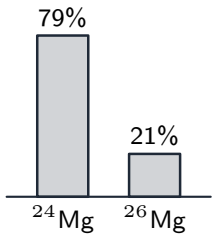
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3.1 The plum pudding model was replaced by the nuclear model: most of the mass and all positive charge concentrated in a tiny nucleus at the centre; most of the atom is empty space, since most alpha particles passed straight through; the few deflected showed the nucleus repelled positive charges.

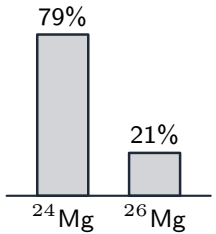
Exercise 3.2

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3.2 $\mathrm{Ar} = (24 \times 79 + 26 \times 21) \div 100 = (1896 + 546) \div 100 = 2442 \div 100 = 24.42$.

Setup for exercise 3.3

3.3 A mixture contains salt, sand and water. Plan how to obtain pure, dry salt. [5]



3.4 Explain why O_2 is an element but H_2O is a compound. State the numbers of H and O atoms in $3H_2O$. Balance $Al + O_2 \rightarrow Al_2O_3$ without changing any formula. [5]



3.5 Calcium-40 has atomic number 20; chlorine-37 has atomic number 17. Give proton, neutron and electron numbers for Ca^{2+} and Cl^-. Explain why ion formation does not change element identity. [5]

$^{40}_{20}Ca^{2+}$ $^{37}_{17}Cl^-$

3.6 A model uses atom radius 0.1 nm. Convert this to metres. Estimate how many atoms of this size fit side by side along 1 mm, ignoring gaps. If the atom's radius is enlarged to 1 m, give an upper comparison radius for its nucleus using the less-than-one-ten-thousandth condition. [5]

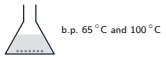


Exercise 3.3

3.7 Draw complete shell diagrams for neutral chlorine and calcium atoms (atomic numbers 17 and 20). Give both numerical arrangements. [4]



3.8 A mixture contains an insoluble powder and two miscible liquids boiling at 65 °C and 100 °C. Plan how to collect the powder dry and then separate the liquids. Explain why filtering alone cannot recover the liquid with the lower boiling point. [4]



3.9 *(HT)* Zinc is placed in copper sulfate solution. Write the zinc oxidation and copper-ion reduction half-equations, then the overall ionic equation. Identify the spectator ion and check the net charge. [5]



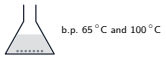
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3.3 Add water and stir to dissolve the salt; filter – the sand is insoluble and stays on the paper; the filtrate is salt solution; evaporate most of the water, then leave to crystallise; dry the crystals on filter paper/in a warm oven.

3.4 O_2 contains only oxygen atoms, whereas H_2O contains two chemically combined elements in a fixed ratio. $3H_2O$ contains 6 H and 3 O atoms. $4Al + 3O_2 \rightarrow 2Al_2O_3$.

Full solution on next slide

Full solution 3.3 (1/3)

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3.4 O_2 contains only oxygen atoms, whereas H_2O contains two chemically combined elements in a fixed ratio. $3H_2O$ contains 6 H and 3 O atoms. $4Al + 3O_2 \rightarrow 2Al_2O_3$. Changing subscripts changes the substance.

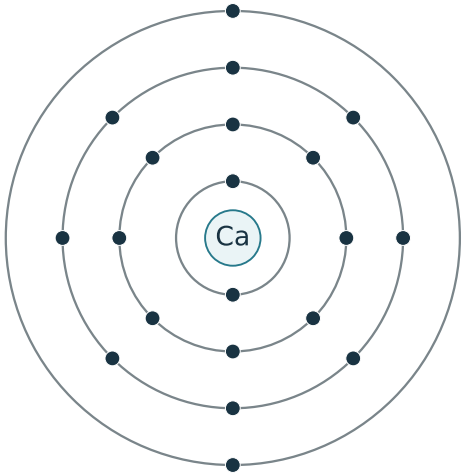
3.5 Ca^{2+}: 20 p, 20 n, 18 e; Cl^{-}: 17 p, 20 n, 18 e. Proton number is unchanged; only electrons change. A positive charge means fewer electrons, not added protons.

3.6 0.1 nm $= 1 \times 10^{-10}$ m. Diameter $= 2 \times 10^{-10}$ m; count $= (1 \times 10^{-3})/(2 \times 10^{-10}) = 5 \times 10^{6}$. Enlarged nucleus radius is less than 1/10000 m = 0.1 mm; this is an upper comparison, not exact equality.

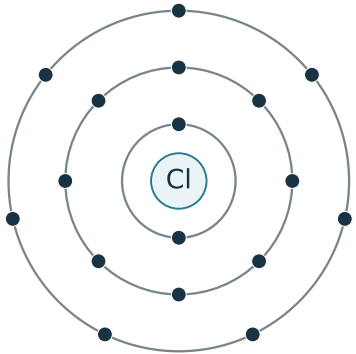
3.7 Chlorine: three shells with 2,8,7 electrons. Calcium: four shells with 2,8,8,2. Count every electron; the first-twenty model applies.

Calcium: 20 electrons **Chlorine: 17 electrons**

Full solution 3.3 (2/3)



2,8,8,2



2,8,7

Full solution 3.3 (3/3)

Neutral atoms • dots are electrons • shell sizes are schematic, not to scale

3.8 Filter to collect insoluble powder; wash with a suitable small amount of solvent and dry it. Fractionally distil the filtrate using the liquids' different boiling points; lower-boiling fraction is collected first. Both dissolved/miscible liquid components pass through filter paper, so filtration cannot separate them. Accept appropriate practical detail without assuming perfect purity from one reading.

3.9 Oxidation: $Zn \rightarrow Zn^{2+} + 2e^{-}$. Reduction: $Cu^{2+} + 2e^{-} \rightarrow Cu$.

Combined ionic equation: $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$. Sulfate is unchanged and omitted as spectator; total charge is +2 on each side and atoms are conserved.