Mark scheme

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>a</td><td></td><td>Any two from:

(Rutherford's model):

Shows that an atom has a <u>positively</u> charged nucleus ✓

Shows that the nucleus contains most of the mass (of the atom) ✓

Shows most of the atom is empty space ✓

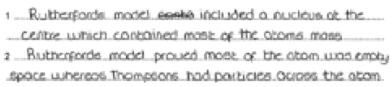
Shows (negative) electrons orbit around (the nucleus) ✓</td><td>2
(2 x AO 1.1)</td><td>IGNORE reference to neutrons

ALLOW idea of electron shells
IGNORE sea of electrons

<u>Examiner’s Comments</u>

This question discriminated well. Responses from less successful candidates lacked clarity and often did not refer to the nucleus. Some candidates described the gold leaf experiment without detailing what it proved while others wrote about electrons orbiting the atom rather than the nucleus. References to neutrons being in Rutherford’s model was also quite common.

Exemplar 1


1 Rutherfords model included a nucleus at the centre which contained most of the atoms mass
2 Rutherfords model proved most of the atom was empty space whereas Thompsons had particles across the atom.

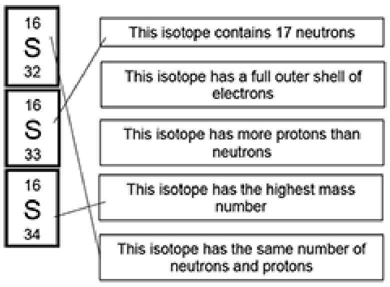
This response clearly describes two differences between Rutherford’s atomic model and Thomson’s “plumpudding” model. The first statement is clear that it is the <u>nucleus</u> at the centre of the atom which contains most of the atom’s mass. Lower attaining candidates tended to just say that most of the massis in the centre.

The second statement is clear that most of the atom is empty space.</td></tr>
<tr><td></td><td>b</td><td>i</td><td>Atoms are oxidised to form positive ions. Atoms lose electrons to form positive ions.

Atoms are reduced to form negative</td><td>2
(2 x AO 2.1)</td><td>Oxidised AND reduced for 1 mark
Lose AND gain for 1 mark

Mark independently</td></tr>
</table>

			ions. Atoms **gain** electrons to form negative ions. ✓ ✓		**Examiner's Comments** Most candidates gained both marks for this question. Those who gained only 1 mark usually knew that atoms lose electrons to form positive ions and gain electrons to form negative ions but confused oxidation and reduction.
		ii	<table><tr><th>Ion</th><th>Number of protons</th><th>Number of neutrons</th><th>Number of electrons</th><th>Mass number</th></tr><tr><td>Mg^{2+}</td><td>12</td><td>**12**</td><td>10</td><td>24</td></tr><tr><td>F^{-}</td><td>9</td><td>10</td><td>**10**</td><td>19</td></tr><tr><td>Li^{+}</td><td>3</td><td>4</td><td>2</td><td>**7**</td></tr></table> ✓ ✓	2 (2 x AO 2.1)	All three correct = 2 marks One or two correct = 1 mark **Examiner's Comments** Most candidates were able to complete the table correctly. The most common error was that the F^{-} ion has 9 electrons, but also a mass number of 6.9 was seen for Li^{+} indicating that some candidates are unclear about the difference between mass number and relative atomic mass.
		iii	**Difference** Different number of neutrons / different mass number / idea that number of neutrons in "new" Li^{+} will not be 3 ✓ **Similarity** Same number of protons / all have 3 protons / same number of electrons / same atomic number / same charge / all have 1+ charge ✓	2 (2 x AO 2.1)	**IGNORE** different (relative) atomic masses **IGNORE** idea that they have all lost 1 electron **Examiner's Comments** Good responses to this question stated that isotopes have a different number of neutrons and the same number of protons. The most common incorrect response was that isotopes have a different number of electrons, presumably because candidates had focused on Li^{+} in the question rather than the ions formed from different isotopes.
		iv	**First check the answer on the answer line** **If answer = 2.6×10^{8} award 3 marks** Atomic radius is in the order of 1×10^{-10} m / 0.1 nm ✓ **Unit conversion mark:** 5.2 cm = 0.052 m / 5.2×10^{-2} m / 5.2 x	3 (AO 1.1) (AO 1.1) (AO 2.2)	**ALLOW** conversion of atomic radius to same units as Mg metal for this MP, e.g., 1×10^{-8} cm **ALLOW ECF** for 5.2 (cm) ÷ (2 x (1 x 10^{-10})) = 2.6×10^{10} **Examiner's Comments**

			10^7 nm ✓ 0.052 or $5.2 \times 10^{-2} \div (2 \times (1 \times 10^{-10}))$ $= 2.6 \times 10^8$ ✓		All but the highest attaining candidates found this question challenging. The typical radius of an atom (quoted in section 1.2c of the specification as 10^{-10} m) was not well known. Candidates who were able to recall the radius of an atom in m often then did not ensure that the values for atomic radius and the width of magnesium metal were in the same units before proceeding with the next part of the calculation. Of those that gained the first 2 marks the most common error was then not recognising that the atomic radius needed to be doubled to calculate the number of ions to fit the width of the magnesium metal sample.
			Total	**11**	
2		i		2 (2 × AO 2.1)	All three correct = 2 marks Two correct = 1 mark **Examiner's Comments** Most candidates correctly matched the three isotopes to their descriptions.
		ii	**First check the answer on answer line** **If answer = 121.3 award 2 marks** 33 + (4 × 16) + 24.3 ✓ = 121.3 ✓	2 (2 × AO 2.2)	**Examiner's Comments** Most candidates correctly calculated the relative formula mass of magnesium sulfate. The most common incorrect response was 24.3 + 33 + 16 = 73.3.
		iii	Solvent / mobile phase ✓	1 (AO 3.3b)	**IGNORE** use a different liquid **IGNORE** change the concentration of the solvent **DO NOT ALLOW** (change) the stationary phase **Examiner's Comments** Many candidates correctly stated the need to change the solvent.

					The most common incorrect responses were: • use gas chromatography • melt the magnesium sulfate • increase the concentration of the solvent or use more solvent • change the stationary phase • add water.
		iv	Strong electrostatic attraction (between oppositely charged ions) / strong forces between oppositely charged ions / strong ionic bonds ✓ Lots of energy is required to overcome the forces / bonds ✓	2 (2 × AO 2.1)	**DO NOT ALLOW** references to intermolecular forces, covalent bonds or metallic bonds – scores 0 for question **<u>Examiner's Comments</u>** Successful responses to this question described the strong electrostatic attraction between oppositely charged ions, which needs lots of energy to overcome. Less successful responses referred to intermolecular forces, even after identifying the bonding in magnesium sulfate as ionic. **Assessment for learning** Candidates should be encouraged to use correct terminology. Many candidates attempted to explain the high melting point of magnesium sulfate in terms of covalent bonds or intermolecular forces. The term intermolecular forces appeared to be used by candidates without understanding of what they are or what type of structure possesses them.
			Total	**7**	
3	a		Alpha / positively charged particles were fired at gold leaf ✓ Idea that most particles went (straight) through ✓	3 (3 × AO 1.1)	**IGNORE** electrons for MP1 **ALLOW** some particles went (straight) through **ALLOW** idea that particles were deflected or reflected **DO NOT ALLOW** idea that <u>most</u>

			Idea that some particles were repelled by the (positive charge of the) nucleus ✓		particles were repelled **Examiner's Comments** This experiment was well known by candidates, with most scoring 2 or 3 marks. Some candidates wrote about expected results, e.g. Rutherford, Geiger, and Marsden expected most/all of the particles to pass through the gold foil, rather than stating that this was what they actually observed. Other candidates did not mention that most of the alpha particles passed straight through the gold foil.
	b		A proton has a positive charge and a relative mass of 1. ☑ An atomic radius is approximately 1 × 10^{-12} m. ☐ An electron has a negative charge and a relative mass of 1. ☐ Most of the mass of the atom is in the nucleus. ☑ The radius of an atom is much smaller than the radius of a nucleus. ☐ ✓✓	2 (2 × AO 1.1)	**Examiner's Comments** Most candidates identified the two correct statements.
			Total	**5**	
4			C ✓	1(AO2.1)	
			Total	**1**	
5			A ✓	1(AO1.1)	
			Total	**1**	
6			B ✓	1(AO1.2)	**Examiner's Comments** **Misconception** C was a common misconception in this question. Candidates had clearly

					appreciated the connection between nm and 10^{-9}, and possibly knew that a number in standard form has to have a value ≥ 1 but < 10 before the power of 10, rather than multiplying 0.14 by 1 × 10^{-9}.
			Total	**1**	