Lone pairs
“Lone Pairs”

• These are valence orbitals that are full, but that does not mean that they do not participate in bonding.

• If an ion with a positive charge comes close enough, the lone pair may attract it and form a new covalent bond.

![Diagram of molecules A, B, and C showing lone pairs.](image-url)
Lone pairs in bonds

• When lone pairs are used to form bonds, it often results in formation of molecules that are charged (ions)
• This means that bonds formed from lone pairs tend to result in positive-charged molecules
Lone pairs as thieves

- Lone pairs can interact with other molecules, and can in some cases be *more attractive* to protons on other molecules than the bond connecting that Hydrogen to its original molecule.
- The lone pair pulls the Hydrogen away from the other molecule—but usually just the H+.
- The further the proton gets away from the other molecule, the more (-) the other molecule gets, and the more it “pulls back” on that proton.
- This results in the two molecules tugging on the same Hydrogen.
- This mutual tugging holds the two molecules together in what is called a *Hydrogen Bond*. 

Other tricks lone pairs play

• The situation described in the previous slide was when one atom/molecule with a lone pair 
  deprotonates a second, in this case we say that atom/molecule is acting as a base

• In many biological reactions, the atom/molecule with the lone pair will instead “attack” the second 
  molecule and attach itself to it, causing another atom (held more weakly by the second molecule) to be 
  kicked off

• In this case, the lone pair atom/molecule is called a 
  nucleophile
Example of nucleophilic substitution
Lone pairs are selective

- Why would a lone pair attack one atom/bond and not another?
- Electronegativity!
- In a polar bond, the electrons are not equally distributed, which means one of the atoms in the bond has a slightly positive charge and is not held onto very tightly
- This weakly held and positive atom (more often than not it is a Hydrogen) is a good target for lone pairs
The lone pair on the Water is attacking the HCl, pulling the weakly held Hydrogen from (deprotonating) the Chlorine.

*Note the conservation of charge in the final products compared to the initial reactants*

We’ll come back to this reaction later...
Other bonds involving lone pairs

- Lone pairs may also participate in a special kind of bond called a **Hydrogen Bond**
- This is the result of a lone pair on one molecule attracting a proton on another molecule
- Both molecules are now in a tug-of-war over that proton, the result of this is that the two molecules are now held together
- This bond can be thought of as a shared proton between two different molecules
Hydrogen Bonds

Figure 2-1

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Hydrogen Bonds

Figure 2-3
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Each water molecule can form 4 Hydrogen Bonds
Water – a polar molecule
Properties of water

• Because of the polarity of the water molecule, it is a very effective solvent
• It is capable of separating any ionic bond (salts such as NaCl, KBr, KCl, etc.)
• It is capable of separating any polar covalent bond (alcohols, sugars, etc.)
• It is *not* capable of separating non-polar covalent bonds (the bonds present in oils, waxes, fats, etc.)
Dissolving solutes

• Water separates cations from anions in ionic compounds
• The ions liberated are charged, and end up being attracted to the water molecules themselves
• In a solution, the solute particles (the ions) are more attracted to the poles on the water molecules than they are to the ions they used to be bonded to
Water dissolving a salt

Figure 2-6
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Non-polar substances

- Water cannot separate non-polar covalent bonds
- For large molecules made up entirely of non-polar bonds, water molecules surround them, but cannot break them up
Water and Hydrogen Bonding

• The lone pairs on Oxygen are very attractive to the Hydrogens on other water molecules

• The attraction between the two results in a property called cohesion

• This property is what causes water molecules to “stick” to other water molecules, it is because of the strength of the Hydrogen Bonds between all the water molecules
Cohesion
Adhesion

- Because of its polarity, water is easily attracted to charges within the molecules of other substances, and so will often “stick” to them against the force of gravity.
Adhesion and capillary action

• The ability of water to *adhere* to surfaces is part of the reason that water is able to move from the roots of trees to the top

• Water sticks the sides of *xylem* tubes in the plant, and “creeps” up the sides as it forms many weak bonds with the material on the inside of the tube

• *Surface tension* holds those molecules clinging to the sides onto the water molecules around it, keeping the surface of the water from breaking
Capillary action
Chemical basis for life

• Water has a high \textit{dielectric constant}
• That means that it does not conduct charge very well, which means that any charged molecule dissolved in water will likely \textit{remain charged}
• Because charge is an important aspect to the \textit{reactivity} of a given molecule, by being in a water medium, the charge is retained
Huh?

• Think back to the concept of “lone pairs”
• Biological molecules can undergo the reactions that they do because life occurs in water
• If all the lone pairs and charges were reduced, no reactions could occur
• So life is possible because of water’s high dielectric: water keeps biological molecules reactive
End of section