

Exercise walk-through

2.3.6

Halogen evidence and controlled analytical methods

Pearson Edexcel · International A-Level · Chemistry

Opposite solubility trends explain the evidence

- 1 **Set up** $\text{Ba}(\text{OH})_2$ is more soluble: its equal saturated volume contains more OH^- and needs more acid.
- 2 **Reason** BaSO_4 is less soluble: equal initial cation amounts give more solid with excess sulfate.
- 3 **Conclude** Solubility controls dissolved amount; it is different from dissociation strength.

Controls distinguish chemical evidence from contamination

- 1 Set up** Match measured amounts, particle size, apparatus and heating rate; compare sample temperature at a consistent decomposition criterion.
- 2 Reason** CO_2 : milky limewater; O_2 : glowing splint relights; NO_2 : brown and acidic.
- 3 Conclude** Clean flame-test wire and keep the flame region/loading consistent. Na yellow, K lilac, Ca brick-red, Sr crimson-red; sodium carry-over can mask another colour.

Independent identification

Your turn

$\text{C}_3\text{H}_6\text{O}$ has a carbonyl IR absorption and gives a positive Fehling's test. Which structure fits all evidence?

- A. CH_3COCH_3
- B. $\text{CH}_3\text{CH}_2\text{CHO}$
- C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- D. CH_3COOH

Exercises 2.1·2.2

2.1 Write balanced equations for sodium and magnesium reacting with chlorine. Explain the different chloride formulae and identify which reactant is oxidised in each reaction.[4]

2.2 Rank chlorine, bromine and iodine by electronegativity. Explain the trend despite increasing nuclear charge, then distinguish the electron attraction meant by electronegativity from that meant by oxidising power. [3]

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2.1 $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$; $\text{Mg} + \text{Cl}_2 \rightarrow \text{MgCl}_2$. Na^+ requires one Cl^- , while Mg^{2+} requires

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2.2 $\text{Cl} > \text{Br} > \text{I}$. Greater radius and shielding down the group weaken attraction despite greater nuclear charge. Electronegativity concerns the shared bonding pair; oxidising power concerns accepting electrons in redox, so the two descriptions must not be conflated.

Exercise 2.3

2.3 State the characteristic aqueous and inert non-polar organic-solution colours of Cl_2 , Br_2 and I_2 . A small amount of bromine water is added separately to excess aqueous KI and aqueous KCl, then each mixture is shaken with cyclohexane under the stated supervised test conditions. Bromine is orange in cyclohexane; iodine is purple. Predict each organic-layer colour, write the reaction that occurs, and explain the result with KCl. Assume excess iodide consumes all added bromine. [7]

3 Exam-style questions

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2.3 Cl_2 : pale green aqueous, pale yellow-green organic; Br_2 : orange/brown aqueous, orange organic; I_2 : brown aqueous, purple/violet organic. KI gives a purple organic layer containing I_2 ; KCl retains orange Br_2 . $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$. Bromine is a weaker oxidising agent than chlorine and does not oxidise Cl^- under these conditions. Colour interpretation explicitly uses cyclohexane rather than the brown aqueous-iodine colour.

Exercises 3.1·3.2

3.1 Predict balanced equations for Br_2 with cold dilute NaOH and I_2 with hot concentrated NaOH , by analogy with chlorine chemistry. Give the two halogen oxidation numbers in each pair of products. Name the chlorine-containing ion in bleach, and write the reversible chlorine–water equation. [6]

3.2 Concentrated sulfuric acid first forms HI from an iodide salt. Write three balanced redox equations using HI and H_2SO_4 that produce I_2 and, separately, SO_2 , S and H_2S . Give sulfur's change in oxidation number for all three and identify the species oxidised. Explain why concentrated H_2SO_4 is unsuitable for preparing pure HI . [6]

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3.1 $\text{Br}_2 + 2\text{NaOH} \rightarrow \text{NaBr} + \text{NaBrO} + \text{H}_2\text{O}$; $3\text{I}_2 + 6\text{NaOH} \rightarrow 5\text{NaI} + \text{NaIO}_3 + 3\text{H}_2\text{O}$. Bromine products contain Br -1 and $+1$; iodine products contain I -1 and $+5$. Bleach contains chlorate(I)/hypochlorite, ClO^- . $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCl} + \text{HClO}$. These are disproportionation reactions: some halogen is reduced and some oxidised.

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3.2 $2\text{HI} + \text{H}_2\text{SO}_4 \rightarrow \text{I}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$; $6\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 3\text{I}_2 + \text{S} + 4\text{H}_2\text{O}$; $8\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$. Sulfur changes $+6 \rightarrow +4$, 0 and -2 respectively. Iodide/ HI is oxidised from I -1 to I_2 0 . The oxidising acid consumes the desired HI and introduces iodine/reduced-sulfur products, preventing pure HI preparation by this route.

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3.3 $n(\text{NaOH}) = 0.1000 \times 0.02460 = 0.002460 \text{ mol}$; $\text{HCl}:\text{NaOH} = 1:1$; $c(\text{HCl}) = 0.002460/0.02460 = 0.09840 \text{ mol dm}^{-3}$. Rinse the pipette with HCl , burette with NaOH , and flask with deionised water; transfer the aliquot with the pipette using a filler. Fill the burette jet, remove the funnel and read initial/final menisci at eye level. Add indicator and swirl; approach the endpoint dropwise over a white tile, rinsing flask walls with deionised water if needed. Phenolphthalein changes from colourless to the first persistent pale pink as slight alkali excess is reached. Obtain a rough titre, then repeat accurately to concordance and average the accepted concordant titres, rather than including the rough run.

Exercise 3.4

3.4 An approved supervised flame-test method is used to compare sodium, potassium, calcium and strontium salts. Describe how to avoid sample carry-over, state the four expected colours and one experimental condition to keep the same. Explain why a yellow contaminated flame is weak evidence for sodium in an unknown. Separately, describe the positive test for CO_2 released from a carbonate; a flame colour is not that gas test. [6]

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3.4 Clean the test wire according to the approved method, using hydrochloric acid and heating until no colour remains, and avoid carrying material from one salt to the next. Sodium is yellow; potassium lilac. Calcium is brick-red; strontium crimson-red. Keep the wire, sample-loading method and flame region/conditions matched. Sodium contamination gives a strong yellow signal that may mask another salt, so a contaminated yellow flame alone does not establish sample identity. Bubble the evolved CO_2 through limewater: it turns milky from CaCO_3 ; this is distinct from a flame test.

Exercise 3.5

3.5 Outline a controlled supervised comparison of thermal stability for Group 1 and Group 2 nitrates/carbonates. Explain how to control the amount and heating, what to measure instead of simply comparing elapsed bubble times, and how to identify CO_2 , O_2 and NO_2 among the possible gases. [6]

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3.5 Use comparable measured molar amounts and similar particle size/apparatus; keep the heating rate and other apparatus conditions matched. Record sample temperature at an agreed detectable onset/extent of decomposition, rather than interpreting bubble time alone as a decomposition temperature. CO_2 turns limewater milky; O_2 relights a glowing splint; NO_2 is a brown gas with acidic behaviour on damp indicator. These

are observations in an approved ventilated supervised setup, not instructions to smell or handle decomposition gases independently. The detected onset depends on apparatus and sensitivity; compare it consistently rather than claiming a universal sharp decomposition temperature.