

Intramolecular and Intermolecular Forces
(after, Silberberg, *Chemistry*, Table 12-2, McGraw Hill)

	Type of Force	Interaction	Energy Range (kJ/mol) per interaction		Examples
intramolecular bonding interactions	ion-ion	cation-anion	400-4000	strong	$\text{Na}^+\text{Cl}^-(\text{s})$, $\text{Ba}^{2+}\text{O}^{2-}(\text{s})$
	covalent	shared electron pairs	150-1100	strong	$\text{F}_2(\text{g})$, $\text{CH}_4(\text{g})$, $\text{C}_2\text{H}_4(\text{g})$
	metallic	nuclear cations + 'sea of valence electrons'	75-1000	strong	$\text{Mg}(\text{s})$, $\text{Na}(\text{s})$
intermolecular interactions	ion-dipole	charged ion—permanent dipole (δ^+ — δ^-)—	40-600	strong	$\text{Na}^+ - \text{H}_2\text{O}$,
	hydrogen bond	polar $-\text{H}^{\delta^+}$ with non-bonding electron pair (δ^-) on $:\text{N}-$, $:\text{O}-$, $:\text{F}-$ $-\text{H}^{\delta^+} \quad \circ \quad \circ \quad :\text{O}^{\delta^-} -$	10-40	moderate	$\text{H}_2\text{O}-\text{H}_2\text{O}$, $\text{H}_2\text{O}-\text{CH}_3\text{OH}$, $\text{H}_2\text{O}-\text{NH}_3$, between bases on strands of DNA and RNA
	dipole-dipole	permanent dipoles interact ($\delta^+-\delta^-$)—($\delta^+-\delta^-$); <i>polar-polar</i>	5-25	moderate	$\text{HCl}-\text{HCl}$
	ion-induced dipole	ion with dipole induced by ion ; <i>ion - non polar</i>	3-15	weak	$\text{Fe}^{2+} - \text{O}_2$
	dipole- induced dipole	permanent dipole with dipole induced by polar molecule <i>polar - non polar</i>	2-10	weak	$\text{HCl}-\text{Cl}_2$
	dispersion (London or van der Waals)	instantaneous dipole induces dipole <i>non polar - non polar</i>	0.05-40	weak	$\text{Ar}(\text{g}) - \text{Ar}(\text{g})$, $\text{C}_6\text{H}_{14} - \text{C}_6\text{H}_{14}$
many become quite strong due to many interactions					