Bonding & Formulas

Unit 8

Organic Chemistry

Unit Overview

Topic 1 - Bonding

Topic 2 - Organic Chemistry

Topic 3 - Polar & Non-Polar Bonds

Topic 4 - Polar & Non-Polar Molecules

Topic 5 - Intermolecular Forces

Topic 6 - Molecular Math

Bonding & Formulas

Topic 1

- What do you already know about BONDING?
- If ionic bonds are metal + nonmetal and covalent bonds are nonmetal + nonmetal, what must the third type of bonding be? **metal + metal**
- If metals want to lose electrons, how do you think they will bond together? **metal cations with a 'sea of electrons'**
- If metals conduct electricity, what 2 conditions MUST exist inside all metals?

charged particles, mobile

Bonding Comparison

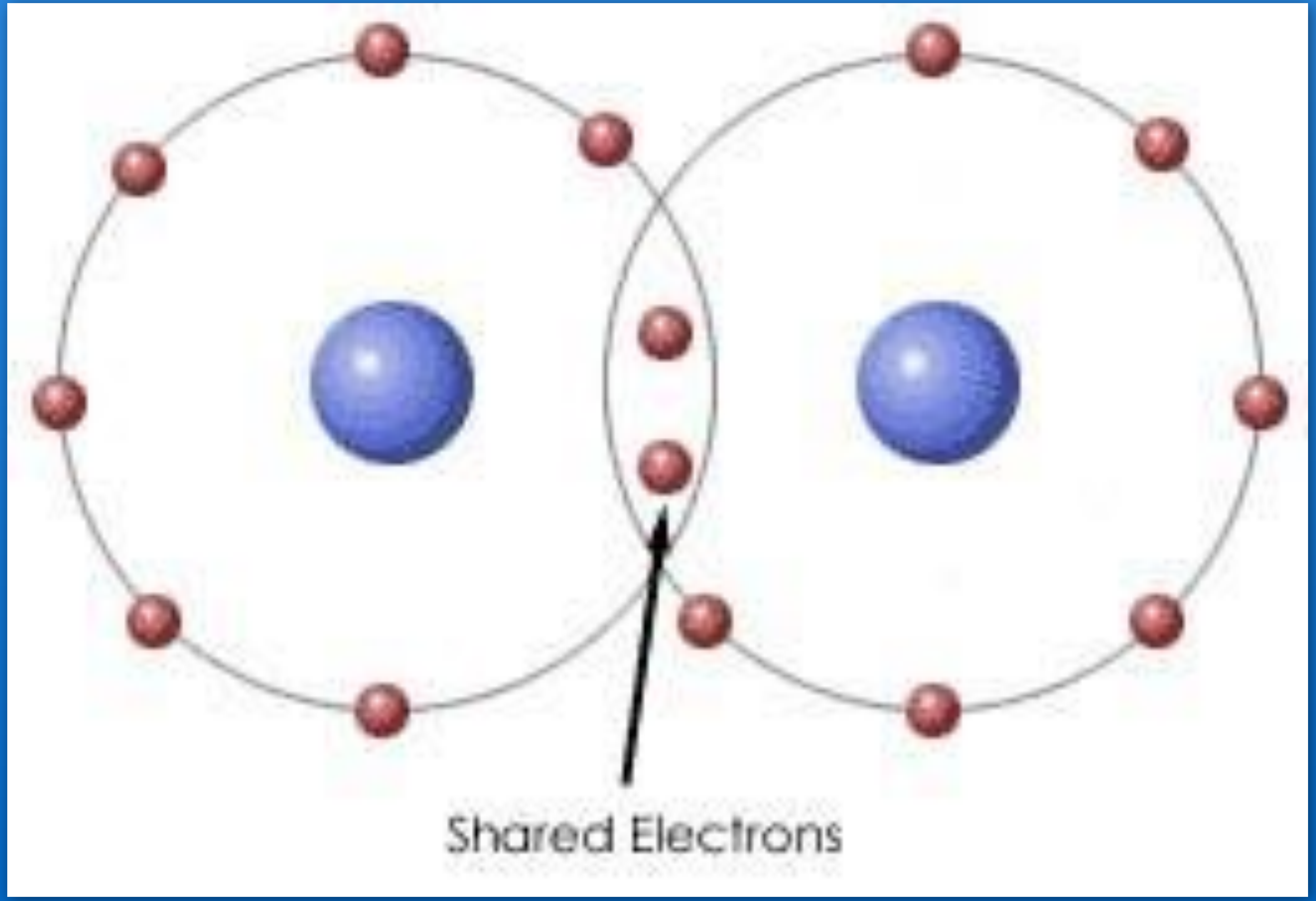
Ionic	Covalent	Metallic
metal & nonmetal e- transferred from metal to nonmetal VERY strong bond	nonmetal & nonmetal e- shared between nonmetals weaker bond	metal & metal metals loosely hold electrons so there is a 'sea of electrons'
hard, brittle, high boiling / melting points *conduct electricity as liquids or aqueous (NOT at solids)*	soft, usually gas or liquid at room temperature, low boiling / melting pts., *do not conduct electricity in any phase*	can be hard or soft, with varying melting / boiling points *conduct electricity*
When writing formulas, make sure charges add to zero. Naming uses 'ide', sometimes roman numerals, Table E.	Names uses 'ide' ending with prefixes (mono, di, tri, tetra)	Naming uses the elemental metal (i.e. Gold, Copper, Tin, Iron)

What is Organic Chemistry?

Topic 2

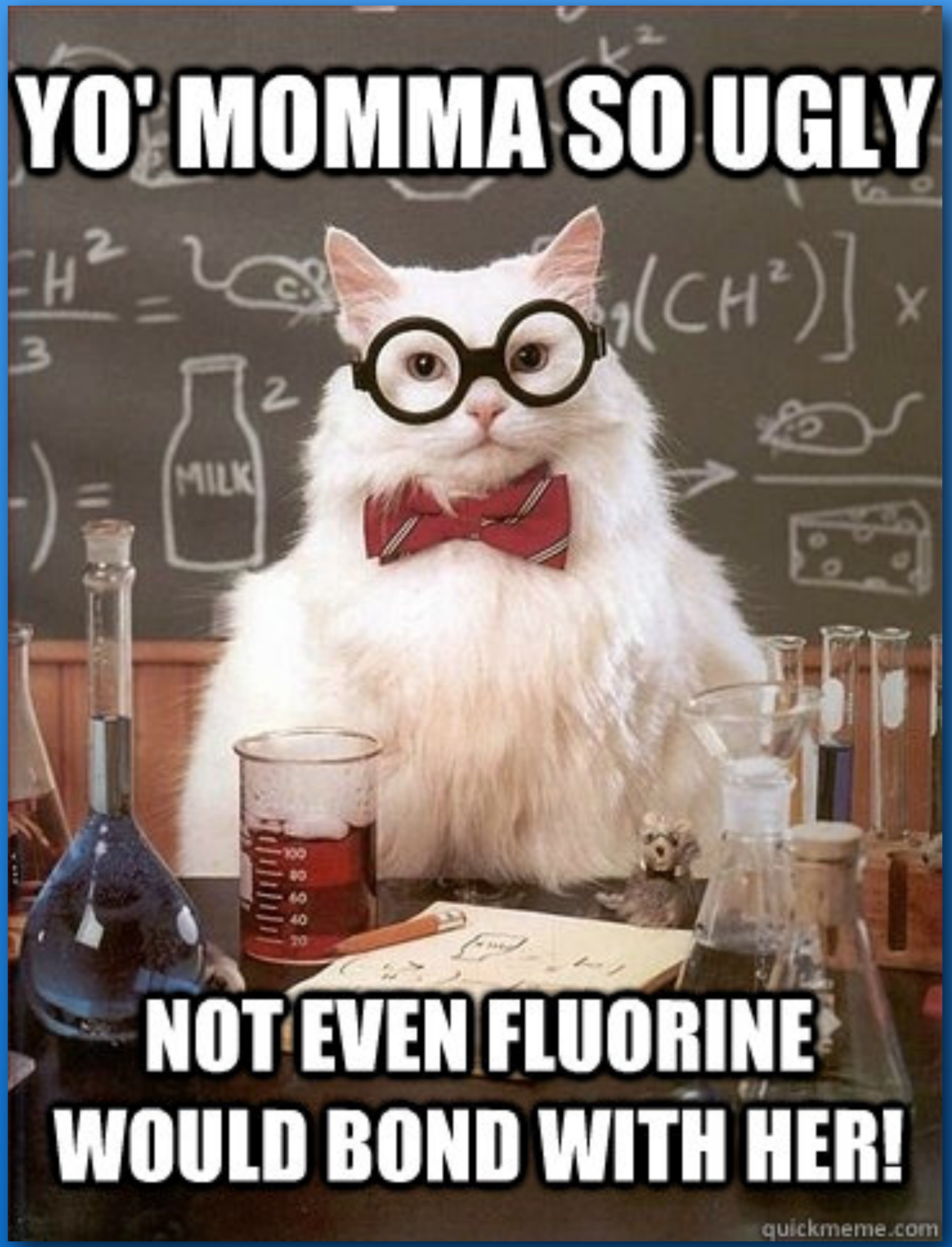
- Atoms of Carbon, Hydrogen, Oxygen and Nitrogen bonding together to form molecules

- Atomic structure and sharing of electrons to form covalent bonds.

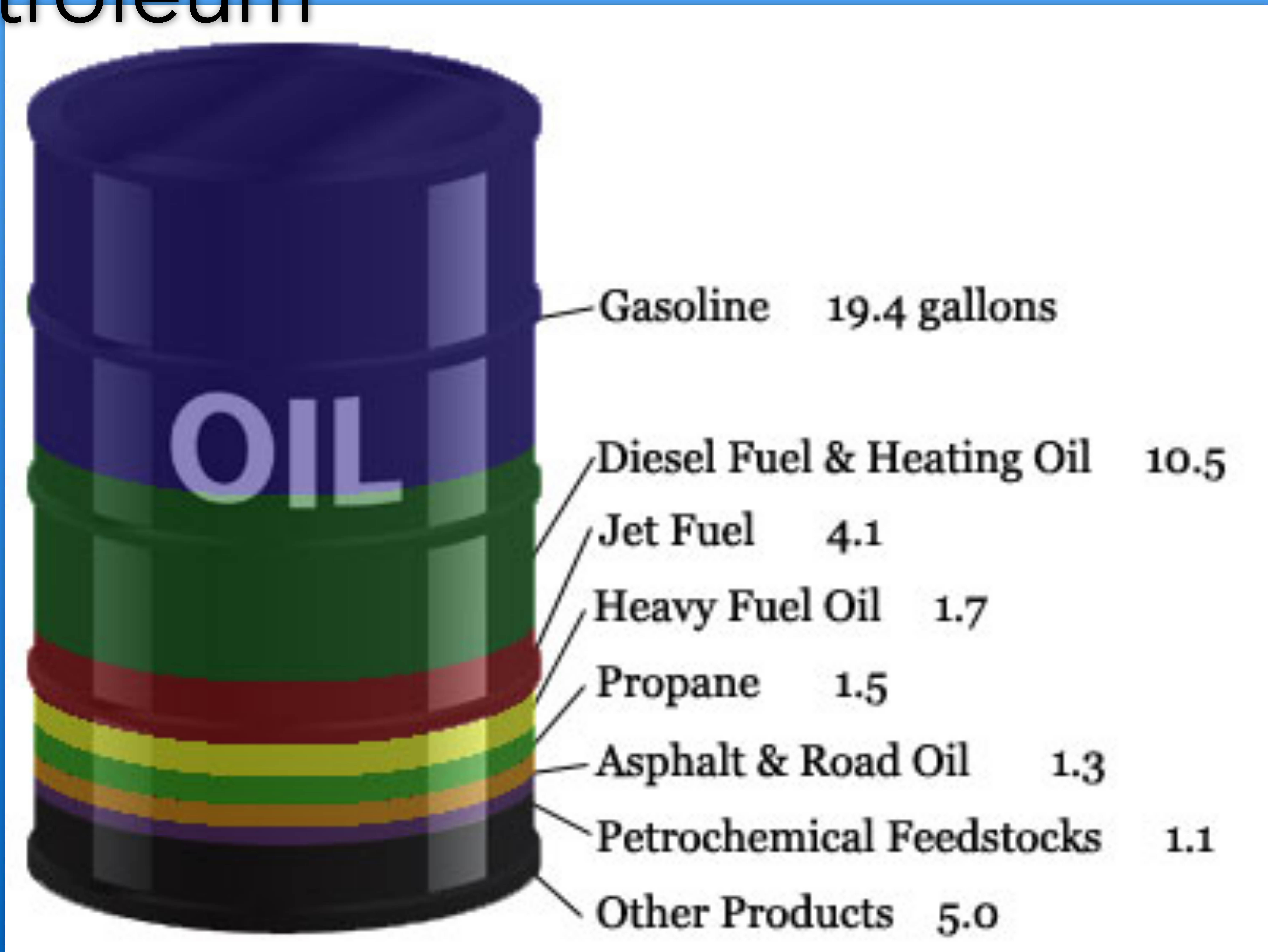


Organic hydrocarbons

- Watch the following video on petroleum refining and answer the questions in your booklet.
- Petroleum Refining



More on Petroleum



Organic Hydrocarbons

- “Organic” molecules (making up living things)
- Made of carbon and hydrogen ONLY
- Carbon has __4__ valence electron(s), so it will always make __4__ bond(s).
- Hydrogen has __1__ valence electron(s), so it will always make __1__ bond(s).

Saturated hydrocarbons

- Alkanes
  - Hydrocarbons with all ___single___ bonds.
  - Can't add any more H atoms to it, it's full. We call that ___saturated___.
  - Name alkanes using Table P (prefixes) and Table Q (general formula).
  - General formula for alkanes is C_nH_{2n+2}
  - Examples...

Isomers (of Alkanes)

- Isomer: molecules with the same *formula*, but different *structures*.
- Isomers are different molecules with different chemical properties.
- When asked to draw isomers, make sure you include the ‘original’ molecule
- The more carbon atoms in a molecule, the more isomers it has.

Naming Rules

- Name based on longest carbon chain
- Branches get '-yl' ending
  - ex. 1 carbon branch = 'methyl', 2 carbon branch = 'ethyl'
- Numbers tell you which carbon(s) the branch(es) are attached to.
- Count carbons so that the numbers in the name are the smallest #s possible.
- A bend in the chain is NOT a branch.

Unsaturated Hydrocarbons

- Unsaturated = can add more hydrogen by breaking double or triple bonds. (Ever heard of *unsaturated fats and oils*???)
- Alkenes
  - Have a double bond. (Represented by a double line)
  - General formula is C_nH_{2n}
  - Example: C_2H_4

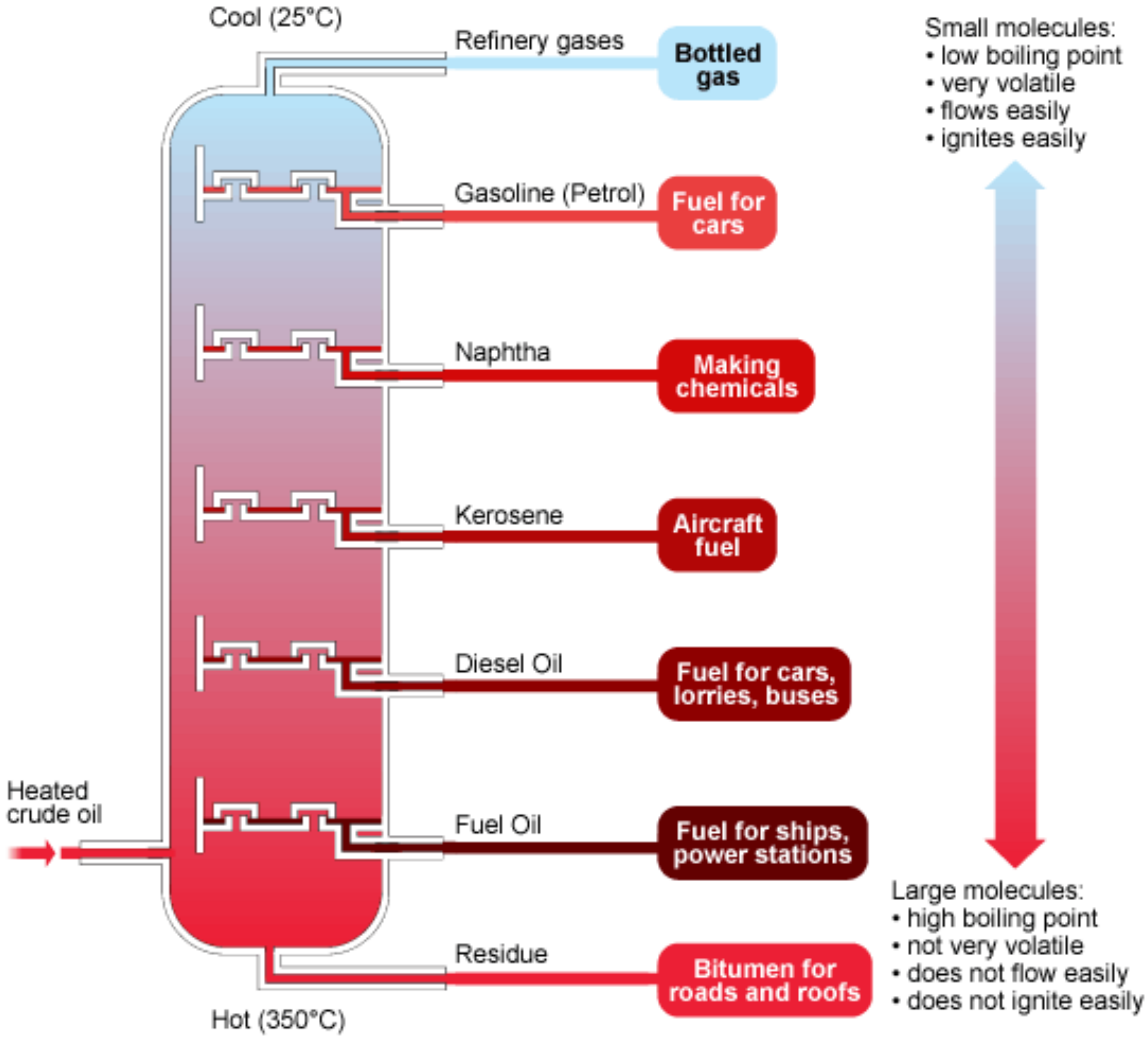
Unsaturated Hydrocarbons

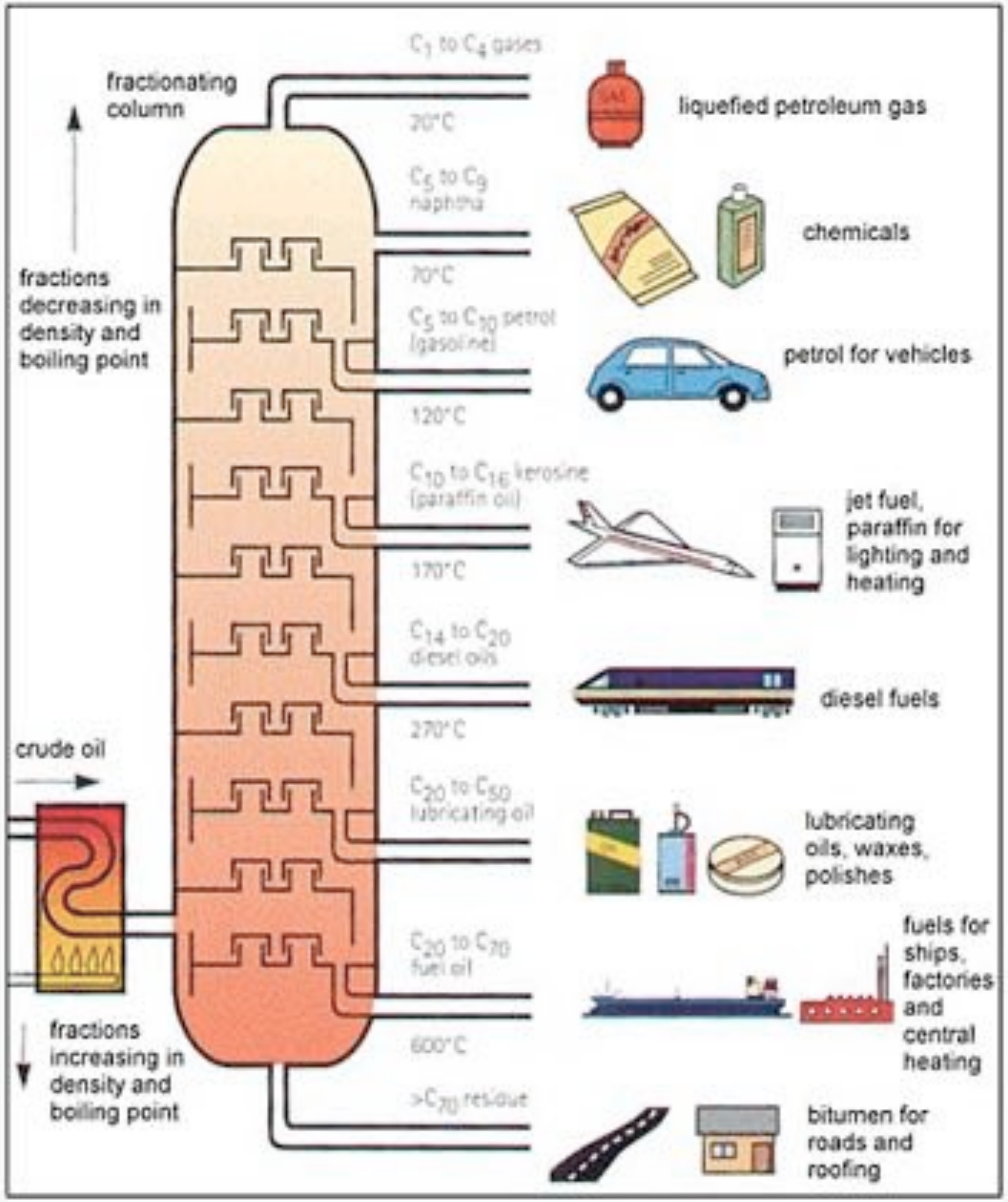
- Alkynes
  - Have a triple bond. (Represented by a triple line)
  - General formula is C_nH_{2n-2}
  - Example: C_2H_2

- Naming Rules:
  - numbers tell you which carbon atom has the double / triple bond.
  - count carbons from end that keeps numbers smallest.

Hydrocarbon Refining

Hydrocarbons
separated by
BOILING POINT

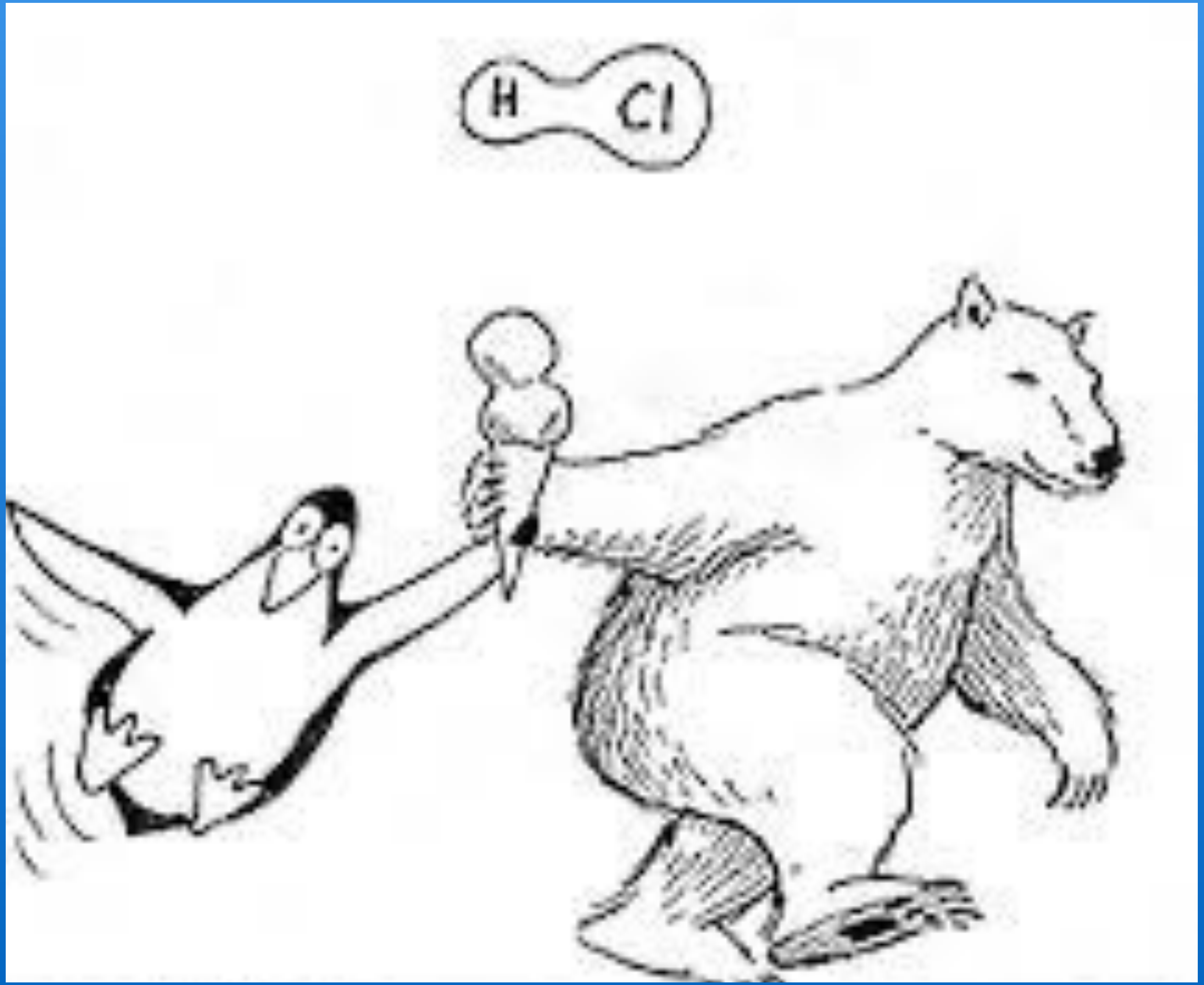

Cool (25°C)
Refinery gases
Bottled gas
Gasoline (Petrol)
Fuel for cars
Naphtha
Making chemicals
Kerosene
Aircraft fuel
Diesel Oil
Fuel for cars, lorries, buses
Heated crude oil
Fuel Oil
Fuel for ships, power stations
Residue
Bitumen for roads and roofs
Hot (350°C)
Small molecules:
• low boiling point
• very volatile
• flows easily
• ignites easily
Large molecules:
• high boiling point
• not very volatile
• does not flow easily
• does not ignite easily


fractionating column
fractions decreasing in density and boiling point
crude oil
fractions increasing in density and boiling point
C_1 to C_4 gases
20°C
C_5 to C_9 naphtha
70°C
C_5 to C_{10} petrol (gasoline)
120°C
C_{10} to C_{16} kerosine (paraffin oil)
170°C
C_{14} to C_{20} diesel oils
270°C
C_{20} to C_{50} lubricating oil
C_{20} to C_{70} fuel oil
600°C
$>C_{70}$ residue
liquefied petroleum gas
chemicals
petrol for vehicles
jet fuel, paraffin for lighting and heating
diesel fuels
lubricating oils, waxes, polishes
fuels for ships, factories and central heating
bitumen for roads and roofing

Polar and Non-Polar Bonds

Topic 3

- Covalent Bonds: SHARING of electrons
  - Covalent = sharing…but…
  - Is ***<u>sharing</u>*** always equal??
    - Polar vs. Non-Polar



Covalent Bonds

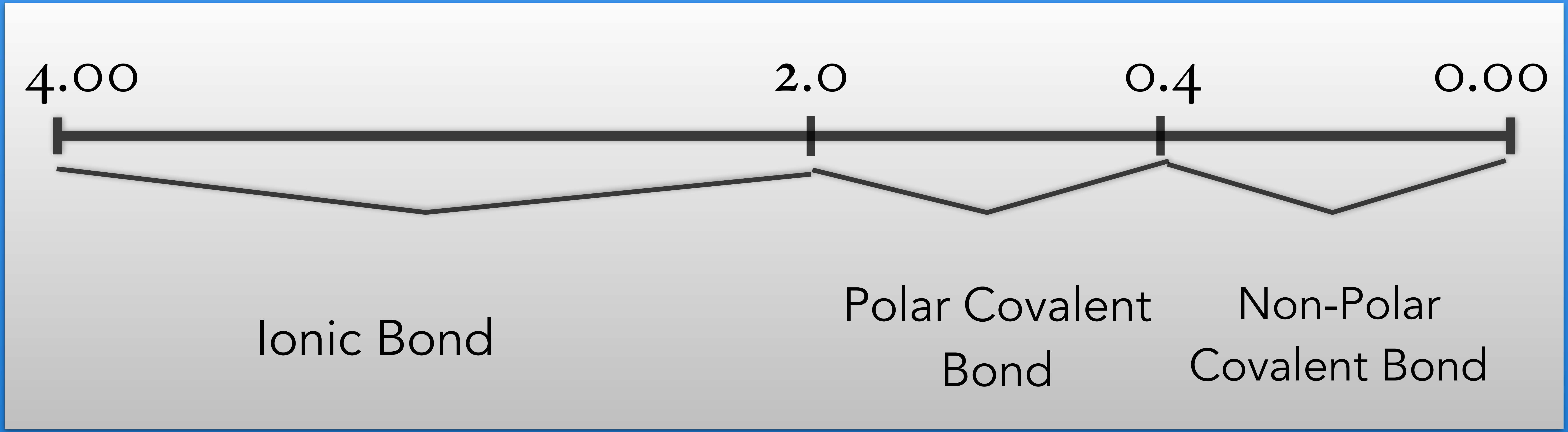
Non-Polar Covalent Bond	Polar Covalent Bond
electrons are evenly shared between the two atoms **electronegativities of the two atoms are very similar** **ALL diatomic substances (made up of two of the same atoms) are non-polar because atoms of the same element will have identical electronegativies.**	One atom has more electronegativity Polar covalent bond has a negative and positive side. + or - symbol or by an arrow. The arrow points to the stronger 'puller'. water has a polar covalent bond between the H and O

The Bonding ‘continuum’

- The three types of bonds should be viewed as a continuum..
  - no difference in electronegativity = the bond is **non-polar**
  - As the difference increases, the bond becomes more polar…
  - until the extreme case, forming an ionic bond!

Write this in your reference table.

Difference in Electronegativity - these are approximations



Practice

- Identify the bonds between each pair of elements as non-polar covalent, polar covalent, or ionic

H and Br

Polar Covalent

C and O

Polar Covalent

K and Cl

Ionic

Br and Br

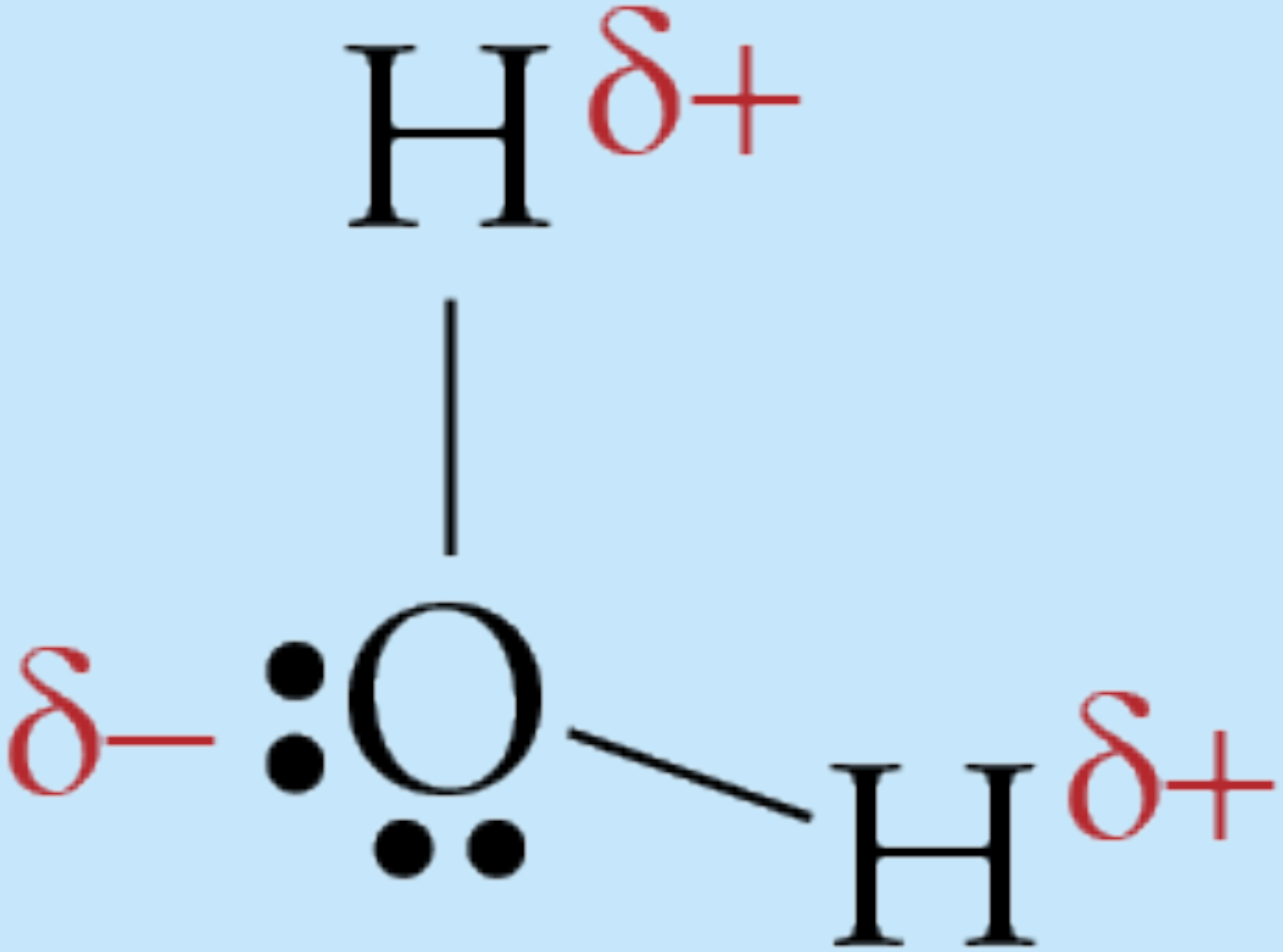
Non-Polar Covalent

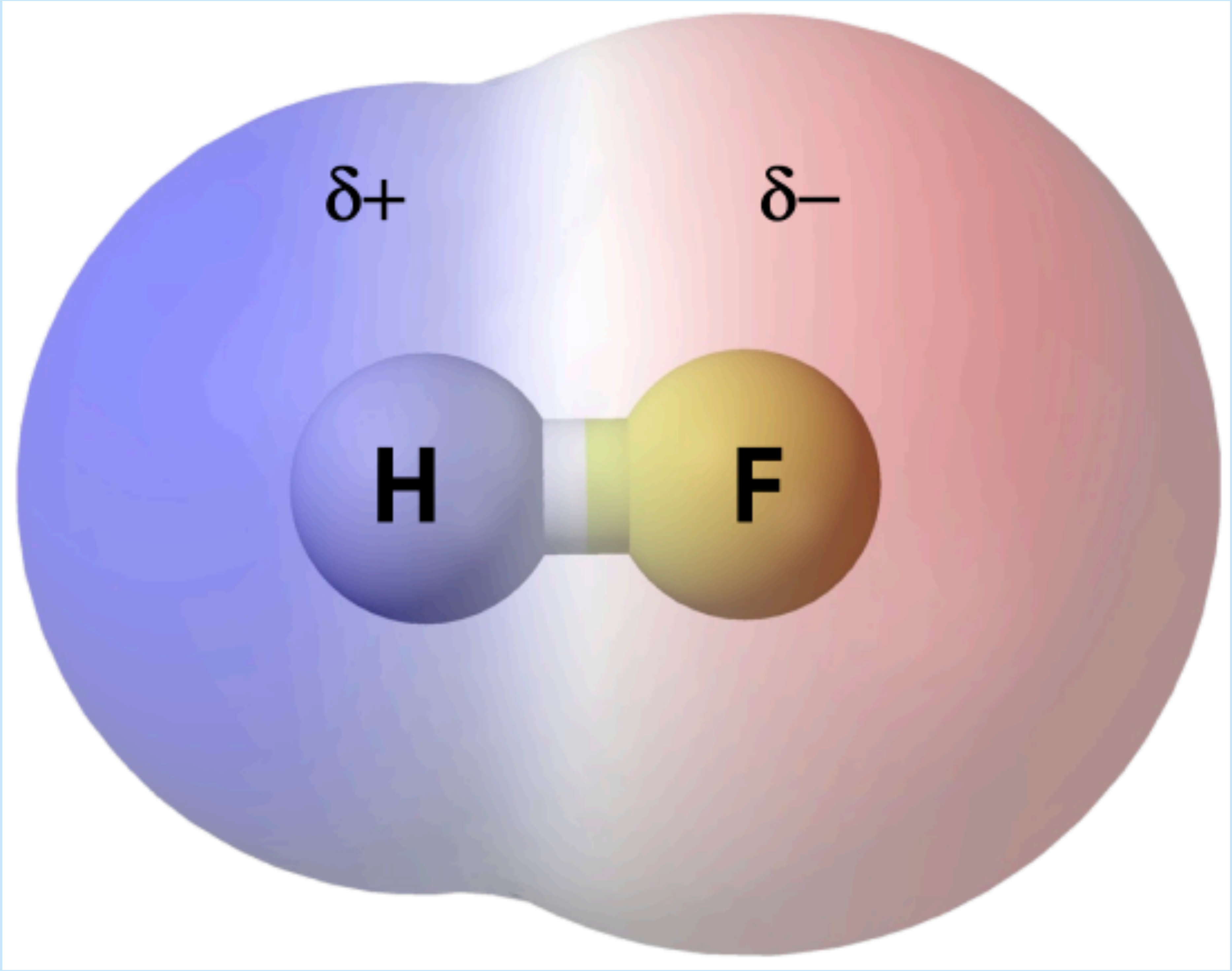
More Practice

- Place the following covalent bonds in order from *least to most* polar.
  - A. H–C
  - B. H–Cl
  - C. H–Br
  - D. H–Si

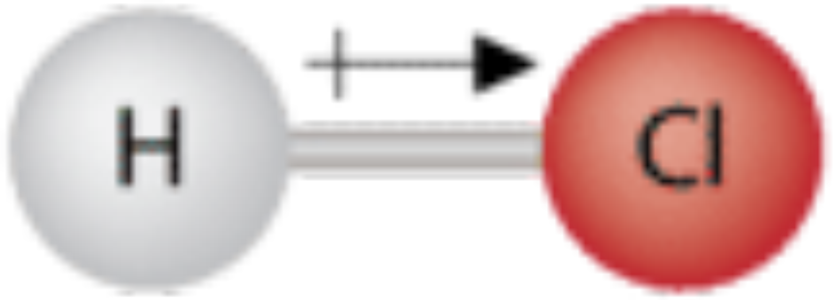
Polar & non-Polar Molecules

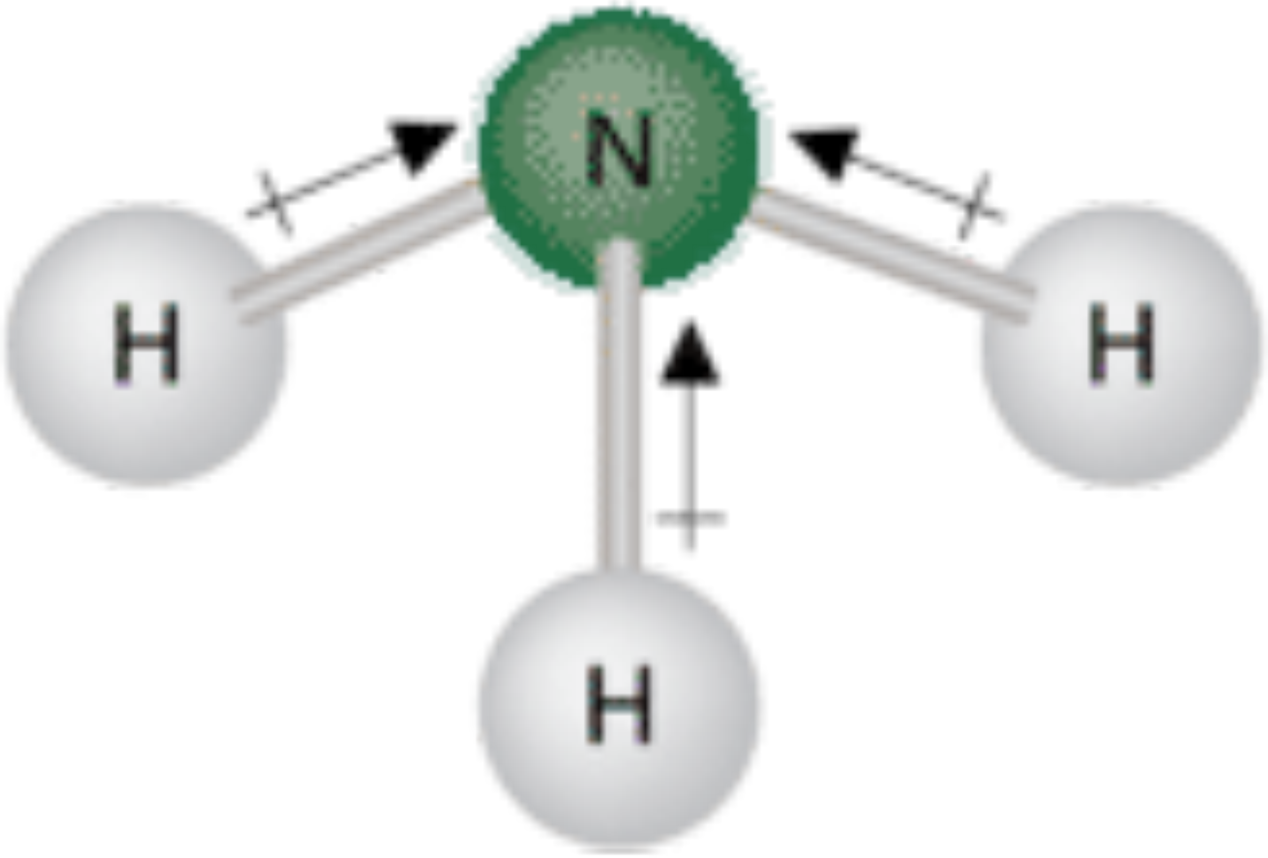
Topic 4

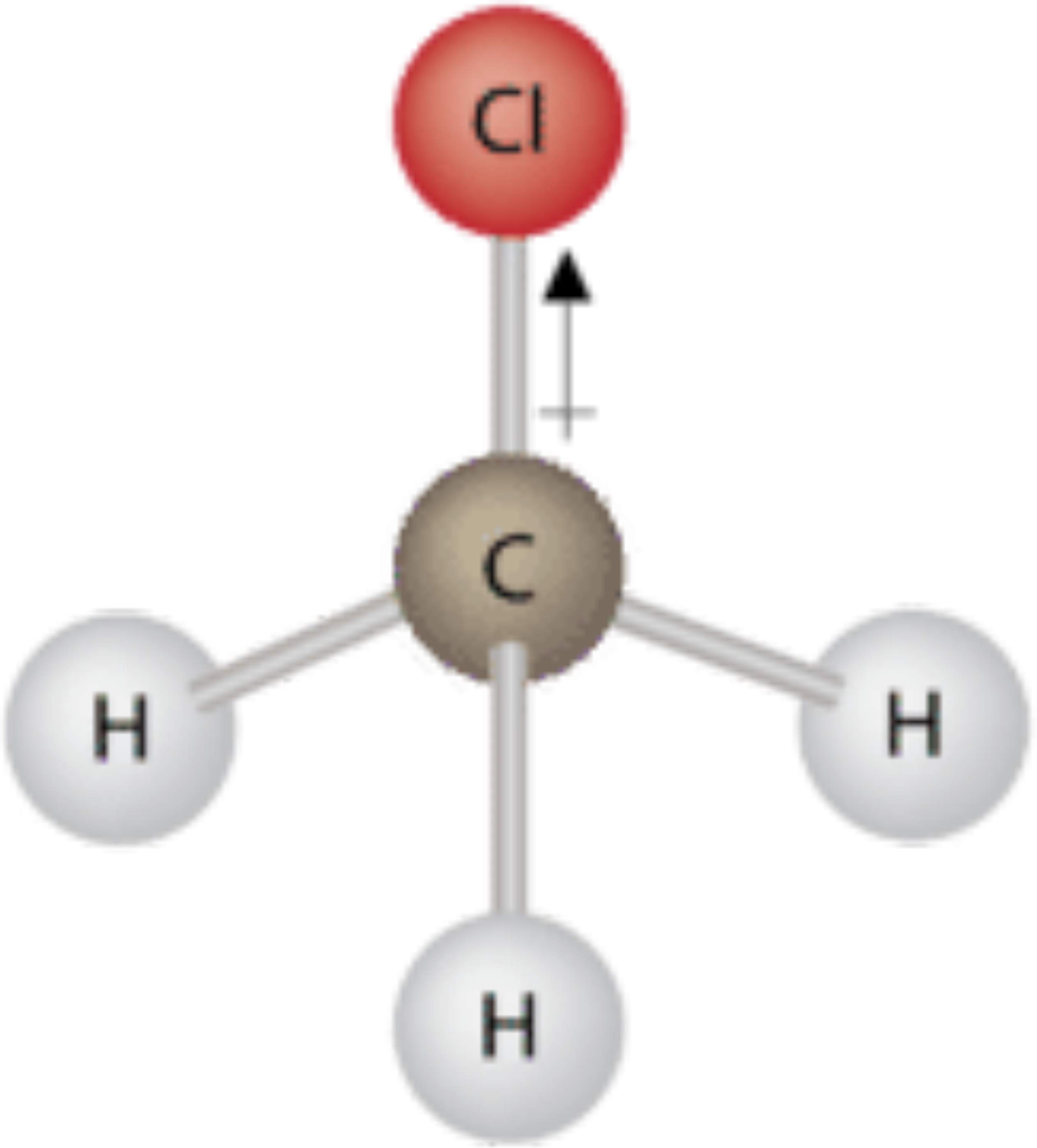




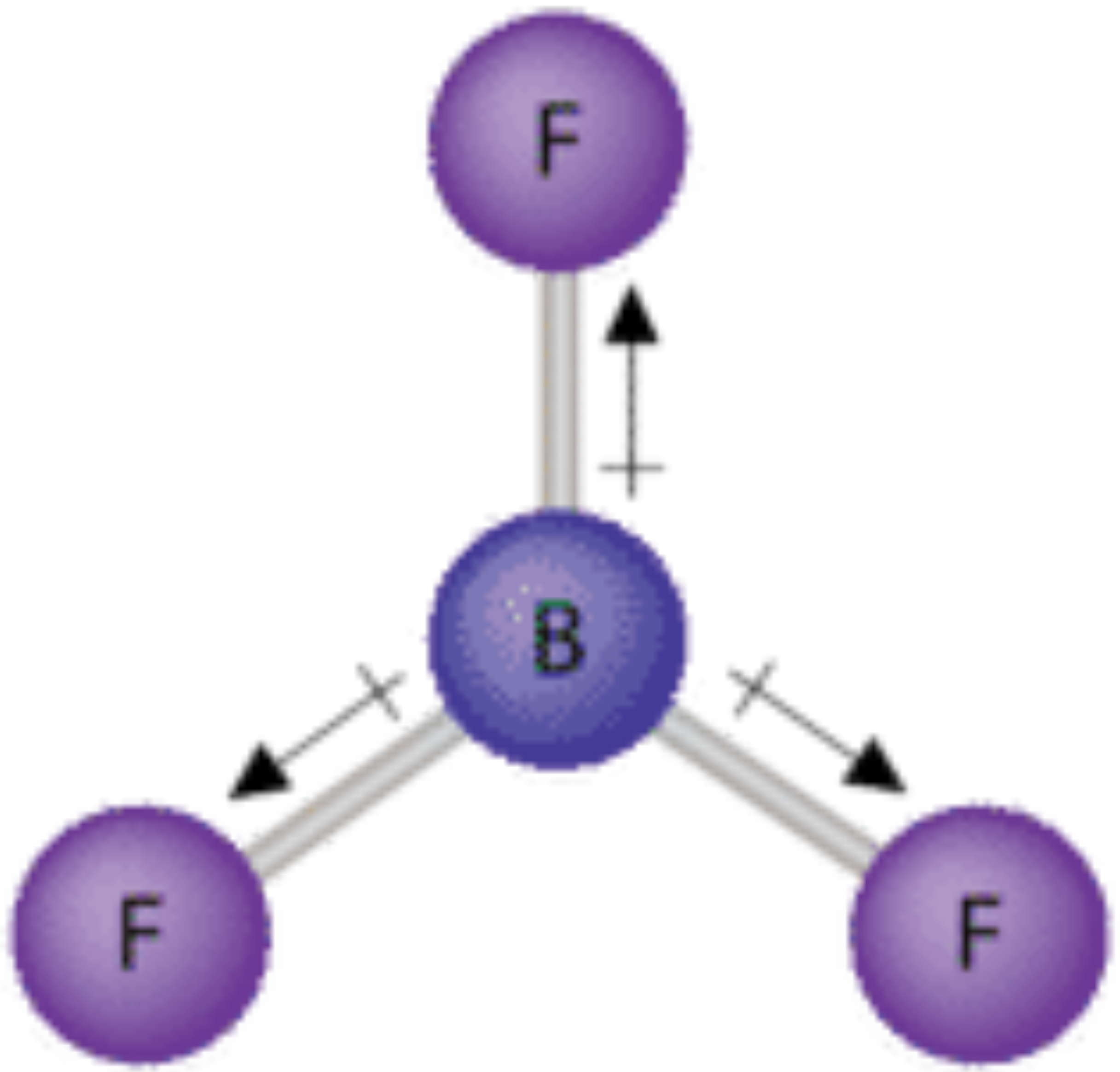
Polar:

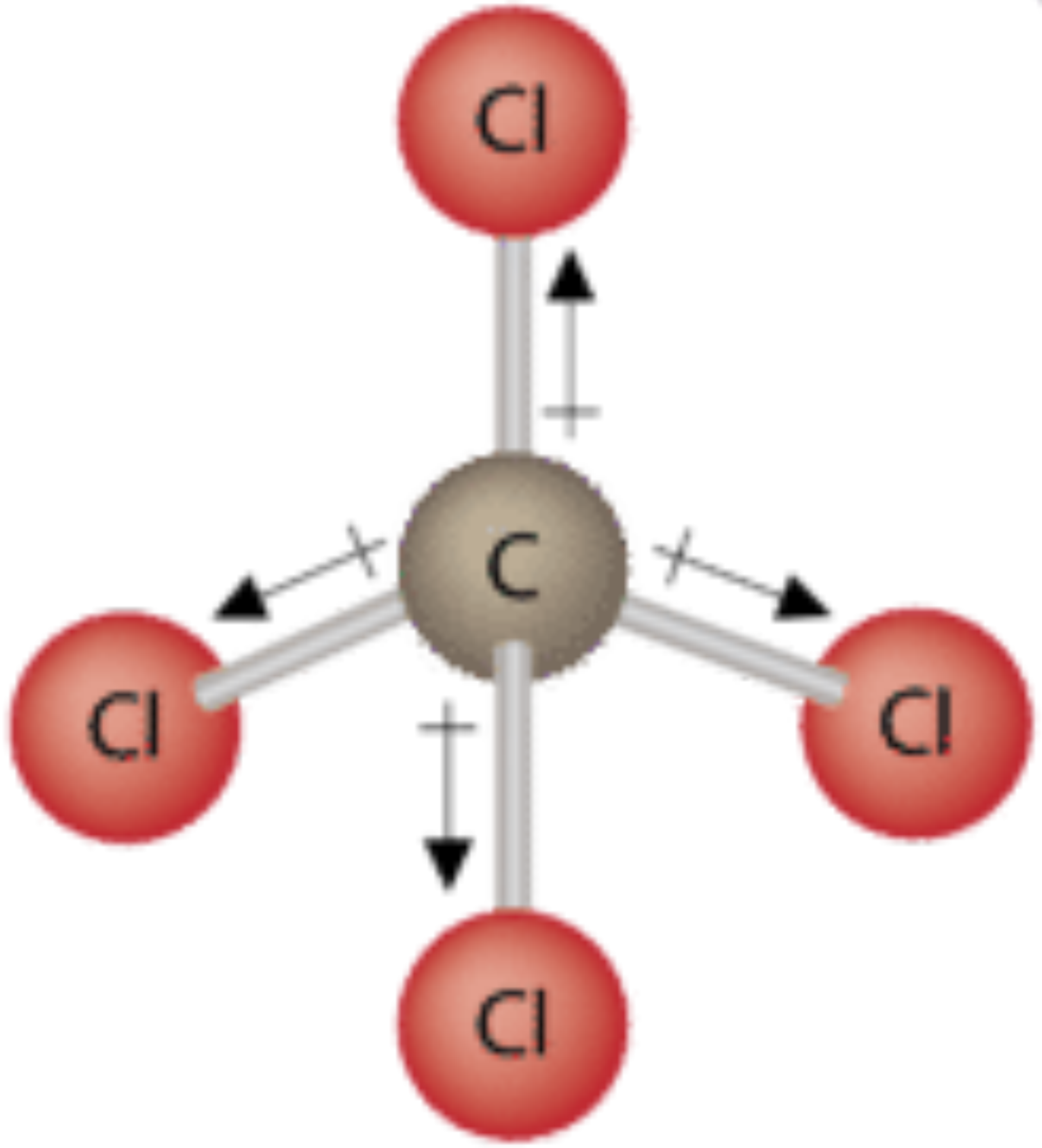






Non-polar:





Covalent Molecules

- To determine if a MOLECULE is polar or nonpolar, you MUST look at its SHAPE.

Nonpolar Molecules	Polar Molecules
molecules with a SYMMETRICAL SHAPE	molecules with an ASYMMETRICAL SHAPE
even distribution of electrons all around the molecule	*uneven distribution of electrons all around the molecule*
	electrons 'pulled' to one end of the molecule, which creates a negative 'pole' on the molecule. (The other end then becomes the 'positive' pole.
	polar asymmetric molecules are also called DIPOLES (meaning 'two poles')

Intermolecular Forces (IMFs)

Topic 5

Introduction

- the STRONGER the attractions between the particles in a substance, the HIGHER the melting point temperature (or boiling point) becomes.

- Using Table H, which of the 4 substances consists of particles with the strongest forces of attraction between them? ____________________

- How did you decide?

- Do you remember how this relates to vapor pressure?

Ionic Bond

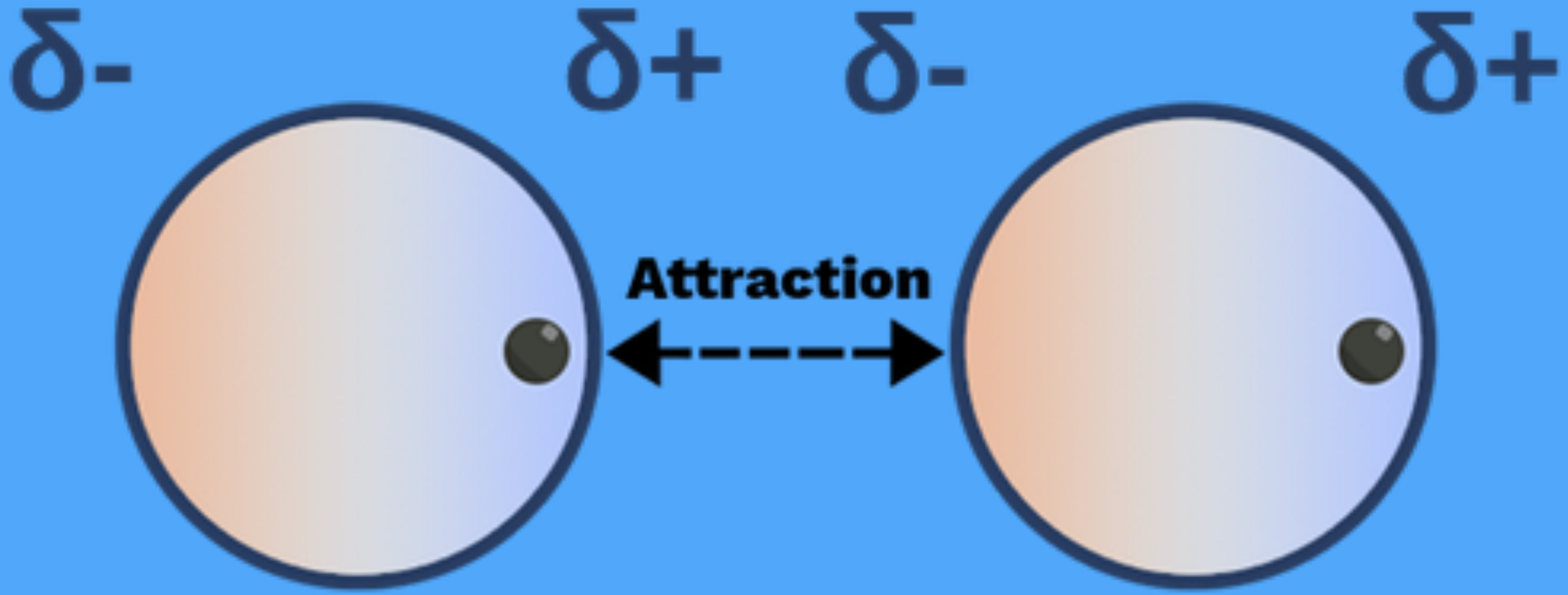
- Ionic substances have higher forces of attraction than covalent substances. The smaller the ions, the larger the attraction.
- If the ions are large, the distances between them are larger and the forces are weaker.
- Attraction also depends on the amount of charge. The more charge the more attraction (CaF_2 > NaF)
- Let's look at the following table …

Ionic Bonds

Type of substance	Common use	State at room temperature	Melting point (°C)
Ionic substances			
Potassium chloride, KCl	salt substitute	solid	770
Sodium chloride, NaCl	table salt	solid	801
Calcium fluoride, CaF_2	water fluoridation	solid	1423

van der Waal Forces

- Weak, Short-range
- Decrease rapidly as molecules get farther apart. (don't affect gases)
- These apply to *non-polar* COVALENT compounds.
- As mass increases, this force increases

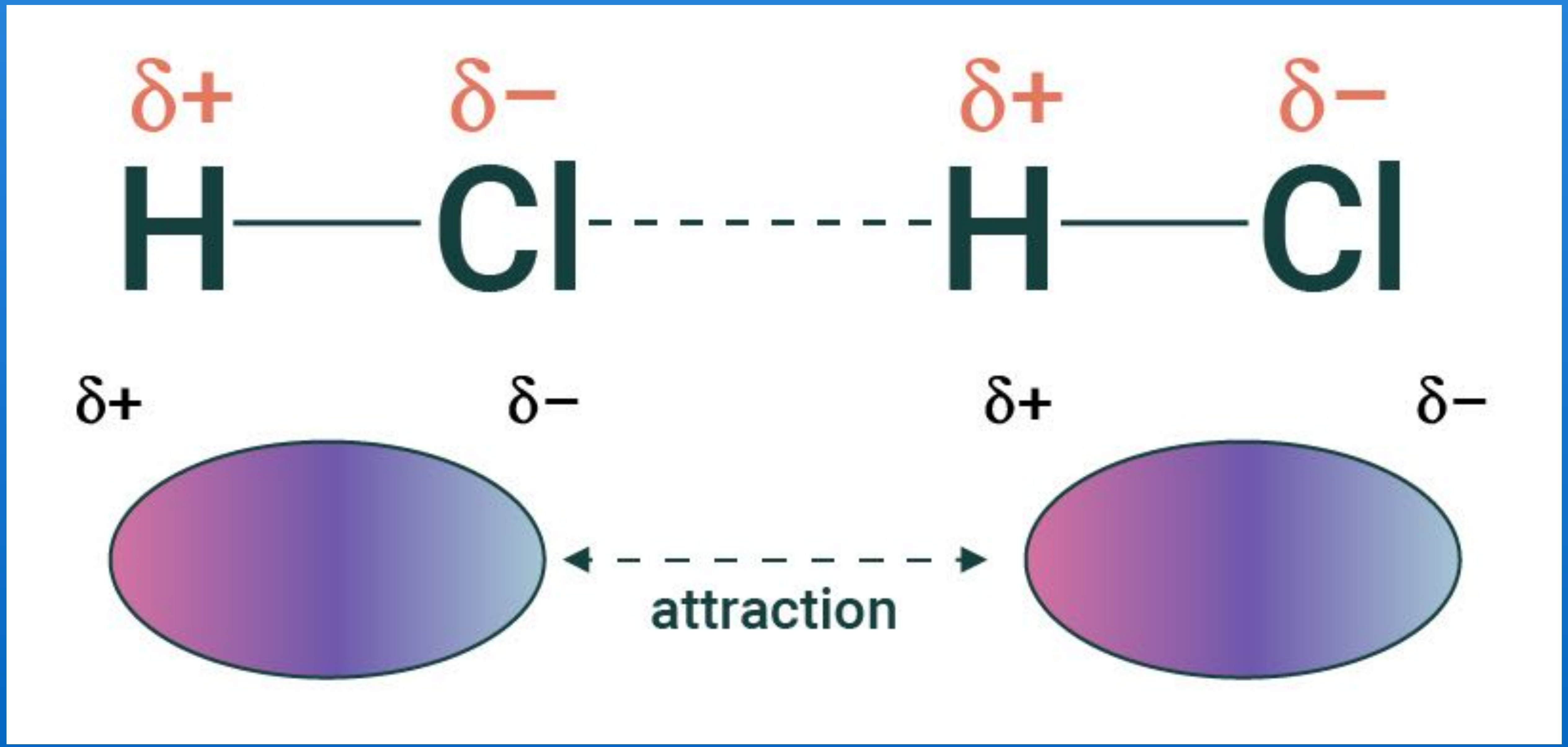


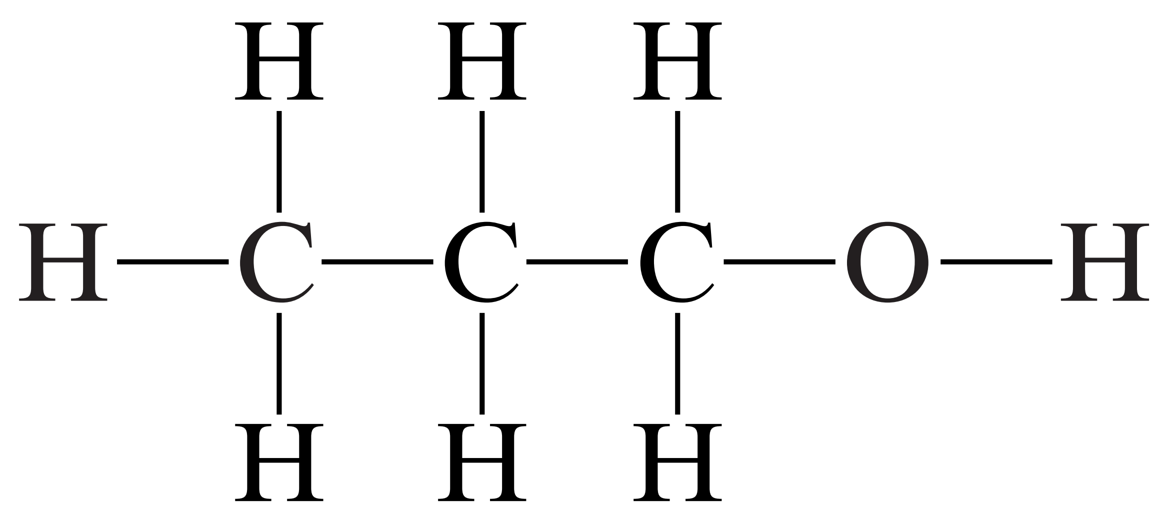
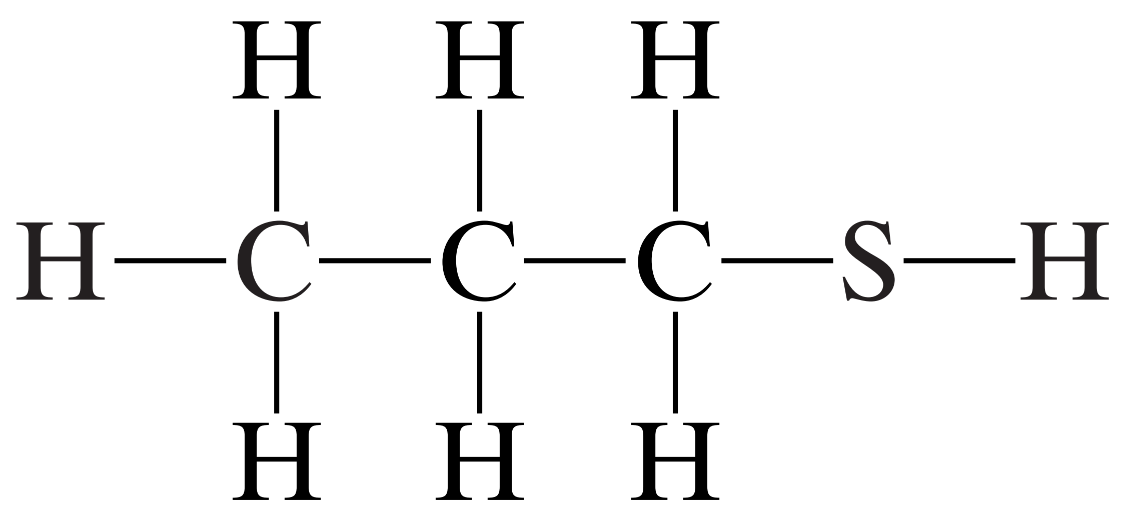
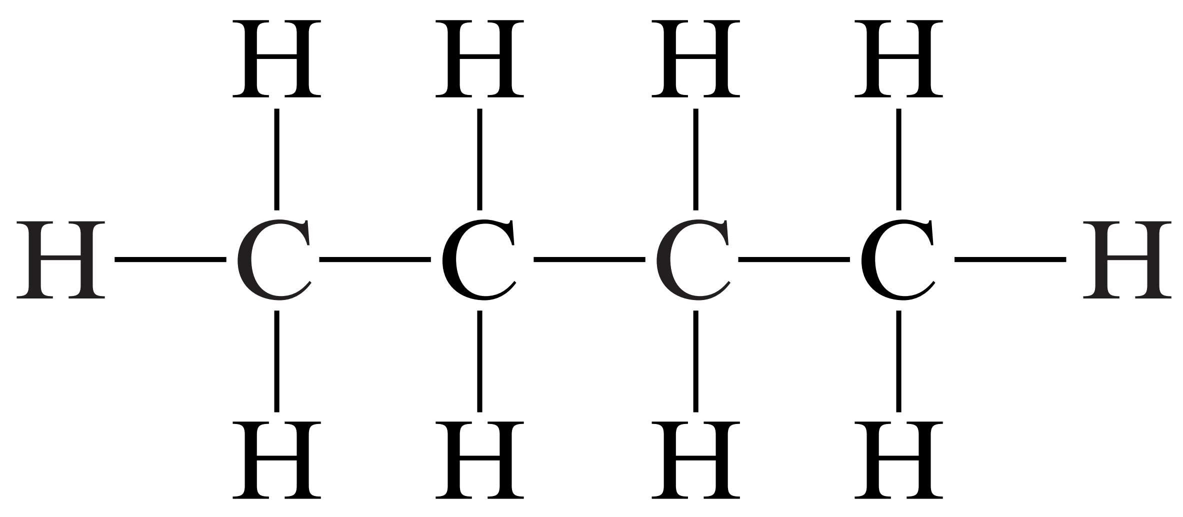
Dipole-Dipole

- The positive end of one molecule attracts the negative end of a neighboring molecule.

- Bonds are *polar* because of electronegativity.

- Polar asymmetric, middle strength, permanent.



Substance	Boiling point (°C)	Polarity	State at room temperature	Structure
1-propanol, C_3H_7OH	97.4	polar	liquid	
1-propanethiol, C_3H_7SH	67.8	less polar	liquid	
Butane, C_4H_{10}	–0.5	nonpolar	gas	

Hydrogen 'Bond'

- A special kind of dipole-dipole force.
- Form with a hydrogen atom that is covalently bonded to very electronegative atoms. **H**old the **F-O-N**!!
- The partial positive charge (on Hydrogen) is attracted to the unshared pairs of electrons of neighboring molecules.
- These are ***strong*** dipole-dipole forces due to differences in electronegativity AND because hydrogen is so small.

Hydrogen 'bond' examples

Table 3 Boiling Points of the Hydrogen Halides

Substance	HF	HCl	HBr	HI
Boiling point (°C)	20	–85	–67	–35
Electronegativity difference	1.8	1.0	0.8	0.5

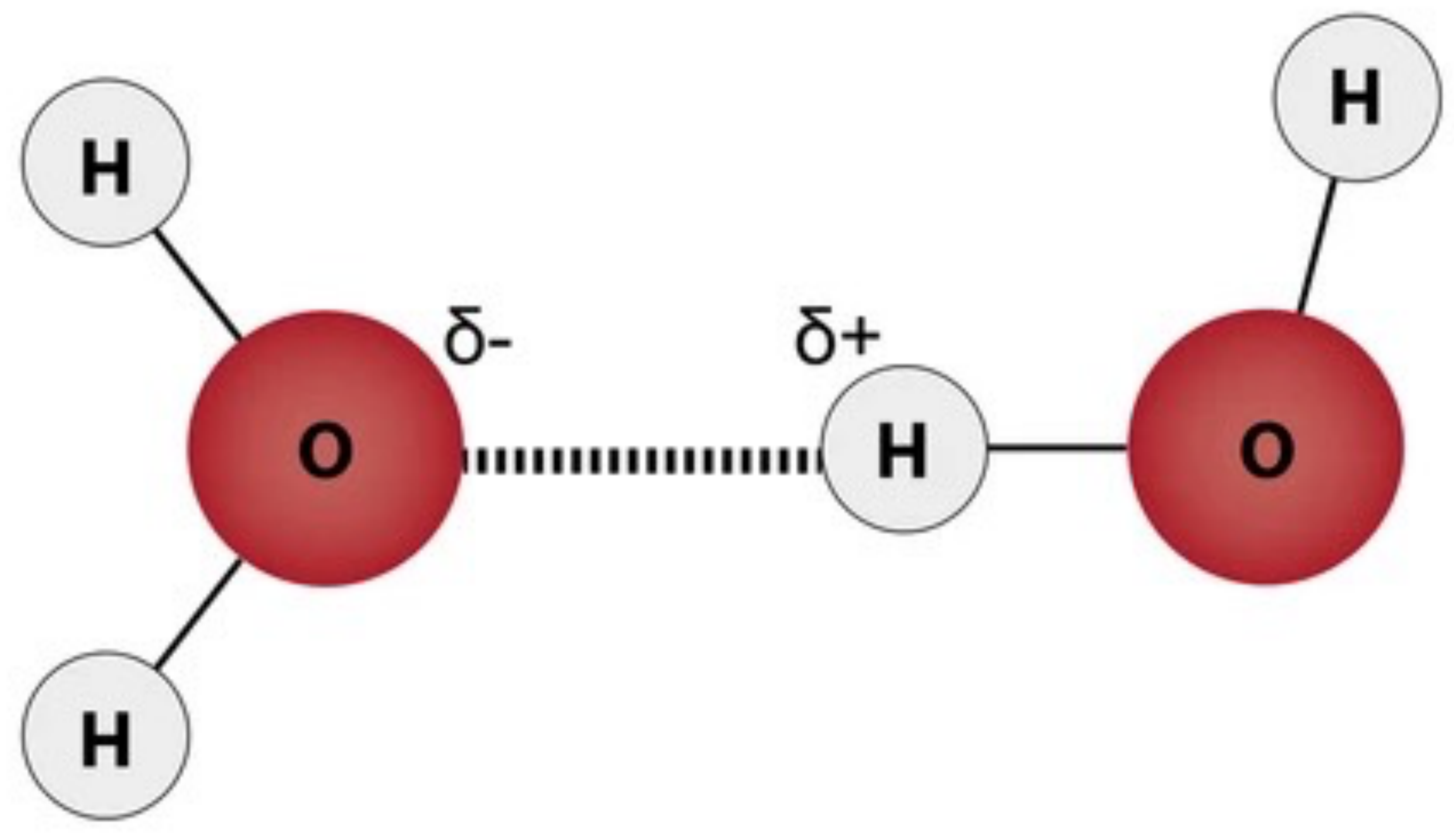
- The energy of hydrogen bonds is lower than that of normal chemical bonds, but can be stronger than that of other intermolecular forces.
- Can account for many properties of substances.

Hydrogen Bonding of Water

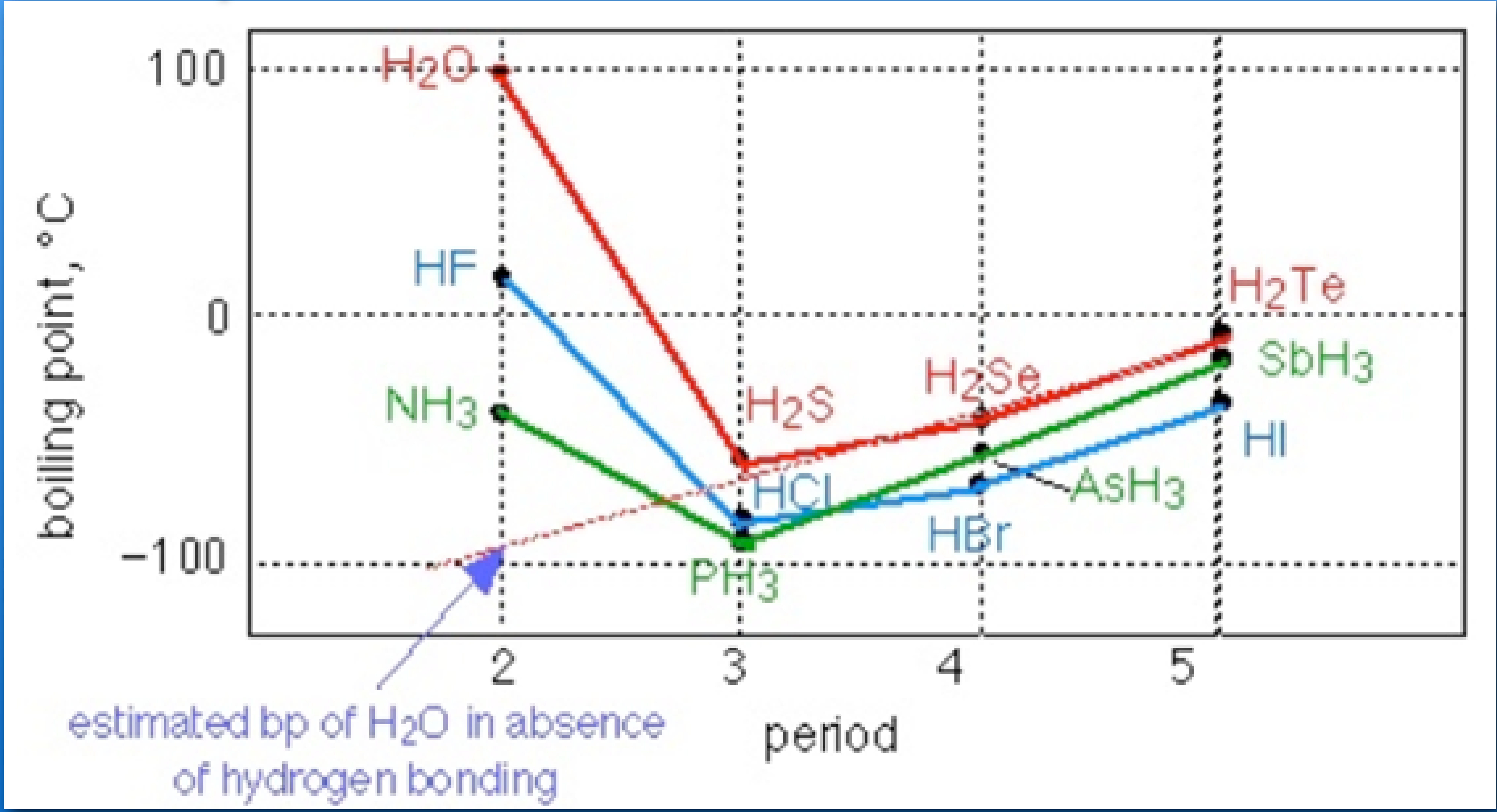
Why do the water molecules line up this way?

Hint: You REALLY need to know how to draw this diagram!!

Label the Hydrogen bond and the Polar Covalent Bonds



Important Graph



- Why are the H_2O, HF, and NH_3 boiling points so much higher than expected?

Summary

In order of increasing strength of force:

- van der Waal (non-polar molecules)
- dipole-dipole (polar asymmetric molecules)
- Hydrogen ‘bond’ (H: F, O, N)
- Ionic

Stronger forces of attraction

Molecular Math

Topic 6

Calculating Percent Composition

Example 1:

- Suppose a sample of a compound contains 7.85 g Nitrogen and 17.92 g Oxygen. What is the percent composition of each element in this compound? (Use Table T)

Empirical Examples

- Now try a few yourself … Write the empirical formula for each of the following:

- C_2H_6
- C_2H_4
- C_2H_2
- NO_2
- C_3H_9
- N_3O
- C_3PO

Empirical Formula Example #1

- You have a compound and 30.46% of it is Nitrogen and 69.54% of it is Oxygen. To determine its empirical formula:
- Assume you have a **100 gram** sample of the compound. That means you have 30.46 grams of Nitrogen and 69.54 grams of Oxygen.
- Convert grams to moles for both N and O.
- Convert the # of moles of N and O from step 2 into the simplest whole number ratio. (Divide both # of moles by whichever one is the smaller number.)
- This simple ratio becomes the subscripts in the empirical formula.

Example #2

Try this one at your table groups.

- A compound contains 0.467 grams of Sulfur and 1.033 grams of Chlorine. What is the empirical formula of the compound?

How to find Molecular Formula

- If you know BOTH the empirical formula and the gram formula mass of a compound, you can find the *molecular formula* of the compound.
- Once again, let's outline the procedure for an example and then try one at your table groups…

Example #1 Molecular Formula

- The empirical formula of a compound is NO_2, and the molecular mass is 92.0 grams. Find the *molecular formula*.
- Determine the gram formula mass of the empirical formula (*Periodic Table*).
- Divide the molecular mass by the empirical formula mass, then round that answer to the *nearest whole number.*
- Multiply the subscripts in the empirical formula by that number to get the correct molecular formula.

Example #2

- A compound used to whiten teeth has the empirical formula of HO. The molecular mass of this compound is 34.02 u. What is its *molecular formula*?

Unit Overview

- Topic 1 - Bonding (Ionic, Covalent, and Metallic)
- Topic 2 - Organic Chemistry (naming, and drawing structures of alkanes, alkenes, and alkynes).
- Topic 3 - Polar & Non-Polar Bonds (electronegativity affects polarity of a bond. The > the difference in electronegativity, the more polar the bond.)
- Topic 4 - Polar & Non-Polar Molecules (symmetry, non-bonded pairs of electrons)
- Topic 5 - Intermolecular Forces (van der Waal's [London Dispersion / Dipole-Dipole], Hydrogen 'Bond', Ionic)
- Topic 6 - Molecular Math (Percent Composition, Empirical Formula, Molecular Formula)