SCH3U Name:

POLAR COVALENT BONDS

Ionic compounds form repeating ___________________________. Covalent compounds form distinct ___________________________.

Consider adding to NaCl(s) vs. H_2O(s):

Sometimes when atoms of two different elements form a bond by sharing an electron pair there is___________________ sharing of electrons. When this occurs the bond is called a ___________________________ BOND.

The unequal sharing results from the difference in ___________________________ of the two atoms. The one with the ___________________________ electronegativity exerts a ___________________________ attraction for the electrons

Electronegativity

Recall that electronegativity is "a number that describes the relative ability of an atom, when bonded, to attract electrons". The periodic table has electronegativity values.

We can determine the nature of a bond based on Δ EN (electronegativity difference). Δ EN = higher EN – lower EN

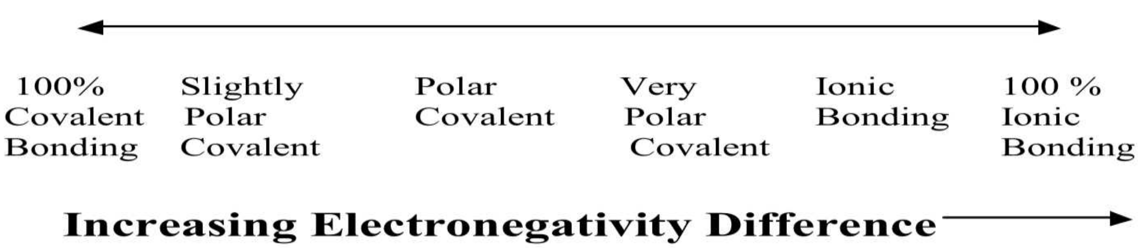
Example: NBr_3

Basically: a ΔEN below 0.4 = covalent, 0.4 - 1.7 = polar covalent, above 1.7 = ionic

Determine the ΔEN and bond type for these:

HCl,	CrO,	Br_2,	H_2O,	CH_4,	KCl

The bonding continuum developed by Pauli, can be used as a guideline to determine if a bond is true covalent polar covalent or ionic.



SCH3U Name:

Inter and Intramolecular Forces

Why do some solids dissolve in water but others do not?

Why are some substances gases at room temperature, but others are liquid or solid?

What gives metals the ability to conduct electricity, what makes non-metals brittle?

Consider a glass of water. Why do molecules of water stay together?

Intramolecular Forces

Forces of electrostatic attraction ___________________________ a molecule. Occur between the _________________ of the atoms and their ___________________________ making up the molecule (i.e.covalent bonds).

Must be broken by ___________________________ means. Form ___________________________ substances when broken

Intermolecular forces

Forces of attraction between ________________ molecules (i.e. London dispersion forces, dipole – dipole interactions or hydrogen bonds).These forces are much ________________ than Intramolecular forces or bonds and are much ________________to break. Physical changes (changes of ________________) break or weaken these forces

Do ________________ form new substances when broken.

These forces affect the ________________ and ________________ points of substances, the ________________ action and ________________tension, as well as the ________________ and _______________ of substances

Types of Intermolecular forces

London Dispersion Forces

London forces result from a type of ________________dipole. These forces exist between ________________molecules. They are masked by stronger forces (e.g. dipole-dipole) so are sometimes insignificant, but they are important in ________________________ molecules.

Because electrons are moving around in atoms there will be instants when the charge around an atom is not ________________________. The resulting tiny dipoles result in attractions between ________________________ and/or ________________________. These forces are based on the simultaneous attraction of the ________________________ of one molecule by the positive ________________________ of neighbouring molecules

The strength of the force is directly related to the ________________________ of electrons and protons in a given Molecule. The greater the number of electrons and protons the ________________________ the force.

”Van der Waal” force

SCH3U Name:

Dipole - Dipole Interactions

Occur between polar molecules having _______________________ .Molecules with dipoles are characterized by oppositely charged _______________________ that are due to an ______________________ distribution of charge on the molecule. The polarity of a molecule is determined by both the polarity of the ______________________ bond and the _______________________ of the molecule. These forces are based on the simultaneous attraction of the _______________________ of one dipole by the _______________________ of neighbouring molecules.

The strength of the force is related to the _______________________ of the given molecule

"Van der Waal" force

Hydrogen Bonds

These forces are a _______________________ of dipole – dipole interaction. Occur between___________________ atoms in one molecule and _______________________ electronegative atoms [F, O, and N] where there are usually unshared pairs of electrons present

Q- Calculate the EN for HCl and H_2O

The high EN of NH, OH, and HF bonds cause these to be strong forces.

Also, because of the small size of hydrogen, it's positive charge can get very close to the negative dipole of another molecule.

H-Bonding Diagram:

Ionic Forces

Ionic forces may be both inter and intra since a crystalline lattice is formed.

For convenience sake ionic substances are referred to by the smallest ratio of atoms present in the lattice.

Question: Why oil and water do not mix

SCH3U Name:

Predicting boiling points using the Strength of Intermolecular forces

Molecules that are isoelectronic have the ________________________ strength of London dispersion forces

More polar molecules have ________________________ dipole – dipole interaction and ________________________ melting and boiling points

The ________________________ the number of electrons per molecule, the ________________________ the London forces and hence the ________________________ the melting and boiling point

Which would have a higher melting/boiling point? NaCl or HCl

Question: For each, pick the one with the lower boiling point a) $CaCl_2$, CaF_2 b) KCl, LiBr c) H_2O, H_2S. Explain.

Polar Molecules

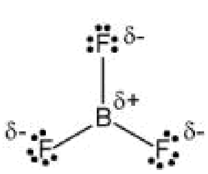
Polar bonds ________________________ cause the whole molecule to be polar.

Polar molecule is a molecule in which the ________________________ distribution of electrons results in a positive charge at ________________________ end and a negative charge at the ________________________ end

Non-polar molecule is a molecule in which the electrons are ________________________ distributed among the atoms, resulting in no localized charges

Bond dipoles may or may not cancel out thereby producing either molecules that are ________________________ , if they ________________________, or ________________________, if they ________________________ cancel.

Example1:



SCH3U Name:

Predicting Molecular Polarity –General Steps

Go over Tutorial 1 and Table 3 on pg. 106; Pg. 228 (Grade 12 Textbook)

Step 1: Draw a reasonable Lewis structure for the substance.

Step 2: Identify each bond as either polar or nonpolar. (If the difference in electronegativity for the atoms in a bond is greater than 0.4, we consider the bond polar. If the difference in electronegativity is less than 0.4, the bond is essentially nonpolar.)

If there are no polar bonds, the molecule is **nonpolar.**

If the molecule has polar bonds, move on to Step #3.

Step 3: If there is only one central atom, examine the electron groups around it.

If there are no lone pairs on the central atom, and if all the bonds to the central atom are the same, the molecule is **nonpolar.**

If the central atom has at least one polar bond and if the groups bonded to the central atom are not all identical, the molecule is **probably polar**. Move on to Step #4.

Step 4: Draw a geometric sketch of the molecule.

Step 5: Determine the symmetry of the molecule using the following steps.

Describe the polar bonds with arrows pointing toward the more electronegative element. Use the length of the arrow to show the relative polarities of the different bonds. (A greater difference in electronegativity suggests a more polar bond, which is described with a longer arrow.)

Decide whether the arrangement of arrows is symmetrical or asymmetrical

If the arrangement is **symmetrical** and the arrows are of equal length, the molecule is **nonpolar.**

If the arrows are of different lengths, and if they do not balance each other, the molecule is **polar**.

If the arrangement is asymmetrical, the molecule is **polar**.

Predicting Molecular Polarity- Exercises

Decide whether the molecules represented by the following formulas are polar or nonpolar. (You may need to draw Lewis structures and geometric sketches to do so.)

a. CO_2 b. OF_2 c. CCl_4 d. CH_2Cl_2 e. HCN

SCH3U Name:

Testing concepts

1. Which attractions are stronger: intermolecular or intramolecular?

2. How many times stronger is a covalent bond compared to a dipole-dipole attraction?

3. What evidence is there that nonpolar molecules attract each other?

4. Which chemical in table 3 on pg. 113 has the weakest intermolecular forces? Which has the strongest? How can you tell?

5. State the difference between London Dispersion forces Dipole-Dipole attractions.

6. A) Which would have a lower boiling point: O_2 or F_2? Explain.

   B) Which would have a lower boiling point: NO or O_2? Explain.

7. Which would you expect to have the higher melting point (or boiling point): C_8H_{18} or C_4H_{10}? Explain.

8. What two factors causes hydrogen bonds to be so much stronger than typical dipole-dipole bonds?

9. So far we have discussed 4 kinds of intermolecular forces: ionic, dipole-dipole, hydrogen bonding, and London forces. What kind(s) of intermolecular forces are present in the following substances?

a) NH_3, b) SF_6, c) PCl_3, d) LiCl, e) HBr, f) CO_2 (hint: consider Δ EN and molecular shape/polarity)

10. <u>Challenge</u>: Ethanol (CH_3CH_2OH) and dimethyl ether (CH_3OCH_3) have the same formula (C_2H_6O). Ethanol boils at 78 °C, whereas dimethyl ether boils at -24 °C. Explain why the boiling point of the ether is so much lower than the boiling point of ethanol.

11. Complete Mini- Investigation on pg. 113 and answer questions A-E and Q – Why does BP increases as period increases, why are some BP high at period 2?

SCH3U Name:

Testing concepts- Answers

1. Intramolecular are stronger.

2. A covalent bond is 100x stronger.

3. The molecules gather together as liquids or solids at low temperatures.

4. Based on boiling points, CH_4 (-162) has the weakest forces, H_2O has the strongest (100).

5. London forces

Are present in all compounds

Can occur between atoms or molecules

Are due to electron movement not to ΔEN

Are transient in nature (dipole-dipole are more permanent).

London forces are weaker

6. A) F_2 would be lower because it is smaller. Larger atoms/molecules can have their electron clouds more easily deformed and thus have stronger London attractions and higher melting/boiling points.

B) O_2 because it has only London forces. NO has a small ΔEN, giving it small dipoles.

7. C_8H_{18} would have the higher melting/boiling point. This is a result of the many more sites available for London forces to form.

8. a large ΔEN, 2) the small sizes of atoms.

9. a) NH_3: Hydrogen bonding (H + N), London.

b) SF_6: London only (it is symmetrical).

c) PCl_3: ΔEN=2.9-2.1. Dipole-dipole, London.

d) LiCl: ΔEN=2.9-1.0. Ionic, (London).

e) HBr: ΔEN=2.8-2.1. Dipole-dipole, London.

f) CO_2: London only (it is symmetrical)

<u>10. Challenge</u>: In ethanol, H and O are bonded (the large EN results in H-bonding). In dimethyl ether the O is bonded to C (a smaller EN results in a dipole-dipole attraction rather than hydrogen bonding).

11. Boiling points increase down a group (as period increases) for two reasons: 1) EN tends to increase and 2) size increases. A larger size means greater London forces.

Boiling points are very high for H_2O, HF, and NH_3 because these are hydrogen bonds (high EN), creating large intermolecular forces