

Exercise walk-through

2.3.4

Group reactions: formulae, solubility and thermal evidence

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 2.1·2.3

2.1 Write the names of FeCl_2 and FeCl_3 using Roman numerals. Write the formula of copper(II) nitrate and use charge balance to justify it. [4]

2.2 Write balanced equations for lithium burning to its oxide, sodium forming its peroxide, and potassium forming its superoxide in excess oxygen. Give the oxidation number of oxygen in each product. [6]

2.3 Write balanced equations for magnesium with steam and for barium with cold water. Compare the observed cold-water reactivity of Mg, Ca and Ba and explain the trend. [5]

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2.1 Iron(II) chloride and iron(III) chloride. $\text{Cu}(\text{NO}_3)_2$; one Cu^{2+} needs two NO_3^- , total

2.2 Write balanced equations for lithium burning to its oxide, sodium forming its peroxide, and potassium forming its superoxide in excess oxygen. Give the oxidation number of oxygen in each product. [6]

2.2 $4\text{Li} + \text{O}_2 \rightarrow 2\text{Li}_2\text{O}$, $\text{O} = -2$. $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2$, $\text{O} = -1$. $\text{K} + \text{O}_2 \rightarrow \text{KO}_2$, average $\text{O} = -\frac{1}{2}$. The products and conditions are specified; do not replace every oxygen product with a simple oxide.

2.3 Write balanced equations for magnesium with steam and for barium with cold water. Compare the observed cold-water reactivity of Mg, Ca and Ba and explain the trend. [5]

2.3 $\text{Mg} + \text{H}_2\text{O}(\text{g}) \rightarrow \text{MgO} + \text{H}_2$; $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2$. Cold-water reactivity increases $\text{Mg} < \text{Ca} < \text{Ba}$. Radius/shielding increase, weakening attraction to outer electrons so electron loss is easier.

Exercises 3.1·3.2

3.1 For K_2O , write balanced equations with water and with dilute HCl . For $\text{Ba}(\text{OH})_2$, write the full equation with HCl and the net ionic equation. State which changes are neutralisation rather than redox. [6]

3.2 Equal volumes of saturated $\text{Mg}(\text{OH})_2$ and $\text{Ba}(\text{OH})_2$ solutions at the same temperature are separately titrated with the same acid. Predict which needs more acid. Separately, predict which gives more precipitate when equal volumes of equally concentrated Mg^{2+} and Ba^{2+} solutions receive excess sulfate. Explain both, and explain why solubility is different from alkali strength. [5]

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3.1 $\text{K}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{KOH}$; $\text{K}_2\text{O} + 2\text{HCl} \rightarrow 2\text{KCl} + \text{H}_2\text{O}$. $\text{Ba}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$. The oxide–acid and hydroxide–acid changes are neutralisation; oxidation numbers do not change, so none of the stated changes is redox.

3.2 Equal volumes of saturated $\text{Mg}(\text{OH})_2$ and $\text{Ba}(\text{OH})_2$ solutions at the same temperature are separately titrated with the same acid. Predict which needs more acid. Separately, predict which gives more precipitate when equal volumes of equally concentrated Mg^{2+} and Ba^{2+} solutions receive excess sulfate. Explain both, and explain why solubility is different from alkali strength. [5]

3.2 The saturated $\text{Ba}(\text{OH})_2$ solution needs more acid because hydroxide solubility increases down Group 2 and it contains more dissolved OH^- per equal volume. The Ba^{2+} solution gives more precipitate because sulfate solubility decreases down the group. Solubility controls how much dissolves; alkali strength concerns dissociation of the dissolved substance, so low solubility does not by itself mean weak alkali.

Exercise 3.3

3.3 Magnesium carbonate decomposes at a lower temperature than barium carbonate. Explain using cation size. Write balanced equations for magnesium carbonate and magnesium nitrate on heating. Give tests/observations distinguishing the released gases. Explain why timing bubbles alone does not establish a decomposition temperature. [7]

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3.3 Mg^{2+} is smaller and has greater charge density, polarising the anion more strongly and