Halogen displacement

Aqueous reactions on a spotting tile

YEAR 10 / LESSON 21 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

Which halogen–halide pairs show a colour change that is more than dilution, and what order of halogen reactivity does that support?

A more reactive halogen can take the place of a less reactive halogen in a halide solution. In this investigation you mix equal drop-counts of chlorine water, bromine water and iodine solution with potassium chloride, potassium bromide and potassium iodide solutions on a spotting tile or dimple tray. You also run dilution controls, because a halogen water becomes paler when it is mixed even if no displacement occurs. You record the colours you actually see and use only those observations, compared with the controls, as evidence for an order of reactivity among chlorine, bromine and iodine. This investigation does not use a hydrocarbon solvent, and it does not investigate electrolysis.

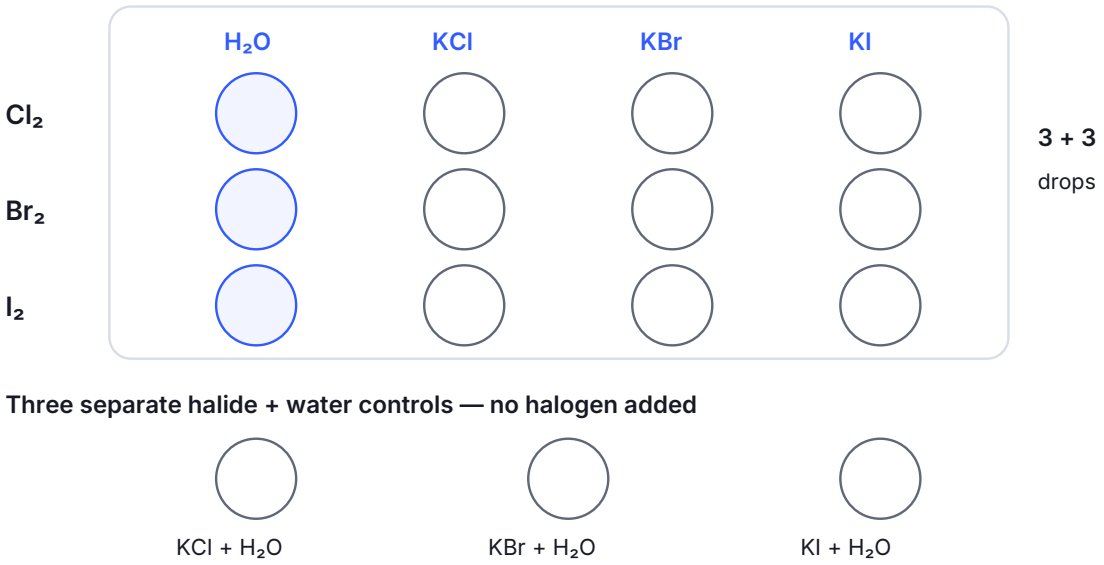
Course link: 2.7 — evidence for the Group 7 reactivity trend. This shared Chemistry / Double Award booklet does not assess electronic configurations.

Wear splash-resistant eye protection throughout. Chlorine and bromine waters release irritating, harmful vapours: use a well-ventilated laboratory, close bottles between uses, do not sniff and do not lean over the tile. Tell your teacher before the lesson about a known chlorine-related breathing problem; effects may be delayed. Bromine water is harmful and irritant; iodine stains. Wash skin splashes with plenty of water and tell the teacher. Nothing is heated. Teacher dispenses halogen waters; bottles and unused solutions stay in the room. Report breakages and wash hands.

Equipment • per group of up to three

Clean, dry white spotting tile or dimple tray with at least 15 wells; white background or labelled paper grid; labelled reagent dropper bottles (page 2); optional well map/pen and paper towel. Your teacher provides access to the labelled used-mixture collection container and a separate tray wash bucket.

Well map • circles are positions, not expected colours



15 wells = 9 pairings + 3 halogen/water + 3 halide/water controls.

Read the reagent labels

Identity, concentration and hazards must remain visible to every handler

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Issued reagent	Concentration	Important label / handling information
Distilled water	As issued	Read every working label.
Potassium chloride, KCl(aq)	0.1 mol dm^{-3}	Actual identity and hazards on label.
Potassium bromide, KBr(aq)	0.1 mol dm^{-3}	Actual identity and hazards on label.
Potassium iodide TEST solution, KI(aq)	0.1 mol dm^{-3} OR staff-issued adjusted concentration	Record actual issued concentration; do not adjust it yourself.
Chlorine water, Cl_2(aq)	0.1–0.3% w/v; freshly prepared	Releases irritating, harmful vapour.
Bromine water, Br_2(aq)	0.1% w/v	Harmful and irritant; vapour.
Iodine solution, I_2 in aqueous KI	0.1 mol dm^{-3} I_2 in 0.5 mol dm^{-3} KI carrier	Stains; carrier iodide is already present.

If the KI TEST solution is labelled “adjusted”, copy the actual issued concentration. It is a separate reagent from the 0.5 mol dm^{-3} KI carrier already in the iodine solution. Never change an issued reagent yourself.

Use 3 drops of each reagent in each well. Equal drop counts are a control, NOT measured equal volumes: drop size can vary between bottles. Use only the aqueous tile method shown here; there is no heating or solvent layer.

Method • start the controls

1. Put the tile on a white background, or a clear dimple tray on the labelled paper grid. Mark rows Cl_2, Br_2, I_2 and columns H_2O, KCl, KBr, KI. Mark three separate halide-control wells.

2. For the three halide + water controls, put 3 drops of KCl, KBr or KI in its separate well, then add 3 drops of distilled water to each. Do not add any halogen solution. Record the actual colour of each control.

Complete the mixtures

15 wells in total: nine pairings and six controls

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3. Add 3 drops of chlorine water to each of the FOUR wells in the Cl_2 row; repeat with bromine water in the Br_2 row and iodine solution in the I_2 row. Add 3 drops of distilled water ONLY to the H_2O column. Record each halogen + water dilution-control colour. These controls are made without adding a test halide solution; the iodine solution already contains carrier iodide.

4. For the nine pairings, add 3 drops of KCl to each well in the KCl column, 3 drops of KBr to each in the KBr column and 3 drops of KI to each in the KI column. Close every dropper bottle after use. Do not sniff wells or bottles.

5. Wait about one minute. Compare each pairing with the dilution control in the SAME halogen row and with the matching halide + water control. Record actual colour, then deeper / similar / paler / unclear compared with that row's dilution control.

6. If unclear, repeat that well once in a clean well with fresh drops. Keep both observations; do not overwrite the first or invent a colour.

7. Return all well contents and leftover used mixtures to the labelled used-halogen/halide waste collection container your teacher has provided, not the sink and not the tray wash bucket. Do not pour used mixtures down the drain. Do not add other waste or try to treat the mixtures. Follow your teacher's direction to that container. Close and return every dropper bottle. Place the tile or dimple tray into the class wash bucket of water if your teacher has provided one. Wash hands.

A paler colour can be caused by dilution alone. Only a clear change beyond the appropriate controls may support displacement. Faint or ambiguous wells are valid observations: write "unclear", not an expected result.

Setup record

Drop count actually used:

Was chlorine water stated to be freshly prepared? Record what you were told:

Actual issued KI TEST concentration (including an adjusted label, if present):

No graph is required: colour categories are not numerical. Use the result spaces on page 4 and the analysis on page 5.

Record all fifteen wells

Blank observations only • compare with the appropriate controls

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Six control wells

Halide + water • no halogen added	Actual colour
KCl + H_2O	
KBr + H_2O	
KI + H_2O	

Halogen + water • no TEST halide added	Actual colour
Cl_2 solution + H_2O	
Br_2 solution + H_2O	
I_2 solution + H_2O (carrier iodide already present)	

Nine halogen–halide pairings

Test halide	Cl_2 row: colour	vs Cl_2 water control	Br_2 row: colour	vs Br_2 water control	I_2 row: colour	vs I_2 water control
KCl						
KBr						
KI						

Comparison vocabulary: deeper / similar / paler / unclear. Use the dilution control for the SAME HALOGEN and the matching halide + water control, not expected colours.

Unclear / repeated well, first observation and repeat:

Explain your evidence

Do not force a complete order when observations are unclear

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1. Which pairings, if any, showed a colour change that was more than dilution, compared with the water control in the same row?

2. Using only those observations, what order of reactivity among chlorine, bromine and iodine is supported? If some wells were unclear, say so and do not force a complete order.

3. Why is a distilled-water (dilution) control needed in each halogen row?

4. Write a word equation, and a balanced symbol equation with state symbols, for one pairing that your observations support as a displacement. If you also write an ionic equation, identify the spectator ion. Do not write an equation for a pairing you judged as no change or unclear.

Your evidence applies to chlorine, bromine and iodine in this aqueous investigation. It does not prove complete reaction in every well or extend the observations to fluorine or astatine. No graph is required.

Sources: Pearson Edexcel International GCSE Chemistry, Issue 3 (2024), 2.7; RSC / Nuffield, Halogens in aqueous solution and their displacement reactions (733); RSC Displacement reactions practical video (4012012) and technician notes ac=512210. Follow your teacher and the school's risk assessment.