



order that repeats in three dimensions, and the ways it breaks



Types of Solids

Crystalline

- constituent particles have a **long range order**, the periodic arrangement repeats through the whole bulk
- sharp, definite melting point
- anisotropic: refractive index, conductivity and other properties differ by direction
- e.g. ice, NaCl, sodium, gold, diamond, graphite

Amorphous

- particles are randomly arranged, only a **short range order** survives, essentially supercooled liquids
- no sharp melting point, softens gradually over a temperature range
- isotropic: every property has the same value in every direction
- e.g. glass, plastic, rubber, tar

most crystalline solids, including metals, are polycrystalline: made of many single crystallites packed at different orientations. A true single crystal is rare, diamond is one of the few that forms naturally

Isomorphism and Polymorphism *

- isomorphism: different substances sharing one crystal structure, with the same atomic ratio. NaF and MgO (1:1), NaNO_3 and CaCO_3 (1:1:3)
- polymorphism: one substance existing in more than one crystal structure, formed under different conditions. Calcite and aragonite (both CaCO_3), alpha-quartz, beta-quartz and cristobalite (all SiO_2)
- polymorphism restricted to elements has its own name: allotropy. Diamond, graphite and fullerene are the allotropes of carbon

Classification of Crystalline Solids

Ionic

particles: cations and anions. Held by electrostatic (coulomb) force. Hard and brittle, high melting point. Insulator as a solid, conducts once melted or dissolved in water. e.g. NaCl, CaF_2

Covalent network

particles: atoms linked by a continuous network of covalent bonds, the whole crystal is one giant molecule. Very hard, high melting point, poor conductor. Diamond conducts heat well and graphite conducts electricity well, the two named exceptions. e.g. diamond, quartz

Molecular

particles: molecules (or lone atoms) held by London forces, dipole-dipole forces or hydrogen bonds. Soft, low melting point, insulator. e.g. ice, solid CO_2 , solid argon

Metallic

particles: metal ions sitting in a sea of delocalised electrons, the metallic bond. Malleable and ductile, good conductor of heat and electricity, hardness varies widely. e.g. Na, Cu, Au

