Department of Chemistry
University of Texas at Austin

Name:______________________

Constructing a Microscopic and Macroscopic View of Substances

Questions to ask yourself…	**Substance characteristics and/or Go To next Question**
1. What elements make up the substance?	
1a. Answer: **Metals**	Metallic solid with metal intermolecular bonds Go to 5
1b. Answer: **Metals and Non-metals**	Ionic solid with ionic intermolecular bonds or ion-ion IMFs Go to 5
1c. Answer: **Non-metals**	Go to 2
2. What is the melting point of the substance?	
2a. Answer: **> 500 K**	Most likely covalent solid with covalent atomic bonds throughout network Go to 5
2b. Answer: **< 500 K**	Most likely molecular compound that would need to be held in condensed phase with IMFs Go to 3
3. Is the molecule polar?	
3a. Answer: **Yes**	Go to 4
3b. Answer: **No**	Has only Dispersion forces for IMFs Go to 5
4. Is there hydrogen bonding?	
4a. Answer: **Yes**	Has H-bonding, dipole-dipole and dispersion forces for IMFs Go to 5
4b. Answer: **No**	Has dipole-dipole and dispersion forces for IMFs Go to 5
5. How do the MP and BP of the substance compare to T(room)?	
5a. Answer: **MP > T(room) and BP > T(room)**	Solid at room temperature
5b. Answer: **MP < T(room) and BP > T(room)**	Liquid at room temperature
5c. Answer: **MP < T(room) and BP < T(room)**	Gas at room temperature

Name:____________________

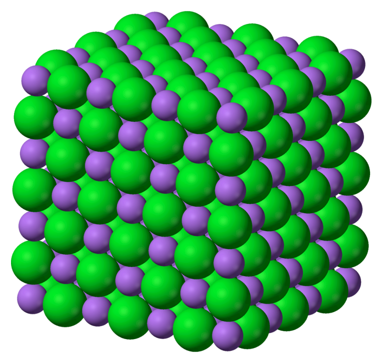
IMF Unit - Constructing a Microscopic and Macroscopic View of Substances

Use the flow chart to help you construct a macroscopic and microscopic view/picture of the substances. Assume you are observing the substance at normal room temperature (298K) and pressure (1 atm). Be sure to state the phase of the material at the normal conditions. In the microscopic (molecular) view, make sure to include any dipole moments and label all types of bonds and/or IMFs present in the substance. If it is a molecular compound, be sure to draw it indicating the proper geometry indicating the bond angles. If the compound is a liquid predict the type of liquid properties you would expect: relative viscosity, surface tension, vapor pressure, boiling point. If it is a solid predict the type of solid it is and why you would expect the type of physical property (relative magnitude of the MP and BP) to be what they are based on the type of bonding in the solid.

1. Potassium chlorate, MP = 629 K, BP = 673K

- $KClO_3$
- Solid because its MP is greater than room temperature (298K)
- A very high boiling point and composition of metals and non-metals = Ionic Solid
- Ionic Solids have:
  - Columbic Attractions
  - Brittle Structure
  - Do not conduct electricity as solids but do conduct electricity as liquids
  - Form a crystal lattice of alternating cations and anions

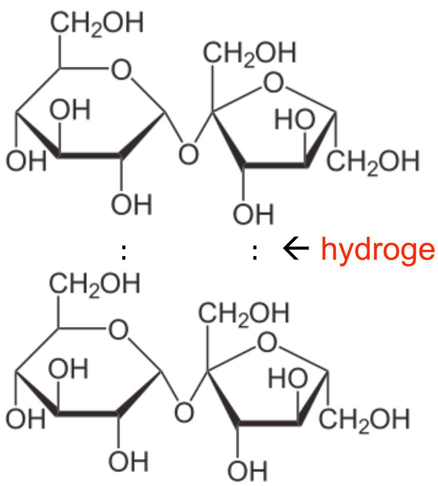
Pile of $KClO_3$ Salt Crystals



Green Anions = ClO_3^-
Purple Cations = K^+

2. Table sugar (sucrose), MP = 459 K, BP = NA

- $C_{12}H_{22}O_{11}$
- Solid because its MP is greater than room temperature (298K)
- A composition of all non-metals suggests it is a molecular solid
- Its relatively high MP is due to the great number of –OH groups that generate a lot of hydrogen bonding IMFs
- Also, dipole-dipole and dispersion interactions
- Brittle
- Does not conduct electricity
- All carbons are sp^3, tetrahedral
- All oxygens are sp^3, bent



← hydrogen bonding interaction

Sugar Cube

3. Ethanol, MP = 159K, BP = 351 K

- C_2H_6O
- Liquid because its MP is less than room temperature (298K) but its BP is greater than room temperature
- All carbons are sp^3, tetrahedral
- All oxygens are sp^3, bent
- IMFs: Hydrogen bonding, dipole-dipole and dispersion forces
- Viscosity:
  - Greater than CH_3OCH_3, similar to H_2O
- Surface Tension
  - Greater than CH_3OCH_3, less than H_2O
- Vapor Pressure
  - Less than CH_3OCH_3, greater than H_2O
- Boiling Point
  - Greater than CH_3OCH_3, less than H_2O

Ethanol can be derived from corn

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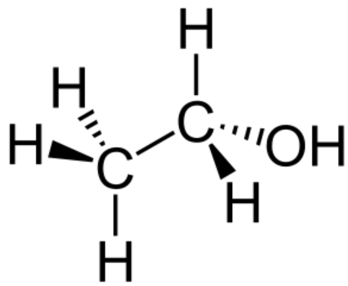

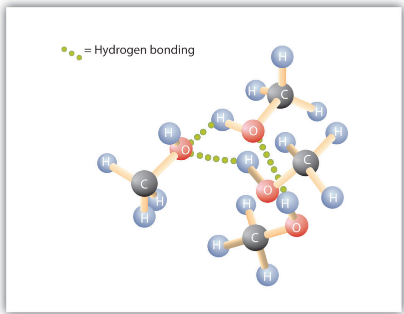

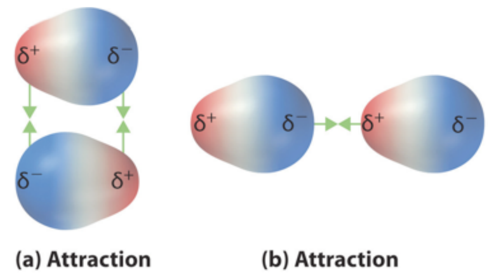

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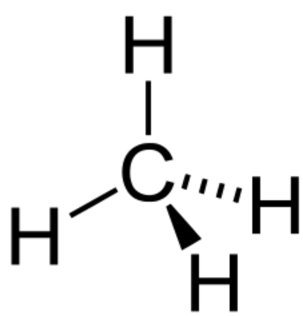
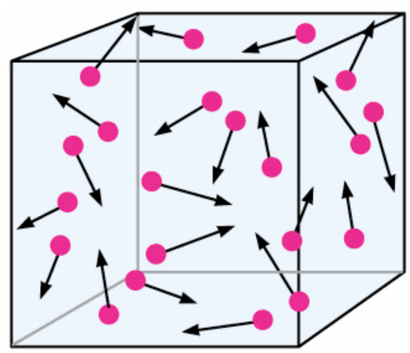
Net Dipole Hydrogen Bonding* Dipole-Dipole Interactions

* The diagram shows methanol molecules hydrogen bonding, but the process is similar in ethanol

4. Methane, MP = 90.5 K, BP = 109 K

- CH_4
- Gas because its boiling point is less than room temperature (298K)
- NO IMFs (essentially) maybe only very slight dispersion forces
- Particles move around freely
- C-H bonds considered non-polar

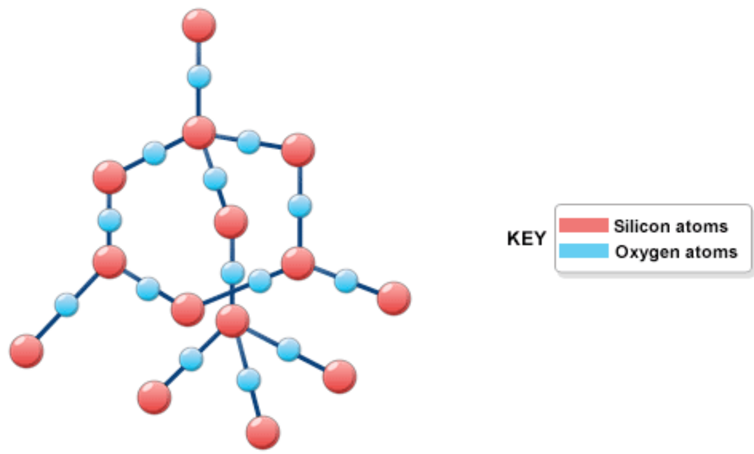




5. Sandbox type Sand (SiO_2), MP = 1900 K, BP = 2,503 K

- Its melting and boiling points are very high and it is composed of all non-metals. So that indicates it is a covalent solid/network solid
- There is COVALENT bonding between all of the adjacent atoms – stronger than IMFs
- SiO_2 is a ratio of the composition
- Does not conduct electricity

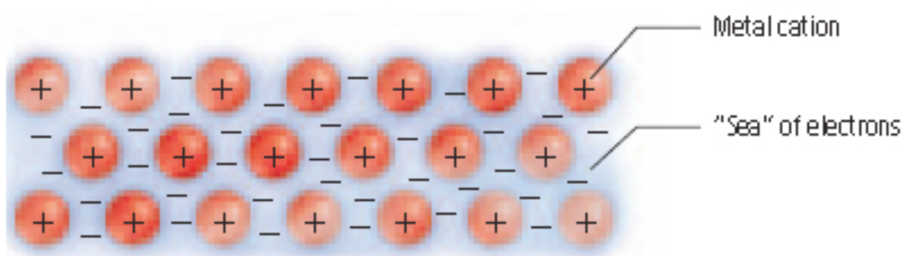
Name:____________________



SiO_2 is found in sand, quartz and glass

6. Gold, MP = 1337 K, BP = 3129 K

- Gold (Au) is a metal and has very high melting and boiling points which means it is a metallic solid
- Conducts electricity due to its "sea of electrons" (good conductor)
- Ductile, Malleable



7. Carbon Tetrachloride, MP = 250 K, BP = 350 K

- CCl_4
- Liquid because its MP is less than room temp, but its BP is higher than room temp
- Each C-Cl bond is polar, but the molecular itself is non-polar
- Only dispersion forces, but there are quite a lot of lone pairs contributing to these dispersion forces (that's why it is a liquid at room temp and methane is a gas)
- All carbons are sp^3, tetrahedral, 109.5˚ bond angles
- Viscosity:
  - Less than H_2O
- Surface Tension
  - Less than H_2O
- Vapor Pressure

Name:______________________

   - Greater than H_2O
- Boiling Point
   - Less than H_2O