Ions, formulae and chemical tests

Common ions and their charges, how to build a formula, and every test from the 0620 qualitative analysis notes on one sheet.

Positive ions (cations)	Charge
hydrogen H^+, lithium Li^+, sodium Na^+, potassium K^+, silver Ag^+, ammonium NH_4^+	1+
magnesium Mg^{2+}, calcium Ca^{2+}, barium Ba^{2+}, copper(II) Cu^{2+}, zinc Zn^{2+}, iron(II) Fe^{2+}, lead(II) Pb^{2+}	2+
aluminium Al^{3+}, iron(III) Fe^{3+}, chromium(III) Cr^{3+}	3+

Negative ions (anions)	Charge
chloride Cl^-, bromide Br^-, iodide I^-, hydroxide OH^-, nitrate NO_3^-, hydrogencarbonate HCO_3^-	1-
oxide O^{2-}, sulfide S^{2-}, sulfate SO_4^{2-}, sulfite SO_3^{2-}, carbonate CO_3^{2-}	2-
phosphate PO_4^{3-}	3-

Building a formula: the charges must add up to zero. Al^{3+} and O^{2-} → 2 × (+3) = +6 and 3 × (-2) = -6 → **Al_2O_3**. Put brackets round a group ion when you need more than one: Ca^{2+} and OH^- → **$Ca(OH)_2$**; NH_4^+ and SO_4^{2-} → **$(NH_4)_2SO_4$**.

Formulae to know

Substance	Formula	Substance	Formula
sodium chloride	NaCl	hydrochloric acid	HCl
magnesium oxide	MgO	sulfuric acid	H_2SO_4
calcium carbonate	$CaCO_3$	nitric acid	HNO_3
copper(II) sulfate	$CuSO_4$	sodium hydroxide	NaOH
iron(III) oxide	Fe_2O_3	ammonia	NH_3
aluminium oxide	Al_2O_3	methane	CH_4
calcium hydroxide	$Ca(OH)_2$	ethene	C_2H_4
ammonium sulfate	$(NH_4)_2SO_4$	ethanol	C_2H_5OH
carbon dioxide	CO_2	ethanoic acid	CH_3COOH

Tests for anions

Anion	Test	Result
carbonate CO_3^{2-}	add dilute acid, then test the gas with limewater	effervescence; carbon dioxide turns limewater milky
chloride Cl^- (in solution)	acidify with dilute nitric acid, add aqueous silver nitrate	white precipitate
bromide Br^- (in solution)	acidify with dilute nitric acid, add aqueous silver nitrate	cream precipitate
iodide I^- (in solution)	acidify with dilute nitric acid, add aqueous silver nitrate	yellow precipitate
nitrate NO_3^- (in solution)	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate SO_4^{2-} (in solution)	acidify with dilute nitric acid, add aqueous barium nitrate	white precipitate
sulfite SO_3^{2-}	add a little acidified aqueous potassium manganate(VII)	purple → colourless

Tests for aqueous cations

Cation	Aqueous sodium hydroxide	Aqueous ammonia
aluminium Al^{3+}	white ppt., dissolves in excess (colourless solution)	white ppt., does not dissolve in excess
ammonium NH_4^+	ammonia gas given off on warming	—
calcium Ca^{2+}	white ppt., does not dissolve in excess	no ppt. or very slight white ppt.
chromium(III) Cr^{3+}	green ppt., dissolves in excess	green ppt., does not dissolve in excess
copper(II) Cu^{2+}	light blue ppt., does not dissolve in excess	light blue ppt., dissolves in excess (dark blue solution)
iron(II) Fe^{2+}	green ppt., does not dissolve; turns brown at the surface on standing	same as with sodium hydroxide
iron(III) Fe^{3+}	red-brown ppt., does not dissolve in excess	red-brown ppt., does not dissolve in excess
zinc Zn^{2+}	white ppt., dissolves in excess (colourless solution)	white ppt., dissolves in excess (colourless solution)

Tests for gases

Flame tests

Gas	Test and result
ammonia NH_3	turns damp red litmus paper blue
carbon dioxide CO_2	turns limewater milky
chlorine Cl_2	bleaches damp litmus paper
hydrogen H_2	“pops” with a lighted splint
oxygen O_2	relights a glowing splint
sulfur dioxide SO_2	acidified aqueous potassium manganate(VII): purple → colourless

Metal ion	Flame colour
lithium Li^+	red
sodium Na^+	yellow
potassium K^+	lilac
calcium Ca^{2+}	orange-red
barium Ba^{2+}	light green
copper(II) Cu^{2+}	blue-green

In Papers 5 and 6 you are given these qualitative analysis notes, but in Papers 3 and 4 you must remember them. ppt. = precipitate.