

Reactivity trends in group 2 and the halogens

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train you to use the trends in group 2 and the halogens: balancing equations, gas volumes, titrations, halide tests and redox arguments. They move from recall to multi-step calculations and explanations.

The problems suit A Level, IB Chemistry, CBSE Class 11-12 and WAEC or NECO senior students. Show your working and give units.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.2.2-3.2.3

Problem 1 Group 2 basics (easy)

1. State the number of electrons in the outer shell of a group 2 atom.
2. Write the formula of the ion formed by strontium.
3. State whether barium is more or less reactive than magnesium.

Problem 2 Halogen states (easy)

Emma in Leeds lists the halogens at room temperature.

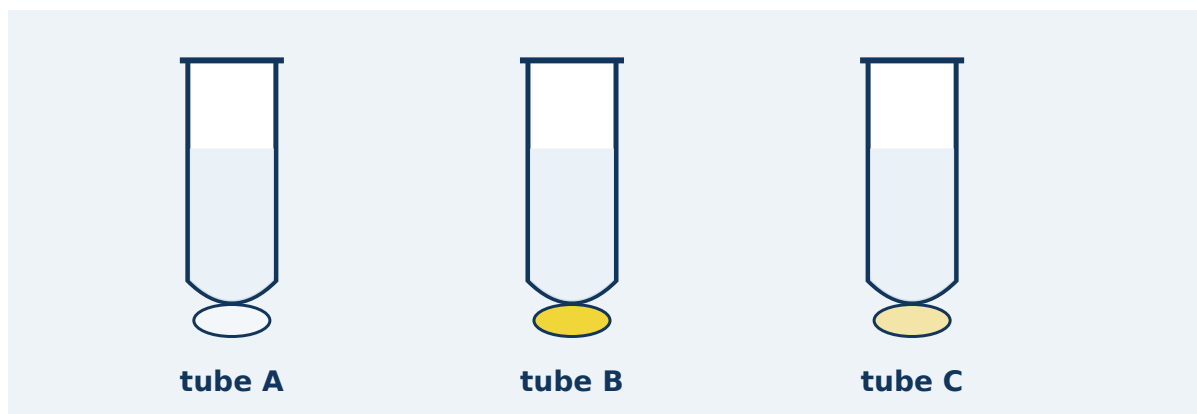
1. State the colour and state of chlorine and of iodine.
2. Explain why iodine is a solid but chlorine is a gas.

Problem 3 Balance the equations (easy)

Balance each equation.

1. $\text{Sr} + \text{H}_2\text{O} \rightarrow \text{Sr}(\text{OH})_2 + \text{H}_2$
2. $\text{Mg} + \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
3. $\text{Ca}(\text{OH})_2 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$

Problem 4 Identify the halide (easy)



Precipitates formed when silver nitrate was added to three acidified solutions.

Kofi in Accra acidifies three solutions and adds silver nitrate (figure).

1. Identify the halide ion in each tube.
2. Describe how dilute and concentrated ammonia separate B from C.
3. Explain why nitric acid is added first.

Problem 5 Hydrogen from magnesium (easy)

Bilal in Lahore reacts 0.486 g of magnesium with excess dilute hydrochloric acid.

1. Write the balanced equation.
2. Calculate the amount of magnesium ($A_r = 24.3$).
3. Calculate the volume of hydrogen at room temperature and pressure ($24.0 \text{ dm}^3 \text{ mol}^{-1}$).

Problem 6 Oxidised or reduced (easy)

Chlorine is bubbled into sodium bromide solution: $\text{Cl}_2 + 2\text{NaBr} \rightarrow 2\text{NaCl} + \text{Br}_2$.

1. Give the oxidation state of chlorine before and after.
2. State which species is oxidised and which is the oxidising agent.
3. Describe the colour change.

Problem 7 Alkalinity of limewater (medium)

A saturated solution of calcium hydroxide has a concentration of $0.020 \text{ mol dm}^{-3}$ at 25°C .

1. Calculate $[\text{OH}^-]$.
2. Calculate the pOH and the pH ($K_w = 1.0 \times 10^{-14}$).
3. Predict whether a saturated barium hydroxide solution has a higher or lower pH, and explain.

Problem 8 Liming acid soil (medium)

Kofi treats an acidic field. The soil contains 2.40 mol of H^+ that must be neutralised by calcium hydroxide.

1. Write the ionic equation.
2. Calculate the mass of $\text{Ca}(\text{OH})_2$ required ($M_r = 74.1$).

Problem 9 Barium hydroxide titration (medium)

A 25.0 cm³ sample of barium hydroxide solution needs 21.40 cm³ of 0.100 mol dm⁻³ hydrochloric acid for neutralisation.

1. Write the balanced equation.
2. Calculate the concentration of the barium hydroxide solution.

Problem 10 Which halogens react? (medium)

Predict whether each mixture reacts.

1. Bromine water and potassium chloride
2. Chlorine water and potassium iodide
3. Iodine solution and sodium bromide
4. Bromine water and potassium iodide

Write the ionic equation for each reaction that occurs.

Problem 11 Cold alkali and chlorine (medium)

Mei in Singapore makes bleach by passing chlorine into cold dilute sodium hydroxide.

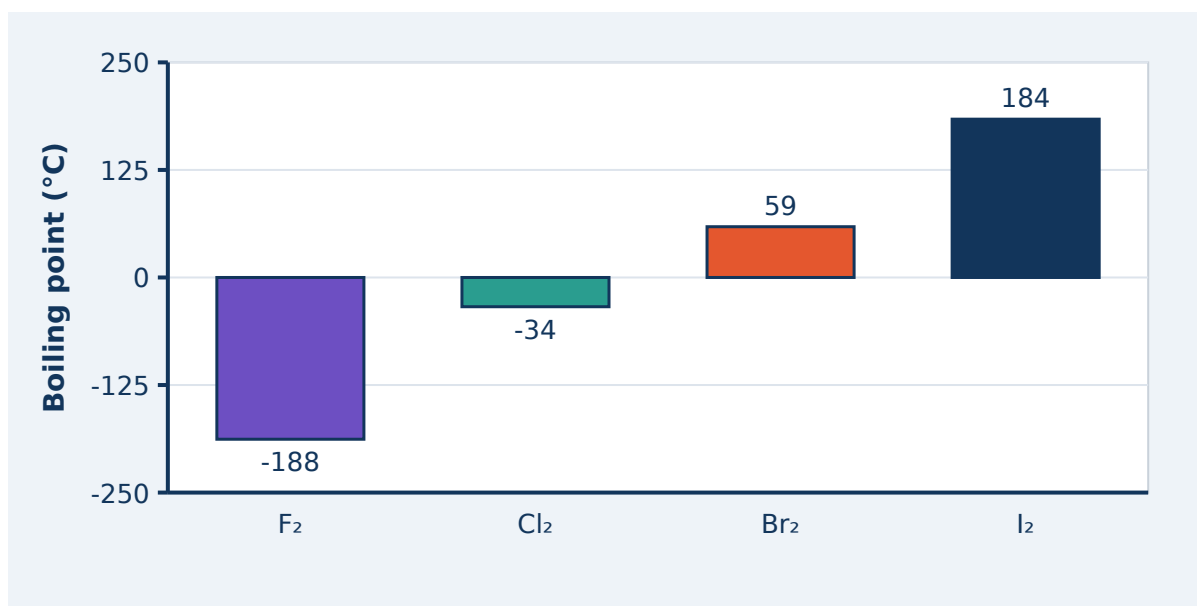
1. Balance: $\text{Cl}_2 + \text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$
2. Give the oxidation state of chlorine in Cl_2 , NaCl and NaClO .
3. Explain why this is disproportionation.

Problem 12 Chloride in a water sample (medium)

A 20.0 cm³ water sample gives 0.287 g of silver chloride on adding excess acidified silver nitrate (M_r of $\text{AgCl} = 143.4$).

1. Calculate the amount of AgCl .
2. Calculate the chloride concentration in mol dm⁻³.

Problem 13 Boiling points of halogens (medium)



Boiling points of the four halogens.

The figure shows the boiling points of the halogens.

1. Calculate the rise in boiling point from chlorine to iodine.
2. Explain the trend in terms of intermolecular forces.
3. Suggest why astatine is expected to be a solid.

Problem 14 Hydrogen halides and sulfuric acid (medium)

Concentrated sulfuric acid reacts with sodium iodide to give iodine, hydrogen sulfide and water.

1. Balance: $\text{HI} + \text{H}_2\text{SO}_4 \rightarrow \text{I}_2 + \text{H}_2\text{S} + \text{H}_2\text{O}$
2. Give the change in oxidation state of sulfur.
3. Explain why iodide ions can reduce sulfuric acid further than chloride ions can.

Problem 15 Spot the errors (medium)

Diego in Texas wrote three statements. Identify the error in each and correct it.

1. Magnesium reacts vigorously with cold water to give magnesium hydroxide.
2. Barium is more reactive than calcium because its first ionisation energy is higher.
3. Silver iodide dissolves in concentrated ammonia.

Problem 16 Barium meal (hard)

Patients swallow barium sulfate before an X-ray, but barium carbonate is poisonous.

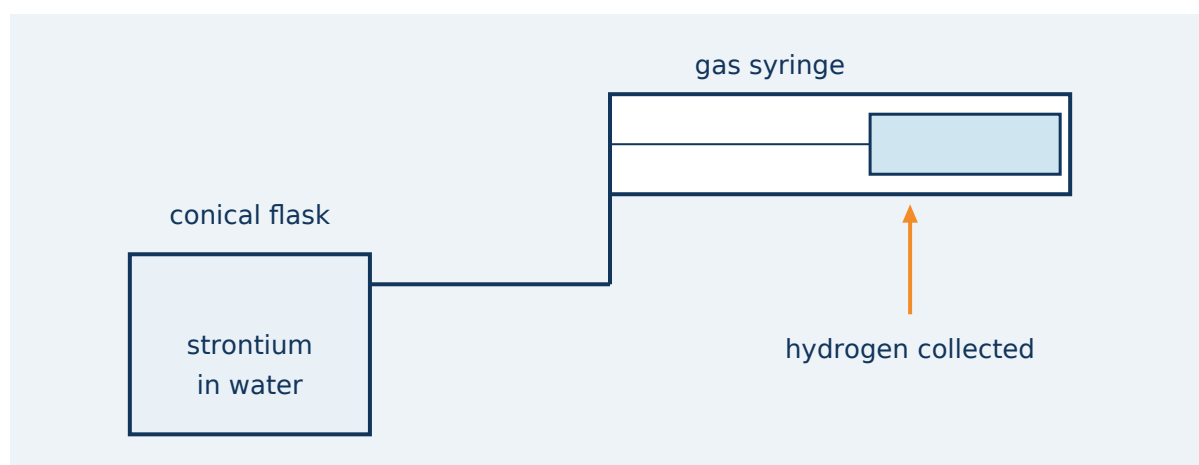
1. Write the equation for barium carbonate reacting with stomach acid (hydrochloric acid).
2. Explain why barium sulfate is safe.
3. Calculate the mass of BaSO_4 formed when 25.0 cm^3 of $0.200 \text{ mol dm}^{-3}$ BaCl_2 is added to excess sodium sulfate ($M_r = 233.4$).

Problem 17 Identify the chloride (hard)

Solution Y is one of MgCl_2 , CaCl_2 or BaCl_2 . Dilute sulfuric acid gives an immediate dense white precipitate. Acidified silver nitrate gives a white precipitate that dissolves in dilute ammonia.

1. Identify Y.
2. Write ionic equations for both precipitates.
3. Explain why calcium chloride would not give such a dense precipitate.

Problem 18 Which group 2 metal (hard)



Collecting the hydrogen from the metal in a gas syringe.

A 1.00 g sample of an unknown group 2 metal X reacts with excess water and gives 274 cm^3 of hydrogen at room temperature and pressure ($24.0 \text{ dm}^3 \text{ mol}^{-1}$).

1. Calculate the amount of hydrogen.
2. Calculate A_r and identify X.
3. Calculate the volume of $0.100 \text{ mol dm}^{-3}$ hydrochloric acid needed to neutralise the hydroxide formed.

Problem 19 Bleach analysis (hard)

Chiamaka in Lagos dilutes 25.0 cm^3 of bleach to 250 cm^3 . A 10.0 cm^3 portion is added to excess acidified potassium iodide and the iodine formed needs 24.50 cm^3 of $0.0500 \text{ mol dm}^{-3}$ sodium thiosulfate. Equations: $\text{ClO}^- + 2\text{I}^- + 2\text{H}^+ \rightarrow \text{Cl}^- + \text{I}_2 + \text{H}_2\text{O}$ and $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$.

1. Calculate $n(\text{S}_2\text{O}_3^{2-})$.
2. Calculate $n(\text{ClO}^-)$ in the 10.0 cm^3 portion.
3. Calculate the concentration of the original bleach in mol dm^{-3} and in g dm^{-3} of NaClO ($M_r = 74.5$).

Problem 20 Explain the halogen trends (hard)

Compare chlorine and iodine.

1. Explain, using atomic radius and shielding, why chlorine is the stronger oxidising agent.

2. Explain why iodide ions are stronger reducing agents than chloride ions.
3. Predict and justify the order of thermal stability of HCl, HBr and HI.