AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



EXAM QUESTION PACK

3.2.4 PERIOD 3 ELEMENTS AND THEIR OXIDES

SCORE	PERCENTAGE
/220	%

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner reports in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

Hydrochloric acid is a strong acid and ethanoic acid is a weak acid.

(a) State the meaning of the term strong acid.

_____

_____

(1)

(b) In an experiment, 10.35 cm^3 of 0.100 mol dm^{-3} hydrochloric acid are added to 25.0 cm^3 of 0.150 mol dm^{-3} barium hydroxide solution.

Calculate the pH of the solution that forms at 30 °C

$K_w = 1.47 \times 10^{-14}$ mol^2 dm^{-6} at 30 °C

Give your answer to 2 decimal places.

pH _____

(6)

(c) The pH of water at 30 °C is 6.92

Give the reason why water is neutral at this temperature.

_____

_____

(1)

(d) Identify the oxide that could react with water to form a solution with pH = 2

Tick (✓) **one** box.

Al_2O_3 ☐

Na_2O ☐

SiO_2 ☐

STEMUP.CO.UK

SO_2 ☐

(1)

(e) Give the expression for the acid dissociation constant (K_a) for ethanoic acid (CH_3COOH).

K_a

(1)

(f) A buffer solution contains 0.025 mol of sodium ethanoate dissolved in 500 cm^3 of 0.0700 mol dm^{-3} ethanoic acid at 25 °C

A sample of 5.00 cm^3 of 2.00 mol dm^{-3} hydrochloric acid is added to this buffer solution.

Calculate the pH of the solution formed.

For ethanoic acid, $K_a = 1.76 \times 10^{-5}$ mol dm^{-3} at 25 °C

pH _____

(5)

(Total 15 marks)

Q2.

(a) When anhydrous aluminium chloride reacts with water, solution **Y** is formed that contains a complex aluminium ion, **Z**, and chloride ions.

Give an equation for this reaction.

_____

(1)

(b) Give an equation to show how the complex ion **Z** can act as a Brønsted–Lowry acid with water.

_____

(1)

(c) Describe **two** observations you would make when an excess of sodium carbonate solution is added to solution **Y**.

Give an equation for the reaction. In your equation, include the formula of each complex aluminium species.

STEMUP.CO.UK

Observation 1 _____

_____

Observation 2 _____

_____

Equation _____

(3)

(d) Aqueous potassium hydroxide is added, until in excess, to solution **Y**.

Describe **two** observations you would make.
For each observation give an equation for the reaction that occurs.
In your equations, include the formula of each complex aluminium species.

Observation 1 _____

_____

Equation 1
_____

Observation 2 _____

_____

Equation 2
_____

(4)

(Total 9 marks)

Q3.

The elements sodium to sulfur in Period 3 all react with oxygen to form oxides.

(a) Give an equation and **two** observations made for the reaction that occurs when sodium is heated in oxygen.

Equation _____

Observation 1 _____

Observation 2 _____

(2)

(b) Give an equation and **one** observation made for the reaction that occurs when phosphorus is heated in oxygen.

Equation _____

Observation _____

(2)

(c) The melting points of the highest oxides of the elements sodium to sulfur are shown in the table.

STEMUP.CO.UK

	Highest oxide of					
	sodium	magnesium	aluminium	silicon	phosphorus	sulfur
Melting point / K	1548	3125	2345	1883	573	290

Explain the increase in melting point from sodium oxide to magnesium oxide.

(2)

(d) Explain why the melting point of the oxide of silicon is much higher than that of the highest oxide of phosphorus.

(3)

(e) A sample of the highest oxide of phosphorus was prepared in a laboratory.

Describe a method for determining the melting point of the sample.
State how the result obtained could be used to evaluate its purity.

STEMUP.CO.UK

_____

_____

_____

_____

_____

(3)

(Total 12 marks)

Q4.

Which element forms an ionic oxide that reacts with strong alkalis?

A Aluminium ⬭

B Magnesium ⬭

C Sodium ⬭

D Sulfur ⬭

(Total 1 mark)

Q5.

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

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

_____

(1)

(b) Describe a test you could carry out in a test tube to distinguish between sodium oxide and the product of the reaction in part (a)

_____

_____

_____

_____

_____

_____

(3)

(c) State the type of crystal structure shown in silicon dioxide and in sulfur trioxide.

Silicon dioxide _____

Sulfur trioxide _____

(2)

STEMUP.CO.UK

(d) Explain why silicon dioxide has a higher melting point than sulfur trioxide.

(4)

(e) Write an equation for the reaction of sulfur trioxide with potassium hydroxide solution.

(1)

(f) Write an equation for the reaction of an excess of magnesium oxide with phosphoric acid.

(1)

(g) Draw the displayed formula of the undissociated acid formed when sulfur dioxide reacts with water.

(1)

(Total 13 marks)

Q6.

Which is the formula of the main aluminium-containing species present when aluminium oxide is added to an excess of water?

A $[Al(H_2O)_6]^{3+}(aq)$ ⬭

STEMUP.CO.UK

B $Al(H_2O)_3(OH)_3(s)$ ⬭

C $[Al(H_2O)_2(OH)_4]^-(aq)$ ⬭

D $Al_2O_3(s)$ ⬭

(Total 1 mark)

Q7.

(a) Explain why the atomic radii of the elements decrease across Period 3 from sodium to chlorine.

_____

_____

_____

_____

_____

_____

(2)

(b) Explain why the melting point of sulfur (S_8) is greater than that of phosphorus (P_4).

_____

_____

_____

_____

_____

_____

(2)

(c) Explain why sodium oxide forms an alkaline solution when it reacts with water.

_____

_____

_____

_____

_____

(2)

(d) Write an ionic equation for the reaction of phosphorus(V) oxide with an excess of sodium hydroxide solution.

STEMUP.CO.UK

_____

(1)

(Total 7 marks)

Q8.

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

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

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

_____

(1)

(ii) Identify element **X**.

_____

(1)

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

_____

(1)

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

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

_____

(1)

(ii) Identify element **Y**.

_____

(1)

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

_____

(1)

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

_____

(1)

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

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

_____

(1)

STEMUP.CO.UK

(ii) Write the formula of this amphoteric oxide.

_____

(1)

(iii) State the meaning of the term amphoteric.

_____

(1)

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

_____

_____

_____

(2)

(Total 12 marks)

Q9.

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

Equation _____

Observations _____

_____

_____

_____

(3)

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

Equation _____

Observations _____

_____

_____

_____

(3)

(Total 6 marks)

Q10.

(a) The table below contains data that show a trend in the melting points of some oxides of the Period 3 elements.

STEMUP.CO.UK

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

(i) Use data from the table above to predict an approximate melting point for sodium oxide.

Tick (✓) **one** box.

250 K ☐

500 K ☐

1500 K ☐

3500 K ☐

(1)

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

_____

_____

_____

_____

_____

(2)

(iii) Use data from the table above 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.

Predicted melting point of sulfur(IV) oxide _____

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

_____

_____

_____

(3)

STEMUP.CO.UK

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

Suggest the pH value of the resulting solution.

Equation

_____

pH value _____

(2)

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

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

_____

_____

_____

_____

_____

(2)

(Total 10 marks)

Q11.

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

(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.

Observations _____

_____

_____

_____

_____

Equation _____

(3)

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

_____

_____

_____

_____

STEMUP.CO.UK

(2)

(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.

Structure _____

Bonding _____

Physical property 1 _____

Physical property 2 _____

(4)

(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.

Formula _____

Structure _____

Bonding _____

_____

_____

_____

(4)

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

Write an equation for this reaction.

_____

(1)

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

_____

(1)

(Total 15 marks)

Q12.

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

(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 _____

STEMUP.CO.UK

_____

_____

_____

_____

_____

(3)

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

_____

_____

_____

_____

_____

_____

_____

(3)

(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 _____

_____

_____

_____

_____

_____

(3)

(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.

_____

(2)

STEMUP.CO.UK

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

Write an equation for its reaction with sodium hydroxide.

_____

(1)

(Total 12 marks)

Q13.

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

	Na_2O	SiO_2	SO_2	SO_3
Melting point / K	1548	1883	200	290

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

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

(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 _____

_____

_____

_____

STEMUP.CO.UK

_____

(3)

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

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

_____

(1)

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

_____

_____

_____

(1)

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

_____

_____

(1)

(Total 10 marks)

Q14.

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

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

_____

_____

_____

(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

_____

_____

_____

(1)

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

_____

STEMUP.CO.UK

_____

_____

_____

_____

(2)

(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)

(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.

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

_____

(1)

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

_____

_____

_____

(1)

(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.

_____

_____

_____

(1)

(Total 9 marks)

Q15.

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

	Na_2O	P_4O_{10}	SO_2
T_m/K	1548	573	200

STEMUP.CO.UK

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

(i) sodium oxide has a high melting point

_____

_____

_____

(2)

(ii) sulfur dioxide has a low melting point.

_____

_____

_____

_____

_____

(2)

(b) Explain why the melting point of P_4O_{10} is higher than the melting point of SO_2

_____

_____

_____

_____

(2)

(c) Write equations for the reactions of Na_2O and P_4O_{10} with water. In each case give the approximate pH of the resulting solution.

Equation for Na_2O _____

pH _____

Equation for P_4O_{10} _____

pH _____

_____

(4)

(d) Write an equation for the acid–base reaction that occurs when Na_2O reacts with P_4O_{10} in the absence of water.

_____

(1)

(Total 11 marks)

STEMUP.CO.UK

Q16.

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

(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 _____

_____

_____

_____

Equation _____

Type of bonding _____

(4)

(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 _____

_____

_____

_____

Equation _____

Type of bonding _____

(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 _____

_____

_____

_____

(3)

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

_____

STEMUP.CO.UK

_____

_____

(2)

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

_____

_____

(1)

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

(i) hydrochloric acid

_____

(1)

(ii) aqueous sodium hydroxide.

_____

(1)

(Total 16 marks)

Q17.

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_2O	SiO_2	P_4O_{10}
T_m/K	1548	1883	573

(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_2O

_____

_____

SiO_2 _____

_____

_____

(4)

(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.

STEMUP.CO.UK

Prediction _____

Explanation _____

_____

_____

(3)

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

(i) State the structure of and bonding in phosphorus(V) oxide.

_____

_____

_____

(2)

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

_____

_____

(1)

(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)

(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)

(Total 16 marks)

Q18.

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.

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

STEMUP.CO.UK

point.

_____

_____

_____

(3)

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

_____

(1)

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

_____

(1)

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

_____

(1)

(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.

_____

(1)

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

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

_____

(1)

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

_____

(1)

(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)

(Total 11 marks)

STEMUP.CO.UK

Q19.

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

(4)

(b) Explain why the oxides of the Period 3 elements sodium and phosphorus have different melting points. In your answer you should discuss the structure of and bonding in these oxides, and the link between electronegativity and the type of bonding.

(6)

(c) A chemical company has a waste tank of volume 25 000 dm^3. The tank is full of phosphoric acid (H_3PO_4) solution formed by adding some unwanted phosphorus(V) oxide to water in the tank.

A 25.0 cm^3 sample of this solution required 21.2 cm^3 of 0.500 mol dm^{-3} sodium hydroxide solution for complete reaction.

Calculate the mass, in kg, of phosphorus(V) oxide that must have been added to the water in the waste tank.

STEMUP.CO.UK

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 15 marks)

Q20.

(a) The melting points of some of the oxides formed by Period 3 elements are given in a random order below.

Oxide	**A**	**B**	**C**	**D**	**E**
T_m/°C	2852	–73	1610	1275	300

(i) Using the letters **A** to **E**, give **two** oxides which have simple molecular structures.

Explain your answer.

Oxide 1 _____

Oxide 2 _____

Explanation _____

_____

(ii) Give a simple chemical test which could be used to show which of the oxides in the table is sodium oxide. State the observation you would make.

Chemical test _____

_____

Observation _____

(6)

(b) The base calcium oxide can be used to remove sulfur dioxide from flue-gases produced when fossil fuels are burnt in coal-fired power stations. Calcium oxide is produced when calcium carbonate, is decomposed by heat.

STEMUP.CO.UK

(i) Write an equation for the action of heat on calcium carbonate.

_____

(ii) Identify the product formed when sulfur dioxide reacts with calcium oxide.

_____

(iii) Despite the additional cost, operators of power stations are encouraged to remove the sulfur dioxide from flue-gases. Explain why this may not be environmentally beneficial.

_____

_____

(4)

(Total 10 marks)

Q21.

Consider the following oxides.

Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10}, SO_3

(a) Identify one of the oxides from the above which

(i) can form a solution with a pH less than 3 _____

(ii) can form a solution with a pH greater than 12 _____

(2)

(b) Write an equation for the reaction between

(i) MgO and HNO_3

_____

(ii) SiO_2 and $NaOH$

_____

(iii) Na_2O and H_3PO_4

_____

(3)

(c) Explain, in terms of their type of structure and bonding, why P_4O_{10} can be vaporised by gentle heat but SiO_2 cannot.

_____

_____

_____

_____

(4)

STEMUP.CO.UK

(Total 9 marks)

STEMUP.CO.UK