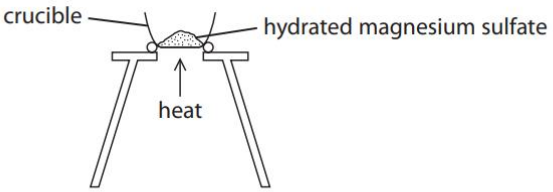
1 This question is about the amount of water of crystallisation in hydrated magnesium sulfate, $MgSO_4 \cdot \mathbf{x} H_2O$.

(a) The value of **x** in the formula was determined in an experiment.

Procedure

Step **1** A crucible was weighed, a spatula measure of hydrated magnesium sulfate was added and the crucible was reweighed.

Step **2** The crucible containing the hydrated magnesium sulfate was heated using the apparatus shown.



Step **3** After heating for two minutes, the crucible containing the magnesium sulfate was allowed to cool and was reweighed.

(i) Complete the table of results.

(1)

Measurement	Mass / g
Mass of empty crucible	21.21
Mass of crucible and hydrated magnesium sulfate before heating	26.71
Mass of crucible and magnesium sulfate after heating for two minutes	24.12
Mass of magnesium sulfate after heating for two minutes	
Mass of water lost	

(ii) Use these results to calculate the value of **x** in $MgSO_4 \cdot \mathbf{x} H_2O$.
Give your answer to the nearest whole number.

[A_r values: H = 1.0 O = 16.0 Mg = 24.3 S = 32.1]

(4)

(b) The correct value of **x** is greater than the value calculated in (a) (ii).

Suggest a way of improving the method to obtain a more accurate result, using the same apparatus.
Justify your answer.

(2)

(c) Potassium chlorate(V) decomposes on heating to form oxygen.

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

What is the atom economy (by mass) for the formation of oxygen?

[A_r values: O = 16.0 Cl = 35.5 K = 39.1]

2 This question is about the bonding in the elements of Period 3 in the Periodic Table.

The melting temperatures of the Period 3 elements are shown in the table.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting temperature / °C	98	650	660	1423	44	120	−101	−189

(a) Sodium, magnesium and aluminium are metals.

(i) State what is meant by metallic bonding.

(1)

(ii) Melting temperature depends on the strength of metallic bonding.

Explain why the metallic bonding in magnesium is much stronger than that in sodium.

(3)

(b) (i) In the elements silicon, phosphorus, sulfur and chlorine, the atoms are joined by covalent bonds.

Describe the attraction between the atoms in a covalent bond.

(1)

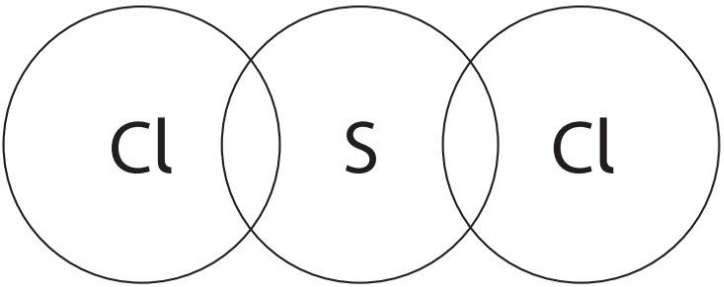
(ii) Explain why the melting temperature of silicon is much higher than that of phosphorus, by referring to their structures.

(3)

(c) Sulfur reacts with chlorine to form sulfur dichloride, SCl_2.

(i) Complete the dot-and-cross diagram of a molecule of sulfur dichloride.
Use dots (•) for the chlorine electrons and crosses (×) for the sulfur electrons.
Show the outer shell electrons only.

(2)

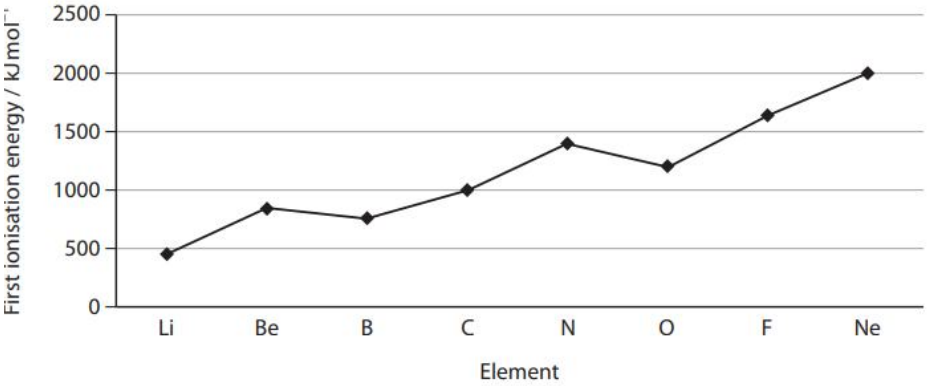


(d) How many molecules are there in 44.0 g of carbon monoxide?

[Avogadro constant $L = 6.02 \times 10^{23}\ mol^{-1}$
A_r values: C = 12.0 O = 16.0]

3 This question is about the ionisation energies of the elements in Period 2 of the Periodic Table.

(a) The first ionisation energies of the Period 2 elements are shown.



(i) Give an equation that represents the first ionisation energy of lithium. Include state symbols.

(1)

(ii) Explain why there is a general increase in the first ionisation energy across the period.

(2)

(iii) Explain why Oxygen has less 1st ionisation energy then nitrogen.

(iii) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.

(2)

(b) All the successive ionisation energies of nitrogen are shown in the table.

Ionisation number	1	2	3	4	5	6	7
Ionisation energy / kJ mol^{-1}	1402	2856	4578	7475	9445	53 267	64 360

Explain the trend in the successive ionisation energies of nitrogen.

Then draw the graph.

(2)

4 This question is about the structure of atoms.

(a) State what is meant by the term orbital.

(2)

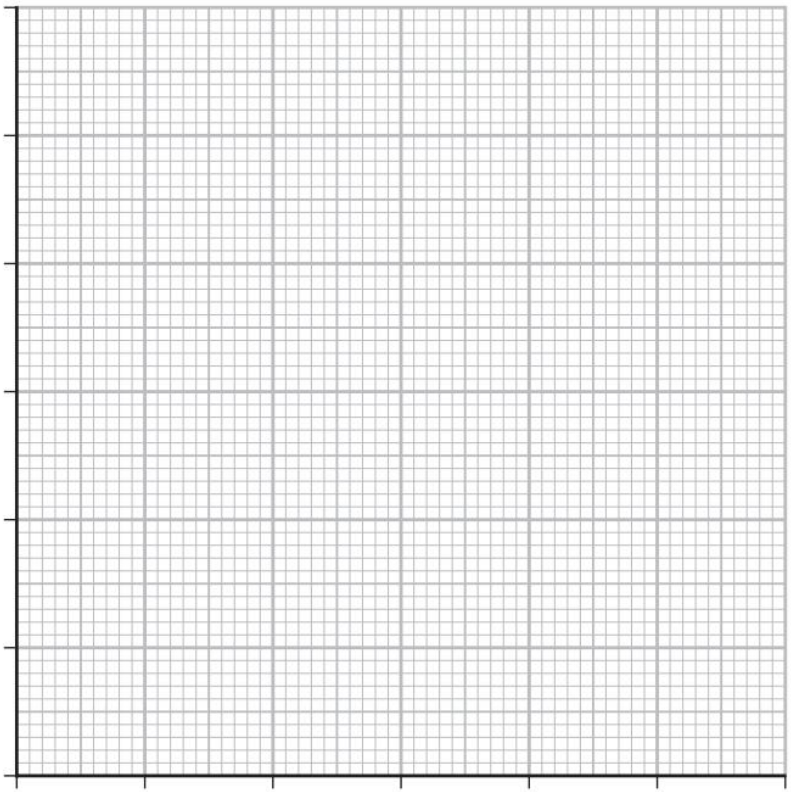
(b) State the shape of an s orbital and the shape of a p orbital. Also draw each orbitals.

(d) (i) The log of the **fourth** ionisation energy for six elements is shown in the table.

Element	$\log_{10}$ (fourth ionisation energy / kJ mol^{-1})
O	3.87
F	3.92
Ne	3.97
Na	
Mg	4.02
Al	4.06

Plot a graph of these data.

(3)



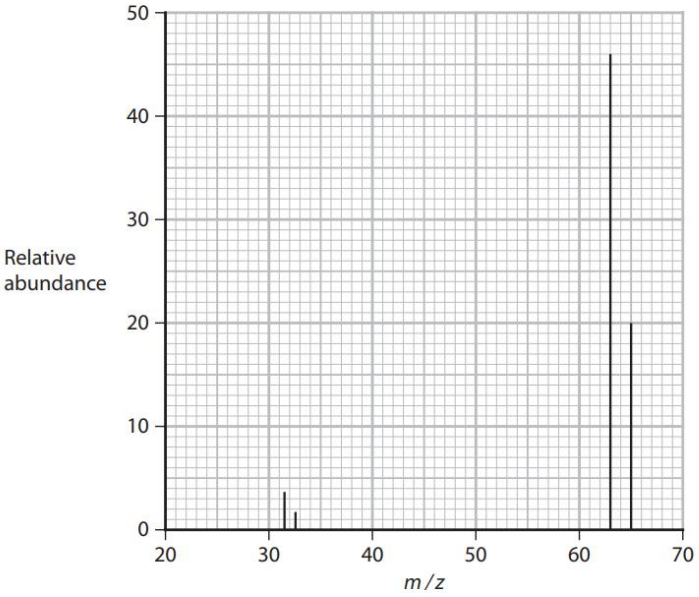
(ii) Use your graph to estimate the fourth ionisation energy for sodium, in kJ mol^{-1}.

(1)

(iii) Suggest why the fourth ionisation energies of neon and sodium are similar in magnitude even though the elements are in different periods of the Periodic Table.

(1)

The mass spectrum of a sample of an element is shown.



(a) What is the A_r of the element?