Chemistry 121 (PS12)
Prof. Mines

Notes on Polarity of Molecules (and H-bond definition)

I. Molecular Polarity

A. **Meaning**: A molecular substance is said to "be **polar**" if its *molecules* are polar

This means that each molecule has a partially positive side and a partially negative side. Such molecules are said to have a "non-zero dipole moment".

A nonpolar substance is thus a substance whose *molecules* are nonpolar,

This means that overall they do not have one end that is partially positive and one end that is partially negative. These molecules have no dipole moment (or a dipole moment of "zero").

Note: The terms "polar" or "nonpolar" do not apply to *ionic* compounds because there are no molecules!

Ways to End up **Nonpolar**	Ways to End Up **Polar**
• no polar bonds, OR	• must have at least one polar bond, AND
• > 2 polar bonds, but bond dipoles completely cancel out	• the bond dipoles do NOT completely cancel out
E.g., H_2, Cl_2, N_2; CH_4, CF_4, PF_5, SF_6, CO_2	E.g., H_2O, SO_2, NH_3, H_2CO, SF_4, BrF_5, CCl_2F_2

B How to determine whether a molecule WITH ONLY ONE CENTER is polar.

1) Are there any polar bonds in the molecule?
   If no, then nonpolar; if yes, continue.
2) Are all of the atoms surrounding the center the same?
   If no, polar unless a special case (see footnote if interested*) If yes, continue.
3) Are there any lone pairs on the center?
   If no, then nonpolar. If yes, continue.
4) Is the atom geometry "square planar" or "linear"?
   If no, the molecule is polar. If yes, the molecule is nonpolar.

* If the molecule's atom geometry is octahedral, square planar, or trigonal bipyramidal, then it is possible to be nonpolar even if not all of the outer atoms are identical. How? If the atoms DIRECTLY ACROSS from one another (i.e., at 180 degrees) are the same as one another in all cases

→ ***Most molecular compounds are polar to some degree. It is actually somewhat "hard" to end up nonpolar for a large molecule (unless it is mostly hydrocarbon).***

II. Miscellaneous comments regarding polarity

A. If a molecule is polar, that does NOT mean that it is "charged"! Molecules are, by definition, neutral. If there is an overall charge on a species with more than one atom, it is a polyatomic ION, not a molecule.

B. Ionic compounds are neither "polar" nor "nonpolar" because there are no molecules! And remember that an ionic compound is overall neutral as well. It is only each individual *ion* that has an overall charge.

C. In my opinion, it doesn't make much sense to contemplate whether or not a polyatomic *ion* is "polar" or not, because it has an overall charge which will dominate its interactions with other species. So I would say that ions are neither polar nor nonpolar—they are "charged".

→ ***The bottom line: "polarity" is basically a property of either bonds or molecules (and thus of molecular substances; see I.A. above). It is not a meaningful property of ions or ionic compounds.***

III. Hydrogen Bond Definition and How to Determine if a Substance "has" H-bonding

A **hydrogen bond** is an interaction between a **H atom** *that is covalently bound to a N, O, or F* and a partially negative **N, O, or F** atom to which it is *not* covalently bound.

To determine if a substance "has" H-bonding as one of its IM forces between its molecules, **look for a N-H, O-H, or F-H bond** in it. If one of these is present, then it can. If not, it cannot.

NOTE: H-bonds (and IM forces in general) can be between two *different* molecules (I call this a "self-other" interaction). In this chapter, where properties of **substances** are discussed, we only consider "self-self" interactions.