AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.1.1.3

The development of the model of the atom (common content with physics)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**6**
Available paper years	**2018–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

4.1.1.3 The development of the model of the atom (common content with physics)

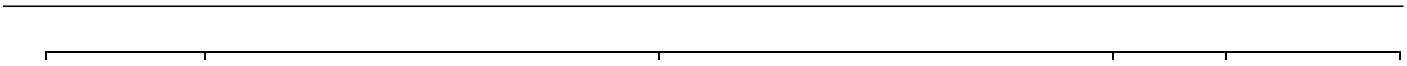
Answer 01 · Mark scheme June 2018 | 8462/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	B		1	AO1 4.1.1.3
04.2	C		1	AO2 4.1.1.3
04.3	A		1	AO2 4.1.1.3
04.4	sum of protons and neutrons	allow number of protons and neutrons	1	AO1 4.1.1.5
04.5	between 69.5 and 70.0		1	AO2 4.1.1.6
04.6	Chadwick provided the evidence to show the existence of neutrons (this was necessary because) isotopes have the same number of protons **or** (this was necessary because) isotopes are atoms of the same element but with different numbers of neutrons	allow Chadwick discovered neutrons allow (this was necessary because) isotopes have the same atomic number ignore isotopes have the same number of electrons allow but with different mass (numbers)	1 1 1	AO1 4.1.1.3 AO3 4.1.1.5 AO1 4.1.1.5
Total			**8**	

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 01 · Mark scheme

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4.1.1.3 The development of the model of the atom (common content with physics)

Answer 02 · Mark scheme

June 2019 | 8462/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	(neutron) 1 0 proton 1 (+1)	both needed allow (neutron) 1 neutral both needed	1 1	AO1 4.1.1.4 4.1.1.5
04.2	number of protons plus neutrons	allow number of protons and neutrons ignore protons and neutrons unqualified do **not** accept references to mass or relative mass of protons and / or neutrons	1	AO1 4.1.1.5
04.3	(the isotopes contain) different numbers of neutrons		1	AO2 4.1.1.5
04.4	most (alpha) particles passed (straight) through (the gold foil) (so) the mass of the atom is concentrated in the nucleus / centre **or** (so) most of the atom is empty space some (alpha) particles were deflected **/** reflected (so) the atom has a (positively) charged nucleus / centre	 if not awarded for MP2, allow (so) the mass of the atom is concentrated in the nucleus / centre.	1 1 1 1	AO1 4.1.1.3
Total			**8**	

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 03 · Mark scheme

November 2020 | 8462/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	any **three** from: (nuclear model) • mostly empty space	allow the plum pudding model has no empty space allow the plum pudding model is solid	3	AO1 4.1.1.3
	• the positive charge is (all) in the nucleus	allow in the plum pudding model the atom is a ball of positive charge (with embedded electrons) do **not** accept reference to protons		
	• the mass is concentrated in the nucleus	allow in the plum pudding model the mass is spread out do **not** accept reference to neutrons		
	• the electrons and the nucleus are separate	allow in the plum pudding model the electrons are embedded allow in the nuclear model the electrons are in orbits		
05.2		do **not** accept reference to protons / neutrons		AO1 4.1.1.3
	electrons orbit the nucleus	allow electrons are in energy levels around the nucleus **or** allow electrons are in shells around the nucleus	1	
	electrons are at specific distances from the nucleus		1	
05.3	atomic number is the number of protons		1	AO3 4.1.1.3 4.1.1.4
	(and) protons were not discovered until later	ignore electrons / neutrons were not discovered until later	1	4.1.2.2

4.1.1.3 The development of the model of the atom (common content with physics)

Question 5 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	so their properties matched the rest of the group	allow converse	1	AO1 4.1.2.2
Total			**8**	

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 04 · Mark scheme

June 2023 | 8462/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	a ball of positive charge with (negative) electrons embedded	do **not** accept references to protons, nuclei, neutrons	1 1	AO1 4.1.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	(earliest) electrons protons (latest) neutrons		1	AO1 4.1.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	(number of outer shell electrons) 7 (reason) (tennessine is in) Group 7	 allow the number of outer electrons is the same as the group number allow tennessine is a halogen MP2 is dependent on MP1 being awarded	1 1	AO2 4.1.2.1 4.1.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	(time needed for) peer review	allow the idea that other scientists had to check the results	1	AO3 4.1.2.2

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	(A_r =) $\frac{(6 \times 7.6) + (7 \times 92.4)}{100}$	allow $\frac{45.6 + 646.8}{100}$ allow (6 × 0.076) + (7 × 0.924) allow 0.456 + 6.468	1	AO2 4.1.1.6
	= 6.924		1	
	= 6.9	allow an answer correctly rounded to 1 decimal place from an incorrect calculation which uses all the data in the table	1	

Total Question 1	9

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 05 · Mark scheme

June 2024 | 8462/1H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	(model **A**) plum pudding (model **B**) Bohr	allow Thomson (model) allow nuclear (model) allow planetary (model) allow Rutherford-Bohr (model)	1 1	AO1 4.1.1.3

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 05 · Mark scheme

June 2024 | 8462/1H | Original Q3

Question	Answers	Mark	AO / Spec. Ref.
03.2	**Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.	3–4	AO1 4.1.1.3
	Level 1: Relevant features are identified and differences noted.	1–2	
	No relevant content	0	
	Indicative content **Similarities** • both contain electrons • both are neutral overall **Differences** • model **A** has no nucleus **or** the model used today has a nucleus • model **A** has no protons **or** the model used today has protons • model **A** has no neutrons **or** the model used today has neutrons • model **A** has positive charge spread throughout the atom **or** model **A** is a ball of positive charge • the model used today has the positive charge in the centre • model **A** the electrons are distributed randomly • the model used today has electrons in shells / energy levels • the mass was spread throughout model **A** • the mass is concentrated at the centre of the model used today • model **A** does not have empty space • model used today is mostly empty space		

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	atoms with the same number of protons	allow atoms of the same element allow atoms with the same atomic number ignore references to electrons	1	AO1 4.1.1.5
	with different numbers of neutrons		1	

Total Question 3	8

4.1.1.3 The development of the model of the atom (common content with physics)

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	a ball of positive charge	allow a positive(ly charged) ball do **not** accept references to protons, nuclei, neutrons	1	AO1 4.1.1.3
	with (negative) electrons embedded		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	any **two** from: • the mass of the atom is concentrated at the centre / nucleus • the nucleus is positive / charged • most of the atom is empty space • electrons orbit the nucleus	do **not** accept references to shells	2	AO1 4.1.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	electrons orbit the nucleus at specific distances	allow electrons orbit the nucleus in energy levels allow electrons orbit the nucleus in shells	1	AO1 4.1.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	~100 000 times larger		1	AO2 4.1.1.5

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(surface area = 6×1.2^2 =) 8.64 (nm^2)		1	AO2 4.2.4.1
	(volume = 1.2^3 =) 1.728 (nm^3)		1	
	(ratio = 8.64 : 1.728 =) $\frac{8.64}{1.728}$ (: 1)	allow (ratio = 1.728 : 8.64 =) (1 :) $\frac{1.728}{8.64}$ allow correct use of incorrectly determined values of surface area and / or volume	1	
	= 5 : 1	allow = 1 : 0.2	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6		allow converse arguments in terms of fine particles		AO3 4.2.4.2
	(nanoparticles) have a higher surface area to volume ratio		1	
	(so) less coating is used	(so) a thinner layer can be used	1	
	OR			
	(with nanoparticles) a thinner layer can be used (1)	allow less coating is used		
	(so) more light gets through the lenses (1)	allow (so) visibility is not reduced (as much)		

Total Question 5	12

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 01 · Examiner comments

June 2018 | 8462/1H | Original Q4

Question 4 (standard, standard / high and high demand)

04.1 87% of students could identify the plum pudding model from the diagrams. E was the most popular distractor, where the charges were reversed.

04.2 68% of students could identify the model resulting from the alpha particle scattering experiment. The Bohr model was the most popular distractor.

04.3 72% of students could identify the Bohr model correctly. The most popular distractor being the model from the alpha particle scattering experiment.

04.4 69% of students could define mass number correctly. Some lost the mark by writing 'protons and neutrons' with no further information. Others mistakenly gave a description of relative atomic mass, or referred to the total mass of the protons and neutrons instead of the total number.

04.5 This question was well answered, with 75% of students able to estimate (or calculate) the relative atomic mass.

04.6 19% of students achieved all three marks. Two marks could be obtained just for defining isotopes. The other mark was for linking this to Chadwick's discovery of the neutron. No knowledge of how he made this discovery was required.

Many students were able to recall that Chadwick discovered the neutron, and that isotopes have different number of neutrons. Many students didn't mention that isotopes have the same number of protons, or are atoms of the same element. Clarity of expression was important here; the statement that isotopes are different forms of the same element gained no credit as it could refer to allotropes. Similarly, 'mass of an element' does not mean 'mass of an atom'.

Some students appear to think that isotopes are not 'normal' atoms of an element, and some think that isotopes are always unstable. There was some confusion of Chadwick with Rutherford, and even with Mendeleev.

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 02 · Examiner comments June 2019 | 8462/1H | Original Q4

Question 4 (standard and standard/high demand)

04.1 Approximately 80% of students scored both marks for the names / properties of the proton and the neutron.

04.2 Approximately 70% of students gave the correct definition of mass number.

However, there were some incorrect references to mass, for example, ‘mass number is the total mass of the protons and neutrons’.

04.3 Approximately 80% of students correctly answered that isotopes of the same element have different numbers of neutrons.

04.4 Most students made a good attempt at this question about the alpha particle scattering experiment.

The marks for the ideas that some particles were deflected and/or reflected and that there is a charged nucleus were the most frequently awarded.

The mark for the idea that most of the particles passed straight through the gold foil was the least frequently awarded.

Those students gained fewer marks tended to focus on expected outcomes but didn’t know exactly what happened in the experiment.

Answer 03 · Examiner comments November 2020 | 8462/1H | Original Q5

Question 5 (standard / high and high demand)

05.1 Students had difficulty in expressing their ideas clearly; electrons in the plum pudding model were variously described as ‘floating’ or ‘covering’ the atom rather than embedded in the atom. A popular misconception was that the plum pudding model had an overall positive charge. A large number of students lost credit by referring to protons and neutrons in the nuclear model, despite the timeline which showed they had not been discovered at the time of the development of the model. Some answers did not make it clear which model was being written about.

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 03 · Examiner comments November 2020 | 8462/1H | Original Q5

05.2 Many students stated that the Bohr model had electrons that orbit the nucleus, but fewer said that the orbits were at specific distances from the nucleus. Again, it was not uncommon to see mention of protons and neutrons despite the timeline provided.

05.3 Many students were able to deduce that the issue was that protons had not yet been discovered, but few also stated the relevance of the fact that the atomic number is the number of protons.

05.4 Few students could express coherently that the reason was to place elements with similar properties in the same group. There was a lot of imprecise language which did not earn credit; 'reactivity' is not the same as properties and placing elements 'with' those with similar properties does not necessarily mean in the same group or column.

Answer 04 · Examiner comments June 2023 | 8462/1H | Original Q1

Question 1 (standard demand)

01.1 Only two fifths of students scored both marks, although three quarters scored at least one mark. The plum pudding model is described in the specification. However, some students referred to a ball of positive energy rather than positive charge, and some did not name the electrons, or implied that they were outside the positive ball rather than embedded in it.

01.2 Nearly three fifths of students could give the correct order of discovery.

01.3 More than three quarters of students scored both marks by locating tennessine in Group 7 and therefore deducing that it has 7 outer shell electrons. Some ignored the instruction to use the periodic table and tried unsuccessfully to work out the electron configuration.

01.4 Only one fifth of students were familiar with the idea of peer review or could apply it to this situation. A common incorrect reason was the scarcity of the element; this was the same for the original group of scientists so does not explain the delay.

01.5 Two thirds of students gave fully correct answers, and the question discriminated well. The great majority scored at least one mark, for giving an attempt at the calculation to one decimal place. Some divided by the sum of the mass numbers instead of the sum of the percentages (ie 100). There were very few rounding errors. Some students did not realise

Answer 04 · Examiner comments June 2023 | 8462/1H | Original Q1

that their answer must lie somewhere between 6 and 7, the two mass numbers of the isotopes.

4.1.1.3 The development of the model of the atom (common content with physics)

Answer 05 · Examiner comments — June 2024 | 8462/1H | Original Q3

Question 3 (standard demand)

03.1 Nearly all students could name the plum pudding model, but most described model B as the nuclear model rather than the Bohr model (the nuclear model would not have the electrons in fixed orbits). This was, however, accepted, as the Bohr model is an adaptation of the nuclear model. Some students described model B as the atomic model, which simply rewords 'model of the atom.' Some described model B as the modern model, which contradicts the information that both were early models of the atom.

03.2 The features of each model were very well known and students scored highly on this question, with over half scoring full marks and more than nine tenths reaching level 2. The structure of many answers, however, sometimes made it difficult to see whether a comparison had been made. Many students described one model and then the other, rather than writing a true comparison of the features of each, with one feature compared at a time. Some of the best answers were written in the form of a table, with comparisons such as 'no nucleus'… 'has a nucleus.' To score full marks it was necessary to note a similarity as well as differences, with the most common similarity being 'both models have electrons.' One fairly common misconception is that the plum pudding model had an overall positive charge, rather than the positive charge being countered by the charges on the electrons, giving a neutral atom overall.

03.3 Many students knew that isotopes had different numbers of neutrons but did not say that isotopes were atoms with the same number of protons or of the same element. Thus, only a third of students scored both marks, although five sixths scored one. Some referred to 'elements' with the same number of protons, which did not gain the first marking point. Some students appear to believe that an isotope is a single atom where the number of neutrons is different to the number of protons, for example 'an atom with more neutrons than protons.' Some students' answers made it clear that they think there is only one 'true' atom of an element, with isotopes being improper deviants.

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Answer 06 · Examiner comments — June 2025 | 8462/1H | Original Q5

Question 5 (standard/high and high demand)

05.1 Over half of students scored both marks by giving the description in the specification. For the first marking point, the idea of both the shape and the charge were needed. Common errors were to refer to a positive 'cloud' or a ball of positive 'energy'. Other errors were to refer to protons, which had not been discovered, or to imply that there was an overall positive charge on the atom as a whole; atoms were known to be neutral in terms of charge. For the second marking point the electrons needed to be referred to as such, not just negative charge. Common errors were to imply that electrons were on the surface rather than embedded, or that they were moving.

05.2 This was well answered, with four fifths of students scoring at least one mark. Many referred to the mass being concentrated at the centre and also the positive charge but

failed to refer to the centre as the nucleus. Many referred to most of the atom being empty space, but some simply said that there is empty space in the atom which is not quite the same. Fewer referred to electrons orbiting the nucleus, and many of those who did referred incorrectly to shells.

05.3 Whilst many students knew that Bohr's contribution to the model of the atom was electron shells, many did not mention that the electrons were orbiting the nucleus in these shells. Even fewer referred to specific distances from the nucleus. Many confused Bohr with Chadwick and stated that Bohr discovered neutrons. Only one third of students gave a fully correct answer.

05.4 More than four fifths of students gave the correct response, with 10 000 times larger being the most popular distractor.

05.5 Two thirds of students gave fully correct answers. Most students could calculate the volume correctly, although some incorrectly gave the units as nm instead of nm^3. They had more difficulty with the surface area, with some forgetting to multiply the area of one face by 6 and others miscounting the number of faces. The marks for calculating the ratio could be obtained from incorrect values for the surface area and / or volume. The simplest ratio was required, so this needed to be either a whole number ratio or with one of the values reduced to 1. Dividing one value by the other was by far the simplest way of finding the ratio. A few students unnecessarily decided to change the units from nm to m, mm or even μm. As this ratio is not dimensionless, this approach gave different values depending on the units chosen. Full marks could be obtained if the conversions were correct, but many were not. If students are not instructed to give an answer in particular units, they should stick with the ones provided.

05.6 Students found this question more difficult than expected, with fewer than half scoring one mark and about one in ten scoring both. Many students gave the general answer; that nanoparticles have a greater surface area to volume ratio. However, fewer were able to express clearly the idea that a thinner coating could be used, with many using ambiguous phrases such as 'less nanoparticles needed' rather than less of the coating or another description of less material in bulk. Fewer concentrated on the specific use in glasses. Although many said that visibility would not be reduced as much if nanoparticles were used, many thoughts this would be because the particles themselves could be seen if fine particles were used, which is not the case. Some students did not give answers in comparative terms, for example referring to a high (rather than higher) surface area to volume ratio.