AQA GCSE Chemistry: atomic structure and the periodic table worksheets with answers

How to use this worksheet

This worksheet covers topic 1 of AQA GCSE Chemistry (8462), Atomic structure and the periodic table, which is also topic 1 of the chemistry part of Combined Science: Trilogy (8464). The questions are grouped into seven sets that follow the order of the specification. They are numbered continuously, carry marks like an exam paper, and total 61 marks, which is roughly the length of one paper's worth of questions on this topic.

Work through one set at a time without looking at the answers. Use a periodic table for atomic numbers and relative atomic masses. Then mark your own work against the answer block that follows each set: the answers give the mark points an examiner would look for, so tick each point you have made rather than just checking the final value. Where a question says "explain", you need a reason, not just a statement; where it says "calculate", show your working, because method marks are awarded even if the final answer is wrong. Set 7 (transition metals) is for students taking separate Chemistry only; it is not examined in Trilogy.

> **Exam tip.** In this topic the most common lost marks are: forgetting that a compound contains two or more *different* elements chemically bonded; mixing up atomic number and mass number; and describing a trend without explaining it. When asked why reactivity changes down a group, the answer always comes back to the distance of the outer electron from the nucleus and the shielding by inner shells.

Set 1: atoms, elements, compounds and mixtures

1. All substances are made of atoms.

(a) State what is meant by an **element**. (1 mark)

(b) State what is meant by a **compound**. (1 mark)

(c) State **one** way in which a mixture differs from a compound. (1 mark)

2. Sodium reacts with chlorine to form sodium chloride.

(a) Write a word equation for this reaction. (1 mark)

(b) Write a balanced symbol equation for this reaction. (1 mark)

3. For each of the following, name the most suitable physical process for separating the mixture. (4 marks)

(a) Sand from a mixture of sand and water.

(b) Pure water from sea water.

(c) Ethanol from a mixture of ethanol and water (ethanol boils at 78 °C, water at 100 °C).

(d) The different coloured dyes in a sample of black ink.

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Answers to Set 1 (9 marks)

1. (a) A substance made of only one type of atom (1). (b) A substance made of two or more different elements chemically combined (bonded) in fixed proportions (1). (c) Any one of: the substances in a mixture are not chemically bonded; a mixture can be separated by physical processes; the proportions in a mixture can vary; the substances in a mixture keep their own properties (1).

2. (a) sodium + chlorine → sodium chloride (1). (b) $2Na + Cl_2 \rightarrow 2NaCl$ (1). The mark is for the correct formulae *and* balancing. A common error is to write Cl instead of Cl_2: chlorine is a diatomic gas.

3. (a) Filtration (1). Sand is insoluble, so it is trapped by the filter paper while water passes through. (b) Simple distillation (1). The water is boiled off and the vapour condensed; the salts stay behind. (c) Fractional distillation (1). The two liquids are miscible and have different boiling points, so the fractionating column lets the lower-boiling ethanol vapour pass while water condenses back. (d) Chromatography (1). The dyes travel different distances up the paper because they have different solubilities in the solvent and different attractions to the paper.

Set 2: the model of the atom and its development

4. Early in the nineteenth century, John Dalton described atoms as tiny solid spheres that could not be divided. In 1897 J. J. Thomson discovered the electron, and in 1904 he proposed the plum pudding model.

Describe the plum pudding model of the atom. (2 marks)

5. In the alpha particle scattering experiment, a thin sheet of gold foil was bombarded with alpha particles, which are positively charged. Most of the alpha particles passed straight through the foil, a small number were deflected through large angles, and a very few bounced back towards the source.

Explain how each of these three observations led to the nuclear model of the atom. (3 marks)

6. The nuclear model was later refined.

(a) State what Niels Bohr added to the nuclear model. (1 mark)

(b) State what James Chadwick discovered, about twenty years after Bohr's work. (1 mark)

7. Give the reason why scientific models of the atom have changed over time. (1 mark)

Answers to Set 2 (8 marks)

4. The atom is a ball (sphere) of positive charge (1) with negatively charged electrons embedded in it (1). The name comes from the picture of raisins (the electrons) scattered through a pudding (the positive charge). It replaced Dalton's indivisible sphere because the electron showed that atoms contain smaller particles.

5. Most alpha particles passed straight through, so most of the atom is empty space (1). Some were deflected, so the centre of the atom carries a positive charge, which repels the positive alpha particles (1). A very few bounced straight back, so the mass of the atom is concentrated in a very small, dense centre, the nucleus (1). Together these results replaced the plum pudding model, in which the positive charge was spread through the whole atom and would not have been able to

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turn an alpha particle round.

6. (a) Bohr proposed that the electrons orbit the nucleus at specific (fixed) distances, in energy levels or shells (1). His theoretical calculations agreed with experimental observations. (b) Chadwick provided evidence for the existence of the neutron, a particle in the nucleus with no charge (1). This explained why the mass of a nucleus is greater than the mass of its protons alone.

7. New experimental evidence was obtained that the existing model could not explain, so the model was changed or replaced to fit the evidence (1). Any answer that mentions new evidence or new experiments gains the mark.

Timeline to learn. Dalton (early 1800s): solid, indivisible spheres. Thomson (1897): electron discovered; plum pudding model (1904). Rutherford, with Geiger and Marsden (1909 to 1911): alpha scattering, nuclear model. Bohr (1913): electrons in shells at fixed distances. Chadwick (1932): the neutron. You will not be asked for the dates, but the order and the reason for each change are examinable.

Set 3: charges, size and mass of atoms, isotopes and relative atomic mass

8. Complete the table to show the relative charge and relative mass of the three sub-atomic particles. (3 marks)

Particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

9. (a) State the approximate radius of an atom, in metres. (1 mark)

(b) Compare the radius of the nucleus with the radius of the atom. (1 mark)

10. Chlorine has two naturally occurring isotopes, ^{35}Cl and ^{37}Cl. The atomic number of chlorine is 17.

(a) State what is meant by **isotopes**. (1 mark)

(b) Give the number of protons, neutrons and electrons in one atom of ^{37}Cl. (1 mark)

11. In a sample of chlorine, 75% of the atoms are ^{35}Cl and 25% are ^{37}Cl. Calculate the relative atomic mass of chlorine. Give your answer to one decimal place. (2 marks)

12. Copper has two isotopes. In a natural sample, 69.2% of the atoms are ^{63}Cu and 30.8% are ^{65}Cu. Calculate the relative atomic mass of copper. Give your answer to one decimal place. (2 marks)

Answers to Set 3 (11 marks)

8. One mark for each correct row.

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Particle	Relative charge	Relative mass
Proton	+1	1
Neutron	0	1
Electron	–1	very small

The specification describes the electron's mass as "very small"; some books give it as 1/1836 or about 0.0005. Either is accepted. Remember that the atom as a whole has no charge because the number of electrons equals the number of protons.

9. (a) About 1×10^{-10} m, which is 0.1 nm (1). (b) The radius of the nucleus is less than 1/10 000 of the radius of the atom (about 1×10^{-14} m) (1). Almost all the mass is in the nucleus, but almost all the volume is the space occupied by the electrons.

10. (a) Atoms of the same element (same number of protons) with different numbers of neutrons (1). Saying "same atomic number, different mass number" is also correct. (b) 17 protons, 20 neutrons (37 – 17), 17 electrons (1). All three must be correct for the mark.

11. Relative atomic mass = (mass number × abundance for each isotope, added together) ÷ 100.

= (35 × 75 + 37 × 25) ÷ 100 (1)

= (2625 + 925) ÷ 100 = 3550 ÷ 100 = **35.5** (1)

The answer should lie between the two mass numbers and closer to the more abundant one; 35.5 is closer to 35, as expected.

12. = (63 × 69.2 + 65 × 30.8) ÷ 100 (1)

= (4359.6 + 2002.0) ÷ 100 = 6361.6 ÷ 100 = 63.616 = **63.6** (1)

If you wrote the method correctly but made an arithmetic slip, you still get the first mark.

Worked example: a harder relative atomic mass question. Boron has a relative atomic mass of 10.8 and two isotopes, ^{10}B and ^{11}B. What is the percentage of ^{11}B? Let the fraction of ^{11}B be x, so the fraction of ^{10}B is (1 – x). Then 10(1 – x) + 11x = 10.8, so 10 + x = 10.8 and x = 0.8. The sample is 80% ^{11}B and 20% ^{10}B. This reverse calculation appears on Higher tier papers.

Set 4: electronic structure

13. Electrons occupy the lowest available energy levels (shells). The first shell holds up to 2 electrons and the second and third shells hold up to 8 each (for the first twenty elements).

Write the electronic structure of each of the following atoms. (4 marks)

(a) Sodium (atomic number 11)

(b) Chlorine (atomic number 17)

(c) Calcium (atomic number 20)

(d) Neon (atomic number 10)

14. An atom has the electronic structure 2,8,6.

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(a) State which period of the periodic table this element is in, and explain how you know. (1 mark)

(b) State which group of the periodic table this element is in, and explain how you know. (1 mark)

15. Another atom has the electronic structure 2,8,8.

(a) Name this element. (1 mark)

(b) Explain why this element is very unreactive. (1 mark)

Answers to Set 4 (8 marks)

13. (a) Sodium: 2,8,1 (1). (b) Chlorine: 2,8,7 (1). (c) Calcium: 2,8,8,2 (1). (d) Neon: 2,8 (1). Check that the numbers add up to the atomic number: for calcium 2 + 8 + 8 + 2 = 20. The fourth shell starts to fill after the third shell has 8, so potassium is 2,8,8,1 and calcium 2,8,8,2.

14. (a) Period 3, because the atom has three occupied shells (1). (b) Group 6, because there are six electrons in the outer shell (1). The element is sulfur, atomic number 16. In the AQA numbering, the group number equals the number of outer electrons for Groups 1 to 7, and Group 0 elements have a full outer shell.

15. (a) Argon (1): 2 + 8 + 8 = 18 electrons, and a neutral atom has 18 protons, so the atomic number is 18. (b) It has a full (stable) outer shell of electrons, so it has no tendency to lose, gain or share electrons (1).

Set 5: the periodic table and its development, metals and non-metals

16. Before the discovery of protons, neutrons and electrons, scientists tried to arrange the known elements in order of atomic weight. In 1869 Dmitri Mendeleev produced a table that is the basis of the modern periodic table.

Describe **three** features of Mendeleev's approach that made his table more successful than earlier attempts. (3 marks)

17. Some pairs of elements in Mendeleev's table appeared to be in the wrong order of atomic weight. Explain how later knowledge of atomic structure showed that Mendeleev was right to swap these elements. (2 marks)

18. The periodic table can be divided into metals and non-metals.

(a) Describe where metals and non-metals are found in the periodic table. (1 mark)

(b) Explain, in terms of electrons, the difference between the way metals and non-metals form ions. (2 marks)

Answers to Set 5 (8 marks)

16. Any three of the following, one mark each: he arranged the elements in order of atomic weight but grouped elements with similar properties together (1); he left gaps where he predicted undiscovered elements would fit (1); he predicted the properties of the missing elements, and when they were discovered (for example germanium) the predictions were confirmed, which convinced other scientists (1); he swapped the order of some elements so that they were grouped with elements of similar properties even though this broke the strict order of atomic weight (1). Earlier attempts, such as Newlands' law of octaves, had no gaps and so forced unlike elements

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into the same group.

17. When atomic numbers were measured, it was found that the elements are correctly ordered by atomic number (number of protons), not by atomic weight (1). The discovery of isotopes explained the problem: an element's relative atomic mass depends on the abundance of its isotopes, so an element with a lower atomic number can have a higher atomic weight than the element after it (1). Tellurium and iodine are the usual example: tellurium (atomic number 52) has a higher relative atomic mass than iodine (53) because it has a greater proportion of heavy isotopes, but by atomic number iodine comes second, in Group 7 with the other halogens, as Mendeleev had placed it.

18. (a) Metals are on the left and in the centre of the periodic table; non-metals are on the right (1). A stepped line separating them runs from boron down to astatine, with the non-metals to its right. (b) Metals lose electrons from their outer shell to form positive ions (1); non-metals gain electrons to form negative ions (or share electrons in covalent bonds) (1). Elements that react to form positive ions are metals; elements that do not form positive ions are non-metals.

Set 6: Group 0, Group 1 and Group 7

19. The elements in Group 0 are the noble gases.

(a) Explain why the noble gases are unreactive. (1 mark)

(b) Neon boils at −246 °C and argon boils at −186 °C. Describe the trend in boiling point down Group 0 and state what it depends on. (1 mark)

20. Potassium is in Group 1. A small piece of potassium is added to a trough of water.

(a) Describe **two** observations that would be made. (2 marks)

(b) Write a balanced symbol equation for the reaction of potassium with water. (2 marks)

(c) Explain why potassium reacts more vigorously with water than sodium does. (2 marks)

21. Chlorine, bromine and iodine are in Group 7, the halogens.

(a) Chlorine water is added to a solution of potassium bromide. State what would be observed and write a balanced symbol equation for the reaction. (2 marks)

(b) Explain why iodine would **not** react with a solution of potassium bromide. (1 mark)

Answers to Set 6 (11 marks)

19. (a) They have a full outer shell of electrons (eight, or two for helium), so they do not need to lose, gain or share electrons (1). (b) Boiling point increases down the group as the relative atomic mass increases (1). Helium has the lowest boiling point of all the elements; radon, at the bottom, has the highest in the group.

20. (a) Any two of: the potassium floats and moves about on the surface; it fizzes or effervesces (bubbles of hydrogen gas); it melts into a ball; it burns with a lilac flame; it gets smaller and disappears (2). Potassium is more reactive than sodium, so the flame is seen with potassium even without the gas being lit.

(b) $2K + 2H_2O \rightarrow 2KOH + H_2$ (2). One mark for the correct formulae of potassium hydroxide (KOH) and hydrogen (H_2), one mark for balancing. The word equation is: potassium + water → potassium hydroxide + hydrogen. The solution turns universal indicator purple because potassium

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hydroxide is an alkali.

(c) Both atoms lose one outer electron to form a 1+ ion, but potassium's outer electron is in the fourth shell, further from the nucleus than sodium's (which is in the third shell), and it is shielded by more inner shells (1). The attraction between the nucleus and the outer electron is therefore weaker, so the electron is lost more easily and potassium reacts faster (1). The same argument explains why reactivity increases down the whole of Group 1.

21. (a) The colourless solution turns orange (or yellow-brown) because bromine is formed (1). $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ (1). Chlorine is more reactive than bromine, so it displaces bromine from the bromide. (b) Iodine is less reactive than bromine (reactivity decreases down Group 7), so it cannot displace bromine from its compound (1). Going down Group 7 the outer shell is further from the nucleus and more shielded, so an electron is gained less easily and the element is less reactive: the reverse of the trend in Group 1.

Definition to learn: displacement reaction. A more reactive halogen will displace a less reactive halogen from an aqueous solution of its salt. Chlorine displaces bromine and iodine; bromine displaces iodine only. Writing the equation with the halogen as a diatomic molecule (Cl_2, Br_2, I_2) is essential.

Set 7: transition metals (separate Chemistry only)

22. Iron and copper are transition metals. Sodium is a Group 1 metal.

Compare the physical properties and the reactivity of transition metals with those of Group 1 metals. Give **three** differences. (3 marks)

23. Transition metals and their compounds have properties that are useful in industry.

(a) Give **one** example of a transition metal used as a catalyst, and name the process it is used in. (1 mark)

(b) State **two** other chemical properties that are typical of transition metals and their compounds. (2 marks)

Answers to Set 7 (6 marks)

22. Any three of: transition metals have higher melting points than Group 1 metals (1); they have higher densities (1); they are harder and stronger (1); they are much less reactive, for example with water or oxygen (1). Sodium can be cut with a knife, floats on water and reacts violently with it; iron is hard, sinks and only rusts slowly in water.

23. (a) Any one of: iron in the Haber process for making ammonia (1); nickel in the hydrogenation of vegetable oils to make margarine (1). Vanadium(V) oxide in the Contact process is also accepted if named correctly. (b) Any two of: they form ions with different charges, for example Fe^{2+} and Fe^{3+} (1); they form coloured compounds, for example blue copper(II) sulfate (1); they or their compounds act as catalysts (if not already used in part (a)) (1).

Checklist for this topic. Can you: define element, compound and mixture; name the right separation technique for a given mixture; describe the plum pudding and nuclear models and the

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evidence that changed them; give the charges and masses of the three sub-atomic particles; calculate a relative atomic mass from isotope abundances; write the electronic structure of any of the first twenty elements; explain why Mendeleev's table worked; explain the trends in Group 1, Group 7 and Group 0 in terms of electronic structure; and (separate Chemistry) compare transition metals with Group 1? If any of these is a no, go back to that set and redo it.

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