

- (b) The halogens are oxidising agents.

State and explain the trend in oxidising power of the halogens.

.....

.....

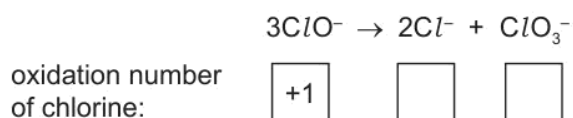
.....

..... [3]

May/June 2017 9701/23 · Q2 (b)

- (iii) The chlorate(I) ion is unstable and decomposes when heated as shown.

Deduce the oxidation number of chlorine in each species. Complete the boxes.



[1]

March 2018 9701/22 · Q3 (c)(iii)

- (c) The elements in the third period, from sodium to silicon, can react with chlorine to form chlorides.

- (i) State and explain the pattern of change of oxidation number which occurs to both chlorine and the different Period 3 elements when they react together.

.....

.....

.....

..... [3]

May/June 2018 9701/21 · Q3 (c)(i)

- (d) Mohr's salt,
- $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot x\text{H}_2\text{O}$
- , is the hydrated form of ammonium iron(II) sulfate.

x represents the number of moles of water in 1 mole of the salt.

A student wanted to determine the value of x. 0.784 g of the hydrated salt was dissolved in water and this solution was acidified.

All of the solution was titrated with $0.0200 \text{ mol dm}^{-3}$ potassium manganate(VII). 20.0 cm^3 of this potassium manganate(VII) solution was required for complete reaction with the Fe^{2+} ions.

- (i) Use changes in oxidation numbers to balance the equation for the reaction taking place.



[1]

May/June 2018 9701/22 · Q2 (d)(i)

(iii) Write an equation for the reaction of chlorine with **hot** aqueous sodium hydroxide.

Use oxidation numbers to explain why this is a redox reaction.

equation

.....

..... [2]

[Total: 15]

Question 4 starts on the next page.

10

May/June 2018 9701/23 · Q3 (e)(iii) (cont.)

(d) Three oxides of nitrogen, NO, NO₂ and N₂O, can be formed under different conditions.**(i)** Complete the table to give the oxidation numbers of nitrogen in NO and NO₂.

compound	NO	NO ₂
oxidation number of N		

[1]

March 2019 9701/22 · Q1 (d)(i)

(b) Element **X** is a metal. **X** reacts with oxygen to form a black solid oxide. The oxidation state of **X** in this oxide is +2. The carbonate of **X**, XCO₃, is a green solid. It decomposes on heating to form the oxide and a colourless gas.**(i)** From the information given, state two similarities and one difference that metal **X** and its compounds have with Group 2 metals and their compounds.

similarity 1

.....

similarity 2

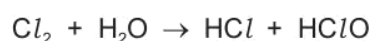
.....

difference 1

.....

[3]

May/June 2019 9701/21 · Q1 (b)(i)

(b) Cl₂(g) dissolves in cold water and reacts with it.**(i)** Identify the oxidation number of chlorine in each of the chlorine-containing species in this reaction.

chlorine-containing species	Cl ₂	HCl	HClO
oxidation number of chlorine			

[2]

May/June 2019 9701/22 · Q3 (b)(i)

(c) In a reaction between hydrogen iodide and concentrated sulfuric acid, the products are hydrogen sulfide, sulfur, iodine and water.

(i) Write an equation for this reaction.

You may wish to use oxidation numbers to help you.

..... [2]

(ii) Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

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

[Total: 9]

May/June 2019 9701/23 · Q2 (c)(i), (c)(ii)

(iv) Explain why NO_2 can be described as a catalyst in the oxidation of atmospheric SO_2 .

.....

.....

..... [2]

[Total: 9]

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9701/23/M/J/19

[Turn over

8

May/June 2019 9701/23 · Q4 (b)(iv)

- 1 (a) Chlorine can be prepared using the following reaction.



- (i) Explain why $\text{MnO}_2(\text{s})$ is described as an oxidising agent in this reaction.

Refer to oxidation numbers in your answer.

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

- (ii) State what you would observe during this reaction.

..... [1]

- (c) Chlorine undergoes disproportionation during many chemical reactions.

- (i) Write an equation for the reaction of chlorine with cold aqueous sodium hydroxide, NaOH .

Explain why it is a disproportionation reaction.

equation

explanation

..... [2]

- (ii) One of the products of the reaction of chlorine with **hot** aqueous sodium hydroxide differs from those in (c)(i).

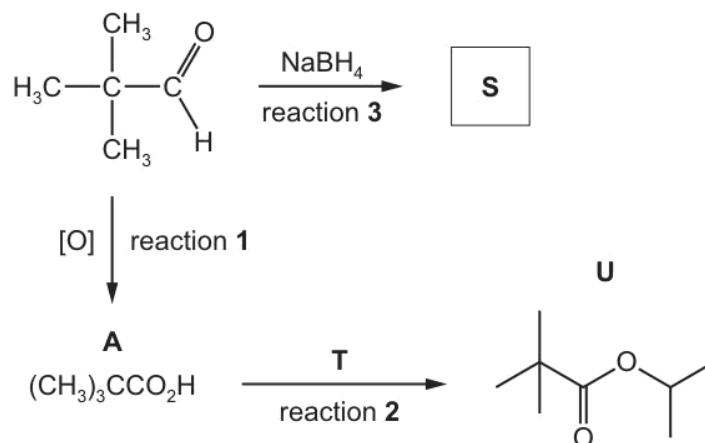
Identify the compound that is formed in this reaction that is different from that formed in the reaction in (c)(i).

..... [1]

- (d) State and explain the use of chlorine in water purification.

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

(b) Two reaction sequences are shown.

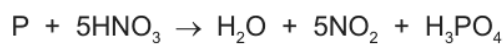


(i) Reaction 1 is an oxidation reaction.

Identify the reagent(s) and conditions for reaction 1.

..... [1]

(iii) H_3PO_4 can be produced by direct reaction of phosphorus with nitric acid.



Use oxidation numbers to show that this reaction is a redox reaction.

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

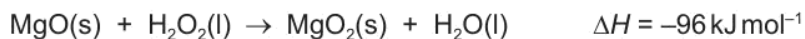
- (iv) Give the balanced equation to represent the reaction of **K**, $\text{C}_5\text{H}_{12}\text{O}_2$, with acidified potassium dichromate(VI) to form **M**, $\text{C}_5\text{H}_8\text{O}_3$.

Use [O] to represent an atom of oxygen provided by the oxidising agent.

..... [1]

Oct/Nov 2019 9701/22 · Q4 (b)(iv)

- (g) Magnesium peroxide, MgO_2 , is made in the following reaction.



compound	enthalpy change of formation, $\Delta H_f^\circ / \text{kJ mol}^{-1}$
MgO(s)	-602
$\text{H}_2\text{O}_2(\text{l})$	-188
$\text{H}_2\text{O(l)}$	-286

- (i) The peroxide ion is O_2^{2-} .

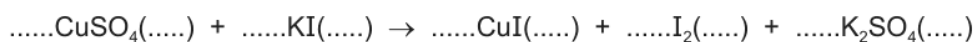
Deduce the average oxidation number of oxygen in the peroxide ion.

..... [1]

March 2020 9701/22 · Q1 (g)(i)

- 2 (a) The equation shown in (a)(i) describes the reaction which occurs when aqueous potassium iodide is added to aqueous copper(II) sulfate. A white precipitate of copper(I) iodide forms in a brown solution of iodine and potassium sulfate.

(i) Balance the equation and include state symbols.



[2]

The table gives the oxidation numbers of iodine in the different species in the equation.

iodine-containing species	oxidation number of iodine
KI	−1
CuI	−1
I ₂	0

(ii) Deduce the oxidation number of copper in CuSO₄ and CuI.

- oxidation number of copper in CuSO₄
- oxidation number of copper in CuI

[1]

(iii) Describe the type of reaction shown by the equation in (a)(i). Explain your answer in terms of electron transfer.

.....

 [2]

- (b) In the reaction described in (a)(i), a student uses 17.43 g of CuSO₄·yH₂O. By further titration of the reaction products the student concludes that the total amount of CuSO₄ in the sample is 0.0982 mol.

Use the *Data Booklet* to complete the table to calculate the value of **y**, where **y** is an integer. Show your working.

mass of 0.0982 mol CuSO ₄	 g
amount of H ₂ O in 17.43 g of CuSO ₄ ·yH ₂ O	 mol H ₂ O
value of y	y =

[4]

[Total: 9]

5

May/June 2020 9701/21 · Q2 (a)(i), (a)(ii), (a)(iii), (b) (cont.)

- (c) (i) In the boxes, give the oxidation numbers of nitrogen in the nitrogen-containing species for the reaction in stage 3.



[2]

- (ii) Explain why the reaction in stage 3 is described as a disproportionation reaction. Include reference to transfer of electrons in your answer.

.....

.....

..... [2]

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May/June 2020 9701/22 · Q2 (c)(i), (c)(ii)

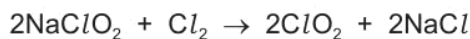
- (ii) Deduce the oxidation number of gallium in Ga_2O_3 .

..... [1]

May/June 2020 9701/23 · Q1 (c)(ii)

- (ii) ClO_2 can be prepared by reacting NaClO_2 with Cl_2 .

Write the oxidation state of chlorine in each species in the boxes provided.



oxidation state of chlorine:

[1]

Oct/Nov 2020 9701/21 · Q2 (d)(ii)

- (b) State and explain the trend, from Na to S, in the maximum oxidation number of the Period 3 elements in their oxides.

.....

 [2]

Oct/Nov 2020 9701/22 · Q2 (b)

- (c) The halide ions, X^- (where $X = Cl, Br, I$), show clear trends in their physical and chemical properties.

- (i) State and explain the relative thermal stabilities of the hydrogen halides, HX .

.....

 [2]

The halide ions react easily with concentrated H_2SO_4 .

The main sulfur-containing product of each reaction is shown in the table.

halide ion	Cl^-	Br^-	I^-
main sulfur-containing product of reaction with concentrated H_2SO_4	HSO_4^-	SO_2	H_2S
oxidation number of sulfur			

- (ii) Complete the table to show the oxidation number of sulfur in each of the sulfur-containing products. [1]

- (d) Cl_2 reacts with aqueous sodium hydroxide in a disproportionation reaction.

- (i) State what is meant by *disproportionation*.

.....
 [1]

March 2021 9701/22 · Q2 (c)(i), (c)(ii), (d)(i)

- (a) Identify the oxidising agent in this reaction. Explain your reasoning with reference to oxidation numbers.

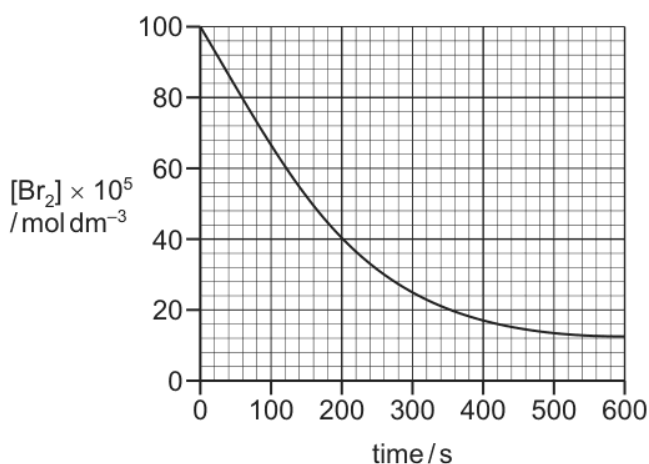
.....
 [1]

- (b) Suggest one change you would observe, ignoring temperature changes, when bromine reacts with methanoic acid.

..... [1]

- (c) This reaction can be followed by measuring the concentration of bromine present in the mixture at regular time intervals.

The graph shows the change in concentration of bromine against time in a reaction carried out at 20 °C.



- (i) Use the graph to calculate the average rate of reaction at 20 °C during the first 600 s. State the units of this rate of reaction.

average rate of reaction units [2]

The experiment is repeated at a temperature of 40 °C. This relatively small increase in temperature produces a large increase in reaction rate.

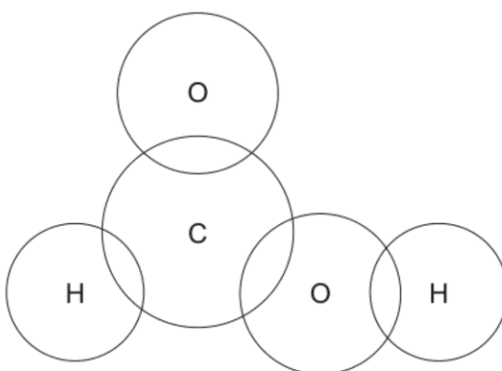
- (ii) Sketch a graph, on the same axes, to show the expected results when repeating the experiment at 40 °C. [1]

- (iii) The rate of reaction increases when the frequency of successful collisions between reactant particles increases.

Explain why an increase in temperature produces this effect.

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

- (d) Complete the 'dot-and-cross' diagram, showing outer electrons only, to show the bonding in methanoic acid, HCO_2H .



[2]

[Total: 9]

- (f) Sodium chlorate(I), NaClO , oxidises dilute hydrochloric acid to form three products. The products which contain chlorine have chlorine species with oxidation number -1 or 0 .

No other species changes its oxidation number during the reaction.

Use this information to complete the ionic equation.



[Total: 13]

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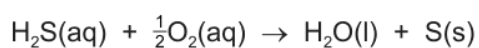
9701/23/M/J/21

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4

May/June 2021 9701/23 · Q1 (f)

- (iii) $\text{H}_2\text{S}(\text{aq})$ reacts slowly with oxygen dissolved in water. The reaction is represented by the following equation.



Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

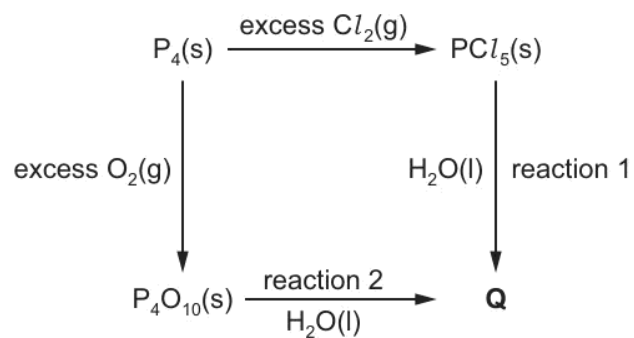
.....

.....

.....

..... [2]

(b) Some reactions of $P_4(s)$ are shown in the reaction scheme.



(i) State the oxidation number of phosphorus in P_4O_{10} .

..... [1]

Oct/Nov 2021 9701/21 · Q3 (b)(i)

- [2]

- [1]

- [1]

- C**
-
- Na₂CO₃ SOCl₂
- E** **F** **G**
- (CH₂OH)₂ (CH₂Cl)₂

- [1]

- [1]

- [1]

(d) Explain why **C** is very soluble in water.

.....

.....

..... [1]

[Total: 12]

15

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- (ii) Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

.....

.....

.....

..... [2]

Oct/Nov 2021 9701/22 · Q1 (d)(ii)

- (iv) Complete the row in the table labelled 'maximum oxidation number'. [1]

Oct/Nov 2021 9701/22 · Q2 (a)(iv)

- (ii) Reaction 3 is a redox reaction.

Identify which of the **reactants** is reduced in this reaction.

..... [1]

Oct/Nov 2021 9701/22 · Q3 (e)(ii)

- (d) Explain why **C** is very soluble in water.

.....

.....

..... [1]

[Total: 12]

(a) Na reacts with O_2 to form Na_2O . Na is the reducing agent in this reaction.

(i) Define reducing agent.

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

(b) Al_2O_3 is an amphoteric oxide found in bauxite.

(i) State what is meant by amphoteric.

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

(ii) Al_2O_3 is purified from bauxite in several steps. The first step involves heating Al_2O_3 with an excess of $NaOH(aq)$. A colourless solution forms.

Write an equation for this reaction.

..... [1]

(c) P_4O_6 is a white solid that has a melting point of 24°C . Solid P_4O_6 reacts with water to form H_3PO_3 .

(i) Deduce the type of structure and bonding shown by P_4O_6 . Explain your answer.

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

(ii) Determine the oxidation number of P in H_3PO_3 .

..... [1]

- (ii) NO_2 can also react with unburned hydrocarbons to form photochemical smog.

State the product of this reaction that contributes to photochemical smog.

..... [1]

- (iii) Fig. 2.2 shows how the temperature of the atmosphere varies with height from the ground.

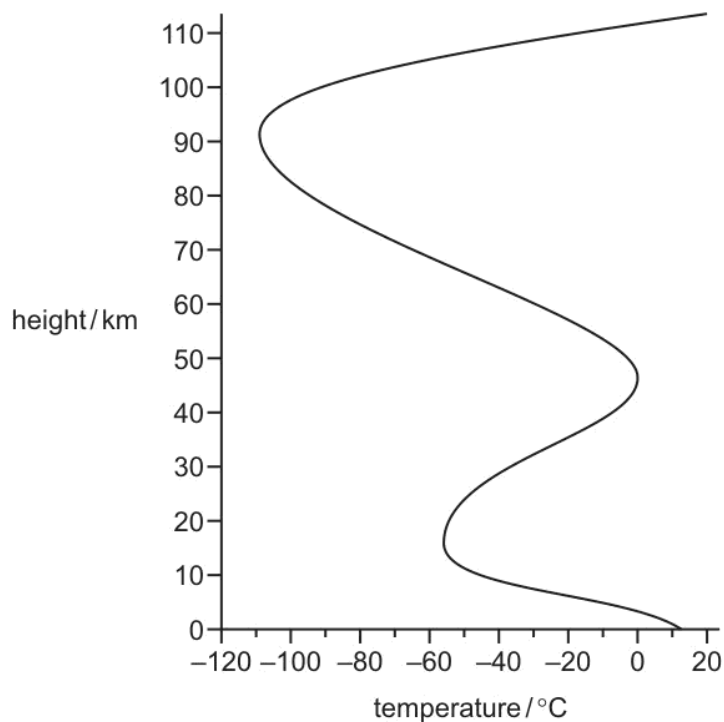


Fig. 2.2

The equilibrium reaction in equation 1 has $\Delta H_r = -168 \text{ kJ mol}^{-1}$.

Suggest how the position of this equilibrium differs at a height of 20 km compared with a height of 50 km from the ground.

Explain your answer.

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

[Total: 16]

March 2022 9701/22 · Q2 (a)(i), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(ii), (d)(iii) (cont.)

(b) When magnesium is heated in air, magnesium oxide, MgO , is the major product. Smaller amounts of magnesium nitride, Mg_3N_2 , are also made.

(i) Calculate the oxidation number for magnesium and for the nitrogen species in Mg_3N_2 to complete Table 1.1.

Table 1.1

species	magnesium in Mg_3N_2	nitrogen in Mg_3N_2
oxidation number		

[1]

May/June 2022 9701/22 · Q1 (b)(i)

(iii) Step 3 is a reduction reaction.

Construct an equation for the reduction reaction in step 3. Use $[\text{H}]$ to represent one atom of hydrogen from the reducing agent.

..... [1]

(iv) State the identity of a suitable reducing agent in step 3.

..... [1]

[Total: 13]

May/June 2022 9701/22 · Q5 (c)(iii), (c)(iv)

(a) Complete Table 2.1.

- Identify the bonding shown by each chloride under standard conditions.
Use C = covalent, I = ionic, M = metallic.
- Identify the structure shown by each chloride under standard conditions.
Use G = giant, S = simple.
- Deduce the oxidation state of the Period 3 element in each chloride.

[4]

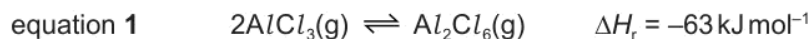
(b) Write equations for the reactions of NaCl and PCl_5 with water.
Include state symbols in both equations.

NaCl

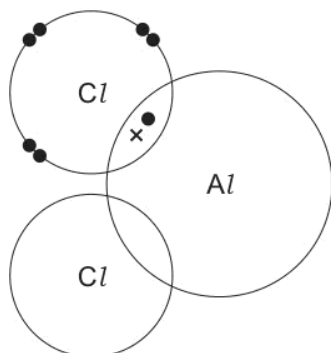
PCl_5

[3]

(c) In the gas phase, $AlCl_3(g)$ exists at equilibrium with $Al_2Cl_6(g)$ as shown.



(i) Complete the dot-and-cross diagram to show the bonding in Al_2Cl_6 .



[2]

(ii) State the effect of an increase in temperature on the equilibrium mixture in equation 1. Explain your answer.

.....
 [1]

(e) (i) An excess of $Cl^-(aq)$ is added to 1 cm^3 of $Br_2(aq)$.

Describe what is observed. Explain your answer.

.....

 [2]

(ii) SCl_2 has $M_r = 103.1$ and is a liquid at room temperature. SBr_2 has $M_r = 191.9$ and is a gas at room temperature.

Explain the difference in the physical state of SCl_2 and SBr_2 . Give your answer in terms of intermolecular forces.

.....

 [2]

- (f) Bismuth is a dense metal in the same group as phosphorus.
- (i) Draw a labelled diagram to show the bonding in bismuth metal.

[2]

- (ii) Bismuth reacts with chlorine to form BiCl_3 .
 BiCl_3 is a solid at room temperature. It melts when heated gently.
 BiCl_3 reacts vigorously with water at room temperature to form an acidic solution.

Suggest the type of bonding and structure shown by BiCl_3 . Explain your answer.

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

[Total: 21]

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[Turn over

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Oct/Nov 2022 9701/22 · Q2 (a), (b), (c)(i), (c)(ii), (e)(i), (e)(ii), (f)(i), (f)(ii) (cont.)

- (f) TeF_x reacts with water to form tellurium hydroxide and HF. The oxidation number of tellurium does **not** change during this reaction.

- (i) Construct an equation for the reaction of TeF_x with water.

..... [1]

May/June 2023 9701/21 · Q1 (f)(i)

- (c) (i) State the reagent and conditions required for the formation of sodium chlorate(V) from $\text{Cl}_2(\text{g})$.

..... [1]

- (ii) Explain why the reaction in (c)(i) is described as a disproportionation reaction. Your answer should refer to relevant species and their oxidation numbers.

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

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May/June 2023 9701/21 · Q3 (c)(ii)

- (a) (i) Complete Table 2.1 to show the maximum oxidation number of the elements Na to P in their chlorides.

Table 2.1

element	Na	Mg	Al	Si	P
maximum oxidation number					

[1]

- (ii) State what determines the maximum oxidation number of elements in Period 3.

.....
 [1]

- (b) An excess of cold water is added to the chloride of silicon.

- (i) Write an equation for the reaction between an excess of cold water and the chloride of silicon.

..... [1]

- (ii) Suggest the pH of the solution produced in (b)(i).

..... [1]

- (c) An excess of cold water is added to the chloride of phosphorus.

- (i) Write an equation for the reaction between an excess of cold water and the chloride of phosphorus.

..... [1]

- (ii) Suggest the pH of the solution produced in (c)(i).

..... [1]

- (d) (i) Write an equation for the reaction of chlorine with water.

..... [1]

- (ii) Write an equation for the reaction of chlorine with hot NaOH(aq).

..... [1]

- (e) Bleach is used as a cleaning product to kill bacteria. It is made by adding compounds like sodium chlorate(I), NaClO , to water.

- (i) Identify the formula of the ion present in bleach that kills bacteria.

..... [1]

- (ii) Sodium chlorate(I), NaClO , reacts with hydrogen peroxide to produce sodium chloride, water and oxygen gas.

Construct an equation for this reaction.

..... [1]

- (iii) A sample of bleach **W** contains an unknown concentration of sodium chlorate(I).

10.0cm^3 of **W** is diluted with distilled water to make a total volume of 100cm^3 of bleach solution. 25.0cm^3 of this diluted bleach solution is added to an excess of hydrogen peroxide and the volume of gas produced measured under room conditions. The experiment is repeated and on average 25.0cm^3 of diluted bleach solution produces 42.0cm^3 of gas.

Calculate the concentration, in g dm^{-3} , of sodium chlorate(I) in **W**.

concentration of NaClO in **W** = g dm^{-3} [3]

[Total: 13]

6

May/June 2023 9701/22 · Q2 (a)(ii), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(ii), (e)(i), (e)(ii), (e)(iii) (cont.)

- (ii) Identify the oxidising agent in this reaction. Explain your answer in terms of electron transfer.

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

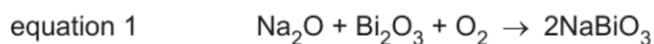
May/June 2023 9701/23 · Q1 (d)(ii)

- (b) Bismuth reduces water to form bismuth oxide, Bi_2O_3 . A colourless gas that ignites with a squeaky pop also forms.

- (i) Construct an equation for the reduction of water by bismuth.

..... [1]

- (c) Bi_2O_3 can be used to form NaBiO_3 , as shown in equation 1.



- (i) Deduce the oxidation number of Bi in Bi_2O_3 and in NaBiO_3 .

oxidation number of Bi:

in Bi_2O_3 in NaBiO_3 [1]

- (ii) Identify the reducing agent in equation 1.

..... [1]

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- (d) NaBiO_3 is an oxidising agent with similar properties to KMnO_4 .

Fig. 1.1 shows an example of the use of NaBiO_3 as an oxidising agent.

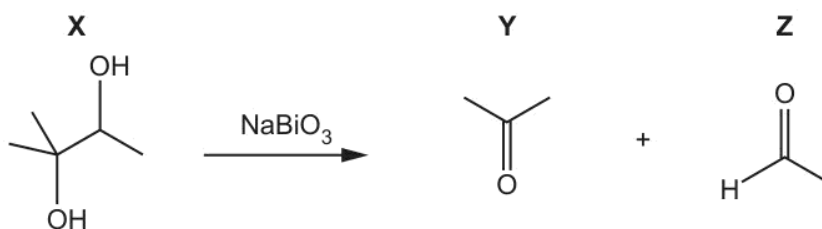


Fig. 1.1

- (i) Explain the term oxidising agent.

.....
 [1]

- (iv) Construct an equation for the reaction of **Z** with NaBH_4 .

Use [H] to represent an atom of hydrogen from the reducing agent.

..... [1]

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[Turn over

4

March 2024 9701/22 · Q1 (b)(i), (c)(i), (c)(ii), (d)(i), (d)(iv) (cont.)

- (b) When Cl_2 reacts with **cold** NaOH(aq) , Cl_2 is both oxidised and reduced. The products are NaCl , water and **G**.

- (i) State the type of redox reaction in which the same species is both oxidised and reduced.

..... [1]

March 2024 9701/22 · Q2 (b)(i)

- (c) Solid magnesium nitride, Mg_3N_2 , is a crystalline solid.

- (i) Deduce the oxidation numbers of magnesium and nitrogen in magnesium nitride to complete Table 2.1.

Table 2.1

	oxidation number in Mg_3N_2
magnesium	
nitrogen	

[1]

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May/June 2024 9701/21 · Q2 (c)(i)

- (b) (i) A sample of Al reacts with an excess of Cl_2 .

State the oxidation number of Al in the product of the reaction.

oxidation number of Al [1]

- (ii) State what determines the maximum oxidation number of the Period 3 elements in their oxides.

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

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- (d) The oxide of silicon reacts with calcium oxide in an addition reaction to produce calcium silicate, $CaSiO_3$. The oxidation number of calcium in $CaSiO_3$ is +II.

- (i) Deduce the oxidation number of silicon in calcium silicate.

oxidation number of silicon [1]

May/June 2024 9701/23 · Q1 (b)(ii), (d)(i)

- (ii) Define disproportionation.

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

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Oct/Nov 2024 9701/21 · Q2 (c)(ii)

(c) Reaction 3 is a reduction reaction.

(i) Construct an equation to represent reaction 3.

Use [H] to represent one atom of hydrogen from the reducing agent.

..... [1]

Oct/Nov 2024 9701/21 · Q4 (c)(i)

(iii) The maximum oxidation state of the Period 3 elements in their oxides varies across the period.

State and explain the variation.

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

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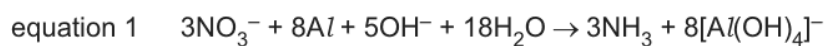


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(b) A common test for nitrates is the reaction with NaOH and Al. Equation 1 shows the reaction.



(i) Deduce the oxidation state of nitrogen in NO_3^- .

..... [1]

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(ii) Define disproportionation.

.....

..... [1]

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- (a) Chlorine forms three different compounds with phosphorus.

The most common compounds are PCl_3 and PCl_5 .

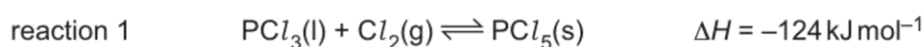
- (i) Complete Table 1.1.

Table 1.1

compound	oxidation number of P	oxidation number of Cl
PCl_3		
PCl_5		

[2]

- (ii) In a closed system, PCl_3 and PCl_5 exist in an equilibrium mixture as shown in reaction 1.



Deduce **two** conditions that favour the production of PCl_5 in reaction 1.

1

2

[2]

- (iv) **W** is a liquid at room temperature and pressure. It reacts vigorously with water to form an acidic solution.

Suggest the structure and bonding in **W**. Explain your answer.

.....

.....

..... [2]



(b) Fig. 1.1 shows a reaction scheme involving P_4 and Cl_2 .

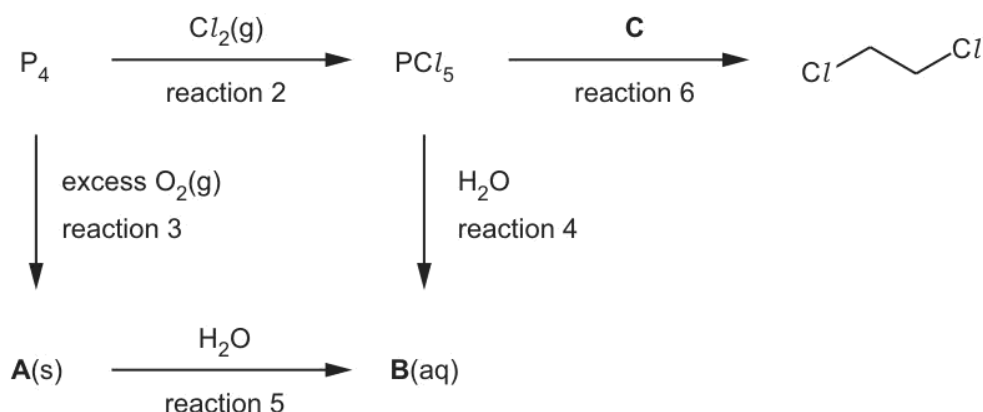


Fig. 1.1

(i) Suggest what is observed in reaction 2.

..... [1]

(iii) Write an equation for the formation of **A** in reaction 3.

..... [1]

(iv) Name **B**, which is formed in both reactions 4 and 5.

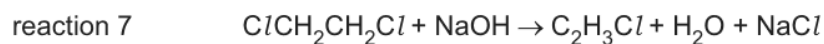
..... [1]

(v) Draw the structure of **C**, used in reaction 6.

[1]



- (c) 1,2-dichloroethane, $\text{ClCH}_2\text{CH}_2\text{Cl}$, reacts with NaOH to produce an unsaturated compound, $\text{C}_2\text{H}_3\text{Cl}$, as shown in reaction 7.



- (i) State what is meant by unsaturated.

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

- (ii) State the conditions for reaction 7.

..... [1]

- (ii) Suggest the structure of D.

[1]

[Total: 17]

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5



March 2025 9701/22 · Q1 (a)(i), (a)(ii), (a)(iv), (b)(i), (b)(iii), (b)(iv), (b)(v), (c)(i), (c)(ii), (d)(ii) (cont.)

- (c) State the oxidation number of the Period 3 elements bonded to Cl in NaCl and PCl_5 . Explain the difference in the oxidation number.

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

- (d) Table 1.2 shows melting points of some oxides.

Table 1.2

oxide	melting point/°C
SO_2	-73
H_2O	0
SO_3	17
SiO_2	1610
MgO	2852
Al_2O_3	2072

A student suggests the following hypothesis.

*The higher the oxidation number of the element combined with oxygen,
the higher the melting point of the oxide.*

Use Table 1.2 to deduce if this hypothesis is true or false or if there is **not** enough information to make a conclusion. Explain your answer.

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

[Total: 11]



May/June 2025 9701/21 · Q1 (c), (d)

(e) **B** reacts with an excess of reducing agent **R** to produce **D**.An excess of PCl_5 is added to **D**.

- A vigorous reaction occurs.
- Misty fumes are seen.
- Organic compound **E** is produced.

(i) Identify the formula of the reducing agent **R**.

..... [1]

May/June 2025 9701/21 · Q5 (e)(i)

(c) Table 2.1 shows the melting points of some oxides.**Table 2.1**

oxide	melting point/°C
SO_2	−73
H_2O	0
SO_3	17
SiO_2	1610
Na_2O	1132
MgO	2852
Al_2O_3	2072

(i) Identify the oxide from Table 2.1 that contains the element with the highest oxidation number.

..... [1]

May/June 2025 9701/23 · Q2 (c)(i)

(ii) When SCl_2 reacts with water, the SCl_2 is broken down and a disproportionation reaction occurs.State the oxidation numbers of sulfur in SCl_2 and H_2SO_3 .oxidation number of S in SCl_2 oxidation number of S in H_2SO_3

[2]

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- (ii) The oxidation state of the carbon atom in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

..... [1]

Oct/Nov 2025 9701/21 · Q1 (c)(ii)

- (b) Table 2.1 gives some information about some of the Period 3 oxides.

Row B gives the pH of the solution that forms when the Period 3 oxide is added to water.

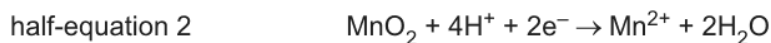
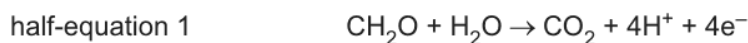
Table 2.1

	formula of Period 3 oxide	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₃
A	oxidation number of Period 3 element			+3			
B	pH of solution			—	—		

- (i) Complete Table 2.1. [1]

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- (c) Manganese(IV) oxide reacts with methanal, CH₂O, in acidic conditions to produce carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.



- (i) Identify the species that is reduced in half-equation 2. Explain your answer.

.....
 [1]

- (ii) The oxidation state of carbon in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

..... [1]

Oct/Nov 2025 9701/22 · Q1 (c)(i), (c)(ii)

(c) Table 2.1 gives some information about some Period 3 chlorides.

Row B refers to the pH of the solution that forms when the Period 3 chloride is added to water.

Table 2.1

	formula of Period 3 chloride	NaCl	MgCl_2	AlCl_3	SiCl_4	PCl_5
A	oxidation number of element bonded to Cl					
B	pH of solution		6.5			
C	bonding			ionic		
D	structure			giant		

Complete Table 2.1.

You may use the following abbreviations.

I = ionic, C = covalent, M = metallic
G = giant, S = simple

[4]

- (ii) Construct an equation to represent reaction 3. Use [O] to represent an atom of oxygen from the oxidising agent.

..... [1]

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[Turn over

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