

## Period 3 Elements

**2** Sodium, aluminium and silicon are solid elements with a silver colour. These elements react with oxygen to form oxides with high melting points. Aluminium is a reactive metal, but it resists corrosion in water because it has a surface coating of aluminium oxide.

**2 (a)** In terms of its structure and bonding, explain why silicon dioxide has a high melting point.

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(3 marks)

(Extra space) .....

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**2 (b)** State the type of bonding in aluminium oxide.

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(1 mark)

**2 (c)** Write an equation for the reaction of aluminium with oxygen.

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(1 mark)

**2 (d)** Suggest **one** property of the aluminium oxide coating that causes aluminium to resist corrosion in water.

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(1 mark)

**2 (e)** Sodium metal is **not** resistant to corrosion in water, despite having a surface coating of sodium oxide. Write an equation to show how sodium oxide reacts with water.

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(1 mark)



2 (f) Aluminium oxide is amphoteric. It reacts with acids and alkalis.

2 (f) (i) Write an equation for the reaction between aluminium oxide and hydrochloric acid.

.....  
(1 mark)

2 (f) (ii) Write an equation for the reaction between aluminium oxide and an excess of aqueous sodium hydroxide.

.....  
(1 mark)

2 (g) Silicon dioxide does **not** react with hydrochloric acid but it does react with sodium hydroxide. State **one** property of silicon dioxide that can be deduced from this information and write an equation for its reaction with sodium hydroxide.

Property .....

Equation .....

(2 marks)

**Turn over for the next question**



**SECTION B**

Answer **all** questions in the spaces provided.

- 8** (a) State and explain the trend in electronegativities across Period 3 from sodium to sulfur.

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(4 marks)

(Extra space) .....

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**4** This question is about the chemistry of the Period 3 elements and the trends in their properties.

**4 (a) (i)** Describe what you would observe when magnesium burns in oxygen. Write an equation for the reaction that occurs. State the type of bonding in the oxide formed.

Observations .....

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.....

Equation .....

Type of bonding .....

(4 marks)

**4 (a) (ii)** Describe what you would observe when sulfur burns in oxygen. Write an equation for the reaction that occurs. State the type of bonding in the oxide formed.

Observations .....

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Equation .....

Type of bonding .....

(4 marks)

**4 (b)** State the type of bonding in sodium oxide. Explain why sodium oxide reacts to form an alkaline solution when added to water.

Type of bonding.....

Explanation.....

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(3 marks)



**4 (c)** Outline an experiment that could be used to show that aluminium oxide contains ions.

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(2 marks)

(Extra space) .....

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**4 (d)** Suggest **one** reason why a thin layer of aluminium oxide protects aluminium from corrosion in moist air.

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.....  
(1 mark)

**4 (e)** Write an ionic equation in each case to show how aluminium oxide reacts with the following

**4 (e) (i)** hydrochloric acid

.....  
(1 mark)

**4 (e) (ii)** aqueous sodium hydroxide.

.....  
(1 mark)

Turn over for the next question

Turn over ►





- 3** There is a link between the properties of the oxides of the Period 3 elements and their structure and bonding. The table below shows the melting points of the oxides of some Period 3 elements.

	Na <sub>2</sub> O	SiO <sub>2</sub>	P <sub>4</sub> O <sub>10</sub>
<i>T<sub>m</sub>/K</i>	1548	1883	573

- 3 (a)** In terms of crystal structure and bonding, explain in each case why the melting points of sodium oxide and silicon dioxide are high.

Na<sub>2</sub>O .....

.....

.....

SiO<sub>2</sub> .....

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.....

(4 marks)

- 3 (b)** Predict whether the melting point of lithium oxide is higher than, the same as, or lower than the melting point of sodium oxide and explain your prediction.

Prediction.....

Explanation.....

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(3 marks)

- 3 (c)** Phosphorus(V) oxide has a lower melting point than sodium oxide.

- 3 (c) (i)** State the structure of and bonding in phosphorus(V) oxide.

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(2 marks)



3 (c) (ii) Explain why the melting point of phosphorus(V) oxide is low.

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.....

(1 mark)

3 (d) Separate samples of phosphorus(V) oxide and sodium oxide were reacted with water. In each case, predict the pH of the solution formed and write an equation for the reaction.

pH with  $P_4O_{10}$  .....

Equation .....

pH with  $Na_2O$  .....

Equation .....

(4 marks)

3 (e) Write an equation for the reaction between  $Na_2O$  and  $P_4O_{10}$ . State the general type of reaction illustrated by this example.

Equation .....

Reaction type .....

(2 marks)

Turn over for the next question



**Section A**Answer **all** questions in the spaces provided.

**1** White phosphorus ( $P_4$ ) is a hazardous form of the element. It is stored under water.

**1 (a)** Suggest why white phosphorus is stored under water.

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(1 mark)

**1 (b)** Phosphorus(V) oxide is known as phosphorus pentoxide.  
Suggest why it is usually represented by  $P_4O_{10}$  rather than by  $P_2O_5$

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.....

(1 mark)

**1 (c)** Explain why phosphorus(V) oxide has a higher melting point than sulfur(VI) oxide.

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(2 marks)

**1 (d)** Write an equation for the reaction of  $P_4O_{10}$  with water to form phosphoric(V) acid.  
Give the approximate pH of the final solution.

Equation .....

pH .....

(2 marks)



**1 (e)** A waste-water tank was contaminated by  $P_4O_{10}$ . The resulting phosphoric(V) acid solution was neutralised using an excess of magnesium oxide. The mixture produced was then disposed of in a lake.

**1 (e) (i)** Write an equation for the reaction between phosphoric(V) acid and magnesium oxide.

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(1 mark)

**1 (e) (ii)** Explain why an excess of magnesium oxide can be used for this neutralisation.

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.....  
.....  
(1 mark)

**1 (e) (iii)** Explain why the use of an excess of sodium hydroxide to neutralise the phosphoric(V) acid solution might lead to environmental problems in the lake.

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(1 mark)

9
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**Turn over for the next question**

**Turn over ►**



- 3** The data in the table below show the melting points of oxides of some Period 3 elements.

	Na <sub>2</sub> O	P <sub>4</sub> O <sub>10</sub>	SO <sub>2</sub>
$T_m/K$	1548	573	200

- 3 (a)** In terms of structure and bonding, explain why

- 3 (a) (i)** sodium oxide has a high melting point

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.....  
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(2 marks)

(Extra space) .....

.....

- 3 (a) (ii)** sulfur dioxide has a low melting point.

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(2 marks)

(Extra space) .....

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- 3 (b)** Explain why the melting point of P<sub>4</sub>O<sub>10</sub> is higher than the melting point of SO<sub>2</sub>

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(2 marks)

(Extra space) .....

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- 3 (c)** Write equations for the reactions of  $\text{Na}_2\text{O}$  and  $\text{P}_4\text{O}_{10}$  with water. In each case give the approximate pH of the resulting solution.

Equation for  $\text{Na}_2\text{O}$  .....

pH .....

Equation for  $\text{P}_4\text{O}_{10}$  .....

pH .....

(4 marks)

- 3 (d)** Write an equation for the acid–base reaction that occurs when  $\text{Na}_2\text{O}$  reacts with  $\text{P}_4\text{O}_{10}$  in the absence of water.

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(1 mark)

11
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**Turn over for the next question**

**Turn over ►**



**4** Magnesium oxide, silicon dioxide and phosphorus(V) oxide are white solids but each oxide has a different type of structure and bonding.

**4 (a)** State the type of bonding in magnesium oxide.  
Outline a simple experiment to demonstrate that magnesium oxide has this type of bonding.

Type of bonding .....

Experiment .....

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.....  
.....  
.....  
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(3 marks)

**4 (b)** By reference to the structure of, and the bonding in, silicon dioxide, suggest why it is insoluble in water.

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(3 marks)



- 4 (c)** State how the melting point of phosphorus(V) oxide compares with that of silicon dioxide. Explain your answer in terms of the structure of, and the bonding in, phosphorus(V) oxide.

Melting point in comparison to silicon dioxide .....

Explanation .....

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(3 marks)

- 4 (d)** Magnesium oxide is classified as a basic oxide.

Write an equation for a reaction that shows magnesium oxide acting as a base with another reagent.

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(2 marks)

- 4 (e)** Phosphorus(V) oxide is classified as an acidic oxide.

Write an equation for its reaction with sodium hydroxide.

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(1 mark)

12
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Turn over ►





4 Some melting points of Period 3 oxides are given in this table.

	Na <sub>2</sub> O	SiO <sub>2</sub>	SO <sub>2</sub>	SO <sub>3</sub>
<b>Melting point / K</b>	1548	1883	200	290

4 (a) Explain, in terms of structure and bonding, why sodium oxide has a high melting point.

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(2 marks)

4 (b) Explain, in terms of structure and bonding, why sulfur trioxide has a higher melting point than sulfur dioxide.

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(2 marks)

4 (c) Some Period 3 oxides have basic properties.

State the type of bonding in these basic oxides.  
Explain why this type of bonding causes these oxides to have basic properties.

Type of bonding .....

Explanation .....

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(3 marks)



**4 (d)** Sulfur dioxide reacts with water to form a weakly acidic solution.

**4 (d) (i)** Ions are formed when sulfur dioxide reacts with water.  
Write an equation for this reaction.

.....  
(1 mark)

**4 (d) (ii)** With reference to your equation from part **(d) (i)**, suggest why sulfur dioxide forms a weakly acidic solution.

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.....  
(1 mark)

**4 (e)** Suggest why silicon dioxide is described as an acidic oxide even though it is insoluble in water.

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.....  
(1 mark)

10
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**Turn over for the next question**

**Turn over ►**



**3** This question is about some Period 3 elements and their oxides.

**3 (a)** Describe what you would observe when, in the absence of air, magnesium is heated strongly with water vapour at temperatures above 373 K.  
Write an equation for the reaction that occurs.

**[3 marks]**

Observations .....

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Equation .....

**3 (b)** Explain why magnesium has a higher melting point than sodium.

**[2 marks]**

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**[Extra space]** .....

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**3 (c)** State the structure of, and bonding in, silicon dioxide.  
Other than a high melting point, give **two** physical properties of silicon dioxide that are characteristic of its structure and bonding.

**[4 marks]**

Structure .....

Bonding.....

Physical property 1 .....

Physical property 2.....



- 3 (d)** Give the formula of the species in a sample of solid phosphorus(V) oxide.  
State the structure of, and describe fully the bonding in, this oxide.

**[4 marks]**

Formula .....

Structure .....

Bonding .....

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- 3 (e)** Sulfur(IV) oxide reacts with water to form a solution containing ions.

Write an equation for this reaction.

**[1 mark]**

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- 3 (f)** Write an equation for the reaction between the acidic oxide, phosphorus(V) oxide, and the basic oxide, magnesium oxide.

**[1 mark]**

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15

**Turn over for the next question**

**Turn over ►**



- 4 (a)** Write an equation for the reaction that occurs when magnesium is heated in steam.  
Describe what you would observe when this reaction occurs.

**[3 marks]**

Equation .....

Observations .....

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- 4 (b)** Write an equation for the reaction that occurs when sodium is heated in oxygen.  
Describe what you would observe when this reaction occurs.

**[3 marks]**

Equation .....

Observations .....

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6

**Turn over for the next question**

**Turn over ►**



- 5 (a) **Table 5** contains data that show a trend in the melting points of some oxides of the Period 3 elements.

**Table 5**

Oxide	Sodium oxide	Magnesium oxide	Aluminium oxide	Silicon(IV) oxide	Phosphorus(V) oxide	Sulfur(IV) oxide
Melting point / K		3125	2345	1883	573	

- 5 (a) (i) Use data from **Table 5** to predict an approximate melting point for sodium oxide.

Tick (✓) **one** box.

[1 mark]

250 K

500 K

1500 K

3500 K

- 5 (a) (ii) Explain, in terms of structure and bonding, why sodium oxide has a high melting point.

[2 marks]

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**5 (a) (iii)** Use data from **Table 5** to predict a value for the melting point of sulfur(IV) oxide.

Suggest, in terms of structure and bonding, why the melting point of sulfur(IV) oxide is different from that of phosphorus(V) oxide.

**[3 marks]**

Predicted melting point of sulfur(IV) oxide .....

Why the melting point is different from phosphorus(V) oxide .....

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.....  
.....

**5 (b)** Write an equation for the reaction of sulfur(IV) oxide with water.

Suggest the pH value of the resulting solution.

**[2 marks]**

Equation

.....

pH value .....

**5 (c)** Silicon(IV) oxide is insoluble in water.

Explain, using an equation, why silicon(IV) oxide is classified as an acidic oxide.

**[2 marks]**

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10

Turn over ►



**Section A**

Answer **all** questions in the spaces provided.

**1** This question is about the elements in Period 3 from sodium to phosphorus (Na to P) and their oxides.

**1 (a)** Element **X** forms an oxide that has a low melting point. This oxide dissolves in water to form an acidic solution.

**1 (a) (i)** Deduce the type of bonding in this oxide of **X**.

[1 mark]

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**1 (a) (ii)** Identify element **X**.

[1 mark]

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**1 (a) (iii)** Write an equation for the reaction between this oxide of **X** and water.

[1 mark]

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**1 (b)** Element **Y** reacts vigorously with water. An oxide of **Y** dissolves in water to form a solution with a pH of 14.

**1 (b) (i)** Deduce the type of bonding in this oxide of **Y**.

[1 mark]

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**1 (b) (ii)** Identify element **Y**.

[1 mark]

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**1 (b) (iii)** Write an equation for the reaction of element **Y** with water.

[1 mark]

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1 (b) (iv) Write an equation for the reaction of this oxide of **Y** with hydrochloric acid.

[1 mark]

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1 (c) Element **Z** forms an amphoteric oxide that has a very high melting point.

1 (c) (i) Deduce the type of bonding in this oxide of **Z**.

[1 mark]

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1 (c) (ii) Write the formula of this amphoteric oxide.

[1 mark]

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1 (c) (iii) State the meaning of the term amphoteric.

[1 mark]

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1 (c) (iv) Write two equations to show the amphoteric nature of the oxide of **Z**.

[2 marks]

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12

Turn over ►



**3** This question is about magnesium chloride.

**3 (a)** Write the equation, including state symbols, for the process corresponding to the enthalpy of solution of magnesium chloride.

[1 mark]

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**3 (b)** Use these data to calculate the standard enthalpy of solution of magnesium chloride.

Enthalpy of lattice dissociation of  $\text{MgCl}_2$  = +2493  $\text{kJ mol}^{-1}$

Enthalpy of hydration of magnesium ions = -1920  $\text{kJ mol}^{-1}$

Enthalpy of hydration of chloride ions = -364  $\text{kJ mol}^{-1}$

[2 marks]

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**3 (c)** Solubility is the measure of how much of a substance can be dissolved in water to make a saturated solution. A salt solution is saturated when an undissolved solid is in equilibrium with its aqueous ions.

Use your answer to part **(b)** to deduce how the solubility of  $\text{MgCl}_2$  changes as the temperature is increased.

Explain your answer.

[3 marks]

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