

- (a) (i) Give the colours and states of chlorine, bromine and iodine at room temperature and pressure.

halogen	colour	state
chlorine		
bromine		
iodine		

[2]

- (ii) The halogens become less volatile down the group.

Explain this trend in volatility.

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

- (c) Concentrated sulfuric acid reacts with solid sodium halides.

- (i) State any observations that would be made on addition of concentrated sulfuric acid to

- solid sodium chloride,
.....
- solid sodium iodide.
.....

[2]

- (ii) Give reasons for the difference in the observations in (i).

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

- (ii) Aqueous ammonia is then added to the test-tube in (i). The mass of precipitate decreases.

Explain this observation.

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

[Total: 15]

(a) At room temperature fluorine and chlorine are gases, bromine is a liquid and iodine is a solid.

(i) State the trend in the volatility of the Group 17 elements down the group.

..... [1]

(ii) Explain this trend.

.....

 [2]

(b) Iodine, I_2 , can be displaced from $NaI(aq)$, by chlorine, Cl_2 .

Write an equation for this reaction.

..... [1]

(c) Silver nitrate solution, $AgNO_3(aq)$, is added to separate solutions of NaI and $NaCl$.
 Precipitates form. An excess of aqueous ammonia is then added to both precipitates.

(i) Complete the table to give the colour and name of the precipitate formed in each reaction and the effect of the addition of an excess of aqueous ammonia to each of the precipitates formed.

	$NaI(aq) + AgNO_3(aq)$	$NaCl(aq) + AgNO_3(aq)$
colour of precipitate		
name of precipitate		
effect of addition of an excess of aqueous ammonia to the precipitate		

[3]

(ii) Write an ionic equation, including state symbols, to show the reaction occurring when $AgNO_3(aq)$ is added to $NaI(aq)$.

..... [1]

- (d) Solid NaI reacts with concentrated sulfuric acid to form purple fumes of $I_2(g)$ and hydrogen sulfide gas, $H_2S(g)$.
However, when solid NaCl reacts with concentrated sulfuric acid the only gas produced is $HCl(g)$.

Explain the difference in the reactions of concentrated sulfuric acid with NaI and with NaCl.
Your answer should refer to the role of the sulfuric acid in each reaction.

.....

.....

.....

.....

.....

..... [3]

- (e) Chlorine is commonly used in water purification. When chlorine is added to water it reacts to produce a mixture of acids, one of which is chloric(I) acid, $HClO$, a powerful oxidising agent.

- (i) Explain the meaning of the term *oxidising agent*, in terms of electron transfer.

.....

.....

..... [1]

- (ii) Suggest an equation for this reaction of chlorine with water.

..... [1]

May/June 2018 9701/23 · Q3 (a)(i), (a)(ii), (b), (c)(i), (c)(ii), (d), (e)(i), (e)(ii) (cont.)

- (a) State and explain the trend in volatility of chlorine, bromine and iodine down the group.

.....

.....

.....

..... [3]

Hydrogen gas reacts with the different halogens under different conditions.

- (b) (i) State the conditions required for chlorine to react with hydrogen at room temperature.

..... [1]

- (ii) On heating, iodine reacts with hydrogen in a reversible reaction.

Give the equation for this reaction. Include state symbols.

..... [2]

- (iii) Name the type of bond formed between H^+ and H_2O to make H_3O^+ .

..... [1]

May/June 2019 9701/22 · Q2 (a), (b)(i), (b)(ii), (c)(iii)

- (c) A mixture of HCl and HClO is added to cold dilute NaOH . One of the products behaves as a bleach.

Suggest the equation for the reaction occurring.

..... [2]

[Total: 13]

© UCLES 2019

9701/22/M/J/19

7

May/June 2019 9701/22 · Q3 (c)

- (b) The halogens chlorine, bromine and iodine are all volatile elements.

State and explain the trend in volatility down Group 17.

.....
.....
..... [3]

Oct/Nov 2019 9701/21 · Q1 (b)

- (a) Describe the trend in the colour of the Group 17 elements down the group.

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

- (b) The Group 17 elements can oxidise many metals to form halides.

- (i) Describe the relative reactivity of the elements in Group 17 as oxidising agents.

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

- (ii) Chlorine reacts with hot tin metal to form tin(IV) chloride, SnCl_4 .

SnCl_4 is a colourless liquid at room temperature that reacts vigorously with water to form an acidic solution.

Suggest the type of structure and bonding shown by SnCl_4 . Explain your answer.

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

- (c) The Group 17 elements form soluble halides with sodium.

- (i) Describe what is seen when dilute $\text{AgNO}_3(\text{aq})$ is added to $\text{NaBr}(\text{aq})$ followed by aqueous ammonia.

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

- (ii) NaCl reacts with concentrated H_2SO_4 to form HCl and NaHSO_4 .

Explain the difference between the reactions of concentrated H_2SO_4 with NaCl and with NaI . Your answer should refer to the role of the sulfuric acid in each reaction.

.....

.....

.....

.....

.....

..... [3]

- (d) The hydrogen halides are useful reagents in organic and inorganic reactions.

- (i) Describe and explain the trend in the boiling points of the hydrogen halides, HCl , HBr and HI .

.....

.....

.....

..... [2]

- (ii) Describe and explain the trend in the thermal stabilities of the hydrogen halides, HCl , HBr and HI .

.....

.....

.....

..... [2]

8

March 2020 9701/22 · Q2 (a), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(i), (d)(ii) (cont.)

(a) (i) State and explain the trend in volatility of the halogens, from chlorine to iodine.

.....

.....

.....

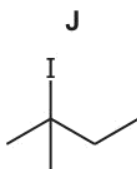
..... [2]

(ii) Explain why HI is the **least** thermally stable of HCl, HBr and HI.

.....

..... [1]

(c) J reacts with NaOH, forming different products dependent on the conditions used.



(i) Name J.

..... [1]

Oct/Nov 2020 9701/21 · Q4 (a)(i), (a)(ii), (c)(i)

(a) Between the molecules of Group 17 elements van der Waals' forces exist.

(i) State the trend in the relative strength of van der Waals' forces down Group 17.

..... [1]

(ii) State the physical state of each of the halogens under room conditions.

chlorine

bromine

iodine [1]

(b) A solution of aqueous bromide ions, $\text{Br}^-(\text{aq})$, is added to separate samples of $\text{Cl}_2(\text{aq})$ and $\text{I}_2(\text{aq})$.

Describe what is observed in each reaction. Explain your answer in terms of the relative reactivity of these elements as oxidising agents.

observation on addition to $\text{Cl}_2(\text{aq})$

.....

observation on addition to $\text{I}_2(\text{aq})$

.....

explanation

.....

..... [3]

(c) Bleach is made by reacting Cl_2 with cold $\text{NaOH}(\text{aq})$.

Write an equation for the reaction of Cl_2 with cold NaOH .

..... [1]

(d) When $\text{ClO}^-(\text{aq})$ is added to water, it behaves as a Brønsted-Lowry base.

(i) Define the term *Brønsted-Lowry base*.

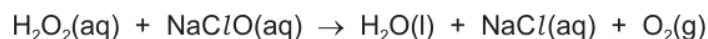
..... [1]

(ii) Write an ionic equation for the reaction between ClO^- and H_2O .

..... [1]

(e) The concentration of NaClO in bleach **S** is $x \text{ g dm}^{-3}$.

NaClO reacts with $\text{H}_2\text{O}_2(\text{aq})$ as shown.



A 5.00 cm^3 sample of **S** completely reacts with $\text{H}_2\text{O}_2(\text{aq})$. The volume of $\text{O}_2(\text{g})$ produced is 24.0 cm^3 under room conditions.

Assume that only the NaClO in **S** reacts with $\text{H}_2\text{O}_2(\text{aq})$.

Calculate x . Show your working.

$x = \dots\dots\dots \text{ g dm}^{-3}$
[3]

May/June 2021 9701/23 · Q1 (a)(i), (a)(ii), (b), (c), (d)(i), (d)(ii), (e) (cont.)

- (a) The hydrogen halides can be formed by reacting the halogens with hydrogen.

Describe and explain the relative reactivity of the halogens down the group when they react with hydrogen to form HCl , HBr and HI .

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

- (b) HCl is a product of several different reactions. Some of these are shown in Fig. 3.1.

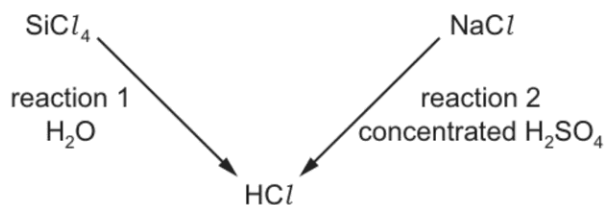


Fig. 3.1

- (i) Write an equation for reaction 1.

..... [1]

- (c) When heated with a Bunsen burner, HCl does not decompose, whereas HI forms H_2 and I_2 .

Explain the difference in the effect of heating on HCl and HI .

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

© UCLES 2022

9701/22/F/M/22

[Turn over

10

- (ii) Explain why the two bromoalkanes are **not** produced in equal amounts by this reaction.

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

March 2022 9701/22 · Q3 (a), (b)(i), (c), (e)(ii) (cont.)

(b) Tennessine, Ts, is an unstable man-made element. It is found below astatine, At, in Group 17. The chemical properties of Ts and its compounds have only been predicted.

(i) Suggest an equation for the reaction of NaTs and Br₂. Assume that Ts follows the same trends as the other elements in Group 17. Explain your answer.

equation

explanation

..... [2]

© UCLES 2022

9701/23/M/J/22

5

May/June 2022 9701/23 · Q2 (b)(i)

(ii) Deduce which halogen is present in Z using Fig. 5.1. Explain your answer.

.....

..... [1]

May/June 2022 9701/23 · Q5 (b)(ii)

1 (a) The elements of Group 17 are called halogens.

Complete Table 1.1.

Table 1.1

halogen	colour at 293 K
chlorine	
bromine	
iodine	

[1]

(b) State the trend in volatility of the halogens chlorine, bromine and iodine. Explain your answer.

.....

.....

.....

..... [3]

(c) Iodine is made by reacting bromine with sodium iodide.

(i) Construct an ionic equation for the reaction of bromine with sodium iodide.

..... [1]

(ii) State the role of bromine in the reaction. Explain your answer.

.....

..... [1]

3

(d) Concentrated sulfuric acid is added to separate samples containing equal amounts of NaCl, NaBr and NaI. All three samples initially react to produce the hydrogen halide.

(i) Write an equation to describe the acid–base reaction that occurs when concentrated sulfuric acid reacts with NaBr.

..... [1]

May/June 2024 9701/21 · Q1 (a), (b), (c)(i), (c)(ii), (d)(i) (cont.)

- (a) (i) Describe the colours of the Group 17 elements, chlorine to iodine, at room temperature.

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

- (ii) Describe the relative reactivity of the elements chlorine to iodine as oxidising agents.

..... [1]

- (iii) State what is observed when chlorine reacts with hydrogen.

..... [1]

- (iv) Explain why the thermal stability of the hydrogen halides decreases down the group.

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

- (ii) State the essential condition for chlorine to react with C_2H_6 at room temperature.

..... [1]

- (iii) Write **two** equations to show the propagation steps in this reaction.

1

2

[2]

Oct/Nov 2024 9701/21 · Q2 (a)(ii), (a)(iii), (a)(iv), (b)(ii), (b)(iii), (c)(iv) (continued ·)

(iv) Aqueous AgNO_3 dissolved in ethanol reacts with an aqueous solution of CHCl_3 .

State what is observed in this reaction. Explain your answer.

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

[Total: 13]



(iv) Aqueous AgNO_3 dissolved in ethanol reacts with an aqueous solution of CHCl_3 .

State what is observed in this reaction. Explain your answer.

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

[Total: 13]

© UCLES 2024



9701/23/O/N/24

8

[Turn over]

- (a) (i) Explain how the Group 17 elements act as oxidising agents.

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

- (ii) Write an equation to show the reaction in which Cl_2 oxidises aluminium metal.

..... [1]

- (iii) A student heats equal amounts of $\text{I}_2(\text{g})$ and $\text{H}_2(\text{g})$ in a sealed flask. The student leaves the contents to cool.

State what you would observe during the reaction.

..... [1]

- (b) Cl_2 and Br_2 can each react with NH_3 to give N_2 and a hydrogen halide, HX .



The relative bond strengths of X-X and H-X determine the difference in enthalpy change of the two reactions.

- (i) Describe and explain the difference in the X-X bond strengths of Cl_2 and Br_2 .

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

- (ii) Describe the relative thermal stabilities of HCl and HBr .

..... [1]



(c) Table 1.2 shows some information about reactions of NaCl, NaBr and NaI.

Table 1.2

	NaCl	NaBr	NaI
observation with $\text{Ag}^+(\text{aq})$	white precipitate		
type of reaction with concentrated H_2SO_4	acid–base	acid–base, then redox	acid–base, then redox
observations with concentrated H_2SO_4			• black solid • yellow solid • effervescence

(i) Complete Table 1.2. [4]

(ii) Suggest an identity for the species that produces each observation in the reaction of NaI with concentrated H_2SO_4 .

black solid

yellow solid

effervescence

[2]

(d) Table 1.3 gives some information about MgCl_2 and SiCl_4 .

Table 1.3

	MgCl_2	SiCl_4
electrical conductivity when liquid	conducts	does not conduct
observation when added to water	dissolves	vigorous reaction

(i) Explain the difference between the electrical conductivity of liquid MgCl_2 and of liquid SiCl_4 . Refer to bonding and relevant particles in your answer.

.....

 [2]

(ii) Suggest the pH of the solutions that form when each chloride is added to water.

MgCl_2 SiCl_4 [2]

[Total: 22]





5

BLANK PAGE





Oct/Nov 2025 9701/24 · Q1 (a)(ii), (a)(iii), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(i), (d)(ii) (cont.)