

Grade 5 skills checklist

296 skills that set grade 5 apart. Do the lists for the grades below first. Tick each one when you can do it.

Cell biology

- ☐ **Compare prokaryotic and eukaryotic cells** Say what both have (cell membrane, cytoplasm, ribosomes) and how they differ, above all whether the DNA is enclosed in a nucleus. (Eukaryotes and prokaryotes)
- ☐ **Convert between mm, μm and nm** Multiply by 1000 for each step down ($\text{mm} \rightarrow \mu\text{m} \rightarrow \text{nm}$) and divide by 1000 for each step up. (Eukaryotes and prokaryotes)
- ☐ **Explain why some plant cells lack chloroplasts** Cells that receive no light, such as root cells, cannot photosynthesise, so they have no chloroplasts. (Animal and plant cells)
- ☐ **Describe the adaptations of each specialised cell** e.g. a sperm cell has a tail, many mitochondria and enzymes in its head. (Cell specialisation)
- ☐ **State what cell division does in adults** In mature animals, cell division is mainly for repair and replacement. (Cell differentiation)
- ☐ **Use magnification = image size $\div$ real size** Rearrange the equation to find the magnification, the image size or the real size. (Microscopy)
- ☐ **Prepare a slide and focus a microscope** Thin sample, stain, coverslip; start on the lowest power and focus with the coarse, then the fine, focus. (Microscopy)
- ☐ **Put cell, nucleus, chromosome and gene in order** Largest to smallest: cell, nucleus, chromosome, gene. (Chromosomes)
- ☐ **Describe what happens in each stage** The cell grows, copies its sub-cellular structures and DNA, divides its nucleus, then splits in two. (Mitosis and the cell cycle)
- ☐ **State why mitosis is important** For the growth and development of multicellular organisms, and to repair and replace cells. (Mitosis and the cell cycle)
- ☐ **Recognise where mitosis is happening** e.g. a root tip growing, a cut healing, an embryo developing. (Mitosis and the cell cycle)
- ☐ **Compare embryonic and adult stem cells** Embryonic stem cells can become most types of human cell; adult bone marrow stem cells form fewer types, including blood cells. (Stem cells)
- ☐ **Describe uses of meristem cloning** Making clones quickly and cheaply, saving rare species, and producing crops with useful features. (Stem cells)
- ☐ **Explain the factors that affect the rate** A bigger concentration gradient, a higher temperature and a larger surface area all increase the rate of diffusion. (Diffusion)
- ☐ **Describe the osmosis required practical** Weigh pieces of plant tissue, leave them in a range of concentrations, then reweigh them. (Osmosis)
- ☐ **Calculate percentage change in mass** $\text{Change in mass} \div \text{starting mass} \times 100$; a loss in mass gives a negative answer. (Osmosis)

- ☐ **Describe two examples of active transport** Mineral ions from the soil into root hair cells; sugar from the gut into the blood. (Active transport)
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Organisation

- ☐ **Classify a structure by its level** For example, a red blood cell is a cell, blood is a tissue, the heart is an organ and the circulatory system is an organ system. (Principles of organisation)
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- ☐ **Recall where each digestive enzyme is made** Amylase in the salivary glands, pancreas and small intestine; proteases in the stomach, pancreas and small intestine; lipases in the pancreas and small intestine. (The human digestive system)
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- ☐ **Describe the double circulatory system** The right ventricle pumps blood to the lungs and the left ventricle pumps blood around the rest of the body. (The heart and blood vessels)
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- ☐ **Describe the role of the pacemaker** A group of cells in the right atrium controls the natural resting heart rate; an artificial pacemaker is an electrical device that corrects an irregular heart rate. (The heart and blood vessels)
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- ☐ **Identify blood cells in a photo or diagram** Red blood cells are biconcave discs with no nucleus, white blood cells are larger with a nucleus, and platelets are tiny fragments. (Blood)
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- ☐ **List substances transported by the plasma** Carbon dioxide, urea, soluble products of digestion such as glucose and amino acids, hormones and antibodies. (Blood)
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- ☐ **Describe how stents and statins treat CHD** A stent holds the coronary artery open; statins lower blood cholesterol, which slows the build-up of fatty material. (Coronary heart disease: a non-communicable disease)
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- ☐ **Describe treatments for faulty valves and heart failure** Faulty valves are replaced with biological or mechanical valves; heart failure can be treated with a donor heart (or heart and lungs) or, occasionally, an artificial heart. (Coronary heart disease: a non-communicable disease)
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- ☐ **Give factors other than disease affecting health** Diet, stress and life situations can have a big effect on both physical and mental health. (Health issues)
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- ☐ **Describe effects of smoking and alcohol in pregnancy** Both can harm the unborn baby, e.g. smoking can cause low birth weight and alcohol can damage the baby's brain development. (The effect of lifestyle on some non-communicable diseases)
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- ☐ **Describe malignant tumours and secondary tumours** Malignant tumour cells are cancers: they invade neighbouring tissues and spread in the blood to form secondary tumours. (Cancer)
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- ☐ **Give lifestyle risk factors for cancer** For example smoking (lung cancer), obesity (e.g. bowel cancer), too much UV light (skin cancer) and some viral infections (e.g. cervical cancer). (Cancer)
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- ☐ **State the function of each leaf tissue** Epidermis covers the leaf, palisade does most photosynthesis, spongy mesophyll lets gases diffuse, xylem carries water and phloem carries sugars. (Plant tissues)
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- ☐ **Describe how root hair cells absorb substances** They take up water by osmosis and mineral ions by active transport, helped by their large surface area. (Plant organ system)
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- ☐ **Compare the structure of xylem and phloem** Xylem is hollow tubes strengthened by lignin; phloem is tubes of elongated cells with pores in the end walls. (Plant organ system)
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Infection and response

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- ☐ **Explain how bacteria and viruses make you ill** Both reproduce rapidly in the body; bacteria release toxins that damage tissues, and viruses reproduce inside cells and damage them. (Communicable (infectious) diseases)
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- ☐ **Describe ways to reduce the spread of disease** Hygiene, isolating infected individuals, destroying or controlling vectors, and vaccination. (Communicable (infectious) diseases)
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- ☐ **Describe how measles and HIV are controlled** Measles: vaccinating young children; HIV: condoms, not sharing needles and antiretroviral drugs. (Viral diseases)
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- ☐ **Describe how each disease is spread** *Salmonella*: bacteria swallowed in food or on food prepared in unhygienic conditions; gonorrhoea: sexual contact. (Bacterial diseases)
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- ☐ **Describe how the spread of each is controlled** Vaccinating poultry and hygienic food preparation for *Salmonella*; antibiotics and condoms for gonorrhoea. (Bacterial diseases)
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- ☐ **Describe how rose black spot is treated** Use fungicides and/or remove and destroy the affected leaves. (Fungal diseases)
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- ☐ **Describe how the spread of malaria is controlled** Stop mosquitoes breeding, and use mosquito nets to avoid being bitten. (Protist diseases)
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- ☐ **Describe phagocytosis** A white blood cell engulfs a pathogen and digests it. (Human defence systems)
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- ☐ **Explain how vaccination prevents illness** If the live pathogen enters later, white blood cells quickly make the correct antibodies and destroy it before it causes illness. (Vaccination)
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- ☐ **Explain why specific antibiotics are needed** Different antibiotics kill different bacteria, so the antibiotic must match the bacterium causing the disease. (Antibiotics and painkillers)
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- ☐ **Describe preclinical testing** The drug is tested in a laboratory on cells, tissues and live animals before any people take it. (Discovery and development of drugs)
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- ☐ **Describe the stages of clinical trials** Very low doses are given first to check safety; further trials on patients find the optimum dose. (Discovery and development of drugs)
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Bioenergetics

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- ☐ **Explain why photosynthesis is endothermic** Energy is transferred from the environment to the chloroplasts by light, so the reaction takes in energy. (Photosynthetic reaction)
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- ☐ **State where the reactants come from** Carbon dioxide diffuses into the leaf from the air through the stomata; water is absorbed by the roots and carried up in the xylem. (Photosynthetic reaction)
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- ☐ **Explain the effect of temperature** The rate rises up to an optimum temperature, then falls quickly because the enzymes that control photosynthesis denature. (Rate of photosynthesis)
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- ☐ **Explain a one-factor rate graph** Where the line rises the factor on the x-axis is limiting; where it levels off another factor has become limiting. (Rate of photosynthesis)
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- ☐ **Describe how glucose reaches storage organs** Sugars made in the leaves are carried in solution in the phloem to where they are used or stored. (Uses of glucose from photosynthesis)
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- ☐ **Describe respiration as a continuous exothermic reaction** It happens all the time in living cells and transfers energy to the surroundings, supplying the energy for living processes. (Aerobic and anaerobic respiration)
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- ☐ **Describe fermentation and its uses** Anaerobic respiration in yeast makes ethanol and carbon dioxide, which are used to make alcoholic drinks and bread. (Aerobic and anaerobic respiration)
- ☐ **Explain when muscles respire anaerobically** When oxygen cannot be supplied fast enough for aerobic respiration alone, as in vigorous exercise. (Response to exercise)
- ☐ **Calculate changes from exercise data** Work out increases, percentage changes and recovery times from tables and graphs of heart rate or breathing rate. (Response to exercise)
- ☐ **Name the building blocks of large molecules** Carbohydrates are made from sugars, proteins from amino acids, and lipids from glycerol and fatty acids. (Metabolism)
- ☐ **State how a lipid molecule forms** One molecule of glycerol joins with three molecules of fatty acids. (Metabolism)

Homeostasis and response

- ☐ **Explain why homeostasis is important** It keeps conditions at the optimum for enzyme action and all cell functions. (Homeostasis)
- ☐ **Describe the job of each part** Receptors detect stimuli, coordination centres process the information, and effectors (muscles or glands) bring about a response. (Homeostasis)
- ☐ **Explain why reflex actions are fast** They are automatic and do not involve the conscious part of the brain. (The human nervous system)
- ☐ **Describe the ruler-drop reaction time practical** Catch a dropped ruler, record the distance it fell and convert it to a reaction time. (The human nervous system)
- ☐ **Compare hormonal and nervous control** Hormones travel in the blood and are slower but longer-lasting; nerve impulses are fast and short-lived. (Human endocrine system)
- ☐ **Compare the causes of Type 1 and 2** Type 1: the pancreas does not make enough insulin. Type 2: body cells stop responding to insulin. (Control of blood glucose concentration)
- ☐ **Describe treatments for each type of diabetes** Type 1: insulin injections. Type 2: a carbohydrate-controlled diet and an exercise regime. (Control of blood glucose concentration)
- ☐ **State the roles of the four cycle hormones** FSH matures an egg, LH triggers its release, and oestrogen and progesterone maintain the uterus lining. (Hormones in human reproduction)
- ☐ **Explain how hormonal methods work** The pill inhibits FSH so no eggs mature; progesterone implants stop eggs maturing and being released. (Contraception)
- ☐ **Describe how IUDs and spermicides work** IUDs prevent an embryo implanting or release a hormone; spermicides kill or disable sperm. (Contraception)

Inheritance, variation and evolution

- ☐ **Name the cell division each type uses** Gametes are made by meiosis; asexual reproduction involves only mitosis. (Sexual and asexual reproduction)
- ☐ **Describe what happens in meiosis** The genetic information is copied, then the cell divides twice to give four genetically different gametes, each with a single set of chromosomes. (Meiosis)

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- ☐ **Give chromosome numbers in body cells and gametes** A human body cell has 46 chromosomes (23 pairs) and a human gamete has 23. (Meiosis)
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- ☐ **Define gene and genome** A gene is a small section of DNA on a chromosome; the genome is all of an organism's genetic material. (DNA and the genome)
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- ☐ **Complete a Punnett square** Put each parent's gametes on the outside and combine one allele from each in every box. (Genetic inheritance)
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- ☐ **Give cross outcomes as ratios or probabilities** For example 3 : 1, or a probability of 0.25, 25%, $\frac{1}{4}$ or 1 in 4. (Genetic inheritance)
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- ☐ **Explain what a carrier is** A heterozygous person with one recessive allele who does not have the disorder but can pass it on. (Inherited disorders)
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- ☐ **State what the other 22 pairs do** 22 pairs control characteristics only; one pair carries the genes that determine sex. (Sex determination)
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- ☐ **Draw a genetic cross for sex** $XX \times XY$ in a Punnett square gives XX, XX, XY, XY. (Sex determination)
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- ☐ **Give examples of each cause** Blood group is genetic, a scar is environmental, and body mass depends on both. (Variation)
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- ☐ **State that populations show genetic variation** There is usually extensive genetic variation within a population of a species. (Variation)
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- ☐ **List the steps of natural selection** Variation, competition, the best suited survive and reproduce, alleles passed on, alleles become more common. (Evolution)
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- ☐ **Describe the steps of selective breeding** Choose parents with the characteristic, breed them, select the best offspring, and repeat over many generations. (Selective breeding)
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- ☐ **State what GM crops are** Crops whose genes have been modified by genetic engineering; they generally give increased yields. (Genetic engineering)
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- ☐ **Explain why genes support Darwin's theory** It has been shown that characteristics are passed on to offspring in genes, which explains how they are inherited. (Evidence for evolution)
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- ☐ **Explain why some remains do not decay** One or more of the conditions needed for decay (such as oxygen, warmth or moisture) are absent. (Fossils)
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- ☐ **Give examples of catastrophic events** Massive volcanic eruptions or collisions with asteroids. (Extinction)
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- ☐ **Explain why bacteria evolve rapidly** They reproduce at a fast rate, so there are many generations in a short time. (Resistant bacteria)
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- ☐ **Describe how Linnaeus classified organisms** Into groups depending on their structure and characteristics. (Classification of living organisms)
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- ☐ **Name the three domains** Archaea, bacteria and eukaryota. (Classification of living organisms)
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Ecology

- ☐ **Explain what interdependence means** Each species depends on others for food, shelter, pollination or seed dispersal, so removing one species can affect the whole community. (Communities)
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- ☐ **Describe a trend in abiotic data** State how one variable changes as the other changes, quoting values from the table or graph. (Abiotic factors)

- ☐ **Explain the effect of food availability** More food means more organisms survive and breed, so the population grows; less food has the opposite effect. (Biotic factors)

- ☐ **Define an extremophile and give an example** An organism that lives in extreme conditions of temperature, pressure or salt concentration, e.g. bacteria in deep sea vents. (Adaptations)

- ☐ **Describe using quadrats to estimate population size** Place quadrats randomly, count the organisms, find the mean per quadrat, then scale up to the whole area. (Levels of organisation)

- ☐ **Name processes that add or remove carbon dioxide** Photosynthesis removes carbon dioxide from the air; respiration and combustion release it. (How materials are cycled)

- ☐ **Explain why biodiversity matters to humans** The future of humans relies on it, e.g. for food, materials, medicines and stable ecosystems. (Biodiversity)

- ☐ **Explain how pollution reduces biodiversity** Pollution kills plants and animals, so fewer species survive in the area. (Waste management)

- ☐ **State why peat bogs are destroyed** Peat is dug up to produce garden compost. (Land use)

- ☐ **Explain how deforestation reduces biodiversity** Forest habitats are destroyed and replaced by grazing land or one crop, so many species are lost. (Deforestation)

- ☐ **Describe biological consequences of global warming** Habitat loss as sea levels rise, changes in distribution and migration, and loss of biodiversity. (Global warming)

- ☐ **Explain how each programme helps biodiversity** Say what the programme does and which species or habitats it protects. (Maintaining biodiversity)

Atomic structure and the periodic table

- ☐ **Write word equations for reactions** Reactants on the left, products on the right, joined by an arrow, e.g. magnesium + oxygen → magnesium oxide. (Atoms, elements and compounds)

- ☐ **Describe simple distillation** The solvent boils off, is cooled and condensed in a condenser, and is collected, leaving the dissolved solid behind. (Mixtures)

- ☐ **Describe fractional distillation** Liquids with different boiling points are separated using a fractionating column; the lowest boiling point liquid is collected first. (Mixtures)

- ☐ **Describe the nuclear model** A tiny, positively charged nucleus that contains almost all the mass, with electrons outside it. (The development of the model of the atom)

- ☐ **Explain why atoms have no overall charge** The number of electrons equals the number of protons, so the charges cancel. (Relative electrical charges of subatomic particles)

- ☐ **Identify an element from its proton number** Different elements have different numbers of protons, so the atomic number tells you the element. (Relative electrical charges of subatomic particles)

- ☐ **Define isotopes** Atoms of the same element with different numbers of neutrons: same atomic number, different mass number. (Size and mass of atoms)

- ☐ **Recall the sizes of atoms and nuclei** Atom radius about 0.1 nm (1×10^{-10} m); nucleus radius less than 1/10 000 of that (about 1×10^{-14} m). (Size and mass of atoms)
- ☐ **Calculate A_r for two isotopes** Multiply each mass number by its percentage abundance, add the results, then divide by 100. (Relative atomic mass)
- ☐ **Explain why A_r is rarely whole** It is an average of isotopes with different mass numbers, weighted by how common each one is. (Relative atomic mass)
- ☐ **Link electronic structure to group and period** Outer electrons = group number (Groups 1 to 7); number of occupied shells = period. (Electronic structure)
- ☐ **Identify an element from its electronic structure** Add up the electrons to get the atomic number, e.g. 2,8,5 is 15, which is phosphorus. (Electronic structure)
- ☐ **Explain why group members react similarly** They have the same number of electrons in their outer shell. (The periodic table)
- ☐ **Link position to electronic structure** Group number = outer electrons (Groups 1 to 7); period = number of occupied shells. (The periodic table)
- ☐ **Describe what Mendeleev did** He left gaps for undiscovered elements and changed the order of some elements to fit their properties. (Development of the periodic table)
- ☐ **Compare the oxides of metals and non-metals** Metal oxides are basic; non-metal oxides are usually acidic. (Metals and non-metals)
- ☐ **Explain their unreactivity using electrons** Their atoms have stable arrangements of electrons: a full outer shell of 8 (2 for helium). (Group 0)
- ☐ **Describe the boiling point trend** Boiling points increase going down the group, as relative atomic mass increases. (Group 0)
- ☐ **Write equations for their reactions** With water, oxygen and chlorine, e.g. $2K + 2H_2O \rightarrow 2KOH + H_2$. (Group 1)
- ☐ **Describe the compounds halogens form** Ionic compounds with metals (halide ions, 1-); covalent molecules with non-metals, e.g. HCl. (Group 7)
- ☐ **Predict whether a displacement reaction happens** A more reactive halogen displaces a less reactive one from a solution of its salt. (Group 7)

Bonding, structure, and the properties of matter

- ☐ **Decide the bond type from a formula** Use the periodic table to decide whether each element in, for example, KBr, SO_2 or Zn is a metal or a non-metal. (Chemical bonds)
- ☐ **Write the electronic structure of an ion** For example, Na (2,8,1) becomes Na^+ (2,8) and O (2,6) becomes O^{2-} (2,8). (Ionic bonding)
- ☐ **Draw dot and cross diagrams for ionic compounds** Show each ion in square brackets with its charge, using dots and crosses for electrons from different atoms. (Ionic bonding)
- ☐ **State that the forces act in all directions** Each ion is attracted to all the oppositely charged ions around it, throughout the lattice. (Ionic compounds)

- ☐ **Recognise an ionic structure from a diagram** Look for a regular lattice of two types of ion, often labelled with charges, and no separate molecules. (Ionic compounds)
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- ☐ **Draw dot and cross diagrams for simple molecules** Hydrogen, chlorine, hydrogen chloride, water, ammonia and methane, which have single bonds only. (Covalent bonding)
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- ☐ **Describe the metallic bond** Strong electrostatic attraction between positive metal ions and the shared delocalised electrons. (Metallic bonding)
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- ☐ **Predict states from melting and boiling points** Below the melting point: solid; between the melting and boiling points: liquid; above the boiling point: gas. (The three states of matter)
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- ☐ **Add state symbols to a simple equation** For example, $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$. (State symbols)
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- ☐ **Explain high melting points using electrostatic forces** A lot of energy is needed to overcome the many strong electrostatic forces between oppositely charged ions. (Properties of ionic compounds)
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- ☐ **Explain low boiling points using intermolecular forces** Only weak intermolecular forces must be overcome, which needs little energy. (Properties of small molecules)
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- ☐ **Describe the bonds in a polymer chain** The atoms in each chain are linked to each other by strong covalent bonds. (Polymers)
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- ☐ **Recognise a polymer from a diagram** Look for a repeating unit in brackets with bonds through the brackets and n after them. (Polymers)
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- ☐ **Explain their very high melting points** Many strong covalent bonds must be broken, which needs a lot of energy. (Giant covalent structures)
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- ☐ **Explain why most metals have high melting points** Giant structures with strong metallic bonding need a lot of energy to overcome. (Properties of metals and alloys)
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- ☐ **Explain why pure metals are soft** The layers of atoms can slide over each other easily. (Properties of metals and alloys)
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- ☐ **Explain electrical conduction in metals** The delocalised electrons are free to move through the structure, carrying charge. (Metals as conductors)
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- ☐ **Explain why diamond is very hard** Many strong covalent bonds hold the atoms rigidly in a 3D network. (Diamond)
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- ☐ **Explain diamond's very high melting point** A lot of energy is needed to break the many strong covalent bonds. (Diamond)
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- ☐ **Explain why graphite is soft and slippery** There are no covalent bonds between the layers, so the layers can slide over each other. (Graphite)
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- ☐ **Give uses of fullerenes and nanotubes** Fullerenes: drug delivery, lubricants, catalysts; nanotubes: nanotechnology, electronics and strengthening materials. (Graphene and fullerenes)
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Quantitative chemistry

- ☐ **Balance a symbol equation** Change only the big numbers in front of formulae until every element has the same number of atoms on both sides. (Conservation of mass and balanced chemical equations)
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- ☐ **Calculate M_r for formulae with brackets** Multiply everything inside the bracket, e.g. $\text{Ca}(\text{OH})_2 = 40 + 2 \times (16 + 1) = 74$. (Relative formula mass)
- ☐ **Explain why a heated metal gains mass** Oxygen atoms from the air combine with the metal, so the metal oxide has a greater mass than the metal. (Mass changes when a reactant or product is a gas)
- ☐ **Identify an anomalous result** A result that clearly does not fit the pattern of the others; leave it out of the mean. (Chemical measurements)
- ☐ **Calculate concentration in g/dm^3** Concentration = mass of solute (g) $\div$ volume of solution (dm^3). (Concentration of solutions)

Chemical changes

- ☐ **Identify what is oxidised or reduced** In an equation, the substance that gains oxygen is oxidised and the substance that loses oxygen is reduced. (Metal oxides)
- ☐ **Deduce an order of reactivity from results** The more vigorous the reaction (more bubbles, bigger temperature rise), the more reactive the metal. (The reactivity series)
- ☐ **Predict whether a displacement reaction happens** A metal displaces another metal from its compound only if it is more reactive. (The reactivity series)
- ☐ **Write equations for reduction with carbon** For example, $2\text{ZnO} + \text{C} \rightarrow 2\text{Zn} + \text{CO}_2$. (Extraction of metals and reduction)
- ☐ **Tell the difference between bases and alkalis** A base neutralises an acid; an alkali is a base that dissolves in water, such as a soluble metal hydroxide. (Neutralisation of acids and salt production)
- ☐ **Explain why excess solid is added** Excess solid makes sure all the acid reacts, so the salt solution contains no leftover acid. (Soluble salts)
- ☐ **Tell when the solid is in excess** Solid stays undissolved at the bottom, and for a carbonate the fizzing stops. (Soluble salts)
- ☐ **Name the ions in acids and alkalis** Acids produce H^+ ions in water and alkalis produce OH^- ions in water. (The pH scale and neutralisation)
- ☐ **Compare universal indicator with a pH probe** A pH probe gives a more precise numerical reading; universal indicator gives an approximate value from a colour. (The pH scale and neutralisation)
- ☐ **Describe the pH change during neutralisation** As alkali is added to acid, the pH rises to 7 at neutralisation and above 7 when alkali is in excess. (The pH scale and neutralisation)
- ☐ **Predict which electrode each ion moves to** Positive ions move to the cathode and negative ions move to the anode. (The process of electrolysis)
- ☐ **Describe what is seen at each electrode** For lead bromide, silvery lead forms at the cathode and brown bromine vapour at the anode. (Electrolysis of molten ionic compounds)
- ☐ **Name the products from aluminium oxide** Aluminium forms at the cathode and oxygen forms at the anode. (Using electrolysis to extract metals)
- ☐ **Explain why electrolysis is expensive** Large amounts of energy are needed to melt the compound and to produce the electric current. (Using electrolysis to extract metals)

- ☐ **Predict the product at the cathode** Hydrogen forms if the metal is more reactive than hydrogen; otherwise the metal forms. (Electrolysis of aqueous solutions)
 - ☐ **Predict the product at the anode** The halogen forms if halide ions are present; otherwise oxygen forms. (Electrolysis of aqueous solutions)
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Energy changes

- ☐ **Explain energy conservation in a reaction** Energy is not created or destroyed, so in an exothermic reaction the products have less energy than the reactants by the amount transferred. (Energy transfer during exothermic and endothermic reactions)
 - ☐ **Read energy values from a profile** Activation energy = peak – reactants; overall energy change = products – reactants. (Reaction profiles)
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The rate and extent of chemical change

- ☐ **Interpret graphs of product formed against time** The steeper the curve, the faster the rate; a horizontal line means the reaction has stopped. (Calculating rates of reactions)
 - ☐ **Describe the gas-volume method for rates** Measure the volume of gas given off at regular time intervals with a gas syringe or an upturned measuring cylinder. (Factors which affect the rates of chemical reactions)
 - ☐ **Describe the disappearing-cross (turbidity) method** Time how long it takes for a cross under the flask to disappear as a cloudy precipitate forms. (Factors which affect the rates of chemical reactions)
 - ☐ **Explain concentration and pressure effects** There are more particles in the same volume, so collisions are more frequent. (Collision theory and activation energy)
 - ☐ **Explain the effect of surface area** More particles of the solid are exposed to the other reactant, so collisions are more frequent. (Collision theory and activation energy)
 - ☐ **Identify a catalyst from experimental data** It speeds up the reaction, has the same mass at the end and is not in the equation. (Catalysts)
 - ☐ **Describe heating and cooling ammonium chloride** Heating decomposes it into ammonia and hydrogen chloride; cooling makes these gases re-form the white solid. (Reversible reactions)
 - ☐ **Write equations for reversible reactions** Use $\rightleftharpoons$ in word and balanced symbol equations, e.g. $\text{NH}_4\text{Cl} \rightleftharpoons \text{NH}_3 + \text{HCl}$. (Reversible reactions)
 - ☐ **State that equal energy is transferred each way** The energy taken in one way is exactly the same as the energy given out the other way. (Energy changes and reversible reactions)
 - ☐ **Describe the copper sulfate reversible reaction** Heating blue hydrated copper sulfate gives white anhydrous copper sulfate and water; adding water reverses it. (Energy changes and reversible reactions)
 - ☐ **State when equilibrium is reached** When the forward and reverse reactions happen at exactly the same rate. (Equilibrium)
 - ☐ **Know that amounts stay constant at equilibrium** The concentrations of reactants and products stop changing, but they are not necessarily equal. (Equilibrium)
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Organic chemistry

- ☐ **Use the general formula of the alkanes** Recognise an alkane from its formula, and write the formula for any number of carbon atoms: 10 carbon atoms gives $C_{10}H_{22}$. (Crude oil, hydrocarbons and alkanes)

- ☐ **Draw the displayed formula of an alkane** Show every atom and every bond: each carbon atom forms four single bonds and each hydrogen atom forms one. (Crude oil, hydrocarbons and alkanes)

- ☐ **Describe the temperature gradient in the column** The fractionating column is hottest at the bottom and coolest at the top. (Fractional distillation and petrochemicals)

- ☐ **Explain what feedstock means** A raw material used to make other chemicals; fractions are feedstock for the petrochemical industry. (Fractional distillation and petrochemicals)

- ☐ **Choose a suitable fuel using property data** For example, a fuel for a gas stove must have a boiling point below room temperature and be very flammable. (Properties of hydrocarbons)

- ☐ **State what happens to the fuel in combustion** The carbon and hydrogen in the fuel are oxidised, and energy is released. (Properties of hydrocarbons)

- ☐ **Describe the conditions for catalytic and steam cracking** Catalytic: vapour passed over a hot catalyst. Steam: vapour mixed with steam and heated to a very high temperature. (Cracking and alkenes)

- ☐ **Give uses of the products of cracking** Smaller alkanes are used as fuels such as petrol; alkenes are used to make polymers and many other chemicals. (Cracking and alkenes)

Chemical analysis

- ☐ **Describe how impurities change melting and boiling** Impurities lower the melting point and widen the melting range; dissolved impurities raise the boiling point. (Pure substances)

- ☐ **Interpret heating curves to judge purity** A flat section at a fixed temperature shows a pure substance changing state; a sloping section shows a mixture. (Pure substances)

- ☐ **Explain why quantities are carefully measured** The right amount of each component gives the product the properties it needs. (Formulations)

- ☐ **Suggest the purpose of a component** Use the information given, e.g. a pigment gives colour and a sweetener improves taste. (Formulations)

- ☐ **Calculate an R_f value** $R_f = \text{distance moved by substance} \div \text{distance moved by solvent}$, both measured from the start line. (Chromatography)

- ☐ **Name reactions that produce hydrogen** Metals with acids, very reactive metals with water, and electrolysis of many solutions (at the negative electrode). (Test for hydrogen)

- ☐ **Name reactions that produce oxygen** Decomposition of hydrogen peroxide, electrolysis (at the positive electrode) and photosynthesis. (Test for oxygen)

- ☐ **Describe how to test gas from a reaction** Use a delivery tube to bubble the gas from the reaction through limewater. (Test for carbon dioxide)

- ☐ **Name reactions that produce carbon dioxide** Acids with metal carbonates, and complete combustion of fuels that contain carbon. (Test for carbon dioxide)

- ☐ **Name a reaction that produces chlorine** Electrolysis of a chloride solution, such as sodium chloride solution: chlorine forms at the positive electrode. (Test for chlorine)

Chemistry of the atmosphere

- ☐ **Calculate the volume of a gas in air** Multiply the total volume by the percentage divided by 100, e.g. $20 \div 100 \times 500 \text{ cm}^3 = 100 \text{ cm}^3$ of oxygen. (The proportions of different gases in the atmosphere)
- ☐ **Name other gases in the early atmosphere** Nitrogen from volcanoes gradually built up, and there may have been small proportions of methane and ammonia. (The Earth's early atmosphere)
- ☐ **State when algae first produced oxygen** Algae first produced oxygen about 2.7 billion years ago, and oxygen appeared in the atmosphere soon after. (How oxygen increased)
- ☐ **Describe how limestone formed** Shells and skeletons of sea creatures, made of calcium carbonate, settled, were buried and were compressed into rock. (How carbon dioxide decreased)
- ☐ **Describe how coal formed** Remains of plants, mainly trees, were buried and compressed over millions of years. (How carbon dioxide decreased)
- ☐ **Describe what happens to the Sun's radiation** Short wavelength radiation from the Sun passes through the atmosphere and is absorbed by the Earth's surface, warming it. (Greenhouse gases)
- ☐ **Explain how deforestation increases carbon dioxide** Burning the trees releases carbon dioxide, and fewer trees are left to remove it by photosynthesis. (Human activities which contribute to an increase in greenhouse gases in the atmosphere)
- ☐ **Describe four different potential effects** Give four clearly different effects, each with a short consequence, e.g. sea levels rise, causing flooding. (Global climate change)
- ☐ **Describe actions to reduce emissions** Alternative energy, energy conservation, carbon capture and storage, carbon taxes and licences, carbon off-setting and carbon neutrality. (The carbon footprint and its reduction)
- ☐ **Describe how carbon monoxide and soot form** Incomplete combustion in a limited supply of oxygen produces carbon monoxide and carbon particles (soot). (Atmospheric pollutants from fuels)
- ☐ **Describe how sulfur dioxide forms** Sulfur in the fuel reacts with oxygen when the fuel burns. (Atmospheric pollutants from fuels)
- ☐ **Explain why carbon monoxide is hard to detect** It is colourless and odourless, so you cannot see or smell it. (Properties and effects of atmospheric pollutants)

Using resources

- ☐ **Define sustainable development** Development that meets the needs of current generations without compromising the ability of future generations to meet their own needs. (Using the Earth's resources and sustainable development)
- ☐ **Give reasons for each treatment step** Filter beds remove solid particles; sterilising with chlorine, ozone or ultraviolet light kills microbes. (Potable water)
- ☐ **Name two methods of desalination** Distillation, and processes that use membranes such as reverse osmosis. (Potable water)
- ☐ **List the stages of sewage treatment in order** Screening and grit removal, sedimentation, anaerobic digestion of the sludge, and aerobic biological treatment of the effluent. (Waste water treatment)

- ☐ **Compare plastic and paper bags using an LCA** Plastic bags come from crude oil (finite) but can be reused many times; paper bags come from trees but are reused less. (Life cycle assessment)
- ☐ **Describe how glass and metals are recycled** Glass is crushed and melted to make different glass products; metals are melted and recast or reformed. (Ways of reducing the use of resources)
- ☐ **Explain why recycling saves resources and energy** Less of a limited raw material is used, and usually less energy than extracting and processing new material. (Ways of reducing the use of resources)

Energy

- ☐ **Describe energy changes in common situations** Say which store decreases and which increases, e.g. a braking car: kinetic store down, thermal store of the brakes up. (Energy stores and systems)
- ☐ **Calculate kinetic energy** Square the speed first, then multiply by the mass and by 0.5. (Changes in energy)
- ☐ **Calculate elastic potential energy of a spring** Use $E_e = \frac{1}{2} k e^2$ with the extension in metres, as long as the limit of proportionality is not exceeded. (Changes in energy)
- ☐ **Calculate energy using $\Delta E = m c \Delta \theta$** Find the temperature change first, then multiply mass $\times$ specific heat capacity $\times$ temperature change. (Energy changes in systems)
- ☐ **Compare the power of two machines** If two motors do the same work, the one that takes less time has the greater power. (Power)
- ☐ **Explain how lubrication reduces wasted energy** Oil reduces friction between moving parts, so less energy is dissipated by heating. (Energy transfers in a system)
- ☐ **Explain how insulation reduces energy transfer** Thermal insulation lowers the rate of energy transfer by heating, e.g. loft insulation in a house. (Energy transfers in a system)
- ☐ **Give efficiency as a decimal or percentage** Multiply the decimal by 100 to get a percentage; efficiency is never more than 1 (100%). (Efficiency)
- ☐ **Calculate efficiency from power values** Divide the useful power output by the total power input. (Efficiency)
- ☐ **Explain why some resources are more reliable** Wind, solar and waves depend on the weather (and solar on the time of day); fossil fuels and nuclear do not. (National and global energy resources)

Electricity

- ☐ **Recognise thermistor and LDR symbols** Both start from the resistor box: the thermistor has a line with a flat tail through it, the LDR has two arrows pointing in. (Standard circuit diagram symbols)
- ☐ **Place ammeters and voltmeters correctly** Draw an ammeter in series with a component and a voltmeter in parallel across it. (Standard circuit diagram symbols)
- ☐ **State that current is the same around a loop** In a single closed loop the current has the same value at every point. (Electrical charge and current)
- ☐ **Rearrange $V = I R$ for I or R** Use $I = V \div R$ and $R = V \div I$, converting $k\Omega$ and mA first. (Current, resistance and potential difference)
- ☐ **Identify an ohmic conductor from its graph** At constant temperature, current is directly proportional to pd, so the I - V graph is a straight line through the origin. (Resistors)

- ☐ **Describe how a diode controls current** Current flows in one direction only; the diode has a very high resistance in the reverse direction. (Resistors)

- ☐ **Find a missing current or pd** e.g. the supply pd equals the sum of the pds in series; the total current equals the sum of the branch currents. (Series and parallel circuits)

- ☐ **Explain the difference between dc and ac** A direct pd acts in one direction only; an alternating pd keeps reversing direction. (Direct and alternating potential difference)

- ☐ **State the potential of each wire** Live is about 230 V (compared with earth); neutral is at or close to 0 V; earth is at 0 V. (Mains electricity)

- ☐ **Rearrange $P = VI$** Use $I = P \div V$, e.g. to find the current an appliance takes from the mains. (Power)

- ☐ **Calculate energy using $E = QV$** Charge in coulombs $\times$ pd in volts gives energy in joules. (Energy transfers in everyday appliances)

Particle model of matter

- ☐ **Rearrange the density equation** Use $m = \rho \times V$ to find a mass and $V = m \div \rho$ to find a volume. (Density of materials)

- ☐ **Describe the density required practical** Measure mass on a balance and find volume from measured dimensions or by displacement of water. (Density of materials)

- ☐ **Describe particle changes during melting and boiling** Describe how the arrangement, spacing and motion of the particles change. (Changes of state)

- ☐ **Explain why a change of state is physical** No new substance is made: if the change is reversed, the material recovers its original properties. (Changes of state)

- ☐ **State the two possible effects of heating** Heating either raises the temperature of the system or produces a change of state. (Internal energy)

- ☐ **Link temperature to the particles' kinetic energy** A higher temperature means the particles have a higher average kinetic energy: they move or vibrate faster. (Internal energy)

- ☐ **Work out the temperature change $\Delta\theta$** $\Delta\theta$ is the difference between the final and starting temperatures, not the final temperature. (Temperature changes in a system and specific heat capacity)

- ☐ **Define specific latent heat** The amount of energy needed to change the state of 1 kg of a substance with no change in temperature. (Changes of state and specific latent heat)

- ☐ **Use $E = mL$** Calculate the energy for a change of state with E in J, m in kg and L in J/kg. (Changes of state and specific latent heat)

- ☐ **Find changes of state on heating graphs** Flat sections show a change of state at the melting or boiling point; sloping sections show a temperature change. (Changes of state and specific latent heat)

- ☐ **Explain how a gas exerts pressure** Molecules collide with the walls of the container and exert a force on them; the force on each unit area is the pressure. (Particle motion in gases)

Atomic structure

- ☐ **Compare the sizes of atom and nucleus** The nucleus has a radius less than 1/10 000 of the atom's radius, yet contains almost all of its mass. (The structure of an atom)

- ☐ **Work out protons, neutrons and electrons** Protons = atomic number; neutrons = mass number – atomic number; electrons = protons in a neutral atom. (Mass number, atomic number and isotopes)

- ☐ **Describe the nuclear model** A tiny, positively charged nucleus containing most of the mass, with electrons around it. (The development of the model of the atom)

- ☐ **Compare plum pudding and nuclear models** Charge and mass spread out, compared with concentrated in a nucleus with empty space around it. (The development of the model of the atom)

- ☐ **Describe what each radiation is** Alpha: 2 protons and 2 neutrons; beta: a fast electron from the nucleus; gamma: electromagnetic radiation. (Radioactive decay and nuclear radiation)

- ☐ **State how alpha decay changes a nucleus** The mass number falls by 4 and the atomic number falls by 2. (Nuclear equations)

- ☐ **State how beta decay changes a nucleus** The mass number stays the same and the atomic number goes up by 1. (Nuclear equations)

- ☐ **Explain why gamma emission changes neither number** Gamma is electromagnetic radiation with no mass and no charge. (Nuclear equations)

- ☐ **Explain what random decay means** You cannot predict which nucleus will decay or when, but a large sample decays in a predictable way. (Half-lives and the random nature of radioactive decay)

- ☐ **Find a half-life from a graph** Read the time for the activity or count rate to fall to half of any starting value. (Half-lives and the random nature of radioactive decay)

- ☐ **State that irradiation does not cause radioactivity** An irradiated object does not become radioactive. (Radioactive contamination)

Forces

- ☐ **Represent a vector with an arrow** The length of the arrow shows the magnitude and the way it points shows the direction. (Scalar and vector quantities)

- ☐ **Identify the forces acting in a situation** For example, a book on a table has its weight acting down and a normal contact force acting up. (Contact and non-contact forces)

- ☐ **Show forces as vector arrows** Draw each arrow from the object, in the direction of the force, with its length showing the size. (Contact and non-contact forces)

- ☐ **Find mass or g from a weight** $m = W \div g$ and $g = W \div m$. (Gravity)

- ☐ **Describe how to measure weight** Hang the object from a calibrated spring-balance (a newtonmeter). (Gravity)

- ☐ **Recognise balanced forces (zero resultant)** If the resultant force is zero, the object stays at rest or keeps moving at a steady velocity. (Resultant forces)

- ☐ **Find force or distance from work done** $F = W \div s$ and $s = W \div F$. (Work done and energy transfer)

- ☐ **Convert between joules and newton-metres** $1 \text{ J} = 1 \text{ N m}$, so 250 N m of work is 250 J. (Work done and energy transfer)

- ☐ **Calculate force or extension with $F = ke$** For example, $k = 40 \text{ N/m}$ and $e = 0.15 \text{ m}$ give $F = 6.0 \text{ N}$. (Forces and elasticity)

- ☐ **Describe the spring extension required practical** Hang known weights on a spring, measure its length each time, calculate the extension and plot force against extension. (Forces and elasticity)

- ☐ **Calculate distance and displacement along a line** 40 m east then 15 m west: distance 55 m, displacement 25 m east. (Distance and displacement)

- ☐ **Explain why displacement can be zero** After a round trip back to the start, the displacement is zero although the distance travelled is not. (Distance and displacement)

- ☐ **Find speed or time using $s = vt$** $v = s \div t$ and $t = s \div v$. (Speed)

- ☐ **Calculate average speed for a whole journey** Average speed = total distance $\div$ total time. (Speed)

- ☐ **Use + and – signs for velocity** Along a line, e.g. +4 m/s to the right and –4 m/s to the left. (Velocity)

- ☐ **Calculate speed from the gradient** Speed = change in distance $\div$ change in time for a straight section. (The distance–time relationship)

- ☐ **Find acceleration from a velocity–time graph** Acceleration = gradient = change in velocity $\div$ time taken. (Acceleration)

- ☐ **Explain steady motion using balanced forces** A zero resultant force means there is no change in speed or direction. (Newton's First Law)

- ☐ **Find mass or acceleration using $F = ma$** $a = F \div m$ and $m = F \div a$. (Newton's Second Law)

- ☐ **Describe how acceleration depends on force and mass** Acceleration is proportional to the resultant force and inversely proportional to the mass. (Newton's Second Law)

- ☐ **Identify Third Law partner forces** If a boy pushes a wall with 150 N, the wall pushes the boy with 150 N in the opposite direction. (Newton's Third Law)

- ☐ **Calculate thinking distance using $s = v t$** Thinking distance = speed $\times$ reaction time. (Stopping distance)

- ☐ **Calculate thinking distance from reaction time** Thinking distance = speed $\times$ reaction time. (Reaction time)

- ☐ **Describe the ruler-drop reaction time test** Catch a dropped ruler; the further it falls before you catch it, the longer your reaction time. (Reaction time)

- ☐ **Explain the effects of worn tyres and brakes** Worn tyres grip the road less; worn brakes produce a smaller friction force. (Factors affecting braking distance 1)

- ☐ **Calculate the work done by a braking force** $W = F s$, where s is the braking distance. (Factors affecting braking distance 2)

- ☐ **Link braking force to deceleration** The greater the braking force, the greater the deceleration ($F = m a$). (Factors affecting braking distance 2)

Waves

- ☐ **Describe how transverse and longitudinal waves differ** Compare the direction of the oscillations with the direction of energy transfer: perpendicular for transverse, parallel for longitudinal. (Transverse and longitudinal waves)

- ☐ **Identify compressions and rarefactions** In a longitudinal wave, compressions are where the particles are close together and rarefactions are where they are spread out. (Transverse and longitudinal waves)

- ☐ **Use $T = 1/f$** Find the period from the frequency, or the frequency from the period, e.g. $f = 50 \text{ Hz}$ gives $T = 1 \div 50 = 0.02 \text{ s}$. (Properties of waves)

- ☐ **State that all EM waves travel equally fast** All EM waves travel at the same speed through a vacuum (space) or air: $3.0 \times 10^8 \text{ m/s}$. (Types of electromagnetic waves)

- ☐ **Give examples of EM waves transferring energy** E.g. infrared from a fire warming your skin, or microwaves heating food in an oven. (Types of electromagnetic waves)

- ☐ **Draw a ray diagram for refraction** Draw the normal; a ray that slows down (e.g. air into glass) bends towards the normal. (Properties of electromagnetic waves 1)

- ☐ **State which surfaces emit and absorb infrared best** Matt black surfaces are the best emitters and absorbers of infrared; shiny silver surfaces are the worst. (Properties of electromagnetic waves 1)

- ☐ **State the effects of X-rays and gamma rays** They are ionising radiation and can cause mutation of genes and cancer. (Properties of electromagnetic waves 2)

- ☐ **State where gamma rays come from** Gamma rays come from changes in the nucleus of an atom. (Properties of electromagnetic waves 2)

- ☐ **Give uses of visible light and ultraviolet** Visible light: fibre optic communications. Ultraviolet: energy-efficient lamps and sun tanning. (Uses and applications of electromagnetic waves)

Magnetism and electromagnetism

- ☐ **Describe the difference between permanent and induced magnets** A permanent magnet produces its own magnetic field; an induced magnet only becomes a magnet when it is placed in a magnetic field. (Poles of a magnet)

- ☐ **Plot a magnetic field using a compass** Mark where the compass needle points, move the compass on, repeat, then join the dots from N to S. (Magnetic fields)

- ☐ **State how field strength depends on distance** The field is strongest at the poles and gets weaker further from the magnet. (Magnetic fields)

- ☐ **Draw the field around a straight wire** Circles centred on the wire, further apart further out, with arrows showing the direction. (Electromagnetism)

- ☐ **State what affects the strength of the field** The field is stronger for a bigger current, and weaker further from the wire. (Electromagnetism)

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