

Properties of Solutions

Why do things Melt or boil?

Made by Schweitzer

10-25-04

What factors affect whether a substance will be a solid, liquid or a gas?

■ Simple...Attraction

- The more attraction there are between the atoms the more likely they will be a liquid or a solid.
- If there isn't any attraction then they will be a gas.
- Think of these attractions like glue. The more glue the harder it is to separate. Therefore higher boiling points and more likely to be a liquid or even solid at room temperature.

Types of Solids

- Type of solid is determined by type of bond
 - Ionic: metal = Non-metal
 - Covalent: non-metal = non-metal
 - Metallic: metals
 - Network covalent: only C, Si, Ge

Types of Bonds

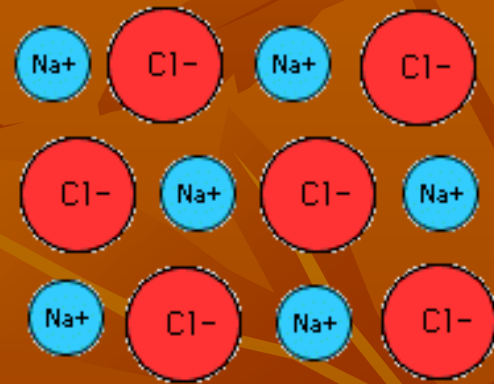
Ionic

- Very strong bond.
- Results in a solid with very high melting points.
- High Attractions are due to + and negative ions bundled together in a lattice crystal.

Lattice Crystal / Lattice Energy

- Energy that is tied up in crystal structure.
- Greater the difference of charge the stronger the crystal structure.
 - +1...-1 vs. +3...-3
- Atomic radius
 - Greater distance lower attraction

Network of Na⁺ and Cl⁻ ions



$$F = \frac{Q_e \times Q_p}{r^2}$$

What about the melting point of these substances?

Compound
NaF
NaCl
NaBr
NaI
MgO

Why the difference?

Compound	Melting Point (Centigrade)	Lattice Energy (kcal/mol)
NaF	988	-201
NaCl	801	-182
NaBr	790	-173
NaI	660	-159
MgO	2800	-3938

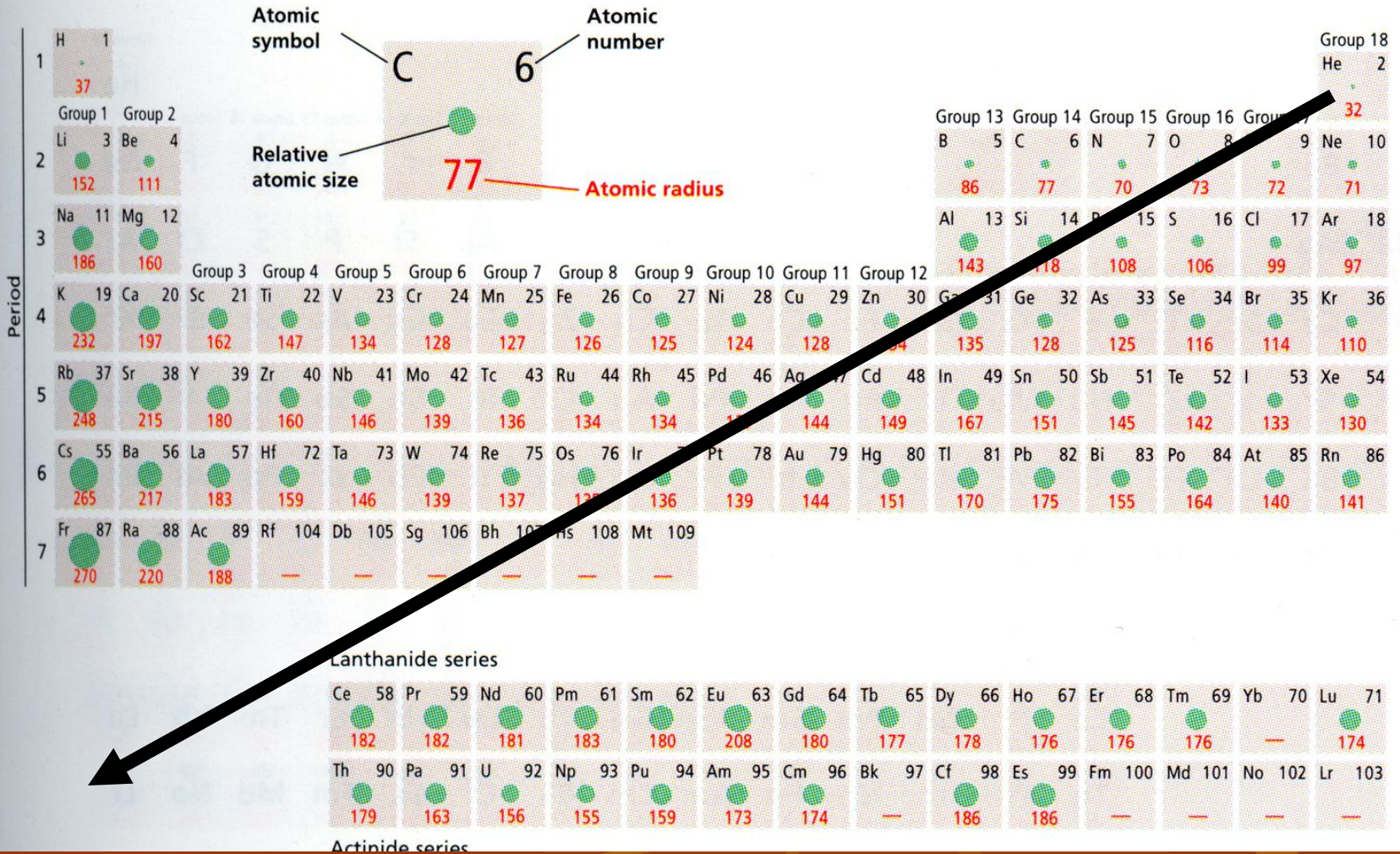
Why the difference?

Compound	Interionic Distance (Angstroms)	Melting Point (Centigrade)	Lattice Energy (kcal/mol)
NaF	2.31	988	-201
NaCl	2.79	801	-182
NaBr	2.94	790	-173
NaI	3.18	660	-159
MgO	3.0	2800	-3938

Atomic Radius and Difference of charge

The larger the distance between nuclei the lower the attraction between atoms

Atomic radius



Summary of Ionic compounds

- When you melt ionic compounds you are breaking an ionic bond! Very hard
- Factors affecting ionic bonds.
 - Difference of charge
 - Atomic radius

Types of Solids

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Covalent Bond(molecular)

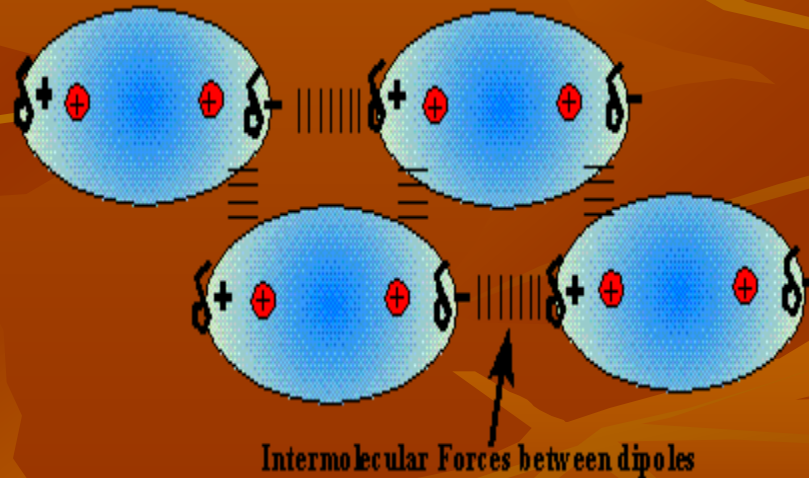
- Intermolecular Forces
 - Bond between 2 or more molecules
 - Determines how much molecules stick together
 - Determines whether molecules are solids, liquids, or gases
 - Larger forces equals more glue = higher melting/boiling points
- Intramolecular Bonds
 - Bond with in a molecule.
 - Covalent bond holding bond together.

Melting/boiling points

- When a Covalent substance is being melted/boiled you are breaking Intermolecular bonds!!!!
- These are weak intermolecular forces
- Not the strong intramolecular force (Covalent)

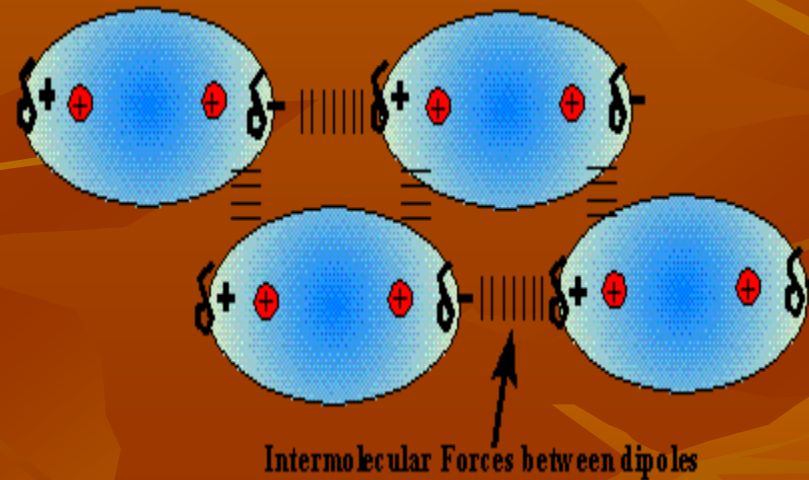
Dipole-dipole / Hydrogen Bonding

- Strongest intermolecular force
- These molecules have +/- charges called polar



What does it mean to be polar?

- A molecule is polar if it contains + and – somewhere in the molecule.

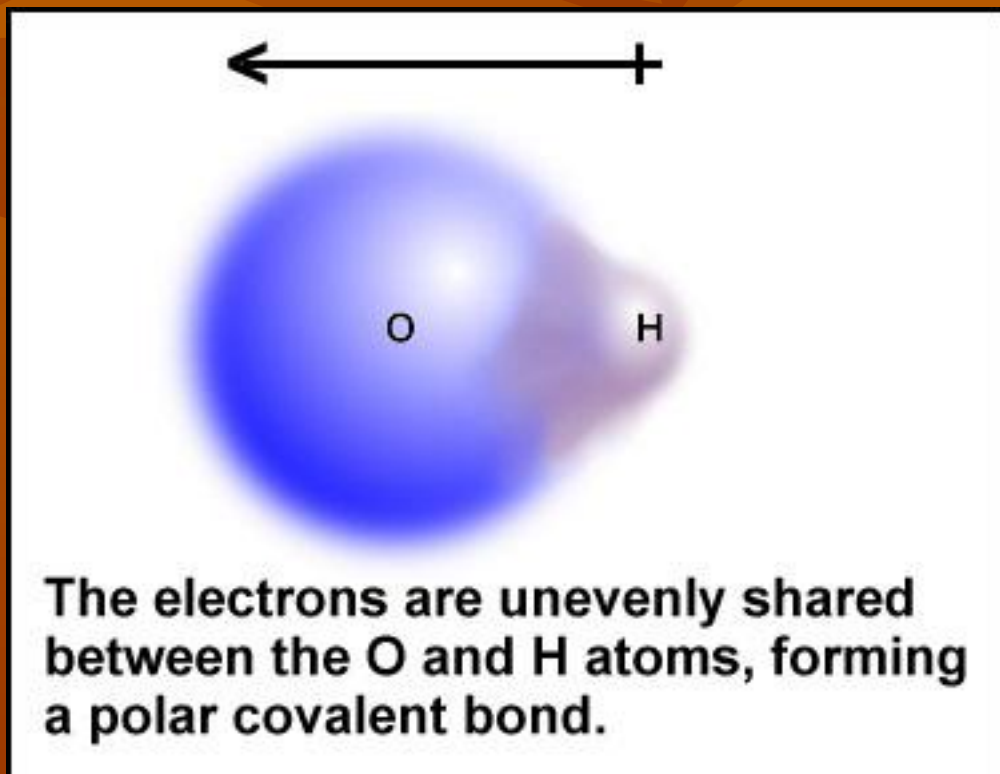


How does polarity affect a molecules properties?

- Solute dissolving in a solvent?
 - “Likes dissolve likes”
 - Non-polar solutes dissolve in non-polar solvents
 - Polar solutes dissolve in polar solutes.
 - Biologically
 - Drugs are absorbed into the brain (past the blood brain barrier) based upon their polarity.
 - Morphine and Heroine are very similar
 - Your body converts heroine to morphine after it enters the brain.
 - Heroin is 90% more polar there for it absorbs a lot faster.

How does a molecule become polar.

- Must have at least one polar bond.
- What is a polar bond?
 - A covalent bond where the electrons are not being shared equally.



Why are or why aren't the electrons being shared equally

- Electronegativity: An atoms attraction for electrons in a bond.
 - Some atoms, when bonded suck the electrons toward them.
- Electronegativity Difference: When you get two atoms bonded where one is highly electronegative and the other is not there will be unequal sharing.

Electronegativity difference?

Mr. Schweitzer



Baby



\$1000 dollars

Who gets the money????

Electronegativity difference?

Mr. Schweitzer



Baby



\$1000 dollars

Who gets the money????

Electronegativity difference?

Mr. Schweitzer



Superman



\$1000 dollars

Who gets the money????

Electronegativity difference?

Mr. Schweitzer

Superman



\$500 dollars



\$500 dollars



Who gets the money????

Electronegativity

1	1 H 2.1																	2 He —
2	3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0	10 Ne —
3	11 Na 0.9	12 Mg 1.2				13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0	18 Ar —							
4	19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.8	28 Ni 1.8	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8	36 Kr 3.0
5	37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5	54 Xe 2.6
6	55 Cs 0.7	56 Ba 0.9	57 La 1.1	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.8	83 Bi 1.9	84 Po 2.0	85 At 2.2	86 Rn 2.4
7	87 Fr 0.7	88 Ra 0.9	89 Ac 1.1	104 Rf —	105 Db —	106 Sg —	107 Bh —	108 Hs —	109 Mt —									

6 — Atomic number
C — Symbol
 2.5 — Electronegativity

Lanthanide series

58 Ce 1.1	59 Pr 1.1	60 Nd 1.1	61 Pm 1.1	62 Sm 1.2	63 Eu 1.1	64 Gd 1.2	65 Tb 1.1	66 Dy 1.2	67 Ho 1.2	68 Er 1.2	69 Tm 1.3	70 Yb 1.1	71 Lu 1.3
90 Th 1.3	91 Pa 1.5	92 U 1.4	93 Np 1.4	94 Pu 1.3	95 Am 1.3	96 Cm 1.3	97 Bk 1.3	98 Cf 1.3	99 Es 1.3	100 Fm 1.3	101 Md 1.3	102 No 1.3	103 Lr —

Actinide series

Electronegativity

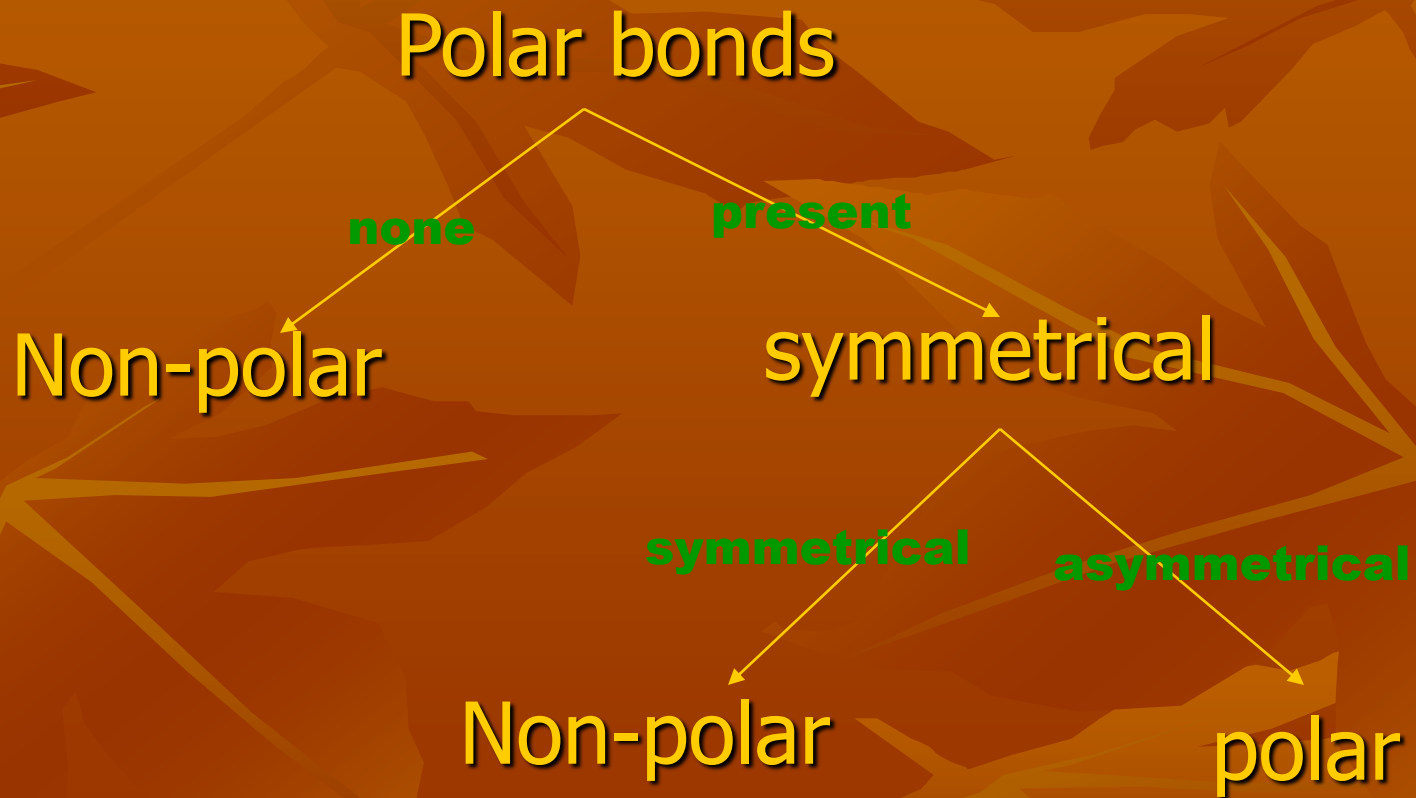
- When ever you have an atom with a large electronegativity bonded to one that is small you will have an unequal sharing of electrons.
- Big Four
 - N, O, F, Cl -- any atom bonded to one of these three will cause a polar bond

H-F

H-Cl

NO₂

Structure also affects polarity



Weak bonds

Vanderwaals Forces

- All atoms have electrons and all those electrons are moving.
- By chance at any one time there will be more negative charge on one side of the atom as apposed to the other.
- Creating a small dipole or charges.

Factors affecting Vanderwaals Forces

1. Bigger molecules

- More electrons more chance of uneven distribution

2. Longer chains

- Longer chains increases surface area allowing more the +/- to attract other +/-

Bigger molecules

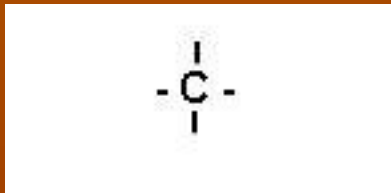
More electrons more chance of uneven distribution

- In the four chemicals below the only intermolecular force is Vanderwaals. This force is amplified by the increased number of electrons
- F_2 -- Gas
- Cl_2 Gas/liquid under mild pressure
- Br_2 -- Liquid
- I_2 -- solid

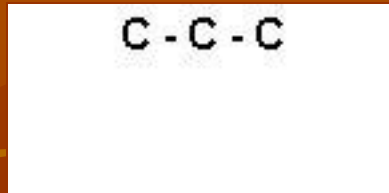
Longer Chains

- As the chain gets longer the amount of Vanderwaals forces increases.

-161.5



-42.1



36.1

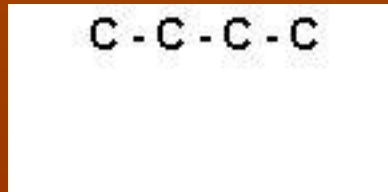


C - C



-88.6

C - C - C - C



-0.5

Boiling points

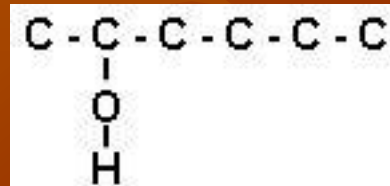
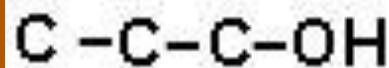
Strength of intermolecular Forces

- Weakest
 - London Forces
 - Dipole- dipole / Hydrogen Bonding
 - Ionic
 - Covalent
- Strongest

London Forces

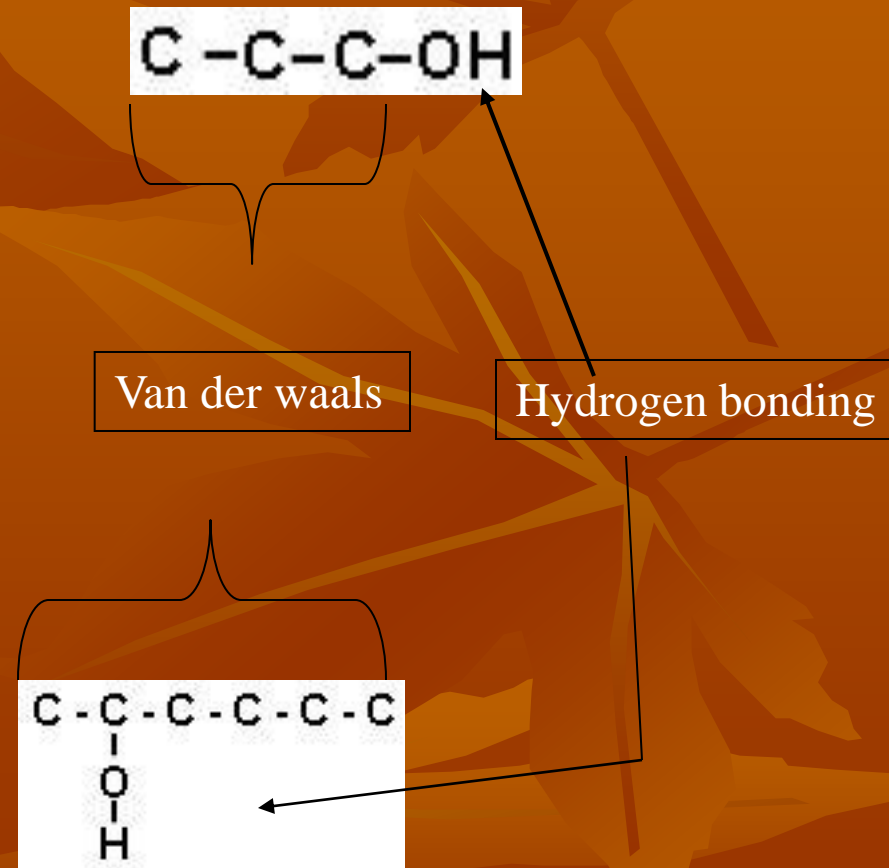
Intermolecular bonding?

- Do you recognize any possible intermolecular forces in either of these molecules?



Intermolecular bonding?

- The extended chain increases Van der Waals.
- Due to larger amount of energy to needed separate and therefore higher melting and boiling points.



How does intermolecular bonding alter melting points?

- Which of the following solids will have the highest melting point.

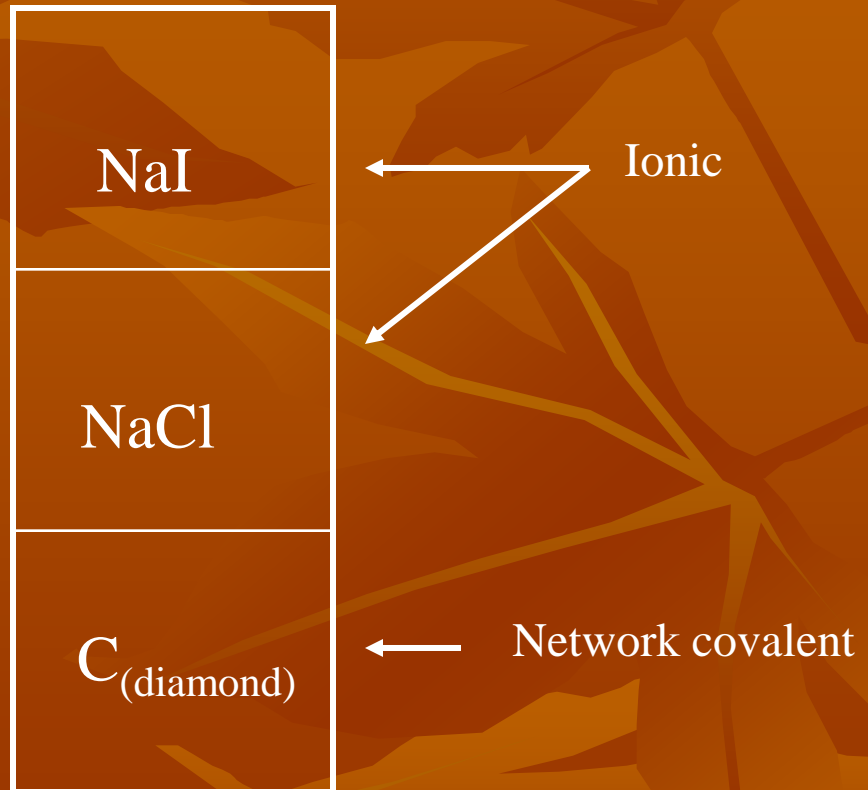
NaI

NaCl

C_(diamond)

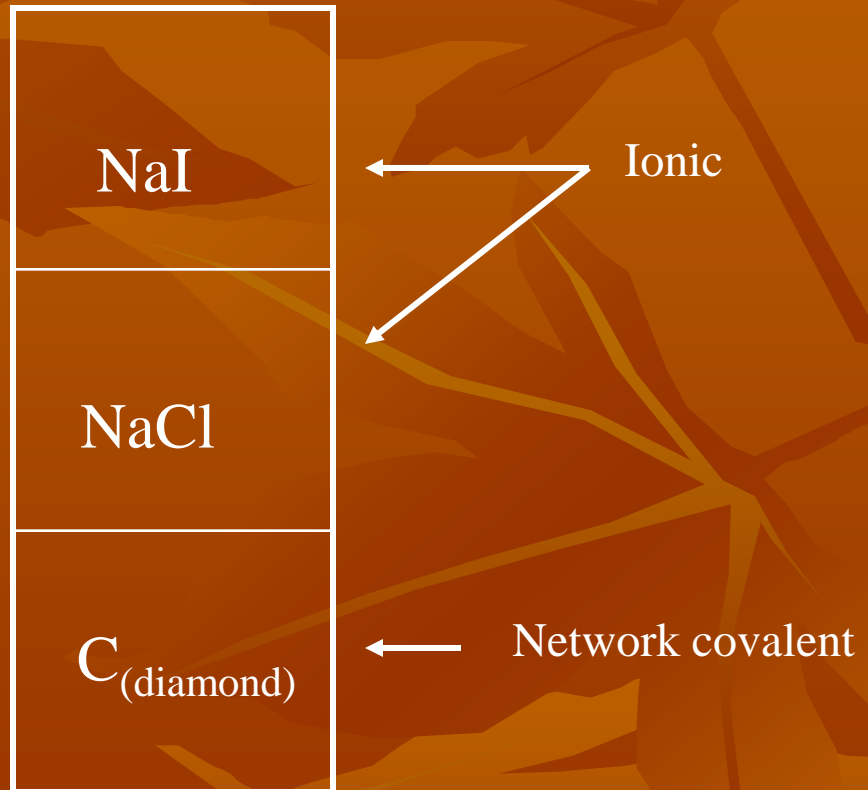
How does intermolecular bonding alter melting points?

- Which of the following solids will have the highest melting point.
- Network covalent is much stronger than the ionic bonds.
- Which of the ionic compounds will have the higher melting point?



How does intermolecular bonding alter Melting points?

- Which of the ionic compounds will have the higher melting point?
- Iodine has a larger radius separating the molecules +/-'s reducing attractions and lowering melting points



Question

- Based on what you know intermolecular bonding why is CO_2 a gas yet H_2O is a liquid at room temperature?
- What do you think?

Network Covalent

- Similar to Ionic Bonds But with Covalent
- Webbing of covalent Bonds.
- Examples
 - Carbon family can do this.
 - C, Si, or Ge
- Very Strong
- Definitely Solid

vapor pressure vs. boiling

- Vapor pressure is determined by the amount of intermolecular forces.
- Increased intermolecular forces then decreases vapor pressure.
- Increasing the temperature also increases the vapor pressure of a substance
- Once Vapor pressure exceeds atmospheric pressure boiling occurs.

Sample AP Questions

(ebbing 11.2) Which of the following compounds is expected to have the highest boiling point?



Sample Problem

(ebbing 11.20)

The forces of attraction between molecules of I_2 are

- a. Induced dipole-dipole attractions
- b. Dipole-dipole
- c. Covalent bonds
- d. London forces
- e. Dipole-induced dipole attractions