

Grade 4 skills checklist

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

Cell biology

- ☐ **Describe the structure of a bacterial cell** Cytoplasm and a cell membrane inside a cell wall, a single loop of DNA not in a nucleus, and often plasmids. (Eukaryotes and prokaryotes)
- ☐ **State the function of each structure** e.g. mitochondria are where aerobic respiration happens; ribosomes are where proteins are made. (Animal and plant cells)
- ☐ **State the function of each specialised cell** e.g. a nerve cell carries electrical impulses; phloem carries dissolved sugars. (Cell specialisation)
- ☐ **Say when animal and plant cells differentiate** Most animal cells differentiate at an early stage; many plant cells can differentiate throughout life. (Cell differentiation)
- ☐ **Calculate the total magnification of a microscope** Multiply the eyepiece lens magnification by the objective lens magnification, e.g. $\times 10$ and $\times 40$ give $\times 400$. (Microscopy)
- ☐ **Compare light and electron microscopes** Electron microscopes have much higher magnification and resolution; light microscopes can show living cells in colour. (Microscopy)
- ☐ **Describe what chromosomes are made of** Chromosomes are made of DNA, and each chromosome carries a large number of genes. (Chromosomes)
- ☐ **State the chromosome number in human cells** Body cells have 23 pairs (46 in total); sperm and egg cells have 23 single chromosomes. (Chromosomes)
- ☐ **Name the three stages of the cell cycle** Growth and DNA replication; mitosis; division of the cytoplasm and cell membrane. (Mitosis and the cell cycle)
- ☐ **Name where stem cells are found** In embryos, in adult bone marrow, and in the meristems of plants. (Stem cells)
- ☐ **Give examples of diffusion in living things** Oxygen and carbon dioxide in gas exchange; urea from cells into the blood plasma. (Diffusion)
- ☐ **Predict the direction of water movement** Water moves from the more dilute solution into the more concentrated solution. (Osmosis)
- ☐ **State where the energy comes from** Active transport needs energy from respiration. (Active transport)

Organisation

- ☐ **Define tissue, organ and organ system** A tissue is a group of cells with a similar structure and function, an organ is a group of tissues working together, and an organ system is a group of organs working together. (Principles of organisation)
- ☐ **State what each digestive enzyme produces** Amylase turns starch into sugars, proteases turn proteins into amino acids, and lipases turn lipids into fatty acids and glycerol. (The human digestive system)

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- ☐ **Describe the food tests and positive results** Benedict's turns from blue to brick red when heated with sugar, iodine from orange-brown to blue-black with starch, and Biuret from blue to purple with protein. (The human digestive system)
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- ☐ **Label the heart's chambers and main vessels** Right and left atria and ventricles, the vena cava, pulmonary artery, pulmonary vein, aorta and coronary arteries. (The heart and blood vessels)
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- ☐ **State the function of each component** Plasma transports dissolved substances, red blood cells carry oxygen, white blood cells defend against pathogens and platelets help the blood clot. (Blood)
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- ☐ **Describe what happens in coronary heart disease** Layers of fatty material build up inside the coronary arteries and narrow them. (Coronary heart disease: a non-communicable disease)
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- ☐ **Tell communicable and non-communicable diseases apart** Communicable diseases are caused by pathogens and can spread; non-communicable diseases cannot be passed from one person to another. (Health issues)
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- ☐ **Match risk factors to the diseases they affect** Diet, smoking and lack of exercise → cardiovascular disease; obesity → type 2 diabetes; alcohol → liver and brain; smoking → lung disease and lung cancer; carcinogens → cancer. (The effect of lifestyle on some non-communicable diseases)
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- ☐ **Describe a benign tumour** A growth of abnormal cells contained in one area, usually within a membrane, that does not invade other parts of the body. (Cancer)
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- ☐ **Label a leaf cross-section** From top to bottom: waxy cuticle, upper epidermis, palisade mesophyll, spongy mesophyll with air spaces and veins, lower epidermis with stomata. (Plant tissues)
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- ☐ **State where meristem tissue is found** At the growing tips of shoots and roots, where cells divide to make new cells. (Plant tissues)
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- ☐ **Define transpiration and translocation** Transpiration is the loss of water vapour from the leaves; translocation is the movement of dissolved sugars through the phloem. (Plant organ system)
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Infection and response

- ☐ **Describe how pathogens are spread** By direct contact, by water and by air, and also in food, in body fluids and by vectors. (Communicable (infectious) diseases)
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- ☐ **Describe the symptoms and spread of measles** Fever and a red skin rash; it is spread by breathing in droplets from coughs and sneezes. (Viral diseases)
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- ☐ **Describe how HIV is spread** By sexual contact or by exchange of body fluids such as blood, e.g. when drug users share needles. (Viral diseases)
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- ☐ **Give the symptoms of *Salmonella* food poisoning** Fever, abdominal cramps, vomiting and diarrhoea, caused by the bacteria and the toxins they secrete. (Bacterial diseases)
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- ☐ **Give the symptoms of gonorrhoea** A thick yellow or green discharge from the vagina or penis, and pain on urinating. (Bacterial diseases)
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- ☐ **Describe the symptoms of rose black spot** Purple or black spots develop on the leaves, which often turn yellow and drop early. (Fungal diseases)
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- ☐ **State how rose black spot is spread** It is spread in the environment by water (e.g. splashing rain) or by wind. (Fungal diseases)
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- ☐ **Describe the main symptom of malaria** Recurrent episodes of fever (the fever keeps coming back); malaria can be fatal. (Protist diseases)

- ☐ **Identify the vector of malaria** Mosquitoes carry the protist and pass it to people when they bite them. (Protist diseases)

- ☐ **Describe how each defence stops pathogens** Skin is a barrier; mucus traps pathogens; cilia move the mucus away; stomach acid kills pathogens. (Human defence systems)

- ☐ **Name three ways white blood cells defend** Phagocytosis, producing antibodies and producing antitoxins. (Human defence systems)

- ☐ **Describe what a vaccine makes the body do** It stimulates white blood cells to produce antibodies against the pathogen. (Vaccination)

- ☐ **Explain why antibiotics don't treat viral diseases** Antibiotics kill bacteria but cannot kill viruses. (Antibiotics and painkillers)

- ☐ **State what new drugs are tested for** Toxicity (is it harmful?), efficacy (does it work?) and dose (how much should be given?). (Discovery and development of drugs)

Bioenergetics

- ☐ **Recognise the formulae of the four substances** Carbon dioxide is CO_2 , water is H_2O , glucose is $\text{C}_6\text{H}_{12}\text{O}_6$ and oxygen is O_2 . (Photosynthetic reaction)

- ☐ **Explain what a limiting factor is** The factor in shortest supply, which stops the rate of photosynthesis increasing; raising it raises the rate. (Rate of photosynthesis)

- ☐ **Describe the light intensity required practical** Put pondweed at different distances from a lamp and count the oxygen bubbles, or measure the volume of oxygen, in a set time. (Rate of photosynthesis)

- ☐ **State what cellulose is used for** Cellulose strengthens the cell wall of plant cells. (Uses of glucose from photosynthesis)

- ☐ **Name where plants store starch and oils** Starch is stored in leaves, roots and tubers such as potatoes; many seeds store oils. (Uses of glucose from photosynthesis)

- ☐ **Write the anaerobic equations for muscles and yeast** In muscles: glucose $\rightarrow$ lactic acid. In plant cells and yeast: glucose $\rightarrow$ ethanol + carbon dioxide. (Aerobic and anaerobic respiration)

- ☐ **Explain why heart and breathing rates increase** To supply the muscles with more oxygenated blood for the extra respiration needed to contract. (Response to exercise)

- ☐ **Give examples of metabolic reactions** For example respiration, making starch, glycogen or cellulose from glucose, making lipids and proteins, and making urea. (Metabolism)

Homeostasis and response

- ☐ **Name the three parts of a control system** Receptors, coordination centres and effectors. (Homeostasis)

- ☐ **Name the parts of the CNS** The central nervous system (CNS) is the brain and spinal cord. (The human nervous system)

- ☐ **Put the reflex arc in order** Stimulus $\rightarrow$ receptor $\rightarrow$ sensory neurone $\rightarrow$ relay neurone $\rightarrow$ motor neurone $\rightarrow$ effector $\rightarrow$ response. (The human nervous system)

- ☐ **Locate the main endocrine glands** Pituitary, thyroid, adrenal glands, pancreas, ovaries and testes on a body diagram. (Human endocrine system)
- ☐ **Match glands to their hormones** E.g. pancreas: insulin; testes: testosterone. (Human endocrine system)
- ☐ **Describe how insulin lowers blood glucose** Insulin makes glucose move from the blood into cells; liver and muscle cells store it as glycogen. (Control of blood glucose concentration)
- ☐ **Define ovulation** The release of a mature egg from an ovary, about every 28 days. (Hormones in human reproduction)
- ☐ **Explain how barrier methods work** Condoms and diaphragms stop sperm reaching the egg. (Contraception)

Inheritance, variation and evolution

- ☐ **Define sexual reproduction** The joining (fusion) of a male gamete and a female gamete. (Sexual and asexual reproduction)
- ☐ **State how many gametes meiosis produces** The cell divides twice to form four gametes. (Meiosis)
- ☐ **Describe the structure of DNA simply** DNA is a polymer made up of two strands forming a double helix. (DNA and the genome)
- ☐ **Put nucleus, chromosome and gene in size order** Nucleus (largest), then chromosome, then gene (a small section of DNA on a chromosome). (DNA and the genome)
- ☐ **Use genotype, phenotype, homozygous and heterozygous correctly** Genotype is the alleles present, phenotype is the characteristic; homozygous means the same alleles, heterozygous different. (Genetic inheritance)
- ☐ **State which allele causes each disorder** Polydactyly is caused by a dominant allele; cystic fibrosis by a recessive allele. (Inherited disorders)
- ☐ **Give the sex chromosomes of each sex** Females are XX; males are XY. (Sex determination)
- ☐ **Classify causes of variation** Genetic (genes inherited), environmental (conditions of development) or a combination of both. (Variation)
- ☐ **State when simple life first developed** All species evolved from simple life forms that first developed more than three billion years ago. (Evolution)
- ☐ **Give examples of chosen characteristics** Disease resistance in crops, more meat or milk, gentle dogs, large or unusual flowers. (Selective breeding)
- ☐ **Define genetic engineering** Modifying an organism's genome by introducing a gene from another organism to give a desired characteristic. (Genetic engineering)
- ☐ **Give examples of genetic engineering** Bacteria that make human insulin; crops resistant to disease, insects or herbicides; bigger, better fruits. (Genetic engineering)
- ☐ **Name two types of evidence for evolution** The fossil record and the evolution of antibiotic resistance in bacteria. (Evidence for evolution)
- ☐ **Describe three ways fossils form** Parts that have not decayed, parts replaced by minerals, and preserved traces such as footprints. (Fossils)

- ☐ **List the causes of extinction** Environmental change, new predators, new diseases, new competitors and catastrophic events. (Extinction)
- ☐ **State ways to reduce antibiotic resistance** Don't prescribe antibiotics for viral or non-serious infections, complete the course, and restrict their use in farming. (Resistant bacteria)
- ☐ **Use binomial names** An organism's scientific name is its genus followed by its species, e.g. Homo sapiens. (Classification of living organisms)

Ecology

- ☐ **List what plants compete for** Light and space, and water and mineral ions from the soil. (Communities)
- ☐ **List what animals compete for** Food, mates and territory. (Communities)
- ☐ **List the abiotic factors in the specification** Light intensity, temperature, moisture level, soil pH and mineral content, wind intensity and direction, carbon dioxide (plants) and oxygen (aquatic animals). (Abiotic factors)
- ☐ **List the four biotic factors in the specification** Availability of food, new predators arriving, new pathogens, and one species outcompeting another. (Biotic factors)
- ☐ **Classify adaptations as structural, behavioural or functional** Structural means body features, behavioural means what it does, and functional means processes inside the body. (Adaptations)
- ☐ **State why food chains start with producers** Producers (green plants and algae) make glucose by photosynthesis, so they produce the biomass for the rest of the chain. (Levels of organisation)
- ☐ **Calculate a mean, median and mode** Mean = total ÷ number of values; median = middle value when in order; mode = most common value. (Levels of organisation)
- ☐ **Name the processes in the water cycle** Evaporation, transpiration, condensation, precipitation, and water draining back into rivers and seas. (How materials are cycled)
- ☐ **Name human activities that reduce biodiversity** For example pollution, building, farming, deforestation and destroying peat bogs. (Biodiversity)
- ☐ **Explain why more waste is produced** The human population is growing rapidly and the standard of living is rising, so more resources are used. (Waste management)
- ☐ **Explain how land use reduces biodiversity** Habitats are destroyed, so there is less space, food and shelter for other plants and animals. (Land use)
- ☐ **Give reasons for tropical deforestation** To provide land for cattle and rice fields, and to grow crops for biofuels. (Deforestation)
- ☐ **Give human activities that increase these gases** Burning fossil fuels, deforestation and destroying peat add carbon dioxide; cattle, rice fields and landfill add methane. (Global warming)

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)

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- ☐ **Match each separation method to its use** Filtration, crystallisation, simple distillation, fractional distillation or chromatography, depending on what is in the mixture. (Mixtures)
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- ☐ **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)
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- ☐ **Describe the plum pudding model** The atom is a ball of positive charge with negative electrons embedded in it. (The development of the model of the atom)
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- ☐ **Put the atomic models in order** Indivisible spheres → plum pudding → nuclear model → Bohr's shells → protons → neutrons (Chadwick). (The development of the model of the atom)
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- ☐ **Define atomic number** The number of protons in an atom; all atoms of the same element have the same number. (Relative electrical charges of subatomic particles)
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- ☐ **Define mass number** The total number of protons and neutrons in an atom. (Size and mass of atoms)
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- ☐ **Find protons, neutrons and electrons in atoms** Protons = electrons = atomic number; neutrons = mass number – atomic number. (Size and mass of atoms)
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- ☐ **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)
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- ☐ **Write electronic structures of the first 20 elements** Fill the innermost shells first, e.g. sodium (11 electrons) is 2,8,1. (Electronic structure)
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- ☐ **Draw electron shell diagrams** Draw circles for the shells around the nucleus and dots or crosses for the electrons. (Electronic structure)
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- ☐ **State how the elements are ordered** In order of atomic (proton) number. (The periodic table)
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- ☐ **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)
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- ☐ **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)
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- ☐ **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)
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- ☐ **State that noble gases are unreactive** They are unreactive and do not easily form molecules; they exist as single atoms. (Group 0)
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- ☐ **Describe their reactions with water** They float and fizz; sodium melts into a ball; potassium's hydrogen burns with a lilac flame. (Group 1)
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- ☐ **State the reactivity trend down Group 1** Reactivity increases going down the group: lithium, then sodium, then potassium. (Group 1)
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- ☐ **Describe the trends down Group 7** Relative molecular mass, melting point and boiling point increase; reactivity decreases. (Group 7)
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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)
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- ☐ **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)
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- ☐ **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)
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- ☐ **Name the force holding the ions together** Strong electrostatic forces of attraction between oppositely charged ions. (Ionic compounds)
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- ☐ **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)
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- ☐ **Describe what delocalised electrons are** The outer shell electrons of metal atoms are delocalised: free to move through the whole structure. (Metallic bonding)
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- ☐ **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)
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- ☐ **Know that aqueous means dissolved in water** Any solution in water, such as sodium chloride solution or dilute hydrochloric acid, is (aq). (State symbols)
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- ☐ **State when ionic compounds conduct electricity** When melted (molten) or dissolved in water, but not when solid. (Properties of ionic compounds)
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- ☐ **State that small molecules don't conduct electricity** The molecules have no overall electric charge. (Properties of small molecules)
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- ☐ **State that polymers are solids at room temperature** The forces between their large molecules are strong enough to keep them solid. (Polymers)
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- ☐ **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: C_{60} , a hollow, spherical molecule. (Graphene and fullerenes)
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Quantitative chemistry

- ☐ **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 chemical equations)
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- ☐ **Calculate M_r of a simple formula** Add the A_r of every atom, e.g. $\text{CO}_2 = 12 + (2 \times 16) = 44$. (Relative formula mass)
- ☐ **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)
- ☐ **Find the range of a set of results** Range = highest value – lowest value. (Chemical measurements)
- ☐ **Convert cm^3 to dm^3** Divide by 1000, e.g. $250 \text{ cm}^3 = 0.250 \text{ dm}^3$. (Concentration of solutions)

Chemical changes

- ☐ **Define oxidation and reduction using oxygen** Oxidation is the gain of oxygen and reduction is the loss of oxygen. (Metal oxides)
- ☐ **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)
- ☐ **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)
- ☐ **Name the salt from the acid used** Hydrochloric acid gives chlorides and sulfuric acid gives sulfates. (Reactions of acids with metals)
- ☐ **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)
- ☐ **Predict products of acid with base or alkali** acid + metal oxide or metal hydroxide $\rightarrow$ salt + water. (Neutralisation of acids and salt production)
- ☐ **Predict products of acid with a carbonate** acid + metal carbonate $\rightarrow$ salt + water + carbon dioxide. (Neutralisation of acids and salt production)
- ☐ **Describe filtering and crystallising** Filter off the excess solid, heat to evaporate some water, then leave the solution to cool and crystallise. (Soluble salts)
- ☐ **Measure pH with universal indicator** Add the indicator and match its colour to a pH colour chart. (The pH scale and neutralisation)
- ☐ **Define an electrolyte** A molten or dissolved ionic compound, which conducts electricity because its ions are free to move. (The process of electrolysis)
- ☐ **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)
- ☐ **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)
- ☐ **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)

Energy changes

- ☐ **Give examples of endothermic reactions** Thermal decomposition and the reaction of citric acid with sodium hydrogencarbonate are endothermic. (Energy transfer during exothermic and endothermic reactions)

- ☐ **Classify a reaction from temperature data** A rise in temperature means the reaction is exothermic; a fall means it is endothermic. (Energy transfer during exothermic and endothermic reactions)
- ☐ **Label the parts of a reaction profile** Identify the reactants, products, activation energy and overall energy change on a given profile. (Reaction profiles)
- ☐ **Identify exothermic or endothermic from a profile** Products lower than reactants means exothermic; products higher than reactants means endothermic. (Reaction profiles)

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 rates of chemical reactions)
- ☐ **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)

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)

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- ☐ **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)

Chemistry of the atmosphere

- ☐ **Name the gases present in small proportions** Carbon dioxide, water vapour and noble gases such as argon are present in small proportions. (The proportions of different gases in the atmosphere)

- ☐ **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. (The proportions of different gases in the atmosphere)

- ☐ **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)

- ☐ **Describe how the oceans formed** Water vapour released by volcanoes condensed to form the oceans. (The Earth's early atmosphere)

- ☐ **Write the word equation for photosynthesis** carbon dioxide + water → glucose + oxygen, with light as the energy source. (How oxygen increased)

- ☐ **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)

- ☐ **State why greenhouse gases are needed** They keep the Earth's temperature high enough to support life. (Greenhouse gases)

- ☐ **Give two activities that release methane** Farming cattle and other livestock, growing rice in paddy fields, and waste decaying in landfill sites. (Human activities which contribute to an increase in greenhouse gases in the atmosphere)

- ☐ **Give potential effects of climate change** For example, rising sea levels, more frequent and severe storms, and changes in rainfall. (Global climate change)

- ☐ **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)

- ☐ **Name the pollutants released by burning fuels** Carbon dioxide, water vapour, carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates. (Atmospheric pollutants from fuels)
- ☐ **Name the gases that cause acid rain** Sulfur dioxide and oxides of nitrogen cause acid rain. (Properties and effects of atmospheric pollutants)
- ☐ **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)

Using resources

- ☐ **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 the Earth's resources and sustainable development)
- ☐ **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 the Earth's resources and sustainable development)
- ☐ **Explain why potable water is not pure** It contains dissolved substances, whereas pure water contains only water molecules. (Potable water)
- ☐ **List the steps in treating fresh water** Choose a suitable source of fresh water, pass it through filter beds, then sterilise it. (Potable water)
- ☐ **State what sewage treatment must remove** Sewage and agricultural waste water need organic matter and harmful microbes removed. (Waste water treatment)
- ☐ **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)
- ☐ **Name materials made from limited raw materials** Metals, glass, building materials, clay ceramics and most plastics. (Ways of reducing the use of resources)

Energy

- ☐ **Name the ways energy is transferred** Mechanically (a force doing work), electrically (a current doing work), by heating and by radiation such as light. (Energy stores and systems)
- ☐ **Calculate gravitational potential energy** Multiply mass (kg) $\times$ gravitational field strength (N/kg) $\times$ height (m) to get the energy in joules. (Changes in energy)
- ☐ **Define specific heat capacity** The amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C. (Energy changes in systems)
- ☐ **Define power** Power is the rate at which energy is transferred, or the rate at which work is done. (Power)
- ☐ **Calculate power from energy and time** Divide the energy transferred (J) by the time taken (s). (Power)
- ☐ **Give examples of energy being dissipated** Friction heats moving parts, air resistance heats the air, and a motor makes sound. (Energy transfers in a system)
- ☐ **Calculate efficiency from energy values** Divide the useful output energy by the total input energy. (Efficiency)
- ☐ **Sort resources into renewable and non-renewable** Coal, oil, gas and nuclear fuel are non-renewable; all the others are renewable. (National and global energy resources)

- ☐ **Link energy resources to their uses** The three main uses are transport, electricity generation and heating. (National and global energy resources)
-

Electricity

- ☐ **Draw a simple series circuit correctly** Use a ruler, straight wires and the correct symbols, with no gaps in the loop. (Standard circuit diagram symbols)
-
- ☐ **Recognise diode, LED, fuse and variable resistor** Tell apart symbols that look alike, such as the diode and the LED, or the resistor and the fuse. (Standard circuit diagram symbols)
-
- ☐ **State what a circuit needs for current** A closed circuit (complete loop) that includes a source of potential difference, such as a cell. (Electrical charge and current)
-
- ☐ **Calculate charge using $Q = I t$** Multiply the current in amps by the time in seconds to get the charge in coulombs. (Electrical charge and current)
-
- ☐ **Describe how resistance affects current** For a given potential difference, the greater the resistance, the smaller the current. (Current, resistance and potential difference)
-
- ☐ **Calculate pd using $V = I R$** Multiply the current in amps by the resistance in ohms to get the pd in volts. (Current, resistance and potential difference)
-
- ☐ **Recall that a thermistor's resistance falls when hot** The resistance of a thermistor decreases as temperature increases. (Resistors)
-
- ☐ **State the series and parallel rules** Series: same current, pd shared. Parallel: same pd across each branch, branch currents add up. (Series and parallel circuits)
-
- ☐ **Add resistances in series** Use $R_{\text{total}} = R_1 + R_2$. (Series and parallel circuits)
-
- ☐ **Name a source of direct pd** Cells and batteries supply a direct potential difference. (Direct and alternating potential difference)
-
- ☐ **State the job of each wire** Live carries the alternating pd from the supply, neutral completes the circuit, earth is a safety wire. (Mains electricity)
-
- ☐ **Explain what power means** Power is the rate of energy transfer: the energy transferred each second. (Power)
-
- ☐ **Calculate power using $P = V I$** Multiply the pd in volts by the current in amps to get the power in watts. (Power)
-
- ☐ **State what affects the energy transferred** The power of the appliance and how long it is switched on for. (Energy transfers in everyday appliances)
-
- ☐ **Calculate energy using $E = P t$** Power in watts $\times$ time in seconds gives energy in joules. (Energy transfers in everyday appliances)
-
- ☐ **State what a step-up transformer does** It increases the potential difference from the power station to the transmission cables. (The National Grid)
-
- ☐ **State what a step-down transformer does** It decreases the potential difference to a much lower value for domestic use. (The National Grid)
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Particle model of matter

- ☐ **Recall and use density = mass ÷ volume** Substitute into $\rho = m / V$ with mass in kg and volume in m^3 to get a density in kg/m^3 . (Density of materials)

- ☐ **State that mass is conserved** When a substance changes state the number of particles stays the same, so its mass does not change. (Changes of state)

- ☐ **Define internal energy** The total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system. (Internal energy)

- ☐ **Define specific heat capacity** The amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C. (Temperature changes in a system and specific heat capacity)

- ☐ **Substitute into $\Delta E = m c \Delta\theta$** Calculate the change in thermal energy with m in kg, c in J/kg °C and $\Delta\theta$ in °C. (Temperature changes in a system and specific heat capacity)

- ☐ **Know temperature stays constant during state changes** While a substance melts, boils, freezes or condenses, its temperature does not change. (Changes of state and specific latent heat)

- ☐ **Link gas temperature to molecules' kinetic energy** The higher the temperature, the greater the average kinetic energy of the molecules, so the faster they move on average. (Particle motion in gases)

Atomic structure

- ☐ **Give the relative charge of each particle** Proton +1, neutron 0, electron -1, so the nucleus is positively charged. (The structure of an atom)

- ☐ **Recall the size of an atom** The radius of an atom is about 1×10^{-10} m. (The structure of an atom)

- ☐ **State what mass number means** The mass number is the total number of protons and neutrons in the nucleus. (Mass number, atomic number and isotopes)

- ☐ **Explain why atoms have no overall charge** An atom has equal numbers of protons and electrons, and their charges are equal and opposite. (Mass number, atomic number and isotopes)

- ☐ **Describe the plum pudding model** The atom is a ball of positive charge with negative electrons embedded in it. (The development of the model of the atom)

- ☐ **Define radioactive decay and activity** Unstable nuclei give out radiation to become more stable; activity is decays per second, in becquerels (Bq). (Radioactive decay and nuclear radiation)

- ☐ **State what absorbs each radiation** Alpha: paper; beta: a few mm of aluminium; gamma: reduced by thick lead or concrete. (Radioactive decay and nuclear radiation)

- ☐ **Recall the symbols for alpha and beta** Alpha is ${}^4_2\text{He}$ and beta is ${}^0_{-1}\text{e}$. (Nuclear equations)

- ☐ **Define half-life** The time for the number of unstable nuclei in a sample, or its count rate, to halve. (Half-lives and the random nature of radioactive decay)

- ☐ **Define contamination and irradiation** Contamination: unwanted radioactive material on or in something; irradiation: exposure to radiation from outside. (Radioactive contamination)

Forces

- ☐ **Sort common quantities into scalars and vectors** Distance, speed, mass, time, energy and temperature are scalars; displacement, velocity, acceleration and force are vectors. (Scalar and vector quantities)

- ☐ **Name examples of non-contact forces** Gravitational, electrostatic and magnetic forces act even when the objects are physically separated. (Contact and non-contact forces)

- ☐ **Calculate weight using $W = m g$** For example, $60 \text{ kg} \times 9.8 \text{ N/kg} = 588 \text{ N}$. (Gravity)

- ☐ **Find the resultant of forces along a line** Add forces acting in the same direction; subtract forces acting in opposite directions. (Resultant forces)

- ☐ **Calculate work done using $W = F s$** For example, $50 \text{ N} \times 3.0 \text{ m} = 150 \text{ J}$. (Work done and energy transfer)

- ☐ **Distinguish elastic and inelastic deformation** An elastically deformed object returns to its original shape when the forces are removed; an inelastically deformed one does not. (Forces and elasticity)

- ☐ **State that displacement is a vector** Displacement is the straight-line distance from the start point to the finish point, with the direction of that line. (Distance and displacement)

- ☐ **Calculate distance using $s = v t$** For example, 1.5 m/s for 60 s gives 90 m . (Speed)

- ☐ **Recall typical speeds of everyday motion** Walking $\sim 1.5 \text{ m/s}$, running $\sim 3 \text{ m/s}$, cycling $\sim 6 \text{ m/s}$, sound in air $\sim 330 \text{ m/s}$. (Speed)

- ☐ **Explain the difference between speed and velocity** Speed is a scalar (magnitude only); velocity is a vector (magnitude and direction). (Velocity)

- ☐ **Plot a distance–time graph from data** Time on the x-axis, distance on the y-axis, labelled axes with units and sensible scales. (The distance–time relationship)

- ☐ **Calculate acceleration using $a = \Delta v \div t$** From 4 m/s to 16 m/s in 3 s : $a = 12 \div 3 = 4 \text{ m/s}^2$. (Acceleration)

- ☐ **Describe motion from a velocity–time graph** Horizontal line: constant velocity; sloping up: accelerating; sloping down: decelerating. (Acceleration)

- ☐ **State Newton's First Law** If the resultant force on an object is zero, it stays at rest or keeps moving at the same velocity. (Newton's First Law)

- ☐ **Find a force from steady motion** At a steady speed in a straight line, the driving force equals the total resistive force. (Newton's First Law)

- ☐ **Calculate force using $F = m a$** For example, $1200 \text{ kg} \times 2.5 \text{ m/s}^2 = 3000 \text{ N}$. (Newton's Second Law)

- ☐ **State Newton's Third Law** Whenever two objects interact, the forces they exert on each other are equal and opposite. (Newton's Third Law)

- ☐ **Calculate stopping distance from given data** Add the thinking distance and the braking distance. (Stopping distance)

- ☐ **List factors that increase reaction time** Tiredness, drugs, alcohol and distractions (e.g. using a phone). (Reaction time)

- ☐ **Explain how wet or icy roads affect braking** There is less friction between the tyres and the road, so the braking distance is longer. (Factors affecting braking distance 1)

- ☐ **Describe the energy transfer when a vehicle brakes** Energy is transferred from the kinetic store of the vehicle to the thermal store of the brakes. (Factors affecting braking distance 2)

Waves

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- ☐ **State what waves transfer** Waves transfer energy (and can carry information) from place to place, but they do not transfer matter. (Transverse and longitudinal waves)
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- ☐ **Define frequency and period** Frequency is the number of waves passing a point each second (Hz); the period is the time for one wave (s). (Properties of waves)
-
- ☐ **Calculate wave speed using $v = f \lambda$** Multiply the frequency in Hz by the wavelength in m to get the wave speed in m/s. (Properties of waves)
-
- ☐ **Link spectrum position to wavelength and frequency** Radio waves have the longest wavelength and lowest frequency; gamma rays have the shortest wavelength and highest frequency. (Types of electromagnetic waves)
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- ☐ **State the effects of ultraviolet on skin** Ultraviolet can make skin age prematurely and increases the risk of skin cancer. (Properties of electromagnetic waves 2)
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- ☐ **Give two uses of microwaves** Satellite communications and cooking food. (Uses and applications of electromagnetic waves)
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- ☐ **Give three uses of infrared** Electrical heaters, cooking food and infrared cameras. (Uses and applications of electromagnetic waves)
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Magnetism and electromagnetism

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- ☐ **Identify magnetic forces as non-contact forces** Magnets attract or repel each other without touching, so these are non-contact forces. (Poles of a magnet)
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- ☐ **Draw the field pattern of a bar magnet** Curved lines from the north pole to the south pole, with arrows, closest together at the poles. (Magnetic fields)
-
- ☐ **Describe how to show a wire's magnetic field** Put plotting compasses around a vertical wire: they line up in a circle when the current is switched on. (Electromagnetism)
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