Department of Chemistry
University of Texas at Austin

Solids and Liquids

Boiling Point (BP) and Melting Point (MP)

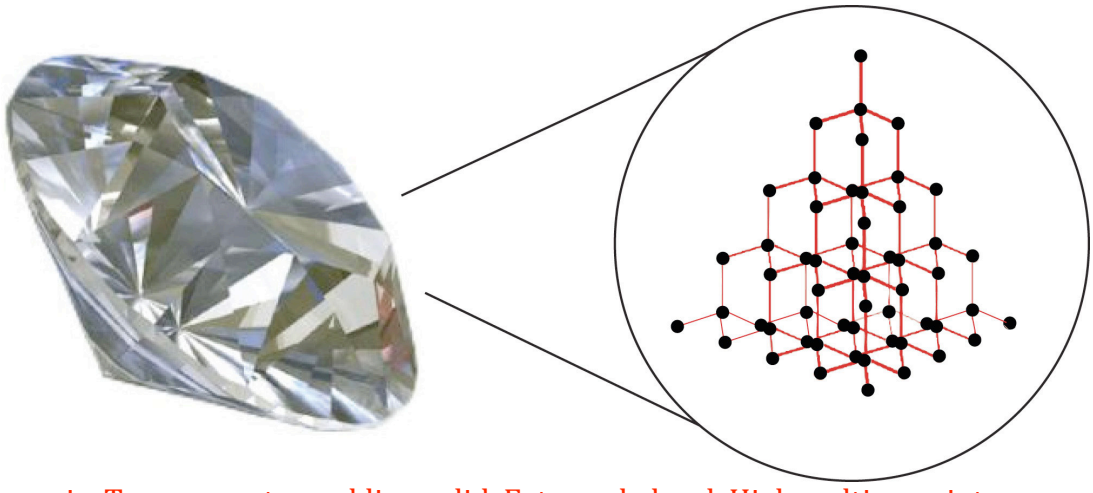
Given the substances' MP and BP, predict what phase it is in at room temperature. When we walk into the lab, what will we see? A solid, liquid or gas? An important question to answer first is: What is room temperature (T_{room}) in degrees Celsius (°C)?

Substance	MP (°C)	BP (°C)	Phase at T_{room}
Mercury	-39	357	Liquid Because MP< T_{room} and BP > T_{room}
Methane	-187	-161	Gas Because MP< T_{room} and BP< T_{room}
Aluminum	660	2519	Solid Because MP> T_{room} and BP> T_{room}
Hexane	-95	69	Liquid Because MP< T_{room} and BP> T_{room}

Macroscopic and Molecular Views of Substances

Describe the following substances from the macroscopic and molecular views using words and sketches. You may need to look online for the molecular structure of substances such as naphthalene, ethyl acetate, and formaldehyde. We do not expect you to know these structures.

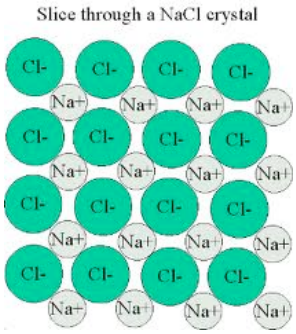
Solid Diamond (Carbon)
Covalent Solid because: non-metals, MP high



Macroscopic: Transparent, sparkling solid. Extremely hard. High melting point.
Microscopic: Only carbon atoms held together in a rigid, tetrahedral pattern.

Solid Table Salt (NaCl)

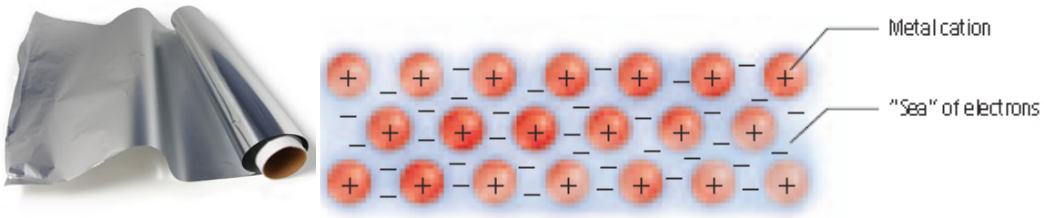
Ionic solid because: metal & non-metal, MP high



Macroscopic: White crystal. High melting point. Dissolves easily in water. Tastes salty.
Microscopic: Lattice of alternating small cations (Na^+) and large anions (Cl^-) held together by columbic attraction forces.

Solid Aluminum (Al)

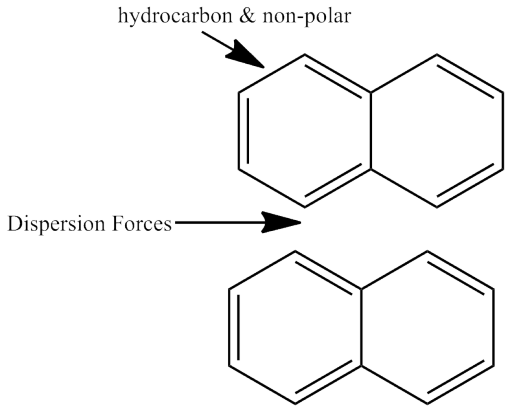
Metal solid because aluminum is a metal.



Macroscopic: Shiny, silver colored metal. Ductile and Malleable. High melting point.
Microscopic: Aluminum nuclei surrounded by a fluid "sea of electrons"

Solid Naphthalene ($C_{10}H_8$)

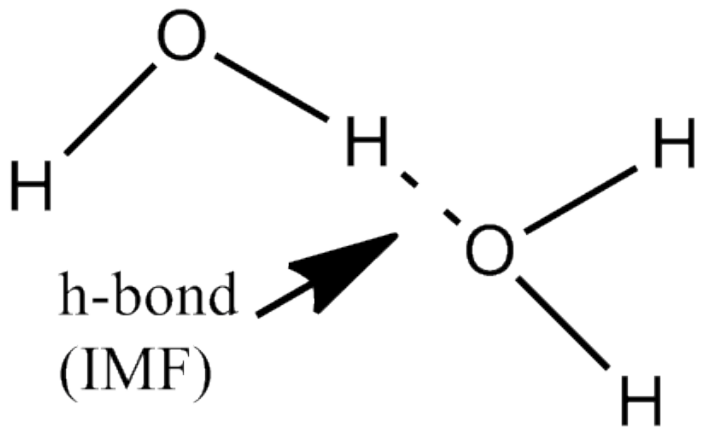
Molecular solid (when is solid phase) because: non-metals, MP low.



Macroscopic: White crystal. Smells like moth balls.
Microscopic: Held together by dispersion forces.

Liquid Water (H_20)

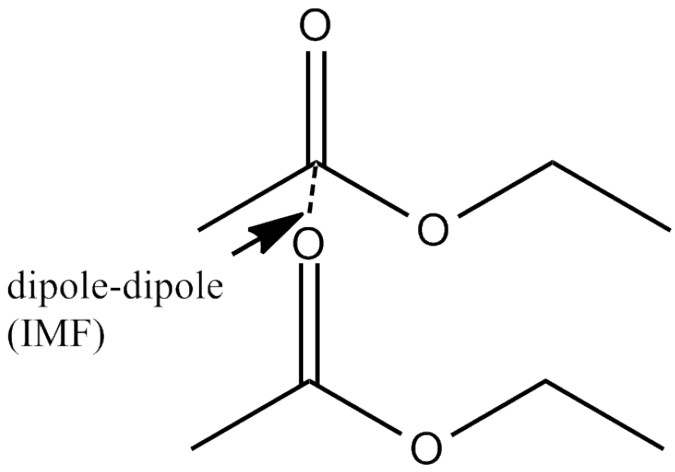
Molecular solid (when in solid phase) because: non-metals, MP low.



Macroscopic: Clear, odorless, high boiling point.
Microscopic: Held together by hydrogen-bonding, dipole-dipole and dispersion forces.

Liquid Ethyl Acetate ($CH_3COOCH_2CH_3$)

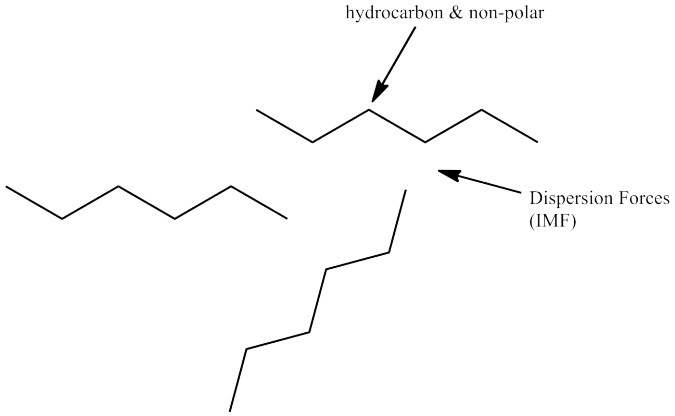
Molecular solid (when in solid phase) because: non-metals, MP low.



Macroscopic: Clear, nail polish smell, low boiling point.
Microscopic: Held together by dipole-dipole and dispersion forces.

Liquid Hexanes (C_6H_{14})

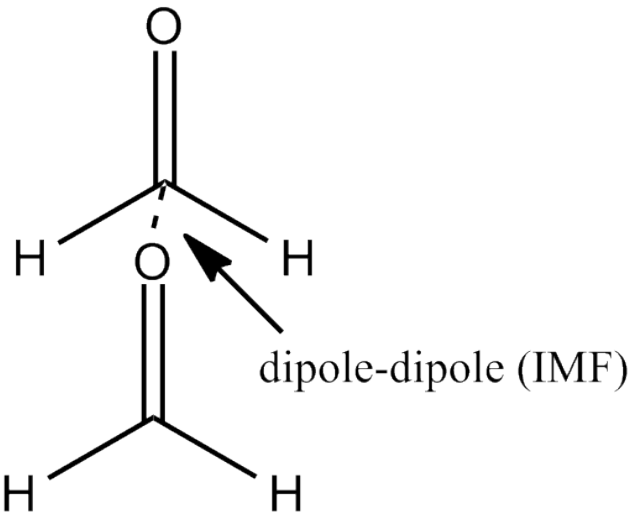
Molecular solid (when in solid phase) because: non-metals, MP low.



Macroscopic: Clear, gasoline smell, low boiling point.
Microscopic: Held together by dispersion forces.

Liquid Formaldehyde (CH_20)

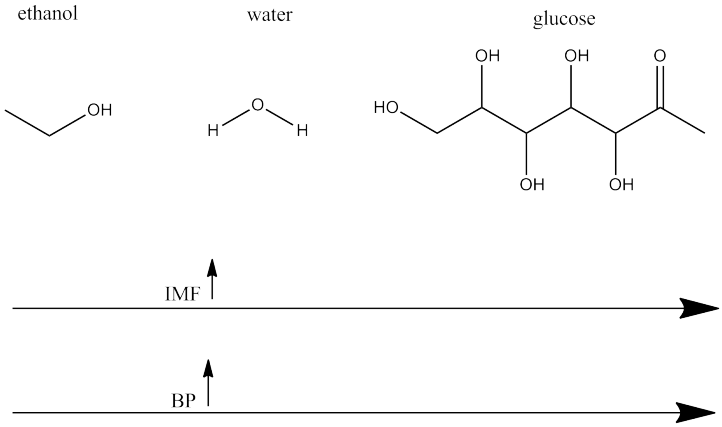
Molecular solid (when in solid phase) because: non-metals, MP low.



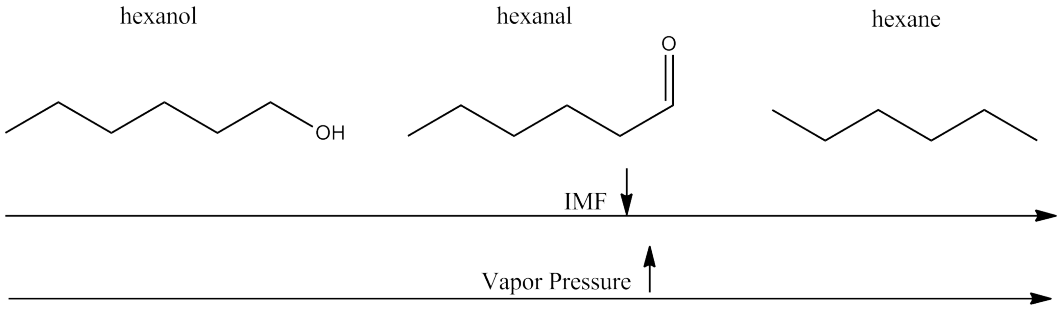
Macroscopic: Clear, pungent smell, low boiling point.
Microscopic: Held together by dipole-dipole and dispersion forces.

Properties of Liquids

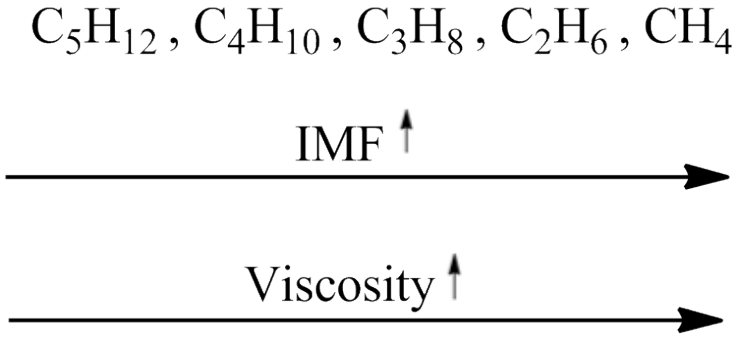
1. Rank the following compounds by BP, from lowest to highest: glucose, ethanol, H_2O.
   Ethanol, water, glucose



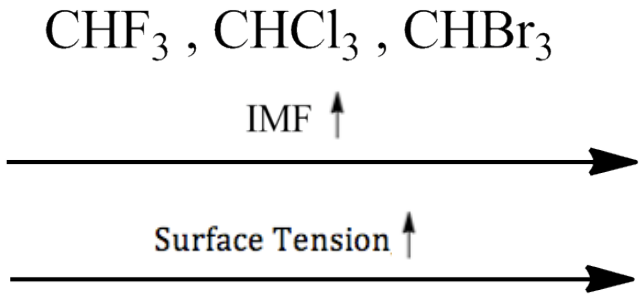
2. Rank the following compounds by vapor pressure, from lowest to highest: hexane, hexanol, hexanal.
   Hexanol, hexanal, hexane



3. Rank the following compounds by viscosity, from most viscous to least: C_5H_{12}, CH_4, C_3H_8, C_2H_6, C_4H_{10}.
   C_5H_{12}, C_4H_{10}, C_3H_8, C_2H_6, CH_4



4. Rank the following compounds by Surface Tension, from lowest to highest: $CHBr_3$, CHF_3, $CHCl_3$.
   CHF_3, $CHCl_3$, $CHBr_3$



5. Rank the following compounds by strength of IMFs: C_2H_6, H_2O, CH_4, NH_3. Then say how each of the following solution properties varies with IMF strength.
   CH_4, CH_6, NH_3, H_2O

   a. Boiling point: With higher IMFs, molecules are more attracted to each other and therefore it takes more energy for one molecule to move from the liquid phase into the gas phase. Thus, BP increases with increasing IMFs.

   b. Viscosity: Since viscosity is resistance to flow, the greater the attraction between molecules, the more resistant it is to flow, and the higher the viscosity.

   c. Vapor pressure: Vapor pressure is the force of the molecules of the substance in the vapor phase pushing down on the liquid phase. Since it takes increasing energy to remove a molecule from the liquid phase as IMFs increase, there will be fewer molecules in the gas phase and thus the vapor pressure will be lower.

   d. Surface tension: Surface tension is the resistance of a liquid to increasing its surface area. Thus, with increasing IMFs, surface tension increases.

Properties of Solids

1. What type of solid are each of these? Why do you think this?
   a. Methane: molecular, because it is made up of all non-metals and has a relatively low MP (-187°C)

   b. Sulfur dioxide: molecular, because it is made up of all non-metals and has a relatively low MP (-187°C)

c. Iron: metal, because Iron (Fe) is a metal

d. Graphite: covalent or network, because it is made up of all non-metals and has a relatively high MP (around 3652 – 3697 °C)

e. Silicon dioxide: covalent or network, because it is made up of all non-metals and has a relatively high MP (around 1600 – 1725 °C)

f. Calcium Bromide: ionic, because it is made up of a metal and a non-metal

g. Lithium: metal, because Lithium (Li) is a metal

2. Arrange the compounds $BaCl_2$, diamond, H_2, HF in order of increasing expected MPs.
H_2, HF, $BaCl_2$, diamond
(molecular solid with only dispersion forces, molecular solid with hydrogen bonding, ionic solid, network solid).