Topic 4: Inorganic Chemistry and the Periodic Table

Edexcel A Level Chemistry • Paper 1 (9CH0/01)

4A.1 Understand reasons for the trend in ionisation energy down Group 2.

Ionisation energy decreases down Group 2 because:

- More electron shells → outer electron is further from the nucleus
- Greater shielding by inner electrons
- These factors outweigh the increase in nuclear charge
- Less energy needed to remove the outer electron

4A.2 Understand reasons for the trend in reactivity of the Group 2 elements down the group.

Reactivity increases down Group 2 because ionisation energy decreases – it becomes easier to lose the two outer electrons. The outer electrons are further from the nucleus and more shielded, so less energy is required to remove them. Reactions occur more vigorously.

4A.3 Know the reactions of the elements Mg to Ba in Group 2 with oxygen, chlorine and water.

With oxygen: $2M + O_2 \rightarrow 2MO$ (white solid oxides). Reactivity increases down the group.

With chlorine: $M + Cl_2 \rightarrow MCl_2$ (white solid chlorides).

With water: $M + 2H_2O \rightarrow M(OH)_2 + H_2$. Mg reacts very slowly with cold water (forms $Mg(OH)_2$) but vigorously with steam ($Mg + H_2O \rightarrow MgO + H_2$). Ca to Ba react increasingly vigorously with cold water.

4A.4 Know the reactions of the oxides of Group 2 elements with water and dilute acid, and their hydroxides with dilute acid.

Oxides + water → hydroxides: $MO + H_2O \rightarrow M(OH)_2$ (alkaline solutions, pH increases down group as hydroxides become more soluble).

Oxides + dilute acid → salt + water: $MO + 2HCl \rightarrow MCl_2 + H_2O$ (neutralisation).

Hydroxides + dilute acid → salt + water: $M(OH)_2 + 2HCl \rightarrow MCl_2 + 2H_2O$.

4A.5 Know the trends in solubility of the hydroxides and sulfates of Group 2 elements.

Hydroxides: solubility increases down Group 2 ($Mg(OH)_2$ sparingly soluble → $Ba(OH)_2$ soluble). Solutions become more alkaline.

Sulfates: solubility decreases down Group 2 ($MgSO_4$ soluble → $BaSO_4$ insoluble). $BaSO_4$ is used in the test for sulfate ions.

Remember: Hydroxides Happy (increase), Sulfates Sad (decrease).

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4A.6 Understand reasons for the trends in thermal stability of the nitrates and the carbonates of the elements in Groups 1 and 2.

Thermal stability increases down both groups.

Explanation: the carbonate/nitrate anion is decomposed by the polarising power of the cation. Smaller, more highly charged cations (e.g. Mg^{2+}) have greater charge density and distort (polarise) the electron cloud of the anion more, weakening it and making it easier to decompose. Down the group, cations are larger with lower charge density, so less polarising → more thermally stable.

Group 2 compounds are less stable than corresponding Group 1 compounds (2+ charge is more polarising than 1+).

4A.7 Understand the formation of characteristic flame colours by Group 1 and 2 compounds in terms of electron transitions.

When heated, electrons are promoted to higher energy levels. When they fall back to lower levels, they emit light of specific wavelengths (colours).

Group 1: Li = crimson/red, Na = yellow/orange, K = lilac

Group 2: Ca = orange-red, Sr = red, Ba = green

The energy gap between levels determines the wavelength (colour) of light emitted.

4A.8 Understand experimental procedures for: (i) patterns in thermal decomposition of Group 1 and 2 nitrates and carbonates, (ii) flame colours.

(i) Thermal decomposition: heat samples in test tubes and test gases evolved. Carbonates produce CO_2 (turns limewater milky). Nitrates produce brown NO_2 gas and O_2 (relights a glowing splint). Time how long until gas is produced – shorter time or lower temperature = less stable.

(ii) Flame tests: clean a nichrome wire loop in concentrated HCl, dip in the sample, hold in a blue Bunsen flame, and observe the colour.

4B.9 Understand reasons for the trends in melting and boiling temperatures, physical state at room temperature, and electronegativity for Group 7 elements.

M.p./b.p. increase down Group 7: larger molecules have more electrons → stronger London forces between molecules → more energy needed to separate them. F_2 and Cl_2 are gases, Br_2 is a liquid, I_2 is a solid at room temperature.

Electronegativity decreases down the group: atomic radius increases and shielding increases, so the nucleus attracts bonding electrons less strongly.

4B.10 Understand reasons for the trend in reactivity of Group 7 elements down the group.

Reactivity decreases down Group 7. Halogens react by gaining an electron. Down the group, atomic radius increases and shielding increases, so the nucleus is less able to attract an incoming electron. It becomes harder to form a halide ion, so reactivity decreases.

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4B.11 Understand the trend in reactivity in terms of the redox reactions of Cl_2, Br_2 and I_2 with halide ions in aqueous solution, followed by the addition of an organic solvent.

A more reactive halogen displaces a less reactive halide from solution:

- $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ (solution turns orange/brown)
- $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ (solution turns brown)
- $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ (solution turns brown)

Adding a non-polar organic solvent (e.g. cyclohexane) helps identify products: Br_2 is orange in organic layer; I_2 is purple/violet in organic layer.

4B.12 Understand, in terms of changes in oxidation number, the following reactions of the halogens: (i) oxidation with Group 1/2 metals, (ii) disproportionation of chlorine with water and use in water treatment, (iii) disproportionation with cold dilute NaOH (bleach), (iv) disproportionation with hot alkali.

(i) $2Na + Cl_2 \rightarrow 2NaCl$: Cl goes from 0 to −1 (reduced); Na goes from 0 to +1 (oxidised).

(ii) $Cl_2 + H_2O$ $\rightleftharpoons$ $HOCl + HCl$: Cl disproportionates (0 → +1 in HOCl and 0 → −1 in HCl). HOCl kills bacteria – used in water treatment.

(iii) Cold dilute NaOH: $Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$ (Cl: 0 → −1 and 0 → +1). NaClO is bleach.

(iv) Hot concentrated NaOH: $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$ (Cl: 0 → −1 and 0 → +5).

4B.13 Understand the following reactions: (i) solid Group 1 halides with concentrated sulfuric acid, (ii) precipitation reactions of Cl^-, Br^- and I^- with $AgNO_3(aq)$, (iii) hydrogen halides with ammonia and with water.

(i) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$ (steamy white fumes). NaBr: also makes HBr, but H_2SO_4 oxidises HBr to Br_2 (orange fumes). NaI: HI is further oxidised to I_2 (purple fumes), H_2S (rotten eggs) and S (yellow solid). Reducing ability: HI > HBr > HCl.

(ii) $Ag^+ + Cl^- \rightarrow AgCl$ (white, soluble in dilute NH_3); $Ag^+ + Br^- \rightarrow AgBr$ (cream, soluble in conc. NH_3); $Ag^+ + I^- \rightarrow AgI$ (yellow, insoluble in NH_3).

(iii) $HCl + NH_3 \rightarrow NH_4Cl$ (white smoke). All hydrogen halides dissolve in water to form strong acids (HF is weak).

4B.14 Be able to make predictions about fluorine and astatine and their compounds, in terms of knowledge of trends in halogen chemistry.

Fluorine: most reactive halogen, highest electronegativity, strongest oxidising agent, lowest b.p., HF is a weak acid (unlike other hydrogen halides), AgF is soluble.

Astatine: least reactive halogen (of the common ones), lowest electronegativity, solid at room temperature, darkest colour, weakest oxidising agent. Predict: At_2 would be displaced by all other halogens; HAt would be the strongest reducing agent.

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4C.15 Know reactions for identifying: (i) CO_3^{2-} and HCO_3^- using acid, (ii) SO_4^{2-} using acidified $BaCl_2$, (iii) NH_4^+ using NaOH and warming.

(i) Carbonate/hydrogencarbonate test: add dilute acid (e.g. HCl). Both produce CO_2 gas which turns limewater milky. $CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2$. $HCO_3^- + H^+ \rightarrow H_2O + CO_2$.

(ii) Sulfate test: add dilute HCl (to remove carbonate/sulfite ions), then add $BaCl_2$(aq). A white precipitate of $BaSO_4$ confirms sulfate ions. $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$.

(iii) Ammonium test: add NaOH(aq) and warm gently. Ammonia gas is produced, which turns damp red litmus paper blue. $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$.

ABOUT THESE NOTES

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