CAMBRIDGE IGCSE · 0620 · EXTENDED · PAPERS 2 & 4

Chemistry Cheat Sheet

Every reaction condition, equation and process in the Extended syllabus, arranged for recall. Figures in **red** are the conditions and colours examiners award marks for.

01 PARTICLES, DEFINITIONS & SEPARATION

TERM	DEFINITION TO MEMORISE
Element	Substance made of one type of atom, cannot be broken down chemically.
Compound	Two or more elements chemically combined in fixed proportions.
Mixture	Two or more substances not chemically combined; components keep their properties.
Isotopes	Atoms of the same element with the same proton number but different numbers of neutrons. Identical chemical properties (same electron arrangement).
Relative atomic mass (A_r)	Average mass of naturally occurring atoms of an element on a scale where $^{12}C = 12$.
Mole	Amount of substance containing 6.02×10^{23} particles (Avogadro constant).
Diffusion	Net movement of particles from high to low concentration. Rate $\propto 1/\sqrt{M_r}$ — lighter gases diffuse faster (NH_3 beats HCl).
Solvent / solute / solution	Liquid that dissolves / substance dissolved / the mixture formed. **Saturated** = no more solute dissolves at that temperature.
Allotropes	Different structural forms of the same element (diamond, graphite).
Pure substance	Melts/boils at one sharp, fixed temperature. Impurities lower melting point and raise boiling point over a range.
SEPARATION TECHNIQUES	
Filtration	Insoluble solid from a liquid. Residue = solid, filtrate = liquid.
Crystallisation	Soluble solid from solution — heat to saturation, cool slowly, filter, dry between filter papers.
Simple distillation	Solvent from a solution (pure water from seawater).
Fractional distillation	Miscible liquids of different boiling points (ethanol 78 °C from water 100 °C; crude oil; liquid air).
Paper chromatography	Soluble coloured/colourless substances. R_f = distance moved by substance ÷ distance moved by solvent front. Colourless spots need a **locating agent**. Pencil baseline, above solvent level.

02 ATOMS, BONDING & STRUCTURE

PARTICLE	RELATIVE MASS	RELATIVE CHARGE	LOCATION
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	1/1840	−1	Shells / energy levels

Proton number = protons = electrons (neutral atom). Nucleon number = protons + neutrons. Neutrons = nucleon − proton number. Shell filling **2, 8, 8, 18**. Group number = outer electrons; period number = number of shells.

THREE TYPES OF BOND

Ionic	Metal + non-metal. Electrons **transferred**; strong electrostatic attraction between oppositely charged ions in a giant lattice.
Covalent	Non-metal + non-metal. **Shared** pairs of electrons; attraction between shared pair and the two nuclei.
Metallic	Lattice of positive metal ions in a **sea of delocalised electrons**; attraction between the two.

STRUCTURE → PROPERTIES

STRUCTURE	MELTING POINT	CONDUCTIVITY	EXAMPLES & NOTES
Giant ionic	High — strong forces throughout lattice	Only when molten or aqueous (ions free to move)	NaCl, MgO. Brittle; usually soluble in water.
Simple molecular	Low — weak **intermolecular** forces broken, not covalent bonds	None	H_2O, CO_2, I_2, CH_4. Larger molecule → stronger forces → higher b.p.
Giant covalent	Very high	Graphite yes, diamond/SiO_2 no	**Diamond**: 4 bonds per C, tetrahedral, hardest — cutting tools. **Graphite**: 3 bonds per C, hexagonal layers, weak forces between layers slide → lubricant/pencil; 1 delocalised electron per atom → conducts, used as electrodes. **SiO_2**: sand, glass, furnace linings.
Metallic	High	Good, solid or liquid (delocalised electrons)	Malleable — layers of ions slide. **Alloys are harder**: different-sized atoms disrupt the layers.

Ion charges: Group I +1 · II +2 · III +3 · V −3 · VI −2 · VII −1 · Group 0 none. **Common ions:** NH_4^+, Ag^+, Zn^{2+}, Pb^{2+}, Cu^{2+}, Fe^{2+}/Fe^{3+}, OH^-, NO_3^-, HCO_3^-, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}. **State symbols:** (s) (l) (g) (aq).

03 STOICHIOMETRY — EVERY FORMULA

moles = mass ÷ M_r	mass in g
moles = concentration × volume	conc in mol/dm^3, volume in dm^3 (cm^3 ÷ 1000)
moles of gas = volume ÷ 24	dm^3 at r.t.p. (or cm^3 ÷ 24 000). **Molar gas volume = 24 dm^3/mol at r.t.p.**
conc (g/dm^3) = conc (mol/dm^3) × M_r	Convert before comparing.
% yield = (actual ÷ theoretical) × 100	Losses: side reactions, reversible reaction, transfer losses.
% purity = (mass of pure ÷ mass of impure) × 100	
% composition = (A_r × number of atoms ÷ M_r) × 100	
number of particles = moles × 6.02 × 10^{23}	

Empirical formula: mass (or %) ÷ A_r → divide all by the smallest → whole-number ratio. **Molecular formula:** (M_r ÷ empirical mass) × empirical formula. **Limiting reagent:** the reactant giving the fewest moles of product — all yields are based on it; the other is in excess. **Gas volumes** react in the same ratio as their balancing numbers.

04 ACIDS, BASES & SALT PREPARATION

REACTION OF AN ACID	GENERAL EQUATION & EXAMPLE
Acid + metal	→ salt + hydrogen · $Mg + 2HCl \rightarrow MgCl_2 + H_2$
Acid + base/alkali	→ salt + water · $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$ · ionic: $H^+ + OH^- \rightarrow H_2O$
Acid + carbonate	→ salt + water + carbon dioxide · $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$
Acid + ammonia	→ ammonium salt · $HNO_3 + NH_3 \rightarrow NH_4NO_3$ (fertiliser)

Acid = proton (H^+) donor; **base** = proton acceptor; alkali = soluble base. **Strong acid** (HCl, HNO_3, H_2SO_4) fully dissociates; **weak acid** (ethanoic, carbonic) partially dissociates — lower $[H^+]$, higher pH, slower reactions, poorer conductor at the same concentration.

Indicators: litmus red ↔ blue · thymolphthalein colourless in acid, **blue in alkali** · methyl orange **red in acid**, yellow in alkali. **Universal indicator:** pH 1–3 red, 4–6 orange/yellow, 7 green, 8–11 blue, 12–14 purple.

Oxides: acidic = non-metal (CO_2, SO_2, NO_2) · basic = metal (CuO, CaO, MgO) · **amphoteric = Al_2O_3 and ZnO** (react with both acids and alkalis) · neutral = CO, N_2O, NO.

CHOOSING THE PREPARATION

SALT TYPE	METHOD
Soluble (from insoluble base, carbonate or metal)	Add the solid **in excess** to warm acid until no more reacts → **filter off excess** → evaporate filtrate to the point of crystallisation → cool → filter → dry between filter papers.
Soluble (from a soluble base/alkali)	**Titration**: find the exact volume with indicator, then repeat with the same volumes and **no indicator**, then crystallise.
Insoluble	**Precipitation**: mix two soluble salt solutions, filter, wash the residue with distilled water, dry. e.g. $Pb(NO_3)_2 + 2KI \rightarrow PbI_2\downarrow + 2KNO_3$

Solubility rules: all sodium, potassium, ammonium and nitrate salts are soluble · all chlorides soluble *except* silver and lead · all sulfates soluble *except* barium, calcium and lead · all carbonates insoluble *except* sodium, potassium, ammonium · hydroxides insoluble except sodium, potassium, ammonium (calcium slightly).

Water of crystallisation: hydrated $CuSO_4 \cdot 5H_2O$ (blue) ⇌ anhydrous $CuSO_4$ (white) + $5H_2O$ — heating drives it off, adding water reverses it.

05 REDOX & ELECTROLYSIS

OIL RIG — Oxidation Is Loss of electrons, Reduction Is Gain. Also: oxidation = gain of oxygen / increase in oxidation number. The **oxidising agent is reduced**; the **reducing agent is oxidised**.

Tests: an oxidising agent turns colourless aqueous potassium iodide **brown** (I_2 formed). A reducing agent turns acidified aqueous potassium manganate(VII) from **purple to colourless**.

Electrolysis: breakdown of an ionic compound, molten or in aqueous solution, by the passage of electricity. **Cathode = negative**, attracts cations, reduction. **Anode = positive**, attracts anions, oxidation. Electrolyte conducts because ions are free to move.

ELECTROLYTE	CATHODE (−)	ANODE (+)	NOTES
Molten $PbBr_2$ **(must be molten)**	$Pb^{2+} + 2e^- \rightarrow Pb$ (silvery liquid)	$2Br^- \rightarrow Br_2 + 2e^-$ (red-brown vapour)	Inert carbon electrodes.
Concentrated NaCl(aq) (brine)	$2H^+ + 2e^- \rightarrow H_2$	$2Cl^- \rightarrow Cl_2 + 2e^-$	NaOH left in solution. Products: hydrogen, chlorine, sodium hydroxide.
Dilute NaCl(aq)	$2H^+ + 2e^- \rightarrow H_2$	$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$	Dilute halide → oxygen instead of the halogen.
Dilute H_2SO_4 / water	H_2	O_2	Volume ratio **H_2 : O_2 = 2 : 1**.
$CuSO_4$(aq), **inert** carbon electrodes	$Cu^{2+} + 2e^- \rightarrow Cu$ (pink-brown coating)	$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$	Blue colour fades as Cu^{2+} is used up.
$CuSO_4$(aq), **copper** electrodes	Cu deposited — cathode gains mass	$Cu \rightarrow Cu^{2+} + 2e^-$ — anode dissolves, loses mass	Basis of **copper purification** and **electroplating** (object = cathode, plating metal = anode, electrolyte = a salt of that metal).
Molten Al_2O_3 in **molten cryolite**	$Al^{3+} + 3e^- \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4e^-$	Cryolite lowers the melting point → less energy. Carbon anodes burn away: $C + O_2 \rightarrow CO_2$, so they are replaced regularly.

Predicting products (aqueous): at the cathode, the **less reactive** of the metal and hydrogen is discharged — metals below H in the reactivity series are deposited, otherwise hydrogen. At the anode, a halide is discharged if **concentrated**; otherwise oxygen from OH^-.

Hydrogen–oxygen fuel cell: $2H_2 + O_2 \rightarrow 2H_2O$. Only product is water; higher efficiency than combustion, but hydrogen is hard to store and manufacture.

06 ENERGETICS, RATES & EQUILIBRIUM

Exothermic	Gives out heat, temperature rises, **ΔH negative**. Products lower in energy. Combustion, neutralisation, respiration, most displacement.
Endothermic	Takes in heat, temperature falls, **ΔH positive**. Thermal decomposition, photosynthesis, electrolysis.
Bond energies	Breaking bonds is **endothermic**, making bonds is **exothermic**. **ΔH = Σ(bonds broken) − Σ(bonds formed)**, in kJ/mol.
Activation energy, E_a	Minimum energy colliding particles need to react — the hump on the energy profile.

RATE OF REACTION — COLLISION THEORY

INCREASE	WHY THE RATE RISES
Concentration (or pressure, for gases)	Particles closer together → more frequent collisions per second.
Temperature	Particles move faster → more frequent collisions **and** a greater proportion have energy ≥ E_a.
Surface area (smaller pieces)	More particles exposed → more frequent collisions.
Catalyst	Provides an **alternative pathway of lower activation energy**. Not used up; unchanged in mass and chemical composition. Enzymes are biological catalysts.
Light (photochemical)	Supplies energy — e.g. photosynthesis, substitution of alkanes, silver halides in photography.

Measuring rate: gas volume vs time (syringe), mass loss vs time (balance), or time for a cross to disappear. Rate = gradient; steepest at the start, zero when the line levels off.

REVERSIBLE REACTIONS & LE CHATELIER

Dynamic equilibrium (closed system): forward and reverse rates are equal, so concentrations stay constant.

CHANGE	EQUILIBRIUM SHIFTS
Increase temperature	To the **endothermic** side.
Increase pressure	To the side with **fewer moles of gas**.
Increase concentration of a reactant	To the products (right), to remove it.
Add a catalyst	**No shift** — equilibrium is reached faster; yield is unchanged.

Classic reversible reaction: $CuSO_4 \cdot 5H_2O \rightleftharpoons CuSO_4 + 5H_2O$ (blue ⇌ white) and $CoCl_2 \cdot 6H_2O \rightleftharpoons CoCl_2 + 6H_2O$ (pink ⇌ blue).

07 INDUSTRIAL PROCESSES — LEARN THE CONDITIONS

PROCESS	EQUATION	CONDITIONS	KEY POINTS
Haber process (ammonia)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$	**450 °C · 200 atm · iron catalyst**	N_2 from air, H_2 from methane/natural gas. Unreacted gases recycled; ammonia removed by cooling. Compromise temperature: low T gives more yield but too slowly.
Contact process (sulfuric acid)	$S + O_2 \rightarrow SO_2$ $2SO_2 + O_2 \rightleftharpoons 2SO_3$ $SO_3 + H_2O \rightarrow H_2SO_4$	**450 °C · 2 atm · vanadium(V) oxide, V_2O_5**	Only the middle step is reversible/catalysed. Uses of H_2SO_4: fertilisers, detergents, paints, batteries.
Blast furnace (iron from haematite)	$C + O_2 \rightarrow CO_2$ $CO_2 + C \rightarrow 2CO$ **$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$** $CaCO_3 \rightarrow CaO + CO_2$ $CaO + SiO_2 \rightarrow CaSiO_3$	**Hot air blast; ~1500 °C. Charge: iron ore, coke, limestone**	CO is the reducing agent. Limestone removes sandy impurities as molten **slag**, which floats on the iron and is tapped off.
Aluminium extraction	$Al^{3+} + 3e^- \rightarrow Al$ (cathode) $2O^{2-} \rightarrow O_2 + 4e^-$ (anode)	**Electrolysis of molten Al_2O_3 dissolved in molten cryolite; carbon electrodes**	Too reactive for carbon reduction. Expensive — large amounts of electricity.
Chlor-alkali	$2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$	**Electrolysis of concentrated aqueous NaCl (brine)**	Cl_2: bleach, sterilising water, PVC. NaOH: soap, paper. H_2: margarine, ammonia.
Cracking	$C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$	**600–700 °C · silica or alumina catalyst**	Long-chain, less useful alkanes → shorter alkanes + alkenes (+ sometimes hydrogen). Supplies alkenes for polymers and extra petrol.
Ethanol by hydration	$C_2H_4 + H_2O \rightarrow C_2H_5OH$	**300 °C · 60 atm · phosphoric acid catalyst · steam**	Continuous, fast, pure product, but uses a finite resource (crude oil).
Ethanol by fermentation	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	**25–35 °C · yeast · absence of oxygen (anaerobic)**	Batch process, slow, impure (needs distillation), but renewable. Above ~37 °C the enzymes denature.
Lime kiln	$CaCO_3 \rightarrow CaO + CO_2$ $CaO + H_2O \rightarrow Ca(OH)_2$	**Strong heating (thermal decomposition)**	Limestone → quicklime → slaked lime. Used to neutralise acidic soils and lakes, and in cement/iron making.
Hydrogenation (margarine)	$C_2H_4 + H_2 \rightarrow C_2H_6$	**150 °C · nickel catalyst**	Hardens unsaturated vegetable oils.

08 PERIODIC TABLE, METALS & CORROSION

GROUP	WHAT TO REMEMBER
I — alkali metals	Soft, low density, low melting points. Stored under oil. **Down the group: more reactive** (outer electron further from nucleus, more shielding, lost more easily); melting point decreases. $2Na + 2H_2O \rightarrow 2NaOH + H_2$ — floats, fizzes, alkaline solution.
VII — halogens	Diatomic. Cl_2 pale yellow-green gas · Br_2 red-brown liquid · I_2 grey-black solid (purple vapour). **Down the group: less reactive**, darker, higher melting point. **Displacement:** a more reactive halogen displaces a less reactive halide — $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ (solution turns orange).
0 — noble gases	Full outer shell → unreactive, monatomic. Uses: helium in balloons, argon in lamps/welding.
Transition elements	High density and melting point, **variable oxidation states**, **coloured compounds**, useful as catalysts (Fe in Haber, V_2O_5 in Contact, Ni in hydrogenation).
Across a period	Metallic → non-metallic character. Metals lose electrons to form positive ions; non-metals gain electrons to form negative ions.

REACTIVITY SERIES & EXTRACTION

K · Na · Ca · Mg · Al · (C) · Zn · Fe · (H) · Cu · Ag · Au — most to least reactive. Carbon and hydrogen are included for comparison.

METAL	COLD WATER	STEAM	DILUTE ACID	EXTRACTION
K, Na, Ca	Vigorous → hydroxide + H_2	Violent	Dangerously violent	**Electrolysis** of the molten compound (above carbon)
Mg, Al	Very slow / none	Reacts → oxide + H_2	Reacts → salt + H_2	
Zn, Fe, Pb	None	Slow (reversible for Fe)	Reacts → salt + H_2	**Reduction with carbon** (below carbon)
Cu, Ag, Au	None	None	None	Found **native** or by simple heating

Rusting: iron + **oxygen + water** both required → hydrated iron(III) oxide. Salt speeds it up. **Prevention:** barrier methods (paint, grease, plastic) · **galvanising** (zinc coating: barrier *and* sacrificial) · **sacrificial protection** — a more reactive metal (Zn, Mg) corrodes instead, losing electrons in place of the iron.

Alloys: brass = copper + zinc · stainless steel = iron + chromium + nickel (resists corrosion) · mild steel = iron + a little carbon.
Uses: aluminium — aircraft, food cans, overhead cables (low density, oxide layer resists corrosion); copper — wiring, pipes (ductile, good conductor).

09 AIR, WATER & THE ENVIRONMENT

Clean dry air: 78% nitrogen, 21% oxygen, ~1% argon (noble gases), ~0.04% carbon dioxide.

POLLUTANT	SOURCE	EFFECT
Carbon monoxide, CO	Incomplete combustion of carbon fuels	Toxic — binds to haemoglobin, reduces oxygen transport.
Sulfur dioxide, SO_2	Combustion of fuels containing sulfur compounds	**Acid rain** — damages buildings/limestone, kills trees and aquatic life.
Oxides of nitrogen, NO_x	N_2 + O_2 react in car engines at high temperature	Acid rain, photochemical smog, respiratory problems.
Particulates	Incomplete combustion	Respiratory problems; increased risk of cancer.
Methane, CO_2	Livestock, decomposition, respiration, combustion	**Greenhouse gases** — absorb re-radiated infrared, raising Earth's temperature (climate change).

Catalytic converter: $2CO + 2NO \rightarrow 2CO_2 + N_2$ — reduces CO and NO_x emissions. **Flue-gas desulfurisation:** $CaO + SO_2 \rightarrow CaSO_3$.

Photosynthesis (endothermic): $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ · conditions: **light and chlorophyll**.

Water treatment: sedimentation and filtration remove solids; **chlorination** kills microbes. Distilled water is used in practical chemistry because tap water contains dissolved ions.

Fertilisers: NPK supply **nitrogen** (protein/growth), **phosphorus** and **potassium**. Ammonium salts and nitrates come from ammonia: $NH_3 + HNO_3 \rightarrow NH_4NO_3$. Excess fertiliser causes eutrophication.

10 ORGANIC CHEMISTRY

SERIES	GENERAL FORMULA	FUNCTIONAL GROUP	FIRST FOUR MEMBERS
Alkanes	C_nH_{2n+2}	None (saturated, single bonds)	methane CH_4 · ethane C_2H_6 · propane C_3H_8 · butane C_4H_{10}
Alkenes	C_nH_{2n}	C=C (unsaturated)	ethene C_2H_4 · propene C_3H_6 · butene C_4H_8 · pentene C_5H_{10}
Alcohols	$C_nH_{2n+1}OH$	−OH	methanol · ethanol C_2H_5OH · propanol · butanol
Carboxylic acids	$C_nH_{2n+1}COOH$	−COOH	methanoic · ethanoic CH_3COOH · propanoic · butanoic
Esters	—	−COO−	ethyl ethanoate $CH_3COOC_2H_5$ — sweet smell, used in perfumes and flavourings

Homologous series: same general formula and functional group, differing by CH_2, similar chemical properties, gradual change in physical properties. **Structural isomers:** same molecular formula, different structural formula.

REACTIONS AND THEIR CONDITIONS

REACTION	EQUATION	CONDITIONS
Complete combustion	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	**Plenty of oxygen**
Incomplete combustion	$2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$	**Limited oxygen — gives CO and soot**
Alkane + halogen (substitution)	$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$	**UV light**
Alkene + bromine (addition)	$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$	**Room temperature — test for unsaturation: bromine water turns orange → colourless**
Alkene + hydrogen	$C_2H_4 + H_2 \rightarrow C_2H_6$	**150 °C · nickel catalyst**
Alkene + steam (hydration)	$C_2H_4 + H_2O \rightarrow C_2H_5OH$	**300 °C · 60 atm · phosphoric acid**
Fermentation	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	**25–35 °C · yeast · no oxygen**
Oxidation of ethanol	$C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$	**Heat under reflux with acidified potassium manganate(VII) — purple to colourless; or bacterial oxidation in air**
Esterification	$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$	**Warm · concentrated sulfuric acid catalyst**
Acid reactions of ethanoic acid	with metals → salt + H_2 · with carbonates → salt + H_2O + CO_2 · with alkalis → salt + water (ethanoates)	Weak acid — partially dissociated
Addition polymerisation	n $C_2H_4 \rightarrow -(CH_2-CH_2)_n-$ (poly(ethene))	**Many alkene monomers, C=C opens; one product only**
Condensation polymerisation	Polyester (PET) from a diol + a dicarboxylic acid; nylon from a diamine + a dicarboxylic acid	**Two monomers with two functional groups; a small molecule (H_2O or HCl) is lost each link**

Fractional distillation of petroleum (fractions in order, decreasing volatility, increasing boiling point and chain length): refinery gas (bottled fuel) · gasoline/petrol (cars) · naphtha (chemical feedstock) · kerosene/paraffin (jet fuel) · diesel oil (engines) · fuel oil (ships, heating) · bitumen (road surfacing).

Uses of ethanol: solvent and fuel. **Plastics:** non-biodegradable; disposal in landfill causes pollution, burning PVC releases toxic HCl.

11 QUALITATIVE ANALYSIS — ALL TESTS & COLOURS

TESTS FOR GASES

Hydrogen, H_2	Lighted splint → **squeaky pop**
Oxygen, O_2	Glowing splint **relights**
Carbon dioxide, CO_2	Limewater turns **milky / cloudy white**
Chlorine, Cl_2	Damp litmus paper is **bleached white**
Ammonia, NH_3	Damp **red** litmus turns **blue**; pungent smell
Sulfur dioxide, SO_2	Acidified potassium manganate(VII) turns from **purple to colourless**
Water	Anhydrous copper(II) sulfate **white → blue**; anhydrous cobalt(II) chloride **blue → pink**. **Purity** is confirmed by a boiling point of exactly 100 °C / melting point 0 °C.

TESTS FOR CATIONS

ION	ADDING AQUEOUS SODIUM HYDROXIDE	ADDING AQUEOUS AMMONIA
Al^{3+}	White ppt, **soluble in excess** → colourless solution	White ppt, **insoluble** in excess
Ca^{2+}	White ppt, insoluble in excess	No precipitate (or very slight white)
Cr^{3+}	Green ppt, soluble in excess → green solution	Green ppt, insoluble in excess
Cu^{2+}	Light blue ppt, insoluble in excess	Light blue ppt, **soluble in excess → dark blue solution**
Fe^{2+}	Green ppt, insoluble in excess (turns brown at the surface)	Green ppt, insoluble in excess
Fe^{3+}	**Red-brown** ppt, insoluble in excess	Red-brown ppt, insoluble in excess
Zn^{2+}	White ppt, **soluble in excess** → colourless	White ppt, **soluble in excess** → colourless
NH_4^+	**Warm** with aqueous sodium hydroxide → ammonia gas, turns damp red litmus blue	

TESTS FOR ANIONS

Carbonate, CO_3^{2-}	Add dilute acid → effervescence, gas turns limewater milky.
Chloride, Cl^-	Acidify with dilute **nitric** acid, add aqueous silver nitrate → **white** ppt.
Bromide, Br^-	Same test → **cream** ppt.
Iodide, I^-	Same test → **yellow** ppt.
Nitrate, NO_3^-	Add aqueous sodium hydroxide **and aluminium foil, then warm** → ammonia gas (damp red litmus blue).
Sulfate, SO_4^{2-}	Acidify with dilute nitric acid, add aqueous barium nitrate → **white** ppt.
Sulfite, SO_3^{2-}	Add acidified aqueous potassium manganate(VII) → **purple to colourless**.

FLAME TESTS

Li^+ red · Na^+ yellow · K^+ lilac · Ca^{2+} orange-red · Ba^{2+} light green · Cu^{2+} blue-green

Method: clean the wire in concentrated hydrochloric acid, dip in the solid, hold in a hot blue Bunsen flame.

12 MNEMONICS

MNEMONIC	WHAT IT HOLDS
OIL RIG	Oxidation Is Loss of electrons · Reduction Is Gain.
An Ox / Red Cat	Anode = Oxidation · Reduction = Cathode.
PANIC	Positive is Anode, Negative Is Cathode (in electrolysis).
"Please Send Cats, Monkeys And Cute Zebras Into Hot Countries Signed General"	Potassium, Sodium, Calcium, Magnesium, Aluminium, Carbon, Zinc, Iron, Hydrogen, Copper, Silver, Gold — the reactivity series in order.
"Met Eth Prop But"	meth- 1 C, eth- 2 C, prop- 3 C, but- 4 C, pent- 5 C.
Alkane = A-lone	Alkanes are saturated, single bonds only; alk**e**nes have a doubl**e** bond.
Iron in the Haber, Vanadium in the Contact	Both run at **450 °C** — only the pressure differs: 200 atm (Haber) vs 2 atm (Contact).
Endo takes, Exo exits	Endothermic takes heat in, ΔH positive · exothermic gives heat out, ΔH negative.
"White, Cream, Yellow"	Silver nitrate precipitates in halogen order: chloride, bromide, iodide.
Zinc and Aluminium are the "excess twins"	Both give a white precipitate that dissolves in excess NaOH — only zinc also dissolves in excess ammonia.
"Nitrates Are Never Insoluble"	All nitrates, and all sodium/potassium/ammonium salts, are soluble.
MAD CAT	Rate of reaction rises with More concentration, Added catalyst, Divided solid (surface area), and higher Temperature.