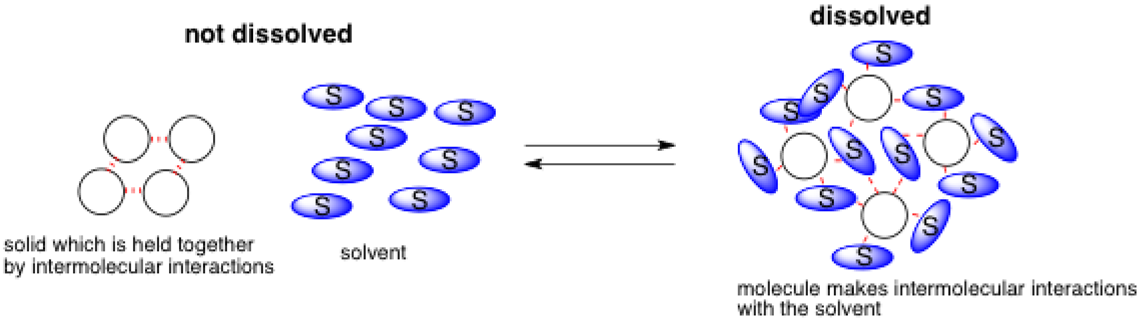
The key is to understand why a molecule might want to dissolve in a solvent (or if two solvents are miscible)? Condensed matter has cohesive molecule-molecule interactions that keep them together as a solid (or liquid). So why would it want to break these interactions?

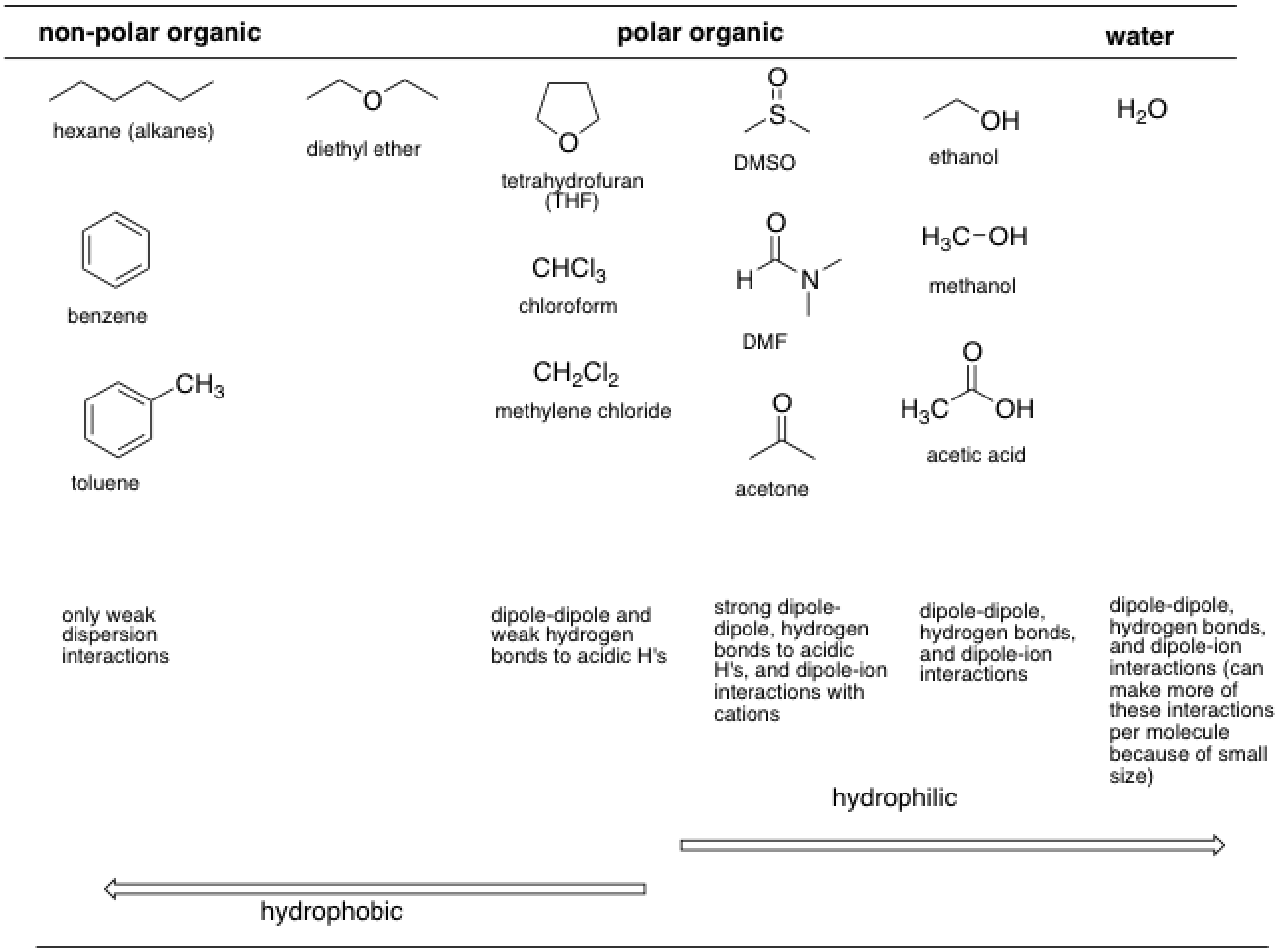
The answer is that a solvent will dissolve a molecule if the solvent can form equally strong or stronger molecule-solvent interactions than the molecule-molecule interactions. In other words, does the molecule like the solvent more than it likes itself?



In order to answer this question, we have to be able to predict what interactions a molecule can make with itself or a solvent and what the relative strengths of these interactions are. Below are a list of intermolecular interactions and their relative strengths.

interaction	nature of attraction	strength	types of functional groups
ion-ion	the attraction of a positively and negatively charged ions	very strong	molecules with charges such as ionic species
ion-dipole	interaction of a molecule with a charge and a molecule with a dipole	strong	an example is the interaction of water (that has strong dipole) with positive and negative ions (like Na^+ or Br^-)
hydrogen-bond	special type of dipole-dipole interaction between an acidic hydrogen (δ+) and a lone pair (δ-).	medium	**alcohols, carboxylic acids, 1° and 2° amides, thiols, 1° and 2° amines** (any molecule with a lone pair **and** an acidic hydrogen)
dipole-dipole	strong molecular dipoles generate partial charges (δ+ and δ-)	weak	**ketones, esters, (C=O), alkyl halides**, (any molecule with a dipole or a strongly polarized bond)
dispersion (London forces)	attraction of weak random dipoles formed on molecular surfaces	very weak	**alkanes, alkenes, benzenes** (larger the surface area the better - shape and size matters) (every molecule can form these but they are weak so if there are other interactions, those interactions will be dominant.)

We also need to classify the common solvents by their ability to make the above continuum. Notice that as we go toward water, we can make more an more of the strong intermolecular forces. And on the left-hand side, the non-polar organic solvents can only make weak intermolecular (dispersion) interactions.



How to:

So the simplest prediction that we can make is: will a molecule dissolve in non-polar organic solvent (hydrophobic) or in water (hydrophilic).

Molecules that have strong cohesive molecule-molecule interactions such as ions (charged molecules and salts) or strong hydrogen bonds (alcohols, carboxylic acids etc) will not dissolve in non-polar solvents because the hydrophobic solvents cannot form strong interactions with these molecules. Water, on the hand, can form strong ion-dipole and hydrogen bonding interactions and thus can dissolve molecules that are held together by strong cohesive interactions.

Non-polar organic solvents will dissolve hydrophobic molecules, which are molecules that do not have polar groups like ions and hydrogen bonding functionality (alcohols, carboxylic acids. The reason is that they are all in the 'weakly attractive club' so the solvent can break the weak molecule-molecule dispersion interactions.

One interesting question is why doesn't water dissolve hydrophobic molecules (and solvents)? The answer is that, yes, water can form cohesive interactions with hydrophobic molecules but that water can form much stronger cohesive interactions with itself. So water, effectively, excludes the 'unattractive' hydrophobic molecules from its 'clique' of 'attractive molecules' like itself.