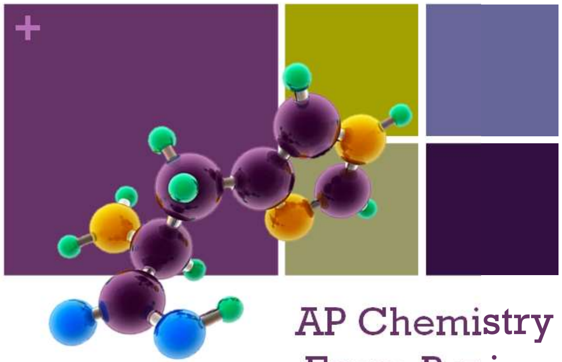
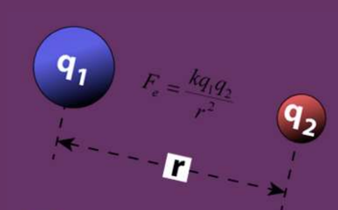


AP Chemistry Exam Review



$$F_e = \frac{kq_1q_2}{r^2}$$

Big Idea #2
Properties of Matter

Source

Properties Based on Bonding

Bonding	e.g.	Melting & Boiling Points	State at 1 atm, 298 K	Does solid conduct electricity	Does liquid conduct electricity	Soluble in H_2O
Ionic	NaCl $MgCl_2$	High	Solid	No	Yes	Yes★
Simple Covalent	CO_2 I_2 H_2O	Low: Only have to overcome IMF's	Usually liquid or gas but may be solid (I_2)	No	No	Depends how polarised the molecule is
Network Covalent	Diamond Graphite SiO_2	High	Solid	No (except graphite)	/	No
Metallic	Fe Mg Al	High	Solid	Yes	yes	No

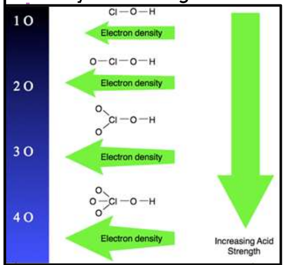
Video 1
Video 2
Video 3
Video 4

- Visit the Virtual Lab to explore properties based on bond type (click on perform)

★ Not all ionic compounds are soluble, but those containing ammonium, nitrate, alkali metals, and halogens (except bonded to Ag, Hg and Pb) are typically

LO 2.1: Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views

Oxyacid Strength



The increased number of oxygen atoms pulls negative charge away from the O-H bond, weakening the attraction of the proton for the electron pair and thus strengthening the acid.

Binary Acid Strength

Increasing electronegativity
Increasing acidity

Decreasing bond strength
Increasing acidity

6A	7A
H_2O	HF
H_2S	HCl
H_2Se	HBr
H_2Te	HI

The greater the size of the negative ion, the weaker its attraction for the proton, and so the stronger the acid, and the weaker the conjugate base. HI is the strongest binary acid.

Source

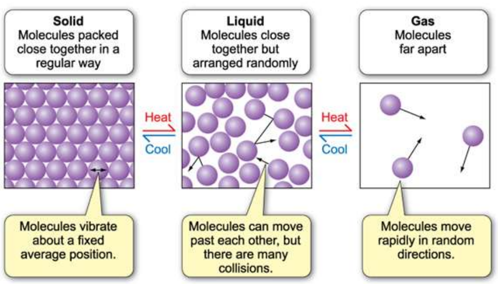
Reading

LO 2.2: student is able to explain the relative strengths of acids and bases based on structure, IMF's, & equilibrium.

+ Behaviors of Solids, Liquids, and Gases

Source

Video
Video 2



LO 2.3: The student is able to use particulate models to reason about observed differences between solid and liquid phases and among solid and liquid materials.

+ Kinetic Molecular Theory (KMT)

Source

1. Lots of tiny particles that are relatively far apart.
2. Elastic collisions- no loss of energy
3. Continuous, rapid, random motion
4. No interaction between molecules

Video 1
Video 2

- IF the temperature is not changed, *no matter what else is listed in the problem,* the average kinetic energy of a gas does not change. That is the definition of temperature!
- All gases begin to act non-ideally (aka real) when they are at low temperatures and/or high pressures because these conditions increase particle interactions
- Under the same conditions, the stronger the intermolecular attractions between gas particles, the LESS ideal the behavior of the gas

LO 2.4: The student is able to use KMT and IMF's to make predictions about the macroscopic properties of gases, including both ideal and non-ideal behaviors

+ Properties of a Gas - Factors

Source

- Don't worry about individual gas law names, but do worry about the effect of changing moles, pressure and temperature on a sample of gas

Virtual Lab

(a) P vs. V (Boyle's law): At constant temperature and amount of gas, pressure decreases as volume increases (and vice versa).

(b) V vs. T (Charles' law): At constant pressure and amount of gas, volume increases as temperature increases (and vice versa).

(c) V vs. n (Avogadro's law): At constant pressure and temperature, volume increases as amount of gas increases (and vice versa).

LO 2.5: Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample

+ The Ideal Gas Law

Source

Question:
15.5 grams of an unknown substance are placed in an sealed 5.00 L container. At 150 °C the substance has fully converted to a gas and the pressure in the container is 1.10 atm. Which of the following equations represents the molar mass of the unknown compound?

a. $\frac{5.00L\cdot 1.10atm}{15.5g\cdot 0.0821\frac{atm}{mol}\frac{L}{K}\cdot 423K}$

b. $\frac{5.00L\cdot 1.10atm}{0.0821\frac{atm}{mol}\frac{L}{K}\cdot 150K}$

c. $\frac{15.5g\cdot 0.0821\frac{atm}{mol}\frac{L}{K}\cdot 150K}{5.00L\cdot 1.10atm}$

d. $\frac{0.0821\frac{atm}{mol}\frac{L}{K}\cdot 150K}{5.00L\cdot 1.10atm}$

e. $\frac{15.5g\cdot 0.0821\frac{atm}{mol}\frac{L}{K}\cdot 423K}{5.00L\cdot 1.10atm}$

Video

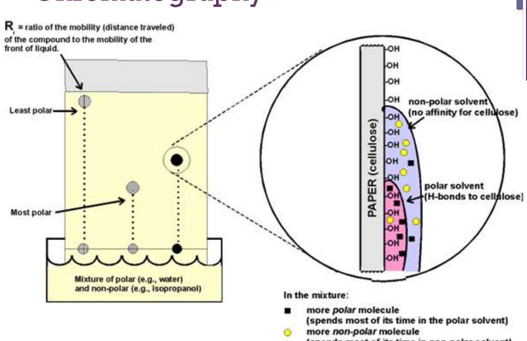
Click reveals answer and explanation.

LO 2.6: The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases

+ Chromatography

Source

Video

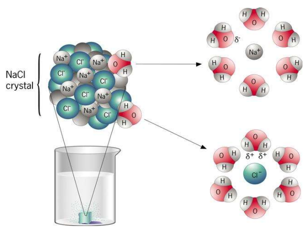


LO 2.7: The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions.

Source

+ Dissolving/Dissociation: Solute and Solvent

Video



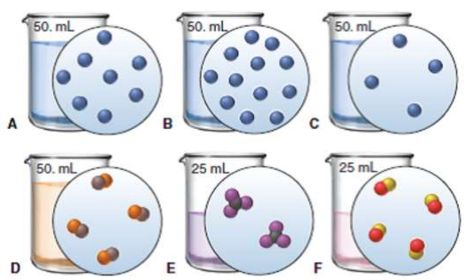
- When drawing solute ions:
  1. pay attention to size (Na^+ is smaller than Cl^-)
  2. Draw charges on ion, but not on water
  3. draw at least 3 water molecules around each
  4. the negative dipole (oxygen side) points toward cation and the postive dipoles (H side) points towards the anion

LO 2.8: The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.

Source

+ Molarity and Particle Views

Video



- QUESTION: Rank the six solutions above in order of increasing molarity. Pay attention to volume, and some have equal concentration

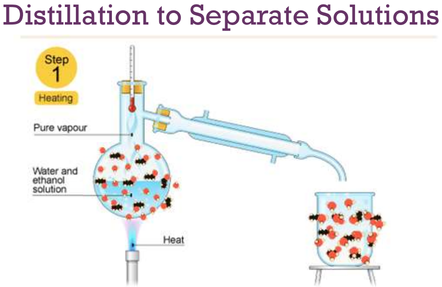
Click reveals answer

LO 2.9: The student is able to create or interpret representations that link the concept of molarity with particle views of solutions

Source

+ Distillation to Separate Solutions

Video



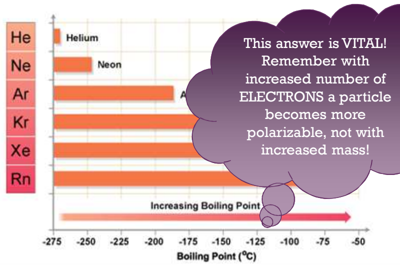
- In the diagram above, ethanol has lower IMF's and a resulting lower boiling point than water, so it can be heated, vaporized and condensed easily.
- Ethanol hydrogen bonds as water does and is polar, but part of the ethanol has only weaker LDF's because it's nonpolar resulting in a lower boiling point

LO 2.10: Design/interpret the results of filtration, paper/column chromatography, or distillation in terms of the relative strength of interactions among the components.

Source

+ London Dispersion Forces and Noble and Nonpolar Gases

Qu
Wh



This answer is VITAL! Remember with increased number of ELECTRONS a particle becomes more polarizable, not with increased mass!

LO 2.11: The student is able to explain the trends in properties/predict properties of samples consisting of particles with no permanent dipole on the basis of LDF's.

Source

+ Deviations from Ideal Gas Behavior

Video

Question:
At which values of temperature and pressure will the gas N_2 behave least like an ideal gas?

	Temperature (K)	Pressure (atm)
a.	100	100
b.	100	1.0
c.	700	0.1
d.	700	1.0
e.	700	100

When watching the video, don't concern yourself with Van der Walls – AP Exam focuses on LDF's instead

Click reveals answer and explanation.

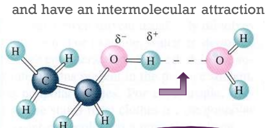
LO 2.12: The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions

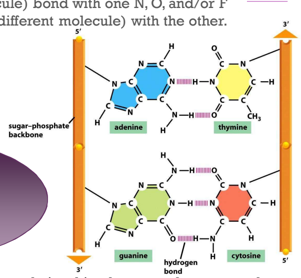
Source

+ Hydrogen Bonding

- Hydrogen bonding is seen in the following molecules: water, DNA, ammonia, HF, and alcohols. H-bonding is an attraction or force not a true intramolecular bond.
- Hydrogen bonds are like a sandwich with N, O, and/or F as the bread. H will be in a intramolecular (same molecule) bond with one N, O, and/or F and have an intermolecular attraction (different molecule) with the other.

Video





Remember this tip: hydrogen bonds just wanna have FON

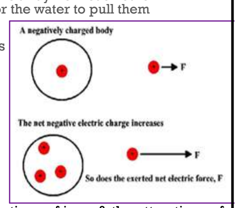
LO 2.13: The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.

Source

+ Coulomb's Law and Solubility

- Ionic compounds can dissolve in polar liquids like water because the ions are attracted to either the positive or negative part of the molecule.
- There is a sort of tug-of-war involved with species dissolved in water. The water pulls individual ions away from the solid. The solid is pulling individual ions back out of the water. There exists an equilibrium based on how strongly the water attracts the ions, versus how strong the ionic solid attracts the ions.
- We can predict the degree of solubility in water for different ionic compounds using Coulomb's law. The smaller the ions, the closer together they are, and the harder it is for the water molecules to pull the ions away from each other. The greater the charge of the ions, the harder it is for the water to pull them away as well.
  - QUESTION: Predict which of the following pairs should be more soluble in water, based on Coulombic attraction.
  - LiF or NaF
  - NaF or KF
  - BeO or LiF

Video



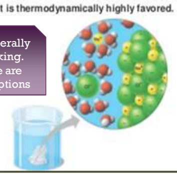
LO 2.14: Apply Coulomb's law to describe the interactions of ions, & the attractions of ions/solvents to explain the factors that contribute to solubility of ionic compounds.

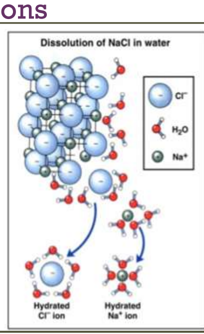
Source

+ Entropy in Solutions

Water dissolves salts by forming a shell of interacting water molecules around the ions. This weakens electrostatic interactions between the ions and counteracts their tendency to form a crystal lattice. Dissolution of the salt is accompanied by a large increase in entropy★ as the individual ions become more mobile. The change in free energy of the system is overall very negative ($\Delta G = \Delta H - T\Delta S$) and hence dissolution of the salt is thermodynamically highly favored.

★Generally speaking. There are exceptions





Video

Do NOT say "like dissolves like." You'll, like... get no points. DO refer to LDF's, hydrogen bonding and dipole-dipole interactions

LO 2.15: Explain observations of the solubility of ionic solids/molecules in water and other solvents on the basis of particle views that include IMF's and entropic effects.

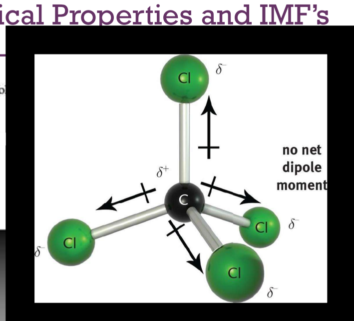
Source

+ Physical Properties and IMF's

Question:
Which of the fo … C?

a. H_2O
Hg
c. CCl_4
d. $C_{10}H_{22}$

… om



Video

LO 2.16: Explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of IMF's.

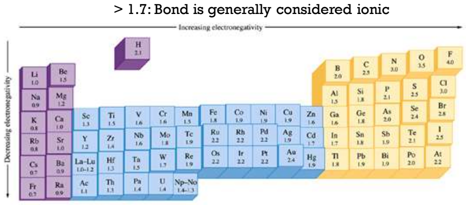
Source

+ Bonding and Electronegativity

Video

Differences in electronegativities lead to different types of bonding*:

0.0 – 0.4: Bond is generally considered nonpolar
0.5 – 1.7: Bond is generally considered polar
> 1.7: Bond is generally considered ionic



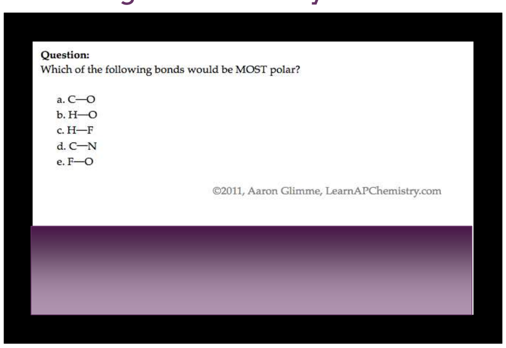
Electronegativities are assigned values and are relative to fluorine. Electronegativity is a function of shielding / effective nuclear charge.
*Values presented are one possibility – other scales exist.

LO 2.17: The student can predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements.

Source

+ Ranking Bond Polarity

Video

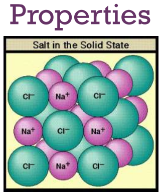


LO 2.18: The student is able to rank and justify the on the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.

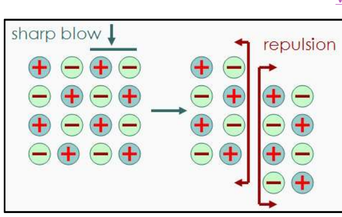
Source

+ Ionic Substances and their Properties

Video



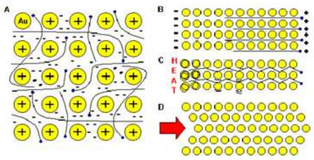
Ionic compounds are brittle. As the crystal structure is struck, the ions become displaced. The displaced ions will repel like charges and fracture.



LO 2.19: The student can create visual representations of ionic substances that connect the microscopic structure to macroscopic properties and/or use representations to connect microscopic structure to macroscopic properties (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity).

Source

Metallic Properties – Sea of



Video

"The metallic bond is not the easiest type of bond to understand, so an analogy may help. Imagine filling your bathtub with golf balls. Fill it right up to the top. The golf balls will arrange themselves in an orderly fashion as they fill the space in the tub. Do you see any spaces between the balls? If you turn on the faucet and plug the drain, the water will fill up those spaces. What you now have is something like metallic bonding. The golf balls are the metal kernals, and the water represents the valence electrons shared by all of the atoms."

LO 2.20: The student is able to explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., conductivity, malleability, ductility, and low volatility) and the shell model of the atom.

Source

Question:
Which

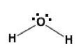
a. N
b. H
c. Bl
d. C
e. H

Question:
Which

a. C
b. N
c. H
d. H
e. C

Question:
Which hybridization would best represent the oxygen atom in the following molecule?

a. sp
b. sp^2
c. sp^3
d. dsp^3
e. d^2sp^3



LO 2.21: The student i... hybridization, and ma...

Great Lab Example

+ Ionic or Covalent? Bonding Tests

As the type of particles and forced of attraction in ionic and covalent compounds differ, their properties also

Properties	Ionic Compounds	Covalent Compounds
Melting/Boiling Points	High	Low except for some giant covalent molecules
Electrical Conductivity	Conduct electricity in molten and in aqueous solution	Does not conduct electricity in any state when pure, may conduct in aqueous solution (i.e., acids)
Solubility in water and organic solvents	Soluble in water Insoluble in organic solvent	Insoluble in water, except for some simple molecule Soluble in organic solvent
Volatility	Not volatile	Highly volatile

Video
Source

Substance	Type of Bonding	Phase at room temperature	Melting Point (C)	Electrical Conductivity without water	Electrical conductivity in water	Solubility in water (does it dissolve)
Distilled Water		Liquid	0	[illegible]	[illegible]	n/a
Sodium chloride (NaCl)		Solid	[illegible]	[illegible]	[illegible]	[illegible]
Potassium Iodide (KI)		Solid	[illegible]	[illegible]	[illegible]	[illegible]
Sucrose ($C_{12}H_{22}O_{11}$)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Olive Oil		Li[illegible]	[illegible]	[illegible]	[illegible]	no
Ethanol (C_2H_6O)		Liquid	[illegible]	[illegible]	[illegible]	yes
Corn Starch		Solid	Dec[illegible] at hig[illegible] tempera[illegible]	[illegible]	Click to view results	no
Glycerin		Liquid		Click to view results	Click to view results	no
Calcium Chloride ($CaCl_2$)		Solid		Click to view results	Click to view results	yes

Click here to do a virtual lab on bonding type (chart pictured below)

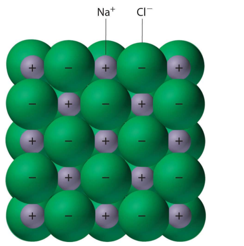
Use properties of compounds to differentiate them from one another. Other tests may be performed to positively identify the compound, but are not necessary to observe types of bonds present.

LO 2.22: The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid.

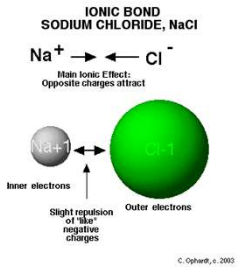
Source

+ Crystal Structure of Ionic Compounds

Video



(a) Ionic solid: strong electrostatic interactions



LO 2.23:The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.

Source

+ Crystal Structure of Ionic Compounds

Video

Sodium chloride and magnesium oxide have exactly the same structure. Their melting and boiling points are:

	NaCl	MgO
melting point (K)	1074	3125
boiling point (K)	1686	3873

Explain why the values for magnesium oxide are much higher than those for sodium chloride.

LO 2.24:The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.

Source

+ Alloys and their Properties

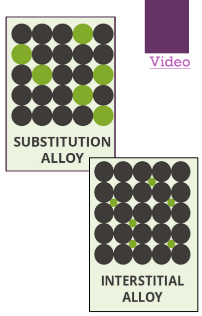
Video

Question:

Metal	Metalic Radius (pm)	Common Oxidation States	Number of Valance Electrons
Silver	144	+1	1
Gold	144	+3	1
Copper	128	+1, +2	1

Pure silver is generally considered too soft to form useful objects and is generally alloyed with other metals such as copper and gold. Two alloys of sliver were created with equal amounts of silver alloyed with either gold or copper. If the silver/copper alloy is harder than the silver/gold alloy, which of the following would best explain the difference based on the table above.

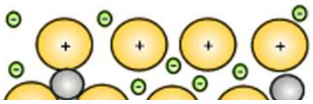
a. Silver and gold have very similar metallic radii making them easy to alloy.
b. Silver has a higher electronegativity than copper making the alloy tougher.
c. Copper has a small radius than silver disturbing the crystal structure and making the alloy harder.
d. Copper and gold do not have any oxidation states in common, making the alloy much softer.



LO 2.25:The student is able to compare the properties of metal alloys with their constituent elements to determine if an alloy has formed, identify the type of alloy formed, and explain the differences in properties using particulate level reasoning.

Source

Alloys!



Video

Type of Alloy	Example	Notes:
substitutional	*sterling silver* Ag 93% Cu 7%	- atomic radii are within ~15% to not affect the overall crystal structure[1] - crystal structure of elements *should* be same for least disruption - resulting solid remains malleable, ductile, similar density
interstitial	*steel* Fe >99% C <1%	- interstitial substituted elements commonly non-metals (H, B, C, N, O, Si) - resulting solid is more rigid, less malleable / ductile
intermetallic*,[2]	$MgZn_2$ Na_5Zn_{21} Cu_3Zn	- definite proportions of constituent elements - crystal lattice structure is different from any of constituent metals - resulting solid has properties often different from constituents
heterogeneous	*solder* Pb ~50% Sn ~50%	- multiple phases / crystal structures throughout the solid (ie. phase of lead only → phase of tin and lead* → phase of tin only)[3] - properties can vary broadly

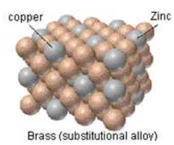
* intermetallic is sometimes used to describe phases in heterogeneous alloys with multiple metals

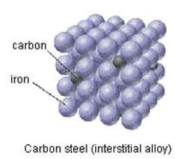
LO 2.26: Students can use the electron sea model of metallic bonding to predict or make claims about macroscopic properties of metals or alloys.

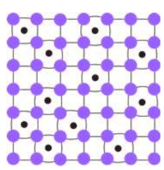
Source

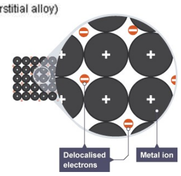
+ Metallic Solids - Characteristics

Video









LO 2.27: The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance.

Source

+ Properties of Metallic Solids

Video

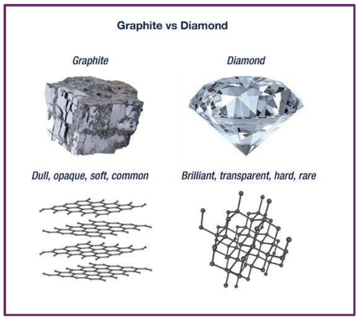
Question:
One type of semiconductor is a germanium crystal adding some impurities can increase the conductivity of the semiconductor. Adding which of the following would create a P-type semiconductor with increased conductivity?

a. The addition of silicon.
b. The addition of phosphorus.
c. The addition of selenium.
d. The addition of gallium.

LO 2.28: The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level.

+ Covalent Compounds - Interactions

Source



Graphite are sheets of carbon atoms bonded together and stacked on top of one another. The interactions between sheets is weak, much like the substance itself.

Diamond's carbon atoms are more connected in a three dimensional structure, adding strength to the network.

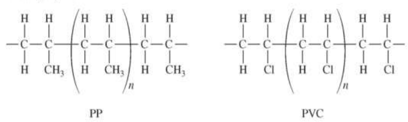
Video

LO 2.29: The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance.

+ Covalent Solids

Source

A student places a mixture of plastic beads consisting of polypropylene (PP) and polyvinyl chloride (PVC) in a 1.0 L beaker containing distilled water. After stirring the contents of the beaker vigorously, the student observes that the beads of one type of plastic sink to the bottom of the beaker and the beads of the other type of plastic float on the water. The chemical structures of PP and PVC are represented by the diagrams below, which show segments of each polymer.



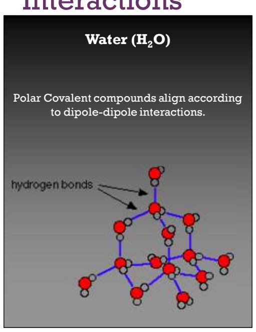
(a) Given that the spacing between polymer chains in PP and PVC is similar, the beads that sink are made of which polymer? Explain.

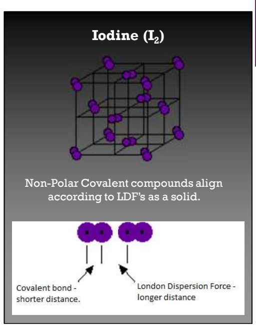
Video

LO 2.30: The student is able to explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level.

+ Molecular Compounds - Interactions

Source





Video

LO 2.31: The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions in the substance.

+ Molecular Compound Interactions

Source

Which of the following are broken when water boils?

a. Covalent bonds
b. Hydrogen bonds
c. Dipole-dipole interactions
d. London Dispersion Forces

Video

Explain why iodine is a solid with a low melting and boiling point, almost insoluble in water, but soluble in organic solvents such as hexane, and is also a non-conductor of electricity.

LO 2.32: The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level.