

Grade 4 skills checklist

137 skills that set grade 4 apart. Do the lists for the grades below first. Tick each one when you can do it.

Atomic structure and the periodic table

- ☐ **Name compounds from their formulae** A metal with a non-metal ends in -ide (NaCl, sodium chloride); -ate means oxygen is also present (CaCO₃, calcium carbonate). (Atoms, elements and compounds)
- ☐ **Count the atoms in a formula** In Ca(OH)₂ the 2 multiplies everything in the brackets: 1 Ca, 2 O and 2 H, so 5 atoms. (Atoms, elements and compounds)
- ☐ **Match each separation method to its use** Filtration, crystallisation, simple distillation, fractional distillation or chromatography, depending on what is in the mixture. (Mixtures)
- ☐ **Describe filtration and crystallisation** Filter off an insoluble solid; evaporate some water from a solution, then cool it so crystals of the dissolved solid form. (Mixtures)
- ☐ **Describe the plum pudding model** The atom is a ball of positive charge with negative electrons embedded in it. (Development of the model of the atom)
- ☐ **Put the atomic models in order** Indivisible spheres → plum pudding → nuclear model → Bohr's shells → protons → neutrons (Chadwick). (Development of the model of the atom)
- ☐ **Define atomic number** The number of protons in an atom; all atoms of the same element have the same number. (Relative charges of subatomic particles)
- ☐ **Define mass number** The total number of protons and neutrons in an atom. (Size and mass of atoms)
- ☐ **Find protons, neutrons and electrons in atoms** Protons = electrons = atomic number; neutrons = mass number – atomic number. (Size and mass of atoms)
- ☐ **Explain what relative atomic mass means** An average value for the atoms of an element that takes account of the abundance of each isotope. (Relative atomic mass)
- ☐ **Write electronic structures of the first 20 elements** Fill the innermost shells first, e.g. sodium (11 electrons) is 2,8,1. (Electronic structure)
- ☐ **Draw electron shell diagrams** Draw circles for the shells around the nucleus and dots or crosses for the electrons. (Electronic structure)
- ☐ **State how the elements are ordered** In order of atomic (proton) number. (The periodic table)
- ☐ **Describe problems with early tables** They were incomplete, and strict atomic weight order put some elements in groups with the wrong properties. (Development of the periodic table)
- ☐ **Define metals by the ions they form** Elements that react to form positive ions are metals; elements that do not are non-metals. (Metals and non-metals)
- ☐ **Compare physical properties of metals and non-metals** Metals are usually shiny, high melting, malleable conductors; non-metals are usually dull, brittle, low melting and poor conductors. (Metals and non-metals)
- ☐ **State that noble gases are unreactive** They are unreactive and do not easily form molecules; they exist as single atoms. (Group 0)

- ☐ **Describe their reactions with water** They float and fizz; sodium melts into a ball; potassium's hydrogen burns with a lilac flame. (Group 1)

- ☐ **State the reactivity trend down Group 1** Reactivity increases going down the group: lithium, then sodium, then potassium. (Group 1)

- ☐ **Describe the trends down Group 7** Relative molecular mass, melting point and boiling point increase; reactivity decreases. (Group 7)

- ☐ **Compare melting points and densities** Transition metals have much higher melting points and densities than Group 1 metals. (Comparison with Group 1 elements)

- ☐ **Compare strength and hardness** Transition metals are strong and hard; Group 1 metals are soft enough to cut with a knife. (Comparison with Group 1 elements)

- ☐ **State three typical transition metal properties** Ions with different charges, coloured compounds, and use as catalysts. (Typical properties)

Bonding, structure and the properties of matter

- ☐ **Choose the bond type from the elements** Metal + non-metal gives ionic bonding; non-metals only give covalent bonding; metals (elements or alloys) have metallic bonding. (Chemical bonds)

- ☐ **Name the particles in each type of bond** Ionic: oppositely charged ions; covalent: atoms sharing pairs of electrons; metallic: positive ions and delocalised electrons. (Chemical bonds)

- ☐ **Work out the charge from the group number** Group 1 $\rightarrow$ 1+, Group 2 $\rightarrow$ 2+, Group 6 $\rightarrow$ 2-, Group 7 $\rightarrow$ 1-. (Ionic bonding)

- ☐ **Name the force holding the ions together** Strong electrostatic forces of attraction between oppositely charged ions. (Ionic compounds)

- ☐ **Recognise small molecules from their formulae** Formulae of a few non-metal atoms, e.g. H_2 , Cl_2 , HCl , H_2O , NH_3 , CH_4 . (Covalent bonding)

- ☐ **Describe what delocalised electrons are** The outer shell electrons of metal atoms are delocalised: free to move through the whole structure. (Metallic bonding)

- ☐ **Describe particles in solids, liquids and gases** Regular and vibrating in solids, close but moving around in liquids, far apart and moving quickly in gases. (The three states of matter)

- ☐ **Know that aqueous means dissolved in water** Any solution in water, such as sodium chloride solution or dilute hydrochloric acid, is (aq). (State symbols)

- ☐ **State when ionic compounds conduct electricity** When melted (molten) or dissolved in water, but not when solid. (Properties of ionic compounds)

- ☐ **State that small molecules don't conduct electricity** The molecules have no overall electric charge. (Properties of small molecules)

- ☐ **State that polymers are solids at room temperature** The forces between their large molecules are strong enough to keep them solid. (Polymers)

- ☐ **State that they have very high melting points** They are solids at room temperature with very high melting and boiling points. (Giant covalent structures)

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- ☐ **Define an alloy** A mixture of a metal with other elements, usually other metals. (Properties of metals and alloys)
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- ☐ **Name the particles that carry the charge** Delocalised electrons carry electrical charge through the metal.
(Metals as conductors)
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- ☐ **Describe the bonding in diamond** Each carbon atom forms four covalent bonds with other carbon atoms.
(Diamond)
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- ☐ **State the number of bonds each carbon forms** Each carbon atom forms three covalent bonds with three other carbon atoms. (Graphite)
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- ☐ **Describe fullerenes as hollow carbon molecules** They are based on hexagonal rings of carbon atoms, sometimes with rings of five or seven atoms. (Graphene and fullerenes)
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- ☐ **Name buckminsterfullerene and give its formula** The first fullerene discovered: C₆₀, a hollow, spherical molecule. (Graphene and fullerenes)
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- ☐ **State the size range of nanoparticles** Nanoparticles are 1 to 100 nm across and contain a few hundred atoms. (Sizes of particles and their properties)
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- ☐ **List the main uses of nanoparticles** Medicine, electronics, cosmetics and sun creams, deodorants, and catalysts. (Uses of nanoparticles)
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Quantitative chemistry

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- ☐ **Calculate a missing mass in a reaction** Total mass of reactants = total mass of products, so subtract the known masses from the total. (Conservation of mass and balanced equations)
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- ☐ **Calculate M_r of a simple formula** Add the A_r of every atom, e.g. CO₂ = 12 + (2 × 16) = 44. (Relative formula mass)
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- ☐ **Explain a mass decrease when gas forms** The gas produced escapes into the air, so its mass is no longer measured. (Mass changes when a reactant or product is a gas)
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- ☐ **Find the range of a set of results** Range = highest value – lowest value. (Chemical measurements and uncertainty)
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- ☐ **Convert cm³ to dm³** Divide by 1000, e.g. 250 cm³ = 0.250 dm³. (Concentration of solutions)
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- ☐ **State what is meant by yield** The amount of product obtained from a reaction. (Percentage yield)
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- ☐ **State what atom economy measures** The amount of the starting materials that ends up as the useful (desired) product. (Atom economy)
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Chemical changes

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- ☐ **Define oxidation and reduction using oxygen** Oxidation is the gain of oxygen and reduction is the loss of oxygen. (Metal oxides)
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- ☐ **Describe metal reactions with water and acid** Say what you would see, e.g. fizzing, and name the products (metal hydroxide or salt, plus hydrogen). (The reactivity series)
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- ☐ **State which metals carbon can extract** Metals below carbon in the reactivity series, such as zinc, iron and copper, can be extracted by heating their oxides with carbon. (Extraction of metals and reduction)
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- ☐ **Name the salt from the acid used** Hydrochloric acid gives chlorides and sulfuric acid gives sulfates. (Reactions of acids with metals)
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- ☐ **Describe the test for hydrogen** A lit splint held at the mouth of the tube burns the hydrogen with a squeaky pop. (Reactions of acids with metals)
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- ☐ **Predict products of acid with base or alkali** acid + metal oxide or metal hydroxide → salt + water. (Neutralisation and salt production)
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- ☐ **Predict products of acid with a carbonate** acid + metal carbonate → salt + water + carbon dioxide. (Neutralisation and salt production)
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- ☐ **Describe filtering and crystallising** Filter off the excess solid, heat to evaporate some water, then leave the solution to cool and crystallise. (Soluble salts)
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- ☐ **Measure pH with universal indicator** Add the indicator and match its colour to a pH colour chart. (The pH scale and neutralisation)
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- ☐ **Name the equipment used in a titration** Burette, pipette with pipette filler, conical flask, indicator and white tile. (Titrations)
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- ☐ **Define an electrolyte** A molten or dissolved ionic compound, which conducts electricity because its ions are free to move. (The process of electrolysis)
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- ☐ **Predict products for any molten binary compound** The metal forms at the cathode and the non-metal forms at the anode. (Electrolysis of molten ionic compounds)
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- ☐ **State when electrolysis is used for extraction** When the metal is too reactive to be extracted by carbon, or when it reacts with carbon. (Using electrolysis to extract metals)
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- ☐ **State the products from sodium chloride solution** Hydrogen forms at the cathode and chlorine at the anode, leaving sodium hydroxide solution. (Electrolysis of aqueous solutions)
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Energy changes

- ☐ **Give examples of endothermic reactions** Thermal decomposition and the reaction of citric acid with sodium hydrogencarbonate are endothermic. (Energy transfer in exothermic and endothermic reactions)
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- ☐ **Classify a reaction from temperature data** A rise in temperature means the reaction is exothermic; a fall means it is endothermic. (Energy transfer in exothermic and endothermic reactions)
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- ☐ **Label the parts of a reaction profile** Identify the reactants, products, activation energy and overall energy change on a given profile. (Reaction profiles)
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- ☐ **Identify exothermic or endothermic from a profile** Products lower than reactants means exothermic; products higher than reactants means endothermic. (Reaction profiles)
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- ☐ **Describe how to make a simple cell** Put two different metals in contact with an electrolyte and connect them with wires, e.g. to a voltmeter. (Cells and batteries)
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- ☐ **Explain how a battery gives a bigger voltage** A battery is two or more cells connected in series, so their voltages add together. (Cells and batteries)
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- ☐ **State the product of a hydrogen fuel cell** The only product is water: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. (Fuel cells)
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The rate and extent of chemical change

- ☐ **Calculate a mean rate of reaction** Divide the quantity of reactant used or product formed by the time taken, e.g. $30 \text{ cm}^3 \div 20 \text{ s} = 1.5 \text{ cm}^3/\text{s}$. (Calculating rates of reactions)
- ☐ **Give the correct unit for rate** Use g/s for a mass or cm^3/s for a volume of gas, matching the units of the quantity and the time. (Calculating rates of reactions)
- ☐ **State how each factor changes the rate** Increasing the concentration, pressure, surface area or temperature, or adding a catalyst, increases the rate. (Factors which affect the rate of reaction)
- ☐ **Define activation energy** The minimum amount of energy that particles must have to react. (Collision theory and activation energy)
- ☐ **Know that enzymes are biological catalysts** Enzymes are the catalysts that speed up reactions in living things. (Catalysts)
- ☐ **Describe what a reversible reaction is** The products of the reaction can react to produce the original reactants. (Reversible reactions)
- ☐ **Know the reverse has the opposite energy change** If the forward reaction is exothermic, the reverse reaction is endothermic, and the other way round. (Energy changes and reversible reactions)
- ☐ **Define a closed system** Apparatus that prevents the reactants and products from escaping. (Equilibrium)

Organic chemistry

- ☐ **Name the first four alkanes and their formulae** Methane CH_4 , ethane C_2H_6 , propane C_3H_8 and butane C_4H_{10} . (Crude oil, hydrocarbons and alkanes)
- ☐ **Define a fraction** A mixture of hydrocarbons with a similar number of carbon atoms, and so similar boiling points. (Fractional distillation and petrochemicals)
- ☐ **Recall how properties change with molecule size** Bigger molecules: higher boiling point, higher viscosity and lower flammability. (Properties of hydrocarbons)
- ☐ **Name the two types of product** Cracking produces smaller alkanes and another type of hydrocarbon called alkenes. (Cracking and alkenes)
- ☐ **Describe the bromine water test for alkenes** Shake with bromine water: it turns from orange to colourless if an alkene is present. (Cracking and alkenes)
- ☐ **Name the first four alkenes** Ethene C_2H_4 , propene C_3H_6 , butene C_4H_8 and pentene C_5H_{10} . (Structure and formulae of alkenes)
- ☐ **Explain why alkenes burn with smoky flames** In air they tend to undergo incomplete combustion, which produces soot (carbon). (Reactions of alkenes)
- ☐ **Name and draw the first four alcohols** Methanol, ethanol, propanol and butanol; ethanol is $\text{CH}_3\text{CH}_2\text{OH}$. (Alcohols)
- ☐ **State the conditions for fermentation** Sugar solution, yeast, a warm temperature (about 30°C) and no air. (Alcohols)
- ☐ **Name the first four carboxylic acids** Methanoic, ethanoic, propanoic and butanoic acid; ethanoic acid is CH_3COOH . (Carboxylic acids)

- ☐ **Name the polymer made from an alkene** Write 'poly' and put the monomer's name in brackets: propene gives poly(propene). (Addition polymerisation)
- ☐ **Name the monomers of each natural polymer** DNA: nucleotides. Proteins: amino acids. Starch and cellulose: sugars (glucose). (DNA and other naturally occurring polymers)
- ☐ **State what DNA does** DNA encodes the genetic instructions for the development and functioning of living organisms and viruses. (DNA and other naturally occurring polymers)

Chemical analysis

- ☐ **Contrast everyday and chemical meanings of pure** In everyday language 'pure' means nothing has been added (e.g. pure milk), but the product can still be a mixture. (Pure substances)
- ☐ **Use melting points to spot pure samples** A pure substance melts at a specific temperature; a mixture melts over a range of temperatures. (Pure substances)
- ☐ **Identify formulations from given information** Look for a product made by mixing measured amounts of components, each with a purpose. (Formulations)
- ☐ **Match spots to known reference substances** Spots of the same substance travel the same distance on the same paper with the same solvent. (Chromatography)
- ☐ **Describe the paper chromatography method** Pencil start line, small spots, solvent below the line, lid on, mark the solvent front. (Chromatography)
- ☐ **Tell the hydrogen and oxygen tests apart** Hydrogen: burning splint gives a pop. Oxygen: glowing splint relights. (Test for hydrogen)
- ☐ **Tell the oxygen and hydrogen tests apart** Oxygen: glowing splint relights. Hydrogen: burning splint gives a pop. (Test for oxygen)
- ☐ **Name the chemical in limewater** Limewater is an aqueous solution of calcium hydroxide. (Test for carbon dioxide)
- ☐ **Give a safety precaution for chlorine** Chlorine is toxic, so use small amounts in a fume cupboard. (Test for chlorine)
- ☐ **Identify a metal ion from a flame colour** Match the colour seen to the metal ion that gives it. (Flame tests)
- ☐ **Describe how to carry out a flame test** Dip a clean wire loop in the sample and hold it in a hot, blue Bunsen flame. (Flame tests)
- ☐ **Name the ions giving white precipitates** Aluminium, calcium and magnesium ions all give a white precipitate. (Metal hydroxides)
- ☐ **Describe the test for halide ions** Add dilute nitric acid, then silver nitrate solution, to a solution of the sample. (Halides)
- ☐ **State the three advantages of instrumental methods** They are accurate, sensitive and rapid. (Instrumental methods)
- ☐ **Describe how flame emission spectroscopy works** The sample is put into a flame and the light given out passes through a spectroscope, giving a line spectrum. (Flame emission spectroscopy)

Chemistry of the atmosphere

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- ☐ **Name the gases present in small proportions** Carbon dioxide, water vapour and noble gases such as argon are present in small proportions. (Proportions of gases in the atmosphere)
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- ☐ **State how long the proportions have been similar** The proportions of the gases have been much the same as today for about 200 million years. (Proportions of gases in the atmosphere)
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- ☐ **Name the main gas in the early atmosphere** It was mainly carbon dioxide with little or no oxygen, like the atmospheres of Mars and Venus today. (The Earth's early atmosphere)
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- ☐ **Describe how the oceans formed** Water vapour released by volcanoes condensed to form the oceans. (The Earth's early atmosphere)
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- ☐ **Write the word equation for photosynthesis** carbon dioxide + water → glucose + oxygen, with light as the energy source. (How oxygen increased)
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- ☐ **Name rocks and fuels that lock up carbon** Sedimentary rocks such as limestone, and the fossil fuels coal, crude oil and natural gas. (How carbon dioxide decreased)
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- ☐ **State why greenhouse gases are needed** They keep the Earth's temperature high enough to support life. (Greenhouse gases)
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- ☐ **Give two activities that release methane** Farming cattle and other livestock, growing rice in paddy fields, and waste decaying in landfill sites. (Human activities that increase greenhouse gases)
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- ☐ **Give potential effects of climate change** For example, rising sea levels, more frequent and severe storms, and changes in rainfall. (Global climate change)
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- ☐ **Define carbon footprint** The total amount of carbon dioxide and other greenhouse gases emitted over the full life cycle of a product, service or event. (The carbon footprint and its reduction)
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- ☐ **Name the pollutants released by burning fuels** Carbon dioxide, water vapour, carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates. (Atmospheric pollutants from fuels)
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- ☐ **Name the gases that cause acid rain** Sulfur dioxide and oxides of nitrogen cause acid rain. (Properties and effects of atmospheric pollutants)
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- ☐ **Give effects of acid rain** It damages buildings and statues, harms trees and plants, and makes lakes acidic, harming aquatic life. (Properties and effects of atmospheric pollutants)
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Using resources

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- ☐ **Define finite and renewable resources** A finite resource is used faster than it forms, so it will run out; a renewable resource is replaced as fast as it is used. (Using resources and sustainable development)
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- ☐ **Give natural products replaced by synthetic ones** For example, wool and cotton supplemented by synthetic fibres such as polyester, or natural rubber by synthetic rubber. (Using resources and sustainable development)
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- ☐ **Explain why potable water is not pure** It contains dissolved substances, whereas pure water contains only water molecules. (Potable water)
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- ☐ **List the steps in treating fresh water** Choose a suitable source of fresh water, pass it through filter beds, then sterilise it. (Potable water)
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- ☐ **State what sewage treatment must remove** Sewage and agricultural waste water need organic matter and harmful microbes removed. (Waste water treatment)
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- ☐ **State what an LCA is used for** To assess the environmental impact of a product over its whole life, including transport at each stage. (Life cycle assessment)
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- ☐ **Name materials made from limited raw materials** Metals, glass, building materials, clay ceramics and most plastics. (Ways of reducing the use of resources)
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- ☐ **State the conditions needed for rusting** Iron needs both air (oxygen) and water to rust. (Corrosion and its prevention)
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- ☐ **Name barrier methods of preventing corrosion** Greasing, painting and electroplating keep air and water away from the metal. (Corrosion and its prevention)
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- ☐ **Name the metals in bronze and brass** Bronze is copper and tin; brass is copper and zinc. (Alloys as useful materials)
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- ☐ **Recall a use for each named alloy** For example, bronze for statues, brass for musical instruments, stainless steel for cutlery, aluminium alloys for aircraft. (Alloys as useful materials)
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- ☐ **Describe how clay ceramics are made** Wet clay is shaped and then heated in a furnace, e.g. to make pottery and bricks. (Ceramics, polymers and composites)
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- ☐ **Name the two parts of a composite** A matrix (binder) surrounds and binds together fibres or fragments of the reinforcement. (Ceramics, polymers and composites)
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- ☐ **Give the sources of nitrogen and hydrogen** Nitrogen comes from the air; hydrogen comes from natural gas (methane). (The Haber process)
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- ☐ **Recall the conditions used** An iron catalyst, about 450 °C and about 200 atmospheres. (The Haber process)
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- ☐ **Explain what an NPK fertiliser is** A formulation of salts containing appropriate percentages of nitrogen, phosphorus and potassium. (Production and uses of NPK fertilisers)
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- ☐ **Name the sources of the three elements** Nitrogen from ammonia; potassium from mined potassium chloride and potassium sulfate; phosphorus from mined phosphate rock. (Production and uses of NPK fertilisers)
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