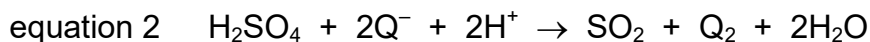


- 21** Equation 1 and equation 2 show two different reactions of halide ion Q^- with concentrated sulfuric acid.



What is Q?

- A** Cl^- or Br^- **B** Br^- or I^- **C** Cl^- only **D** I^- only

- 22** What happens when iodine solution is added to a solution of sodium bromide?

- A** A reaction occurs without changes in oxidation state.
B Bromide ions are oxidised; iodine atoms are reduced.
C Bromide ions are reduced; iodine atoms are oxidised.
D No reaction occurs.

- 23** Which statement is correct?

- A** Nitrogen is unreactive due to the absence of lone pairs in the molecule.
B Aqueous ammonia contains both $\text{NH}_3(\text{aq})$ and $\text{NH}_4^+(\text{aq})$. The $\text{NH}_4^+(\text{aq})$ ion is a Brønsted–Lowry acid.
C High temperatures are needed to supply the energy to break the strong double bonds in nitrogen molecules when they react.
D Atmospheric SO_2 reacts with unburnt hydrocarbons to form a component of photochemical smog.

1 The Group 17 elements are oxidising agents.

(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 $I_2(g)$ and $H_2(g)$ 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]

(iii) Define enthalpy change of formation, ΔH_f .

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

(iv) Table 1.1 gives data relevant to the reaction of $Cl_2(g)$ with $NH_3(g)$.

Table 1.1

compound	enthalpy change of formation, $\Delta H_f / \text{kJ mol}^{-1}$
$NH_3(g)$	–46
$HCl(g)$	–92

Use the data in Table 1.1 to calculate the enthalpy change of the reaction of $Cl_2(g)$ with $NH_3(g)$.

enthalpy change of reaction = kJ mol^{-1} [2]

(v) I_2 reacts with NH_3 to form NI_3 .

Predict the shape of a molecule of NI_3 . Explain your answer.

shape

explanation

..... [2]

(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

- 3 (a)** A bottle labelled **FA 5** is thought to contain hydrated zinc sulfate. It would therefore contain zinc ions and sulfate ions as well as water of crystallisation.
- (i)** Devise and carry out tests to investigate whether zinc ions, sulfate ions and water of crystallisation are present.

Record the tests you carry out and the observations you see in the space provided.

[5] .

- (ii) Use your observations in (a)(i) to complete Table 3.1 to show whether each species is present in **FA 5**.

Use a tick (✓) if the species is present.

Use a cross (X) if the species is **not** present.

Table 3.1

Zn^{2+}	
SO_4^{2-}	
H_2O	

[1]

- (b) You are provided with solid **FA 6**.

- (i) Heat a few crystals of **FA 6** in a hard-glass test-tube until no further gas is evolved. Record all your observations.

Leave the test-tube until it is cool.

Keep the cooled residue for use in (b)(ii).

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

- (ii) To the cooled residue from (b)(i), add approximately 3 cm depth of distilled water and stir. Filter the solution formed into a test-tube.

The colour of the solution is

[1]

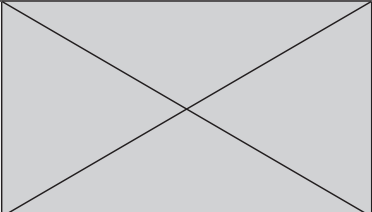
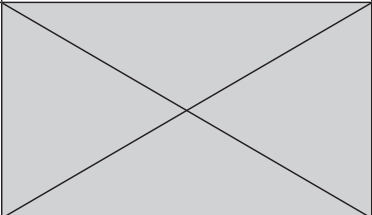
(c) You are provided with aqueous solutions **FA 7** and **FA 8** and with solid **FA 9**.

FA 7 is an aqueous solution of **FA 6**.

FA 7, **FA 8** and **FA 9** contain compounds which all have one metal that is the same but which may be in different oxidation states.

- (i) Carry out the following tests on **FA 7**, **FA 8** and **FA 9** and record your observations in Table 3.2. For each test use a 1 cm depth of a solution or a spatula measure of solid.

Table 3.2

test	observations		
	FA 7	FA 8	FA 9
Test 1 Add hydrogen peroxide.			
Test 2 Add aqueous sodium hydroxide, then			
leave to stand.			
Test 3 Add aqueous iron(II) sulfate.			

[4]

- (ii) Suggest the identity of the metal in **FA 6/FA 7**, **FA 8** and **FA 9**.

The metal is

[1]

- (iii) Complete Table 3.3 to suggest the oxidation state of the metal in **FA 6/FA 7** and **FA 8**.

Table 3.3

	FA 6/FA 7	FA 8
oxidation state		

[1]

[Total: 15]

Qualitative analysis notes

1 Reactions of cations

cation	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on warming	–
barium, Ba ²⁺ (aq)	faint white ppt. is observed unless [Ba ²⁺ (aq)] is very low	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. unless [Ca ²⁺ (aq)] is very low	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	pale blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

anion	reaction
carbonate, CO ₃ ²⁻	CO ₂ liberated by dilute acids
chloride, Cl ⁻ (aq)	gives white ppt. with Ag ⁺ (aq) (soluble in NH ₃ (aq))
bromide, Br ⁻ (aq)	gives cream/off-white ppt. with Ag ⁺ (aq) (partially soluble in NH ₃ (aq))
iodide, I ⁻ (aq)	gives pale yellow ppt. with Ag ⁺ (aq) (insoluble in NH ₃ (aq))
nitrate, NO ₃ ⁻ (aq)	NH ₃ liberated on heating with OH ⁻ (aq) and Al foil
nitrite, NO ₂ ⁻ (aq)	NH ₃ liberated on heating with OH ⁻ (aq) and Al foil; decolourises acidified aqueous KMnO ₄
sulfate, SO ₄ ²⁻ (aq)	gives white ppt. with Ba ²⁺ (aq) (insoluble in excess dilute strong acids); gives white ppt. with high [Ca ²⁺ (aq)]
sulfite, SO ₃ ²⁻ (aq)	gives white ppt. with Ba ²⁺ (aq) (soluble in excess dilute strong acids); decolourises acidified aqueous KMnO ₄
thiosulfate, S ₂ O ₃ ²⁻ (aq)	gives off-white/pale yellow ppt. slowly with H ⁺

3 Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint