

- (iii) State the role of nitrogen dioxide, NO_2 , in the formation of acid rain by oxides of sulfur. Write suitable equations to explain this role.

role

equation 1

equation 2

[3]

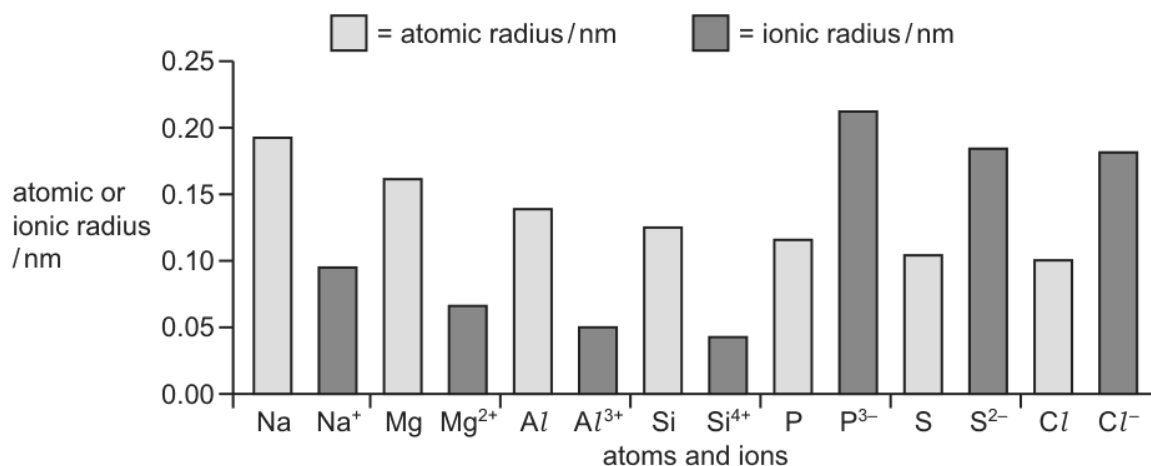
May/June 2017 9701/22 · Q2 (b)(iii)

- (e) The SO_3 produced is converted to sulfuric acid in two stages. In the first stage the SO_3 is reacted with concentrated sulfuric acid to produce oleum, $\text{H}_2\text{S}_2\text{O}_7$. The oleum is then reacted with water to form sulfuric acid.

Suggest an equation for the reaction of oleum, $\text{H}_2\text{S}_2\text{O}_7$, with water to form sulfuric acid.

..... [1]

(a) A graph of the atomic and ionic radii across the third period is shown.



(i) Explain the decrease in atomic radius across the third period.

.....

 [2]

(ii) Explain why, for sodium to silicon, the ionic radii are less than the atomic radii.

.....
 [1]

(iii) Explain why, for phosphorus to chlorine, the ionic radii are greater than the atomic radii.

.....

 [2]

(ii) Give the equations to show the reactions of sodium chloride and silicon(IV) chloride when separately added to water.

sodium chloride

silicon(IV) chloride

[2]

- (iii) Complete the table to describe the structure and bonding in sodium chloride and silicon(IV) chloride.

	structure	bonding
sodium chloride		
silicon(IV) chloride		

[2]

[Total: 16]

- (a) The table shows the differences in observations which occur when two Period 3 chlorides are added to water.

Period 3 chloride	observations when added to water	pH of solution formed with water
NaCl	White solid disappears. Colourless solution made.	7
SiCl_4	Pale yellow solution forms. Bubbles form and the test-tube feels hot. White precipitate forms.	1–2

- (i) Write an equation for the reaction occurring when SiCl_4 is added to cold water. Include state symbols.

..... [1]

- (ii) Name the type of reaction occurring when SiCl_4 is added to water. Ignore the exothermic/endothermic nature of the reaction.

..... [1]

- (iii) Explain, in terms of bonding, why NaCl and SiCl_4 behave differently when added to water.

.....

 [2]

- (ii) Name the type of reaction occurring.

..... [1]

- (iii) Explain why chlorine is used in the purification of water.

.....
 [1]

May/June 2019 9701/22 · Q3 (a)(i), (a)(ii), (a)(iii), (b)(ii), (b)(iii)

- 2 (a) Complete the table to give details of the type of bonding and structure shown by some of the oxides of Period 3 elements.

	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	SO ₃
boiling point/°C	1275	3670	2977	2950	45
nature of oxide	basic	basic	amphoteric	acidic	acidic
bonding					
structure					

[2]

- (ii) Al₂O₃ is an amphoteric oxide.

Explain what is meant by the term *amphoteric*. Use chemical equations to illustrate your answer.

.....

 [3]

- (iii) State what you would observe when a small sample of Na₂O is placed in water.

..... [1]

(iii) SeO_2 shows similar chemical reactions to SO_2 .

Suggest an equation to show the reaction of SeO_2 with aqueous sodium hydroxide, NaOH .

..... [1]

[Total: 13]

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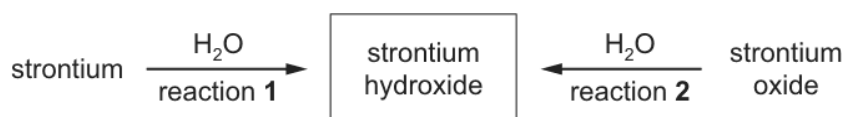
Oct/Nov 2019 9701/21 · Q2 (a), (b)(ii), (b)(iii), (c)(iii) (cont.)

- (a) Complete the table to give the formulae and acid/base behaviour of some of the oxides of the Period 3 elements.

element	sodium	aluminium	silicon	phosphorus	sulfur
formula of oxide	Na ₂ O				SO ₃
acid/base behaviour		amphoteric			

[2]

- (iii) Two methods of preparing strontium hydroxide are shown.



State **one** difference between the observations you would make for reaction 1 and reaction 2.

.....

 [1]

- (c) Sodium peroxide, Na₂O₂, reacts with CO₂.



The partial pressure of CO₂(g) in a 0.500 dm³ sample of air is 5.37 kPa at 20 °C.

- (i) Calculate the amount, in moles, of CO₂(g) present in the sample of air at 20 °C.

amount of CO₂(g) = mol [2]

- (ii) Calculate the mass of Na₂O₂(s) that would react fully with the amount of CO₂(g) calculated in (i).

mass of Na₂O₂(s) = g [1]

- (b) The two most common oxides of sulfur are SO_2 and SO_3 .

When SO_2 dissolves in water, a small proportion of it reacts with water to form a weak Brønsted-Lowry acid.

- (i) Explain the meaning of the term *weak Brønsted-Lowry acid*.

.....
..... [2]

- (ii) Write the equation for the reaction of SO_2 with water.

..... [1]

Oct/Nov 2020 9701/21 · Q2 (b)(i), (b)(ii)

- (a) State the trend in acid/base behaviour of the oxides of the Period 3 elements, from Na to S.

.....
..... [1]

- (c) Sodium oxide and phosphorus(V) oxide both react with water.

Name the product of each reaction.

reaction	product
sodium oxide with water	
phosphorus(V) oxide with water	

[2]

- (e) Aluminium oxide, Al_2O_3 , reacts separately with both acids and alkalis.

- (i) Write an equation for the reaction of aluminium oxide with excess aqueous hydrochloric acid.

..... [1]

- (f) Describe the lattice structure of silicon(IV) oxide.

Your answer should include reference to the arrangement of the silicon and oxygen atoms and the bonds between them.

.....
.....
.....
..... [2]

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- (ii) Give the formula of another Period 3 oxide which behaves as a ceramic material.

..... [1]

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- (ii) Write an equation for the reaction of Na_2O with water.

..... [1]

- (iv) Write an equation for the reaction of P_4O_{10} with water.

..... [1]

March 2022 9701/22 · Q2 (a)(ii), (c)(iv)

2 (a) Period 3 elements and their compounds show trends in their physical properties.

(i) On Fig. 2.1 sketch a graph to show the melting points of the first five elements in Period 3.

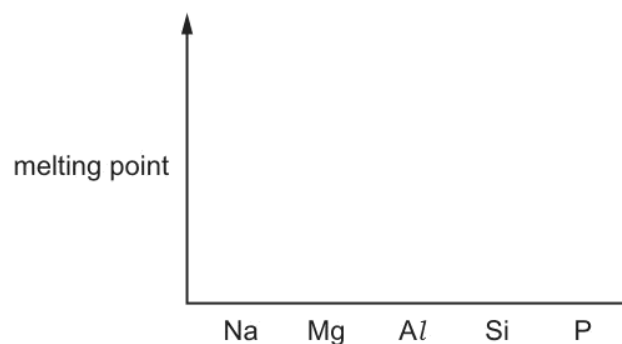


Fig. 2.1

[3]

(ii) Complete Table 2.1 with information for sodium chloride and phosphorus(V) chloride.

Table 2.1

	sodium chloride	phosphorus(V) chloride
state at room temperature		
name of change which occurs on addition of water		
pH of final solution		

[3]

May/June 2022 9701/23 · Q2 (a)(i), (a)(ii), (b)(ii) (continued ·)

- (ii) Some scientists predict that Ts has properties typical of metals like copper.

Complete Table 2.2 with:

- the predicted melting point of tennessine
- the lattice structure of solid chlorine, bromine and tennessine.

Assume that Ts has properties typical of metals like copper.

Table 2.2

element	chlorine	bromine	tennessine
melting point/°C	−101	−7.2	
lattice structure of crystalline solid			

[2]

[Total: 10]

May/June 2022 9701/23 · Q2 (a)(i), (a)(ii), (b)(ii) (cont.)

- (ii) Name a chloride of a different Period 3 element that is also a liquid at room temperature and produces misty fumes when added to water.

..... [1]

May/June 2024 9701/21 · Q2 (a)(ii)

- (d) Fig. 1.1 shows the variation in melting point of some Period 3 elements in their standard states at room temperature and pressure.

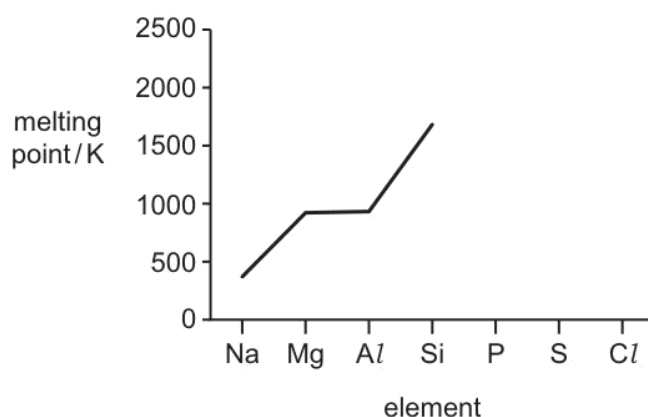


Fig. 1.1



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- (i) Explain why Si has a high melting point.

.....

.....

..... [1]

- (e) Two Period 3 elements react with an excess of oxygen at room pressure.

- (i) Complete Table 1.2.

Table 1.2

1	2	3
Period 3 element	state of oxide at room temperature and pressure	approximate pH of solution made when oxide is added to water
Na		
S		

[2]

- (iii) Write an equation to describe the reaction between P_4O_{10} and an excess of water.

..... [1]

(b) H_2O reacts with both inorganic and organic compounds.

(i) Complete Table 2.1 to give details of the reactions of some Period 3 oxides with H_2O .

Table 2.1

Period 3 oxide	product of reaction with H_2O	pH of solution formed
	$\text{Mg}(\text{OH})_2$	
P_4O_{10}		

[2]

Oct/Nov 2024 9701/22 · Q2 (b)(i)

(ii) Identify the formula of a Period 3 oxide that is amphoteric.

..... [1]

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May/June 2025 9701/22 · Q1 (c)(ii)



- (a) A Period 3 oxide produces a solution with a pH greater than 10 when it is added to water. State the formula of the oxide.

..... [1]

- (b) P_4O_{10} is added to an excess of aqueous NaOH. Write an equation to describe the reaction.

..... [1]

- (ii) A student suggests the following hypothesis.

The melting point of an ionically bonded oxide is only determined by the charge on the cation.

Use Table 2.1 to deduce if this hypothesis is true or false or if there is **not** enough information to make a conclusion. Explain your answer.

.....
.....
..... [2]

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- (e) Al_2O_3 is a white amphoteric compound.

- (i) State the formula of the aluminium-containing species produced when Al_2O_3 reacts with NaOH(aq).

..... [1]

May/June 2025 9701/23 · Q2 (a), (b), (c)(ii), (e)(i), (e)(ii) (continued ·)

- (ii) State the formula of the aluminium-containing salt produced when Al_2O_3 reacts with $\text{H}_2\text{SO}_4(\text{aq})$.

..... [1]

[Total: 8]



(b) The relative electrical conductivities of the Period 3 elements are shown in Fig. 1.1.

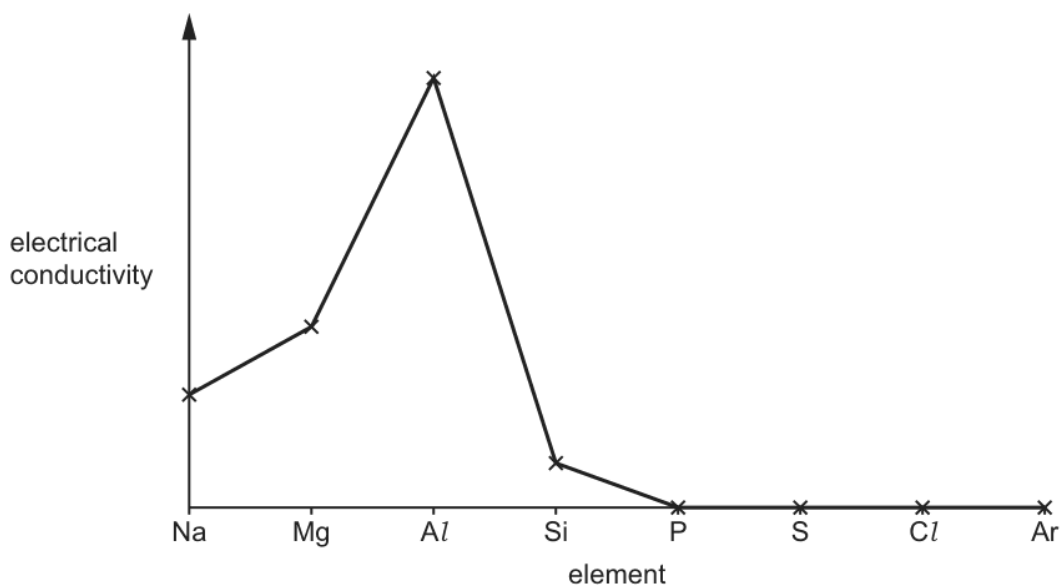


Fig. 1.1

Explain why there is an increase in conductivity from Na to Al and why P, S and Cl are non-conductors of electricity.

.....

.....

.....

.....

..... [2]

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(d) Most Period 3 elements react with oxygen to form oxides.

(i) Write an equation for the reaction of phosphorus with oxygen.

..... [1]

(a) Fig. 2.1 shows the variation in atomic and ionic radii of the Period 3 elements Na to Cl.

The ionic radius of Si is **not** shown.

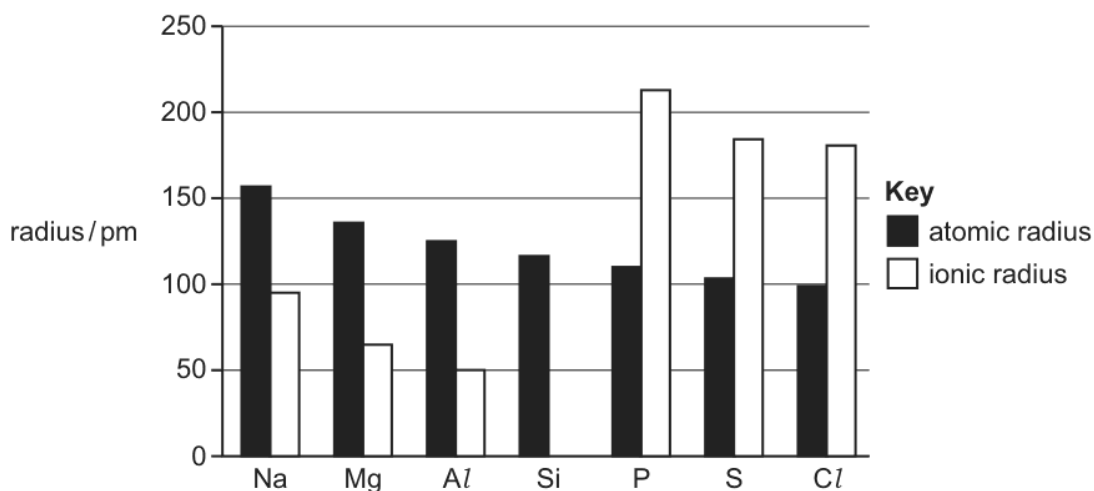


Fig. 2.1

(i) Explain the trend shown in the atomic radii of the Period 3 elements Na to Cl.

.....

.....

.....

..... [2]

(ii) Explain why there is a large difference in the ionic radii of Al and P.

.....

.....

.....

..... [2]



(ii) State why there is no data given in row B for Al_2O_3 and SiO_2 .

..... [1]

(c) (i) Write an equation for the reaction of Na_2O with dilute hydrochloric acid.

..... [1]

(ii) Construct an equation for the reaction of Al_2O_3 with a base to form $NaAlO_2$.

..... [1]

Oct/Nov 2025 9701/21 · Q2 (a)(i), (a)(ii), (b)(ii), (c)(ii) (cont.)

(b) Fig. 2.1 shows the variation in melting point of the Period 3 elements Si to Cl.

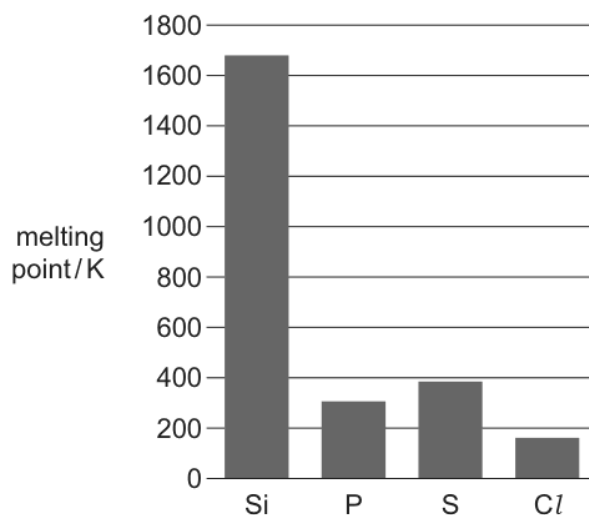


Fig. 2.1

The Period 3 elements Si to Cl are all non-metals.

Explain why there is a large difference between the melting point of Si and the melting points of P, S and Cl.

.....

.....

.....

..... [2]

(ii) Explain why there is a large difference in the ionic radii of Al and P .

.....

.....

.....

..... [2]

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(iii) Write an equation to show the reaction of P_4O_{10} with an excess of water.

..... [1]

[Total: 11]

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