

A characteristic of matter that can be observed or measured without changing the chemical composition of the substance	Density Melting point Solubility Electrical conductivity Hardness Malleability etc	Atoms Ions Molecules (electrons)	Arrangement of particles Types of particles present Strength of attractive forces between particles
What is a physical property?	What is an example of a physical property?	What particles make up materials?	What determines physical properties of a material?
Separate molecules made from NM atoms joined by strong covalent bonds e.g. H ₂ O, I ₂ , CO ₂ etc	Weak intermolecular forces attract molecules to each other	Only weak intermolecular forces need to be overcome to separate molecules – less energy is required	Iodine molecules are larger and have stronger intermolecular forces, requiring more energy to separate them.
What are molecular substances made from?	What forces hold molecular substances to each other?	Why do molecular substances usually have low mpt and bpt?	Why is iodine a solid at room temperature but water is a liquid?
They are molecules with no freely moving charged particles (no delocalised e ⁻ or ions)	Water molecules are polar and can attract charged particles (ions) and polar molecules	A lattice of positive metal ions surrounded by delocalised electrons	The strong attraction between positive metal ions and delocalised electrons
Why do molecular substances not conduct electricity?	Why does water dissolve many substances?	What are metallic solids made from?	What is metallic bonding?
Delocalised electrons can move through the structure and carry electrical charge	Mobile electrons transfer thermal energy quickly through the metal	Layers of metal ions can slide while the metallic bonds remain intact	Conduct electricity due to mobile / delocalised electrons Can be drawn into wires because they are ductile
Why do metals conduct electricity?	Why do metals conduct heat?	Why are metals malleable and/or ductile?	Why are metals useful for wires?

A 3D lattice of positive and negative ions M + NM ions e.g. NaCl	Strong electrostatic attraction between oppositely charged ions	Strong ionic attractions require large amounts of (heat) energy to overcome	If layers shift, ions with the same charge become aligned. Like charges repel, causing the structure to break
What are ionic materials made from?	What holds ionic materials together?	Why do ionic compounds have high melting points?	Why are ionic solids brittle?
Ions are free to move and carry electrical charge	The ions are fixed in place and cannot move	Large molecules made from repeating smaller units called monomers e.g. DNA, polyethene	Length of chains, arrangement of chains, strength of forces between chains, cross-linking between chains etc
Why do ionic compounds conduct electricity when molten or dissolved / aq ?	Why does solid sodium chloride not conduct electricity?	What are polymers?	What determines the properties of a polymer?
Polymer chains can move and slide past each other	Strong forces or cross-links hold polymer chains together.	Chemically resistant, waterproof, durable, non-stick, electrical and heat insulators etc	Giant structures where atoms are joined by many strong covalent bonds e.g. diamond, graphite
Why are many polymers flexible?	Why are some polymers strong and rigid?	Why are polymers useful as coatings?	What are covalent network solids?
Many strong covalent bonds must be broken to separate atoms	Each carbon atom is strongly bonded to four other carbon atoms in a rigid 3D structure	It has delocalised electrons that can move between carbon layers	Layers of carbon atoms are held together by weak forces and can slide past each other
Why does diamond have a high melting point?	Why is diamond very hard?	Why can graphite conduct electricity?	Why is graphite soft / slippery?

Strong attractive forces between particles require more (heat) energy to overcome	Weak attractive forces between particles require less (heat) energy to overcome	Rigid arrangements with strong bonds resist movement, making materials harder	Materials with particles that can move or slide are more flexible
What causes a material to have a high melting point?	What causes a material to have a low melting point?	Why does particle arrangement affect hardness?	Why does particle arrangement affect flexibility?
Electrical conduction requires mobile charged particles such as electrons or ions	Property ↓ Particle arrangement ↓ Attractive forces ↓ Suitability for use	Metallic bonding with delocalised electrons that move through structure, allowing electrical conductivity; also ductile allowing it to be drawn into wires	Giant covalent network with strong covalent bonds throughout structure, making it extremely hard and able to cut other materials
Why does particle type affect conductivity?	How do you evaluate the use of a material?	Explain why copper is used for electrical wires.	Explain why diamond is used in cutting tools.
has layers of carbon atoms held together by weak forces, allowing layers to slide over each other easily	ionic compounds contain ions that can dissolve in water, allowing ions to become available for plant uptake	Structure arrangement of particles → Forces strength of attraction → Property observed behaviour → Use why material is suitable	"The arrangement of ____ means there are ____ forces between particles. This gives the material the property of ____, making it suitable for ____."
Explain why graphite is used as a lubricant.	Explain why potassium nitrate is used as a fertiliser ingredient.	What structure-property-use link should you always include in an Excellence answer?	"The material is suitable because..."
Metals: because delocalised electrons can move Graphite: because it has delocalised electrons	Ionic compounds conduct because their ions can move	They lack mobile electrons and heat is transferred less efficiently between separate molecules	Metal atoms are packed closely together in a regular lattice, so there is more mass in a given volume
Which types of materials conduct electricity as solids?	Which types of materials conduct electricity when molten or dissolved in water?	Why are most molecular substances poor conductors of heat?	Why are metals generally denser than molecular substances?

All four outer electrons of each carbon atom are used in covalent bonds, leaving no delocalised electrons to carry charge	Graphite has one delocalised electron per carbon atom that can move between layers. In diamond, all electrons are involved in covalent bonds and cannot move	Polar water molecules attract and separate the positive and negative ions from the ionic lattice	It is chemically unreactive, has a slippery surface, withstands high temperatures, and food does not stick to it
Why is diamond an electrical insulator?	Why is graphite a good electrical conductor but diamond is not?	Why do ionic compounds often dissolve in water?	Why is polymer PTFE suitable for cookware?
They have metallic bonding, are strong, relatively light, and able to withstand repeated impacts	They are very large molecules made from many repeating smaller units joined together by covalent bonds	A mixture of a metal with one or more other elements (usually M, but sometimes NM) that has improved properties compared with the pure metal	The different-sized atoms in an alloy distort the regular layers of metal atoms, making it more difficult for the layers to slide past each other
Why are magnesium alloys used for car wheels?	Why are proteins and DNA classified as polymers?	What is an alloy?	Why are alloys usually harder than pure metals?
Alloys are often stronger, harder, more durable, or more resistant to corrosion than pure metals, making them more suitable for many applications	Strong covalent bonds between C atoms make graphene extremely strong. Each C atom also has one delocalised electron that can move through the sheet, allowing it to conduct electricity	Graphene is a single layer of carbon atoms arranged in a hexagonal (honeycomb) pattern. Each carbon atom is covalently bonded to three others, forming a giant covalent network	The carbon fibres contain strong covalent bonds, making the material very strong, while its low density makes it lightweight Explain
Why are alloys often used instead of pure metals?	Why is graphene both strong and a good conductor of electricity?	What is graphene, and how is it structured?	Why is carbon fibre used to make aircraft parts, racing cars, and bicycle frames?
NaCl is ionic, made of a 3D lattice of positive and negative ions. Strong electrostatic attractions between oppositely charged ions require large amounts of energy to overcome, giving it a high melting point	The alloy has low density , so it is lightweight. It is harder than pure Al because different-sized atoms disrupt the metal lattice, preventing layers from sliding, making it stronger and more durable	Aluminium has a low density, making aircraft lighter while remaining strong	Strong covalent bonds hold C atoms within each layer, but weak forces between layers allow the layers to slide off easily, making graphite soft enough to leave a mark
Explain why sodium chloride has a high melting point.	Why is an Al-Mg alloy better for a kayak paddle than pure Al or steel?	Explain why aluminium alloys are used in aircraft construction.	Explain why graphite is used in pencil 'leads'.

