






























## CHEMICAL TESTS






 <p><b>Oxidising</b> These substances provide oxygen which allows other materials to burn more fiercely.</p>	 <p><b>Harmful</b> These substances are similar to toxic substances but less dangerous.</p>	 <p>penetrating radiation carcinogenic <b>radioactive</b></p>
 <p><b>Highly flammable</b> These substances easily catch fire.</p>	 <p><b>Corrosive</b> These substances attack and destroy living tissues including eyes and skin.</p>	 <p>very unstable forms gas fast! <b>explosive!</b></p>
 <p><b>Toxic</b> These substances can cause death. They may have their effects when swallowed or breathed in or absorbed through the skin.</p>	 <p><b>Irritant</b> These substances are not corrosive but can cause reddening or blistering of the skin.</p>	<p><b>HAZARD</b></p> <p><b>WARNING</b></p> <p><b>SYMBOLS</b></p>

## INORGANIC TESTS

TEST FOR	TEST METHOD	OBSERVATIONS	TEST CHEMISTRY
 <p><b>hydrogen gas H<sub>2</sub></b></p>	lit splint or spill	<b>squeaky pop!</b> (might see condensation on test tube)	$2\text{H}_{2(g)} + \text{O}_{2(g)} \implies 2\text{H}_2\text{O}_{(l)} + \text{energy!}$
<b>carbon dioxide gas CO<sub>2</sub></b>	bubble into limewater (aqueous calcium hydroxide solution)	<b>turns cloudy</b> – fine milky white precipitate of calcium carbonate	$\text{Ca}(\text{OH})_{2(aq)} + \text{CO}_{2(g)} \implies \text{CaCO}_{3(s)} + \text{H}_2\text{O}_{(l)}$
 <p><b>oxygen gas O<sub>2</sub></b></p>	glowing splint or spill	 re-ignites it - flame	$\text{C}_{(\text{in wood})} + \text{O}_{2(g)} \implies \text{CO}_{2(g)}$
 <p><b>Hydrogen chloride gas HCl</b>, in water hydrochloric acid</p>	(i) blue litmus and (ii) drop of silver nitrate on the end of a glass rod	(i) litmus turns red, (ii) white precipitate with silver nitrate	(i) Strongly acid gas, (ii) in water forms chloride ions - hence precipitate with silver nitrate.
 <p><b>Hydrogen bromide HBr</b> and <b>Hydrogen iodide HI</b></p>	As above. In water they are hydrobromic acid and hydriodic acid.	as above but <b>cream HBr</b> or <b>yellow HI</b> precipitate	as above - combination of acid and halide ion tests

  <b>Sulphur dioxide gas SO<sub>2</sub></b>	freshly made potassium dichromate(VI) paper	paper changes from orange to green	the dichromate(VI) ion, Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> <sub>(aq)</sub> is reduced to the green Cr <sup>3+</sup> <sub>(aq)</sub> ion
 <b>Ammonia gas NH<sub>3</sub></b>	strong pungent odour*, (i) red litmus, (ii) fumes conc. hydrochloric acid	(i) litmus turns blue, (ii) white clouds with HCl fumes.	(i) only common alkaline gas and (ii) forms fine ammonium chloride crystals with HCl (*volatile organic aliphatic amines give the same result, and smell more fishy)
  <b>Chlorine gas Cl<sub>2</sub></b> [test (ii) on its own is no good, could be HCl]	(i) blue litmus, (ii) drop silver nitrate on the end of a glass rod	pungent green gas, (i) litmus turns red and then is bleached white, (ii) white precipitate	(i) non-metal, is acid in aqueous solution and a powerful oxidising agent, (ii) forms chloride ion in water
 <b>Iodine solid</b>	(i) heating, (ii) test aqueous solution or solid with starch solution	(i) purple vapour, (ii) blue black colour with starch solution	
  <b>Nitrogen(IV) oxide (or nitrogen dioxide) NO<sub>2</sub></b>	no simple relatively unambiguous test	nasty brown gas	strong oxidising agent
<b>Water liquid H<sub>2</sub>O</b>	(i) white anhydrous copper(II) sulphate, (ii) dry blue cobalt chloride paper	(i) turns from white to blue, (ii) turns from blue to pink	(i) blue hydrated copper(II) crystals or solution formed, (ii) hydrated cobalt ion formed [Co(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup>
<b>Carbonate ion CO<sub>3</sub><sup>2-</sup> (or hydrogencarbonate HCO<sub>3</sub><sup>-</sup>)</b>	add any dilute strong acid to the suspected carbonate - if <b>colourless gas</b> given off, test with limewater	fizzing - <b>colourless gas - turns limewater milky cloudy</b> (see above CO <sub>2</sub> )	carbonate/hydrogencarbonate + acid ==> salt + water + <b>carbon dioxide</b> , then white precipitate with limewater.
<b>Sulphate ion [sulphate(VI)] SO<sub>4</sub><sup>2-</sup></b>	to a solution of the suspected sulphate add dilute hydrochloric acid and a few drops of <b>barium chloride or nitrate</b> solution	<b>white precipitate of barium sulphate</b>	Ba <sup>2+</sup> <sub>(aq)</sub> + SO <sub>4</sub> <sup>2-</sup> <sub>(aq)</sub> ==> BaSO <sub>4(s)</sub> any soluble barium salt + any soluble sulphate ==> barium sulphate
<b>Sulphite ion [sulphate(IV)] SO<sub>3</sub><sup>2-</sup></b>	(i) add dilute hydrochloric acid to the suspected sulphite, (ii) test any gas evolved with fresh potassium	 (i) acrid choking sulphur dioxide gas formed, (ii) the dichromate paper turns from orange to green	(i) sulphite salt + hydrochloric acid ==> chloride salt + sulphur dioxide, (ii) the sulphur dioxide reduces the dichromate(VI) to chromium(III). Note: sulphites do not give ppt. with acidified barium chloride/nitrate because sulphites dissolve in acids.


	dichromate(VI) paper		
  <b>Sulphide ion</b> $S^{2-}$ for (ii) dangerous hydrogen sulphide formed	(i) If soluble, add a few drops lead(II) ethanoate solution. (ii) If solid, add dil. HCl(aq) acid, test gas with lead(II) ethanoate paper.	(i) Black ppt. of lead sulphide. (ii) Rotten egg smell of hydrogen sulphide and the H <sub>2</sub> S gas turns lead(II) ethanoate paper black.	(i) $Pb^{2+}_{(aq)} + S^{2-}_{(aq)} \Rightarrow PbS_{(s)}$ (ii) $MS_{(s)} + 2H^{+}_{(aq)} \Rightarrow M^{2+}_{(aq)} + H_2S_{(aq)}$ (e.g. M = Pb, Fe, Cu, Ni etc.) Then reaction (i) above occurs.
<b>Chloride ion</b> $Cl^{-}$	(i) if soluble, add dilute nitric acid and silver nitrate solution, (ii) if insoluble salt, add conc. sulphuric acid, warm if necessary then <u>test gas as for HCl above.</u>	 (i) <b>white precipitate of silver chloride</b> soluble in dilute ammonia, (ii) get fumes of hydrogen chloride which turn blue litmus red and give a white precipitate with silver nitrate solution	(i) $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \Rightarrow AgCl_{(s)}$ , any soluble silver salt + any soluble chloride $\Rightarrow$ silver chloride precipitate, (ii) $Cl^{-}_{(s)} + H_2SO_{4(l)} \Rightarrow HSO_{4(s)}^{-} + HCl_{(g)}$ , then $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \Rightarrow AgCl_{(s)}$
<b>Bromide ion</b> $Br^{-}$	(i) if soluble, add dilute nitric acid and silver nitrate solution, (ii) if insoluble salt, add conc. sulphuric acid, warm if necessary	 (i) <b>cream precipitate of silver bromide</b> , only soluble in concentrated ammonia, (ii) orange vapour, <u>test for sulphur dioxide.</u>	(i) $Ag^{+}_{(aq)} + Br^{-}_{(aq)} \Rightarrow AgBr_{(s)}$ any soluble silver salt + any soluble bromide $\Rightarrow$ silver bromide precipitate, (ii) bromide ion is oxidised to bromine and the sulphuric acid is reduced to sulphur dioxide
<b>Iodide ion I<sup>-</sup></b>	(i) if soluble, add dilute nitric acid and silver nitrate solution, (ii) if insoluble salt can heat with conc. sulphuric acid, (ii) get purple fumes of iodine and very smelly hydrogen sulphide, (iii) if soluble, add lead(II) nitrate solution	 (i) <b>yellow precipitate of silver iodide</b> insoluble in concentrated ammonia, (ii) purple vapour and rotten egg smell!, (iii) a yellow precipitate forms	(i) $Ag^{+}_{(aq)} + I^{-}_{(aq)} \Rightarrow AgI_{(s)}$ , any soluble silver salt + any soluble iodide $\Rightarrow$ silver iodide precipitate, (ii) iodide ion is oxidised to iodine and the sulphuric acid is reduced to hydrogen sulphide, (iii) insoluble lead(II) iodide formed, $Pb^{2+}_{(aq)} + 2I^{-}_{(aq)} \Rightarrow PbI_{2(s)}$
 <b>Nitrate ion [or nitrate(V)] NO<sub>3</sub><sup>-</sup></b>	(i) boil the suspected nitrate with sodium hydroxide solution and fine aluminium powder (Devarda's Alloy)	 (i) the fumes contain ammonia, which turns red litmus blue, <u>see ammonia test details</u> (ii) Where the liquids	(i) the aluminium powder is a powerful reducing agent and converts the nitrate ion, <b>NO<sub>3</sub><sup>-</sup></b> , into ammonia gas, <b>NH<sub>3</sub></b> (ii) NO complex of iron(II) formed

	(ii) Add iron(ii) sulphate solution and then conc. sulphuric acid (the <b>'brown ring'</b> test)	meet a brown ring forms	
 <b>Nitrite ion [or nitrate(III)] NO<sub>2</sub><sup>-</sup></b>	<b>No simple test</b> , (i) in acid solution it decomposes to give nasty brown fumes of NO <sub>2</sub> , (ii) it decolourises (purple ==> colourless) acidified potassium manganate(VII), (iii) it liberates iodine from acidified potassium iodide solution, (iv) forms ammonia with hot Al powder/NaOH <sub>(aq)</sub> and gives 'brown ring' test - see nitrate tests above.		
<b>Ammonium ion NH<sub>4</sub><sup>+</sup></b>	no smell at first, add COLD sodium hydroxide solution to the suspected ammonium salt and test any gas with red litmus	 smelly ammonia evolved! and red litmus turns blue	ammonia gas is evolved: NH <sub>4</sub> <sup>+</sup> <sub>(aq)</sub> + OH <sup>-</sup> <sub>(aq)</sub> ==> NH <sub>3(g)</sub> + H <sub>2</sub> O <sub>(l)</sub>
 <b>Hydrogen ion ie acids! H<sup>+</sup> or H<sub>3</sub>O<sup>+</sup></b> (note: to completely identify acids you need to test for the anion eg chloride for HCl etc.)	(i) litmus or universal indicator or pH meter, (ii) add a little sodium hydrogencarbonate powder	(i) litmus turns red, variety of colours with univ. ind. strong - red, weak - yellow/orange, (ii) fizzing with any carbonate - test for CO <sub>2</sub> as above	(i) pH meter gives a value of less than 7, the lower the pH number the stronger the acid, the higher the H <sup>+</sup> concentration, (ii) HCO <sub>3</sub> <sup>-</sup> <sub>(aq)</sub> + H <sup>+</sup> <sub>(aq)</sub> ==> H <sub>2</sub> O <sub>(l)</sub> + CO <sub>2(g)</sub>
 <b>Hydroxide ion ie an alkali OH<sup>-</sup></b> (note: to completely identify alkalis you need to test for the cation eg sodium for NaOH etc.)	(i) litmus or universal indicator or pH meter, (ii) add ammonium salt	(i) turns litmus blue, variety of colours univ. ind. dark green - violet for weak - strong, (ii) if strongly alkaline ammonia should be released, see ammonia test for rest of details	(i) pH meter gives a value of more than 7, the higher the pH number the stronger the alkali, the higher the OH <sup>-</sup> concentration, (ii) ammonia gas is evolved: NH <sub>4</sub> <sup>+</sup> <sub>(aq)</sub> + OH <sup>-</sup> <sub>(aq)</sub> ==> NH <sub>3(g)</sub> + H <sub>2</sub> O <sub>(l)</sub>
 <b>Positive metal cations via flame tests</b> (see below for NaOH and NH <sub>3</sub> for metal ion tests too)	The metal salt or other compound is mixed with concentrated hydrochloric acid and a sample of the mixture is heated strongly in a bunsen flame on the end of a cleaned nichrome wire (platinum if you can afford it!)	<b>lithium Li<sup>+</sup> crimson</b>	All colours are due to electronic excitation to a higher level. You see the light emitted as the electron returns to its lower more stable level. This is the basis of atomic emission and absorption spectroscopy. Aluminium, magnesium, iron and zinc do not produce a useful identifying flame colour.
		<b>sodium Na<sup>+</sup> yellow</b>	
		<b>potassium K<sup>+</sup> lilac</b>	
		<b>calcium Ca<sup>2+</sup> brick red</b>	
		<b>barium Ba<sup>2+</sup> apple green</b>	
<b>copper(II) Cu<sup>2+</sup> blue/green</b>			
<b>Positive metal cations via sodium hydroxide (NaOH)</b>	Dilute <b>sodium hydroxide solution</b> is added to a solution	<b>aluminium ion: Al<sup>3+</sup><sub>(aq)</sub> + 3OH<sup>-</sup><sub>(aq)</sub> ==&gt; Al(OH)<sub>3(s)</sub> white precipitate</b> * The ppt. is not soluble in excess of the weak alkali ammonia, but dissolves in the strong alkali sodium hydroxide: Al(OH) <sub>3(s)</sub> + 3OH <sup>-</sup> <sub>(aq)</sub> ==> [Al(OH) <sub>6</sub> ] <sup>3-</sup> <sub>(aq)</sub> (amphoteric behaviour)	

<p><b>or ammonia (NH<sub>3</sub>) solutions (both alkalis, giving hydroxide ions, OH<sup>-</sup>, in their solutions)</b></p>	<p>containing the suspected ion. Both the <b>precipitate formed</b> and the <b>effect of excess alkali</b> are important observations.</p> <p>All precipitates white, unless otherwise stated and all tend to be gelatinous in nature.</p> <p>The test can be <b>repeated with aqueous ammonia solution</b> (sometimes wrongly called 'ammonium hydroxide'). The observations are usually, but not always, similar.</p> <p>ppt. = precipitate.</p>	<p><b>calcium ion:</b> <math>\text{Ca}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)} \Rightarrow \text{Ca(OH)}_{2(s)}</math> <b>white ppt.</b> * The ppt. is not soluble in excess of NH<sub>3</sub> or NaOH.</p> <p><b>magnesium ion:</b> <math>\text{Mg}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)} \Rightarrow \text{Mg(OH)}_{2(s)}</math> <b>white ppt.</b> * The ppt. is not soluble in excess of NH<sub>3</sub> or NaOH. You could distinguish Mg from Ca with a <b>flame test</b>.</p> <p><b>copper(II) ion:</b> <math>\text{Cu}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)} \Rightarrow \text{Cu(OH)}_{2(s)}</math>  <b>***blue/turquoise ppt.</b> - this does dissolve <b>in excess ammonia to give a deep blue solution.</b></p> <p><b>iron(II) ion:</b> <math>\text{Fe}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)} \Rightarrow \text{Fe(OH)}_{2(s)}</math> <b>dark green ppt.*</b> The ppt. is not soluble in excess of NH<sub>3</sub> or NaOH.</p> <p><b>iron(III) ion:</b> <math>\text{Fe}^{3+}_{(aq)} + 3\text{OH}^{-}_{(aq)} \Rightarrow \text{Fe(OH)}_{3(s)}</math> <b>brown ppt.*</b> The ppt. is not soluble in excess of NH<sub>3</sub> or NaOH.</p> <p><b>zinc ion:</b> <math>\text{Zn}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)} \Rightarrow \text{Zn(OH)}_{2(s)}</math> <b>white ppt.</b> The ppt. dissolves in both excess sodium hydroxide or ammonia to give a clear colourless solution.</p>
<p><b>MISCELLANEOUS CATION TESTS:</b></p> <p>(i) Lead(II) ion</p>	<p>(i) add potassium iodide solution =&gt; yellow precipitate</p>	<p>(i) <math>\text{Pb}^{2+}_{(aq)} + 2\text{I}^{-}_{(aq)} \Rightarrow \text{PbI}_{2(s)}</math> lead(II) iodide ppt.</p>
<p><b>Metal Carbonates</b></p>	<p>Sometimes heating a metal carbonate strongly to decompose it provides some clues to its identity. Adding acid =&gt; CO<sub>2</sub> and the colour of the resulting solution (eg blue Cu<sup>2+</sup><sub>(aq)</sub>), may also provide clues. The metal ion solution might also give a flame colour or a</p>	<p>copper(II) carbonate=&gt; copper(II) oxide + carbon dioxide: <math>\text{CuCO}_{3(s)} \Rightarrow \text{CuO}_{(s)} + \text{CO}_{2(g)}</math></p> <p>[green] =&gt; [black] + [colourless gas, test with limewater, white precipitate]</p> <p>zinc carbonate=&gt; zinc oxide + carbon dioxide</p> <p><math>\text{ZnCO}_{3(s)} \Rightarrow \text{ZnO}_{(s)} + \text{CO}_{2(g)}</math></p> <p>[white] =&gt; [yellow hot, white cold] + [colourless gas, test with limewater, white precipitate]</p>

hydroxide precipitate with sodium hydroxide eg copper.

## ORGANIC TESTS

TEST FOR	TEST METHOD	OBSERVATIONS	TEST CHEMISTRY
 <b>ALKENE or alkyne any other non-aromatic unsaturated hydrocarbons</b>	bubble gas through, or add liquid to, a solution of <b>bromine</b> in hexane or water	the orange/brown bromine, decolourises, as a saturated <b>colourless organic bromo-compound</b> is formed (saturated alkanes give no fast reaction with bromine)	$R_2C=CR_2 + Br_2 \implies BrR_2C-CR_2Br$ $RC\equiv CR + 2Br_2 \implies Br_2RC-CRBr_2$ <p><b>R = H, alkyl or aryl</b></p>