Physical Properties of Molecular Solids – Based on Intermolecular Forces

	Van Der Waals Forces	Dipole Interactions	Hydrogen Bond
relative strength	1 kcal/mol ≈ 4 kJ/mol (can add up to more in larger molecules)	3–5 kcal/mol ≈ 13–21 kJ/mol (per interaction)	10 kcal/mol ≈ 42 kJ/mol (per interaction)
nature of force	electrostatic force of attraction between electrons in one molecule with nuclear charges in a neighboring molecules	electrostatic force of attraction between regions of partial positive or negative charge on one molecule with regions of partial negative or positive charge respectively on a neighboring molecules	electrostatic force of attraction between the positive charge of an "exposed" proton on one molecule and the negative charge of a lone pair on a neighboring molecule
required circumstance	occurs between any discrete covalent molecules but is often overshadowed by a stronger intermolecular force do not consider V. D. W. forces unless no other forces are operating	requires discrete covalent molecules with elements that differ in electronegativity in order to generate regions of partial charge requires a molecular geometry that does not cancel out regions of partial charge (i.e. unsymmetrical molecules)	require a hydrogen that is bonded to the very electronegative elements N, O, or F in order to create the exposed proton AND interaction with the lone pair on another N, O, or F in order to create the stronger interaction of a true hydrogen bond only N, O, or F are electronegative enough to "expose" a proton and only N, O, or F have a dense enough lone pair orbital to interact with the exposed proton to form a "bond"
conditions that alter strength	total number of electrons in molecule: the greater the number of electrons in the molecule the greater the v.d.W. force molecular shape: good surface contact between molecules increases force particularly in liquids, good packing geometry increases force in a solid	magnitude of partial charges: the greater the difference in electronegativity, the greater the partial charge, the great the force of attraction geometry: a geometry that maximizes the availability of partial charge will enhance the force of attraction	all hydrogen bonds are roughly equivalent in strength, see above for required conditions
crystal structure of solid	nil to slight: usually fairly mushy like a wax	slight to considerable: depends packing geometry in the crystal	moderate to highly crystalized: depends on packing geometry in the crystal, ice forms highly crystalline structure under the right conditions
melting and boiling points	low for the size of the molecule	low to moderate	can be fairly high for the size of the molecule
examples	alkanes, alkenes, alkynes, aromatic rings	ketones, aldehydes, ethers	carboxylic acids, alcohols, water, sucrose, glucose, fructose