

Reactivity trends in group 2 and the halogens

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

Each answer gives the formula, the substitution and the result with its unit. Check your method first, then your number, and make sure every equation balances for atoms and charge.

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

- Two outer electrons (ns^2).
- Sr^{2+} .
- Barium is **more reactive**: its larger atom loses electrons more easily.

Problem 2 Halogen states

- Chlorine is a **pale green gas**; iodine is a **grey-black solid**.
- I_2 has many more electrons than Cl_2 , so its London forces between molecules are stronger and more energy is needed to separate them.

Problem 3 Balance the equations

- $Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$
- $Mg + 2HCl \rightarrow MgCl_2 + H_2$
- $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

Problem 4 Identify the halide

- A: **chloride** (white), B: **iodide** (yellow), C: **bromide** (cream).
- Dilute ammonia does not dissolve AgI or AgBr; concentrated ammonia dissolves AgBr (C) but not AgI (B).
- It removes carbonate and hydroxide ions that would give a false precipitate.

Problem 5 Hydrogen from magnesium

- $Mg + 2HCl \rightarrow MgCl_2 + H_2$.
- $n = 0.486 \div 24.3 = \mathbf{0.0200 \text{ mol}}$.
- $n(H_2) = 0.0200 \text{ mol}$, $V = 0.0200 \times 24.0 = 0.480 \text{ dm}^3 = \mathbf{480 \text{ cm}^3}$.

Problem 6 Oxidised or reduced

- Chlorine goes from 0 to -1 .
- Bromide ions ($-1 \rightarrow 0$) are **oxidised**; **chlorine** is the oxidising agent.

3. The colourless solution turns **orange** as bromine forms.

Problem 7 Alkalinity of limewater

- Each $\text{Ca}(\text{OH})_2$ gives 2 OH^- , so $[\text{OH}^-] = 2 \times 0.020 = \mathbf{0.040 \text{ mol dm}^{-3}}$.
- $\text{pOH} = -\log 0.040 = 1.40$, $\text{pH} = 14.00 - 1.40 = \mathbf{12.6}$.
- Higher:** barium hydroxide is more soluble, so $[\text{OH}^-]$ is larger.

Problem 8 Liming acid soil

- $\text{Ca}(\text{OH})_2 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + 2\text{H}_2\text{O}$.
- $n(\text{Ca}(\text{OH})_2) = 2.40 \div 2 = 1.20 \text{ mol}$; mass = $1.20 \times 74.1 = \mathbf{88.9 \text{ g}}$.

Problem 9 Barium hydroxide titration

- $\text{Ba}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O}$.
- $n(\text{HCl}) = 0.02140 \times 0.100 = 2.140 \times 10^{-3} \text{ mol}$; $n(\text{Ba}(\text{OH})_2) = 1.070 \times 10^{-3} \text{ mol}$; $c = 1.070 \times 10^{-3} \div 0.0250 = \mathbf{0.0428 \text{ mol dm}^{-3}}$.

Problem 10 Which halogens react?

- No reaction (bromine is less reactive than chlorine).
- Reacts: $\mathbf{Cl_2 + 2I^- \rightarrow 2Cl^- + I_2}$ (brown).
- No reaction.
- Reacts: $\mathbf{Br_2 + 2I^- \rightarrow 2Br^- + I_2}$ (brown).

Problem 11 Cold alkali and chlorine

- $\mathbf{Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O}$.
- 0, -1 and +1.
- The same element, chlorine, is reduced ($0 \rightarrow -1$) and oxidised ($0 \rightarrow +1$) in one reaction.

Problem 12 Chloride in a water sample

- $n = 0.287 \div 143.4 = \mathbf{2.00 \times 10^{-3} \text{ mol}}$.
- $n(\text{Cl}^-) = 2.00 \times 10^{-3} \text{ mol}$; $c = 2.00 \times 10^{-3} \div 0.0200 = \mathbf{0.100 \text{ mol dm}^{-3}}$.

Problem 13 Boiling points of halogens

- $184 - (-34) = \mathbf{218 \text{ }^\circ\text{C}}$.
- Molecules get larger with more electrons, so London forces between them strengthen and more energy is needed to separate them.
- Astatine has even more electrons than iodine, so its London forces are stronger and it will be a **solid** at room temperature.

Problem 14 Hydrogen halides and sulfuric acid

1. $8\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$.
2. Sulfur goes from +6 to -2, gaining 8 electrons.
3. Iodide ions are larger and give up electrons more easily, so they are stronger reducing agents. Chloride only produces HCl and sulfur does not change oxidation state.

Problem 15 Spot the errors

1. Magnesium reacts **very slowly** with cold water; it reacts quickly with steam to give MgO and H_2 .
2. Barium's first ionisation energy is **lower**, which makes it more reactive.
3. AgI is **insoluble** even in concentrated ammonia; only AgCl and AgBr dissolve.

Problem 16 Barium meal

1. $\text{BaCO}_3 + 2\text{HCl} \rightarrow \text{BaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$; soluble BaCl_2 releases toxic Ba^{2+} .
2. BaSO_4 is insoluble and does not react with acid, so almost no Ba^{2+} is released.
3. $n(\text{BaCl}_2) = 0.0250 \times 0.200 = 5.00 \times 10^{-3} \text{ mol}$, so $n(\text{BaSO}_4) = 5.00 \times 10^{-3} \text{ mol}$; mass = $5.00 \times 10^{-3} \times 233.4 = \mathbf{1.17 \text{ g}}$.

Problem 17 Identify the chloride

1. Y is **barium chloride**.
2. $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4(\text{s})$; $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}(\text{s})$.
3. Calcium sulfate is slightly soluble, so only a faint, slow precipitate would appear; magnesium sulfate is soluble.

Problem 18 Which group 2 metal

1. $n(\text{H}_2) = 0.274 \div 24.0 = \mathbf{0.01142 \text{ mol}}$.
2. $\text{X} + 2\text{H}_2\text{O} \rightarrow \text{X}(\text{OH})_2 + \text{H}_2$, so $n(\text{X}) = 0.01142 \text{ mol}$; $A_r = 1.00 \div 0.01142 = \mathbf{87.6}$, so X is **strontium**.
3. $n(\text{OH}^-) = 2 \times 0.01142 = 0.02283 \text{ mol} = n(\text{H}^+)$; $V = 0.02283 \div 0.100 = 0.2283 \text{ dm}^3 = \mathbf{228 \text{ cm}^3}$.

Problem 19 Bleach analysis

1. $n = 0.02450 \times 0.0500 = \mathbf{1.225 \times 10^{-3} \text{ mol}}$.
2. $n(\text{I}_2) = 6.125 \times 10^{-4} \text{ mol}$ and $n(\text{ClO}^-) = 6.125 \times 10^{-4} \text{ mol}$.
3. Diluted conc = $6.125 \times 10^{-4} \div 0.0100 = 0.06125 \text{ mol dm}^{-3}$; original = $10 \times \text{this} = \mathbf{0.613 \text{ mol dm}^{-3}}$; mass conc = $0.6125 \times 74.5 = \mathbf{45.6 \text{ g dm}^{-3}}$.

Problem 20 Explain the halogen trends

1. Chlorine atoms are smaller with less shielding, so the nucleus attracts an incoming electron more strongly, making Cl_2 **more strongly oxidising**.
2. Iodide has its outer electron further from the nucleus and more shielded, so it is lost more easily: I^- is a **stronger reducing agent**.
3. Bond length increases and bond enthalpy falls from H-Cl to H-I , so stability is **$\text{HCl} > \text{HBr} > \text{HI}$** .