Introduction

In this note pack, we will classify solutions into two broad categories based on how the solutions are put together. We do this because it's easy to describe the properties of these two classes of solution. The actual properties of solutions will be the topic of the next note pack - here we will just classify.

Molecular solutions

Molecular solutions are defined as solutions of atoms or molecules dissolved in one another. There are many types of molecular solutions: air, sugar water, and booze are all examples of molecular solutions.

Molecular solutions are formed when molecules/atoms that are held together by similar intermolecular forces dissolve in each other, The more similar the forces, the easier it is for the molecules to interact and dissolve one another. The more different the forces, the harder it is for the molecules to interact, because the dissolving substance would rather interact with itself than the solvent.

This is the "like dissolves like" principle we discussed previously.

It's helpful at this point to look at a few examples:

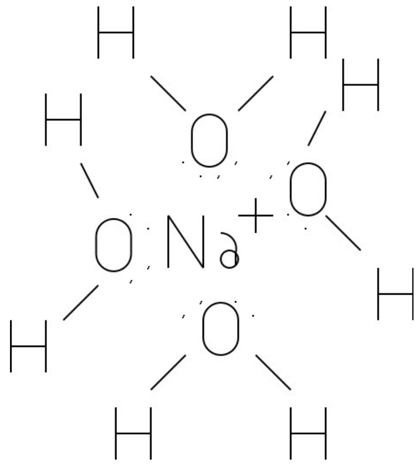
1) **Any two gases**: We assume that gas molecules actually don't interact with each other at all (remember the kinetic theory). So, gas molecules have similar intermolecular forces - no gas molecule cares what kind of molecule is nearby, as the other gas molecule is still too far away to have much influence! Gases are therefore miscible - any amount of one gas will dissolve in another.

2) **Liquids**: Liquids will only dissolve well in other liquids when the forces holding the liquids together are similar. Polar liquids will dissolve in other polar liquids, but not in nonpolar liquids. Liquids that hydrogen bond dissolve best in other liquids that hydrogen bond (and they won't dissolve well in nonpolar liquids).

3) **Solids and liquids**: Molecular solids will dissolve well in liquids held together by similar intermolecular forces. Thus, candle wax (nonpolar) will dissolve in nonpolar solvents, but not in water.

Ionic solutions

Another type of solution is the ionic solution. In an **ionic solution**, **ions** from an ionic species interact with **polar** solvent molecules. If we were to draw what happens in an ionic solution, we might come up with this:

	• Water is polar - the oxygen end (oxygen is electronegative) has a slight negative charge and the hydrogen end has a slight positive charge. • Note that the positively charged sodium ion is attracted to the oxygen end of the water molecule. • If this were a solution of sodium chloride, chloride (Cl^{-}) ions would be surrounded by the hydrogen ends of water molecules.
Illustration 1 - A sodium ion in water	

In solution, the polar molecules surround the ion (this surrounding of ions is what lets polar solvents break up ionic solids in the first place. If the **energy released when an ion is dissolved** (the "energy of hydration") can overcome the **energy holding the crystal lattice of the ionic solid together** (the "lattice energy"), then the ionic compound will dissolve in water.

What affects these two energies? The **hydration energy** depends on how easily water molecules can surround the ion. **Smaller** ions are easier to enclose in water than larger ones. Given similarly sized ions, the energy of hydration also increases with charge.

The lattice energy depends on similar factors. Ions with large charges (+2, etc.) are attracted strongly to each other, so the force holding the crystals together is strong. On the other hand, larger ions are harder to pack in a crystal, so lattice energy is smaller for very large ions.

Which effects dominate? Very small ions like sodium tend to dissolve in water easily, while very large, highly charged ions tend to be insoluble. This should agree with what you remember of the solubility rules.

<u>Summary</u>

We have discussed two common types of solution - molecular solutions (held together by similar intermolecular forces) and ionic solutions (formed by the interaction of ions and polar molecules). At this point, you should understand the "like dissolves like" principle for molecular solutions. You should also be familiar with the way ionic substances dissolve in polar solvents - the charged ends of the polar solvent molecules interact with the ions. Next, we will discuss the unique properties of solutions (compared to pure substances).