1(a). Many scientists were involved in the development of the atomic model.

Describe **two** ways Rutherford's atomic model was an improvement on Thomson's "plum pudding" atomic model.

1 _____

_____

2 _____

_____ **[2]**

(b). Atoms are either oxidised or reduced to form ions.

i. Complete the sentences about how atoms form ions.

Atoms are ..... to form positive ions. Atoms ..... electrons to form positive ions.

Atoms are ..... to form negative ions. Atoms ..... electrons to form negative ions.

[2]

ii. The table shows information about three different ions.

Complete the table.

Ion	**Number of protons**	**Number of neutrons**	**Number of electrons**	**Mass number**
Mg^{2+}	12	.....	10	24
F^-	9	10	.....	19
Li^+	3	4	2	.....

[2]

iii. The element lithium exists as isotopes.

State one difference and one similarity between the Li^+ ions formed from different isotopes of lithium.

Difference _____

_____

Similarity _____

_____ **[2]**

iv. A sample of magnesium metal is 5.2 cm wide.

Estimate how many Mg^{2+} ions would fit across the width of the sample of magnesium metal.

Use your knowledge of the typical radius of atoms in your calculation.

Estimated number of Mg^{2+} ions = ... **[3]**

2. Seawater can contain isotopes of sulfur.

i. Draw **three** lines to connect each **isotope** with its correct **description**.

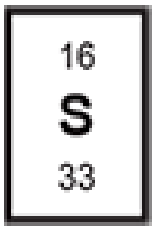
Isotope	Description
$^{32}_{16}S$	This isotope contains 17 neutrons.
$^{33}_{16}S$	This isotope has a full outer shell of electrons.
$^{34}_{16}S$	This isotope has more protons than neutrons.
	This isotope has the highest mass number.
	This isotope has the same number of neutrons and protons.

[2]

ii. Some of this sulfur in seawater is in the form of magnesium sulfate, $MgSO_4$.

What is the relative formula mass of a sample of magnesium sulfate, $MgSO_4$, where all of the sulfur atoms are the isotope sulfur-33?

Sulfur-33 is



Relative atomic mass (A_r): O = 16.0 Mg = 24.3

Relative formula mass = ... **[2]**

iii. A scientist wants to separate magnesium sulfate from other compounds using thin layer chromatography.

The spot does **not** move from the start line on the chromatogram.

State what the scientist should change so that magnesium sulfate is separated from the other compounds.

---

[1]

iv. Explain why magnesium sulfate has a high melting point.

---

[2]

3(a). The model of the atom has developed over time.

Describe the experiment **and** results that Rutherford, Geiger, and Marsden used to determine that an atom has a nucleus.

---

[3]

(b). Which statements about atoms are **correct**?

Tick (✓) **two** boxes.

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]

4. A sample of propanoic acid, $C_3H_6O_2$, is made using an isotope of hydrogen, called deuterium.

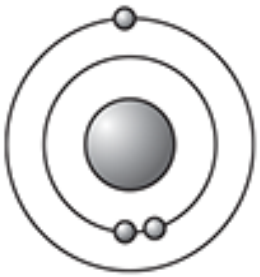
The relative atomic mass of deuterium is 2.0.

What is the relative molecular mass, M_r, of propanoic acid when deuterium atoms replace all the hydrogen atoms?

A 68.0
B 74.0
C 80.0
D 86.0

Your answer ☐ **[1]**

5. The diagram of an atom shows that electrons occupy shells around the nucleus.



Which scientist proposed this atomic model?

A Bohr
B Dalton
C J. J. Thomson
D Mendeleev

Your answer ☐ **[1]**

6. The radius of a helium atom is 0.14 nm.

What is the radius of a helium atom in metres?

A 0.14×10^{-10} m
B 1.4×10^{-10} m
C 1.4×10^{-9} m
D 14×10^{-9} m

Your answer ☐ **[1]**

END OF QUESTION PAPER