Answer **all** the questions.

1. What is the approximate size of an atom?

A 3×10^{-1} metres
B 3×10^{-5} metres
C 3×10^{-9} metres
D 3×10^{-13} metres

Your answer ☐

[1]

2. Rutherford was a scientist who helped to develop the atomic model.

State how Rutherford's work contributed to the development of the atomic model.

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[1]

3(a). Look at the table. It shows some information about three atoms.

Atom	Number of protons	Number of neutrons	Electronic structure
X	17	20	2.8.7
Y	17	18	2.8.7
Z	3	4	2.1

(i) What is the **atomic number** of atom **X**?

answer _____

[1]

(ii) What is the **mass number** of atom **Z**?

answer _____

[1]

(iii) How many electron shells are occupied in atom **Y**?

answer _____

[1]

(b). Atoms **X** and **Y** are **isotopes**.

What is meant by isotopes?

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[2]

4. Look at the table. It shows some information about four atoms.

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Electronic structure
W	17	37	17	20	17	2.8.7
X	17	35	17	18	17	2.8.7
Y	3	7	_____	_____	3	2.1
Z	6	_____	6	6	6	_____

[3]

Complete the table.

5. Look at the table. It shows some information about four atoms.

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Electronic structure
W	17	37	17	20	17	2.8.7
X	17	35	17	18	17	2.8.7
Y	3	7	_____	_____	3	2.1
Z	6	_____	6	6	6	_____

[3]

Atom **W** and atom **X** are both chlorine atoms.

What is the name given to chlorine atoms such as **W** and **X**?

_____

Explain your answer.

_____

_____

_____

_____ **[2]**

6(a). Find magnesium, Mg, on the periodic table.

What is the **atomic number** of magnesium?

answer _____

[1]

(b). The **mass number** of nitrogen, N, is 14.

What is meant by the mass number?

_____

_____ **[1]**

7(a). Look at the information about a chlorine atom and an oxide ion.

$^{37}_{17}Cl$ $^{16}_{8}O^{2-}$

Complete the table to show the number of protons, neutrons and electrons in each particle.

Two have been done for you.

	Chlorine atom, *Cl*	**Oxide ion, O^{2-}**
Number of protons	_____	8
Number of neutrons	_____	_____
Number of electrons	17	_____

[3]

(b). Many scientists have helped in the development of the theory of atomic structure.

Two of these scientists were J. J. Thomson and Niels Bohr.

Describe what J. J. Thomson and Niels Bohr contributed to the theory of atomic structure.

J. J. Thomson

Niels Bohr

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[2]

8(a). An aluminium atom can be shown as

$$^{27}_{13}Al$$

What can be deduced from this information about the structure of an aluminium atom and the position of aluminium in the Periodic Table?

The quality of written communication will be assessed in your answer to this question.

[6]

(b). Rutherford was a scientist who contributed to the development of the theory of atomic structure.

He worked with two other scientists called Geiger and Marsden.

Write about Geiger and Marsden's experiment and how it contributed to the development of ideas about atomic structure.

[2]

9. This question is about atomic structure and bonding.

Atoms are made up of protons, neutrons and electrons.

Complete the table.

Particle	Relative charge	Relative mass
proton	+1	1
neutron	0	_____
electron	_____	0.0005

[2]

10. In 1808, a scientist named Dalton published his atomic theory.

About a century later, a scientist called Rutherford published another atomic theory.

Why is it important that scientists publish their theories?

---

[2]

11(a). An aluminium atom can be shown as

$$^{27}_{13}Al$$

What do the numbers 27 and 13 mean?

Explain what the numbers tell you about the structure of an aluminium atom.

The quality of written communication will be assessed in your answer to this question.

[6]

(b). John Dalton developed his work on an atomic theory in 1803.

J.J. Thomson and E. Rutherford made other discoveries about the atom.

Write about these **other** discoveries.

[2]

12(a). In 1808, a scientist named Dalton published his atomic theory.

Dalton thought that:

- elements were made up of atoms
- atoms could **not** be split into simpler particles.

About a century later, a scientist called Rutherford published another atomic theory.

Rutherford thought that:

- atoms had a positively charged nucleus
- electrons orbited the nucleus.

Write about one **difference** between Dalton's atomic theory and Rutherford's atomic theory.

---

[1]

(b). What is the electrical charge on an electron?

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[1]

13(a). The table shows the electronic structures of the atoms of some elements.

Element	Symbol	Electronic structure
helium	He	2
oxygen	O	2.6
neon	Ne	2.8
magnesium	Mg	2.8.2
chlorine	C*l*	2.8.7
calcium	Ca	2.8.8.2

How many **electrons** are there in one atom of chlorine?

[1]

(b). What is the **atomic number** of magnesium?

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2			idea of the nuclear atom (1)	1	
			Total	**1**	
3	a	i	17 (1)	1	
		ii	7 (1)	1	
		iii	3 (1)	1	**Examiner's Comments** Many candidates correctly answered all three parts of this question, although examiners saw a wide range of incorrect responses.
	b		atoms with the same atomic number / same number of protons / same proton number (1) but different mass numbers / different numbers of neutrons (1)	2	**allow** an element with the same atomic number (1) but different mass number (1) **allow** atoms with same number of protons but different mass for (2) **Examiner's Comments** The meaning of isotopes was not well understood. Examiners saw a wide range of incorrect ideas.
			Total	**5**	
4			atom **Y** – no of protons = **3 and** no of neutrons = **4** (1) atom **Z** – mass number = **12** (1) atom **Z** – electronic structure is **2.4** (1)	3	**Examiner's Comments** This question was about atomic structure. Many candidates could interpret the table to get at least two entries correct. The most likely incorrect answers were to give the mass number of particle **Z** to be 6 and / or to give the incorrect electronic structure. Some able candidates did not attempt this question.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
5			isotopes (1) same atomic number but different mass numbers / same number of protons but different numbers of neutrons (1)	2	**allow** an element with the same atomic number but different mass number / same type of atom with different numbers of neutrons **allow** same element with different numbers of neutrons is sufficient **ignore** references to electrons **ignore** halogens **ignore** wrong number of neutrons quoted **Examiner's Comments** This question was about atomic structure. The term isotope was known by many candidates although a few confused this with allotrope. Another misconception was to call the two types of atom halogens. Candidates often gave the correct explanation even when they did not give the correct term. The best answers referred to atoms with the same atomic number but different mass number (or number of neutrons) however in the context of the question less precise explanations where allowed in the mark scheme.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
6	a		12 (1)	1	**Examiner's Comments** Most candidates could use the periodic table correctly to identify 12 as the atomic number of magnesium. A few quoted 24 and failed to score.
	b		number of protons + number of neutrons (in an atom) (1)	1	**allow** number of particles in the nucleus (1) **Examiner's Comments** Less than a fifth of candidates understood the term mass number. Most thought it was the relative atomic mass of nitrogen. A number realised it was the number of particles but then lost the mark by stating, for example, 'the number of protons and electrons in the atom'.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
7	a		<table><tr><th></th><th>Chlorine atom</th><th>Oxide ion</th></tr><tr><td>Number of protons</td><td>17</td><td>8</td></tr><tr><td>Number of neutrons</td><td>20</td><td>8</td></tr><tr><td>Number of electrons</td><td>17</td><td>10</td></tr></table> chlorine – number of protons **and** number of neutrons correct (1) oxide ion – number of neutrons correct (1) - number of electrons correct (1)	3	**?Examiner's Comments?**? Only a small proportion of the candidates were able to get all four entries in the table correct. Candidates found filling in the information about the chlorine atom easier than that for the oxide ion. Many candidates did not take account of the charge on the oxide ion when calculating the number of electrons.
	b		J J Thomson - discovered the electron (1) Bohr suggested - that electrons occupy orbits / electrons in shells / electrons in energy levels (1)	2	**ignore** reference to plum pudding model **allow** discovered that atoms have electrons **not** electrons were found in the nucleus / discovered that electrons orbit the nucleus / reference to ions **not** discovered neutrons or protons negative particles in shells is **not** sufficient **allow** reference to orbitals **ignore** reference to other aspects of atomic structure e.g. protons and neutrons **?Examiner's Comments?**? Candidates found this recall question quite challenging. Candidates often referred to the 'plum pudding' model when describing J.J. Thomson's contribution. Most candidates failed to appreciate that J.J. Thomson discovered the electron. More candidates were able to describe Bohr's contributions and referred to electron shells or electron orbits. Some candidates referred to the discovery of the Periodic Table or to the 'gold leaf' experiment. A significant proportion of candidates left this question blank.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
8	a		**Level 3** **Deduce the number of protons, neutrons and electrons and the electronic structure for the atom of aluminium** **AND** **Identifies both the group and period for aluminium** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **Level 2** **Deduce the number of protons, neutrons and electrons in the aluminium atom or the electronic structure and identifies the group or the period of aluminium** **OR** **Deduce the number of protons and neutrons in the aluminium atom and the electronic structure of aluminium** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **Level 1** **Deduce the number of protons and neutrons** **OR** **Deduce the electronic structure for aluminium** **OR** **Identifies the group or the period of aluminium** Quality of written communication impedes communication of the science at this level. (1 – 2 marks) **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to A*.** **Indicative scientific points may include:** • number of protons is 13 / bottom number is number of protons • number of neutrons is 14 / difference between mass number and atomic number • number of electrons is 13 / same as number of protons • electronic structure is 2.8.3 – this also shows 13 electrons • Al is in the 3rd period / the number of (occupied) shell electrons is the period number • Al is in Group 3 / the number of electrons in the outer shell is the group number **Allow** row for period and column for group **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This question assessed the quality of written communication in the context of the interpretation of an atomic symbol. Candidates often gave very good answers where they made deductions about the atomic structure of aluminium that included an explanation for the deduction. Candidates were able to deduce the number of subatomic particles in the aluminium atom and also the electronic structure. Many used the electronic structure to state the group number and the period number for aluminium. One common misconception was the mass number represented the relative atomic mass. Some candidates referred to rows and columns in the periodic table rather than periods and groups. If candidates

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>gave a group number it was invariably correct but a small proportion of the candidates gave the period number as 2 rather than 3.</td></tr>
<tr><td></td><td>b</td><td></td><td>Any two from:

Fired alpha particles at gold foil (1)

Geiger and Marsden's experiment gave unexpected results / some alpha particles rebounded (1)

led to theory of nuclear atom / idea of atoms having a nucleus (1)</td><td>2</td><td>Allow wrong particle rebounded if mentioned already at MP1
Allow reflected rather than rebounded

Ignore reference to electrons, protons and shells

Atoms have a dense centre is not sufficient

Examiner's Comments

Only an extremely small proportion of the candidates could describe the correct experiment or appreciate that the results of the experiments were unexpected. Many candidates were awarded a mark that the experiment was connected with the discovery of the nuclear atom. A significant proportion of the candidates did not attempt this question.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>8</td><td></td></tr>
<tr><td>9</td><td></td><td></td><td>relative mass of neutron (1)

relative charge of electron (1)</td><td>2</td><td><table><tr><th>Particle</th><th>Relative charge</th><th>Relative mass</th></tr><tr><td>proton</td><td>+1</td><td>1</td></tr><tr><td>neutron</td><td>0</td><td>1</td></tr><tr><td>electron</td><td>-1</td><td>0.0005</td></tr></table>
Examiner's Comments

The relative charge on an electron was well known but the relative mass of a neutron was less well known.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>2</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
10			**any two from:** so results can be replicated / so work does not need to be duplicated (1) so further evidence can be collected (1) idea of peer review / work can be checked (1) to provide information to other scientists or public or other organisations / AW (1) so he can get recognition for his work (1)	2	allow work can be developed further (1) allow so work can be evaluated (1) allow idea that information can be used by other scientists (1) allow idea of to increase the sum of human knowledge / to educate people (1) allow so other scientists cannot take credit (1) **Examiner's Comments** Candidates often appreciated that scientists publish their results so that their work could be checked. Candidates rarely used the term peer review but often described this in words. Candidates who were awarded two marks often went on to describe the idea of developing the scientific work or collecting more evidence.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
11	a		**Level 3** **Recall or deduce one piece of information about atomic number AND one about mass number** **AND** **deduces the number of protons, neutrons and electrons.** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **Level 2** **Recall or deduce one piece of information about atomic number AND one about mass number** **OR** **deduces the number of protons, neutrons and electrons.** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **Level 1** **Recall or deduce one piece of information about atomic number** **OR** **recall or deduce one piece of information about mass number** **OR** **deduce the number of protons or neutrons or electrons.** Quality of written communication impedes communication of the science at this level. (1 – 2 marks) **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to C.** **Indicative scientific points may include:** • bottom number is atomic number or proton number • atomic number or proton number is 13 • atomic number or proton number is the number of protons in the nucleus • atomic number or proton number is the number of electrons • top number is mass number or atomic mass • mass number or atomic mass is 27 • mass number or atomic mass is the total number of protons and neutrons in the nucleus • number of protons is 13 • number of neutrons is 14 • number of electrons is 13 **allow** higher level answers at level 3 such as: • electronic structure is 2.8.3. • A*l* is in the 3rd period or row • A*l* is in Group 3 or column 3 • A*l* forms 3+ ions **allow 2** or more higher level answers with no other points - 5 marks **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** About a third of candidates scored level 3 (5 or 6 marks) on this question. They could identify the mass number and atomic number and work out the number of protons, neutrons and electrons. The best candidates could work out the electronic structure and state that aluminium was in group 3. Just over a third of candidates gained level 2 (3 or 4 marks). They either identified mass number and atomic number or stated the number of protons, neutrons

Question			Answer/Indicative content	Marks	Guidance
					and electrons.
	b		(J.J. Thomson) discovered the electron (1) (Rutherford) suggested the nuclear atom (1)	2	**allow** references to discovery of electron and nuclear atom without assigning names (up to 2 marks) **allow** more detailed answers re J. J. Thomson or Rutherford for 2 marks **Examiner's Comments** Candidates found this question difficult. Where a mark was scored, it was usually for mentioning the discovery of electrons, although this was rarely attributed to J. J. Thomson. Many candidates confused the work of Rutherford and J. J. Thomson with Mendeleev's work on the development of the periodic table.
			Total	**8**	
12	a		**any one from:** in Rutherford's theory the atom can be split / Rutherford's theory does not have solid atoms / Rutherford's theory has atoms of mostly space (1) in Dalton's theory atoms could not be split (1)	1	**allow** presence of nucleus or electrons in Rutherford's theory / smaller particles present **allow** Dalton was unaware that electrons / nucleus exist **Examiner's Comments** A majority were able to score here, but the use of language was difficult to follow in a lot of answers. The most common answer was that Rutherford stated that atoms could be split.
	b		negative (1)	1	**allow** minus / -1 **Examiner's Comments** A significant proportion of candidates continue to think that electrons are positive.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
13	a		17 (1)	1	**Examiner's Comments** Many correct answers. A few candidates repeated the electronic structure of the elements.
	b		12 (1)	1	**Examiner's Comments** Many correct answers. A few candidates repeated the electronic structure of the elements.
			Total	**2**	