

1.1 Atoms, elements, compounds and mixtures

Name: _____ Class: _____ Date: _____

Total: 48 marks**KEY WORDS** atom • isotope • relative atomic mass

Objective

Distinguish atoms, elements, compounds and mixtures, separate mixtures, and count protons, neutrons and electrons. Original questions for spec statements 4.1.1.1–4.1.1.7.

1 Key knowledge and worked examples

Atom – the smallest part of an element that can exist. **Element** – one type of atom, with a chemical symbol. **Compound** – two or more elements chemically combined in **fixed proportions**; only chemical reactions separate it. **Mixture** – substances not chemically combined; each keeps its properties.

Separation	Separates
filtration	insoluble solid from liquid
crystallisation	dissolved solid from solution
simple distillation	liquid from a dissolved solid
fractional distillation	liquids with different boiling points
chromatography	soluble substances in a mixture

Atom model timeline: indivisible sphere → electron discovered → **plum pudding** → alpha scattering → **nuclear model** → **Bohr orbits** → **proton** → **Chadwick's neutron**.

particle	mass	charge
proton	1	+1
neutron	1	0
electron	negligible	–1

Atomic number = protons = electrons (in an atom). **Mass number** = protons + neutrons. **Isotopes** – same element, different neutrons. **Ar** = $\Sigma(\text{mass number} \times \% \text{ abundance}) \div 100$. **Electronic structure** fills lowest levels first: Na = 2,8,1.

Worked example (2 marks). Chlorine: 75 % Cl-35 and 25 % Cl-37. Calculate Ar.

$$\text{Ar} = (35 \times 75 + 37 \times 25) \div 100 = (2625 + 925) \div 100 = 35.5.$$

2 Practice

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

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

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

3 Exam-style questions

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

3.2 A simplified magnesium sample contains only isotopes 24 (79 %) and 26 (21 %). Calculate its relative atomic mass. [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 $3\text{H}_2\text{O}$. Balance $\text{Al} + \text{O}_2 \rightarrow \text{Al}_2\text{O}_3$ 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]

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]

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]

Solutions

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

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

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.

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.

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

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.

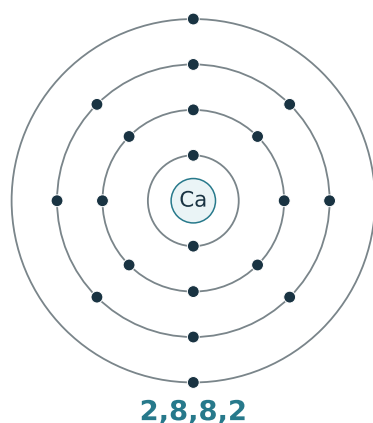
3.4 O_2 contains only oxygen atoms, whereas H_2O contains two chemically combined elements in a fixed ratio. $3\text{H}_2\text{O}$ contains 6 H and 3 O atoms. $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$. Changing subscripts changes the substance.

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

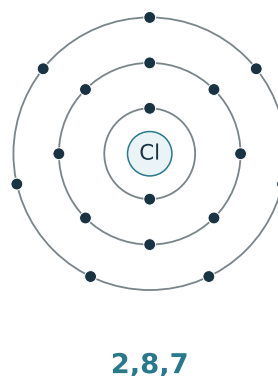
3.7 Chlorine: three shells with 2,8,7 electrons. Calcium: four shells with 2,8,8,2. Count every electron; the first-twenty model applies.

Calcium: 20 electrons



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

Chlorine: 17 electrons



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.