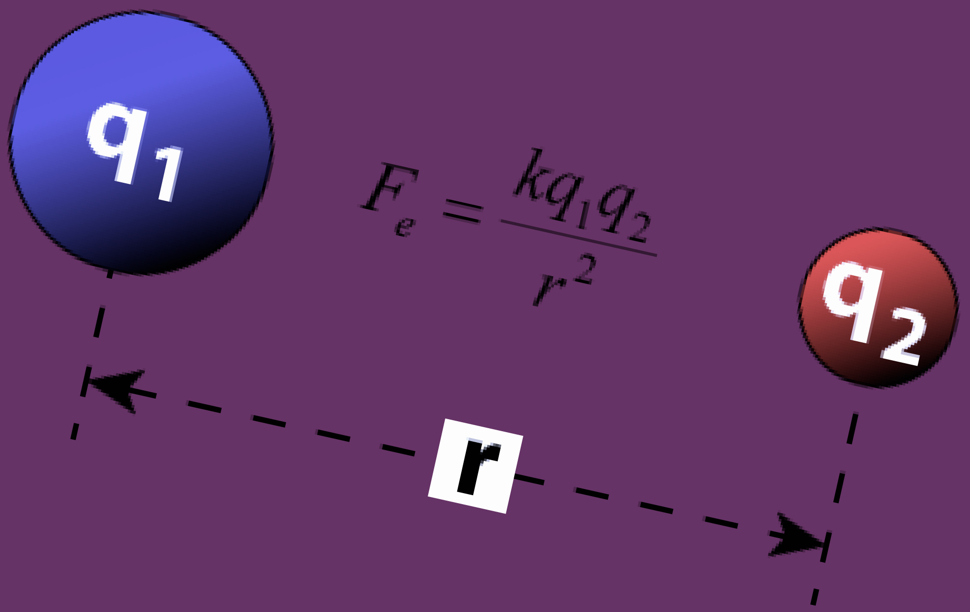

+

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

Source

+ Properties Based on Bonding

1)

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Simple Covalent						
Network Covalent						
Metallic	Mg Al	High	Solid	Yes	yes	No

Which of the following substances will be LEAST soluble in water at room temperature?

A. KNO_3

B. CH_3OH

C. C_2H_5OH

D. C_6H_{14}

Video 1
Video 2
Video 3
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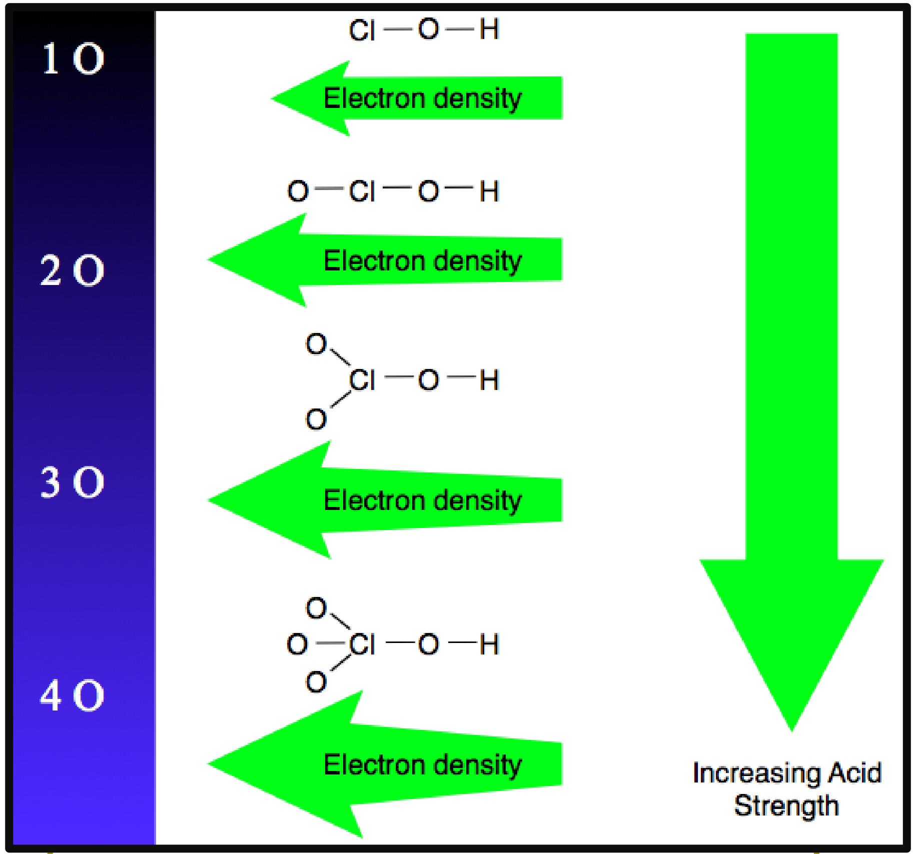
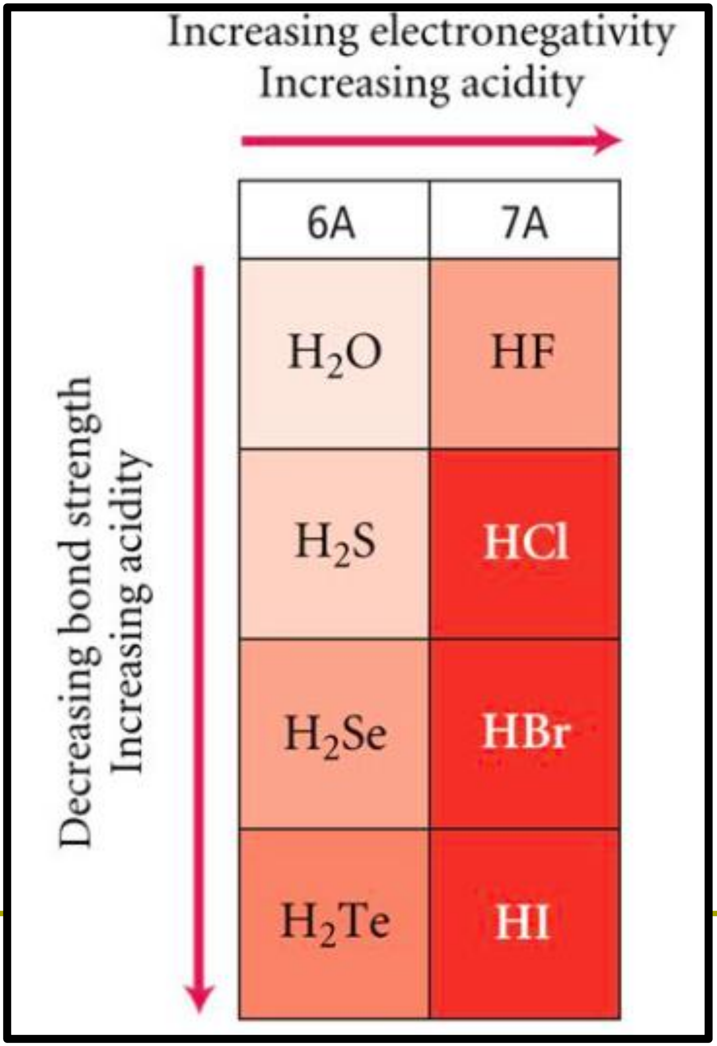
Source

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



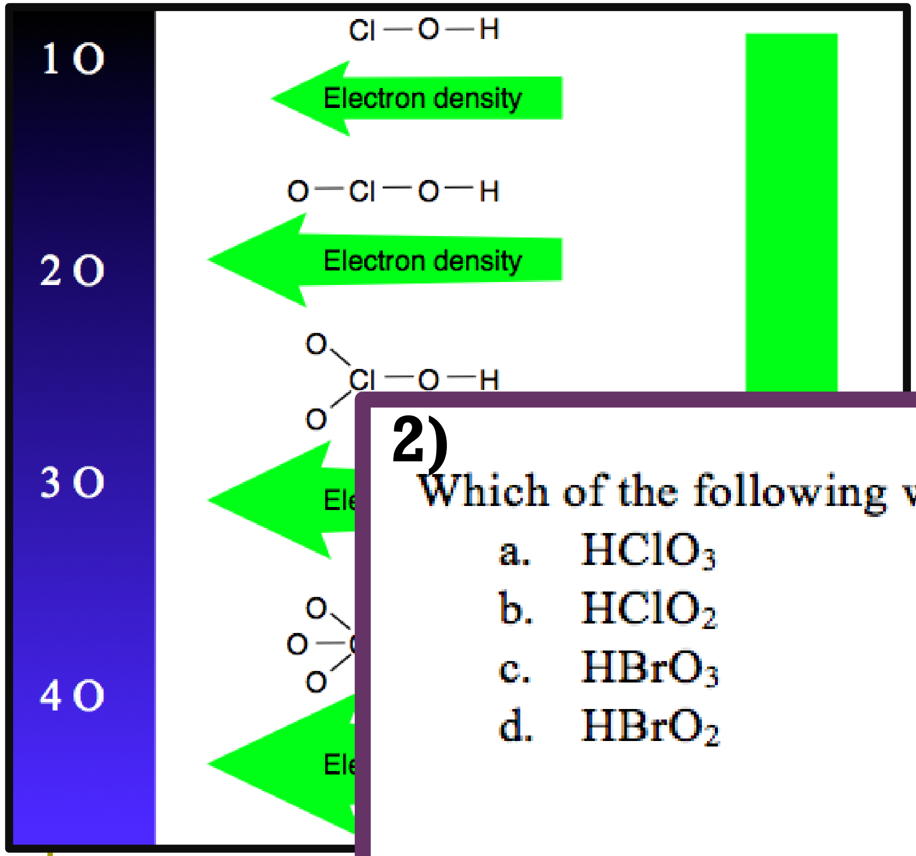
The greater the size of the negative ion, the weaker its attraction for the proton, and so the stronger the acid, and the weaker the conjugate base. HI is the strongest binary acid.

Reading

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

.

Oxyacid Strength



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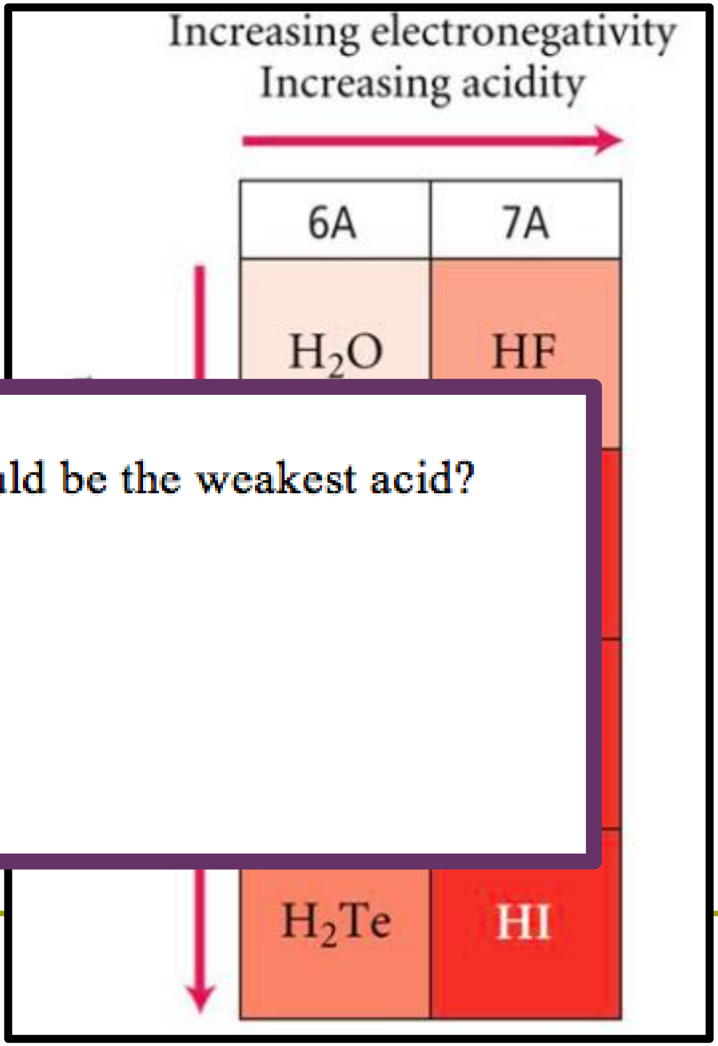

Source

2)

Which of the following would be the weakest acid?

a. $HClO_3$
b. $HClO_2$
c. $HBrO_3$
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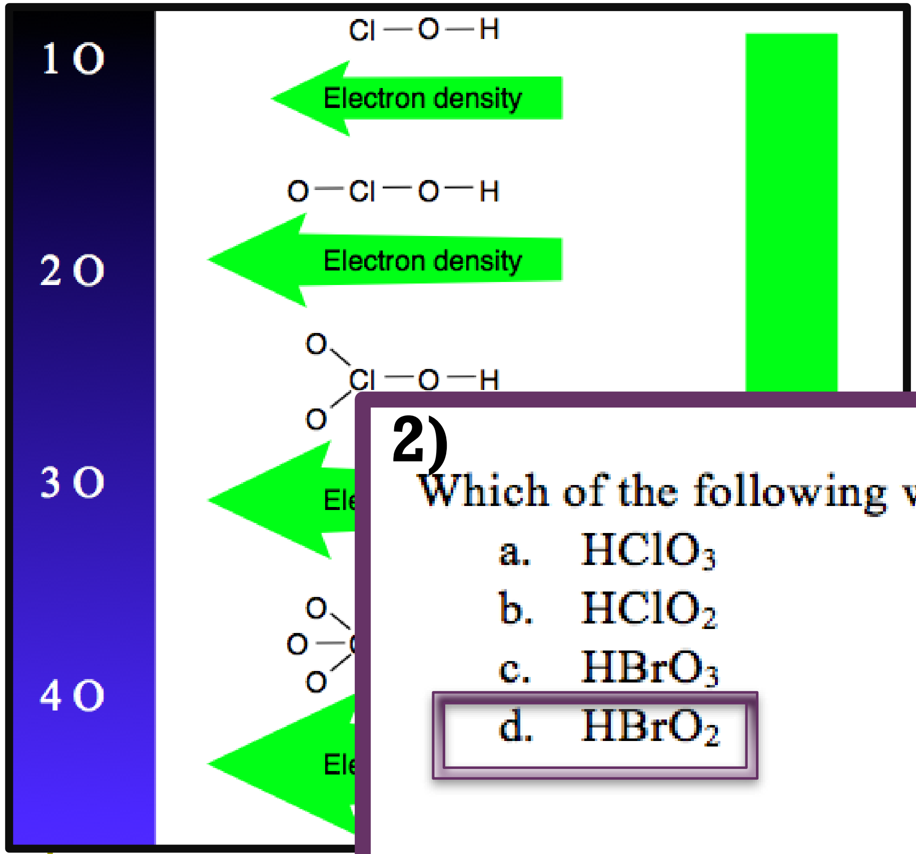

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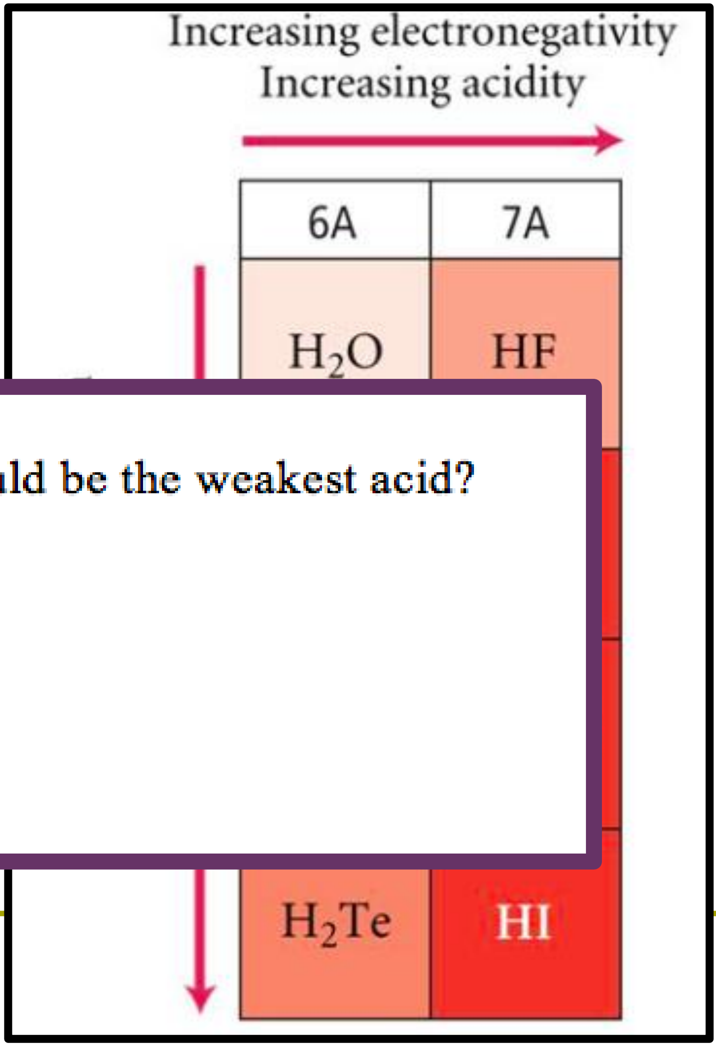

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LO 2.2: student is able to explain the relative strengths of acids and bases based on structure, IMF's, & equilibrium

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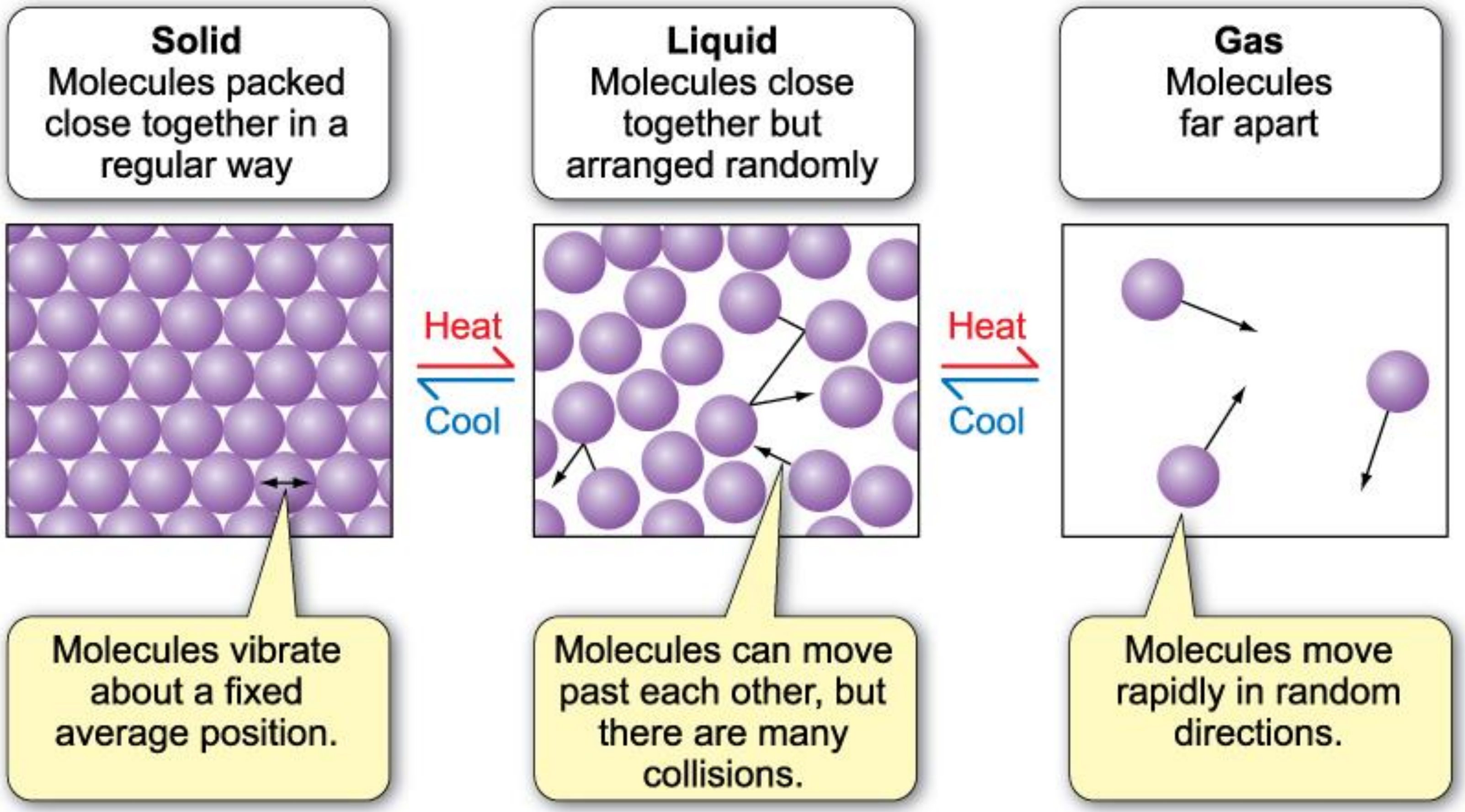
Source

+

Behaviors of Solids, Liquids, and Gases

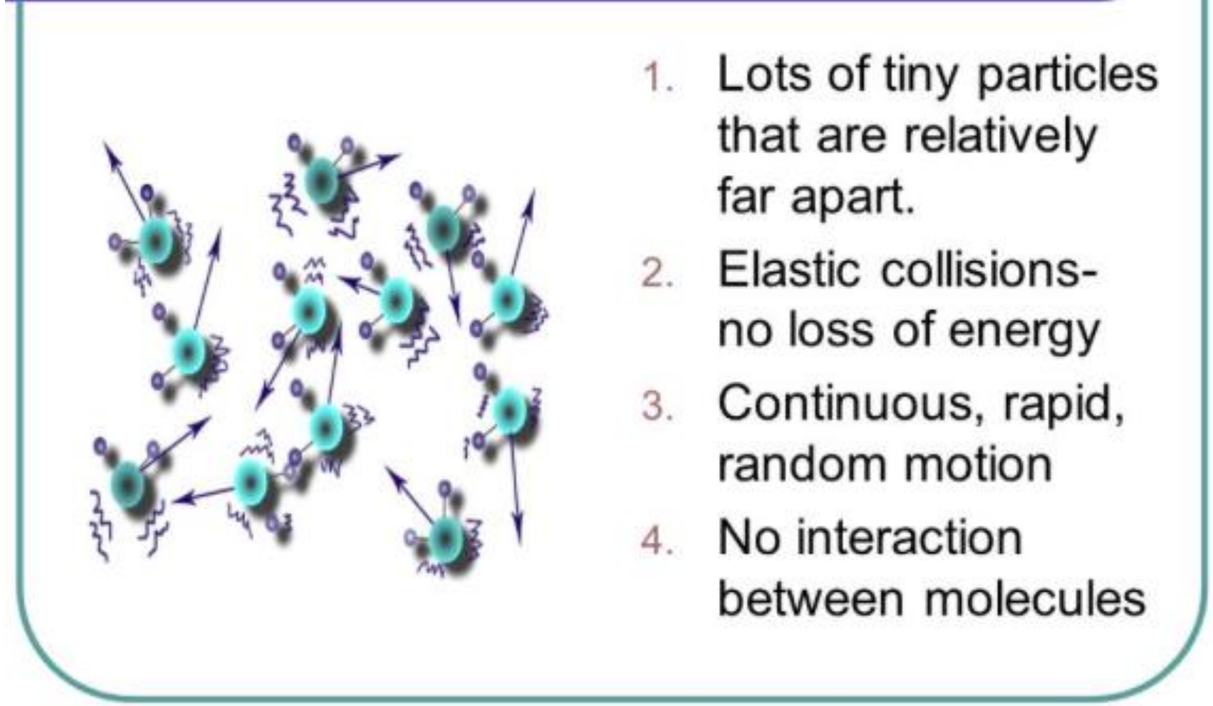
Video
Video 2



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.

[Source]

Kinetic Molecular Theory (KMT)



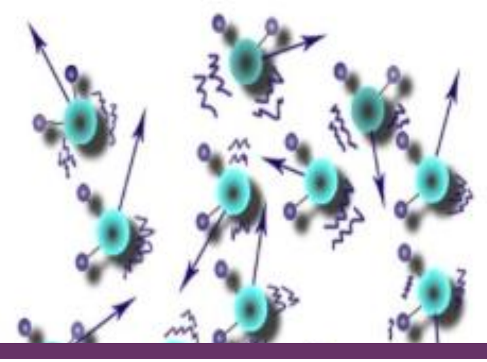
[Video 1]
[Video 2]

- 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

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

ules

Video 1
Video 2

3)

Which combination of conditions of P, T, and n, respectively, are most ideal?

a) low P, high T, high n
b) low P, low T, low n
c) high P, low T, high n
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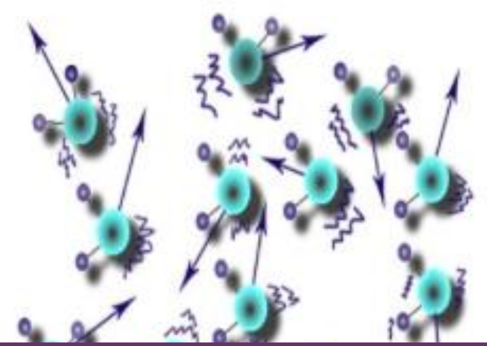

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Source

+

Properties of a Gas - Factors

- 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).

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(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

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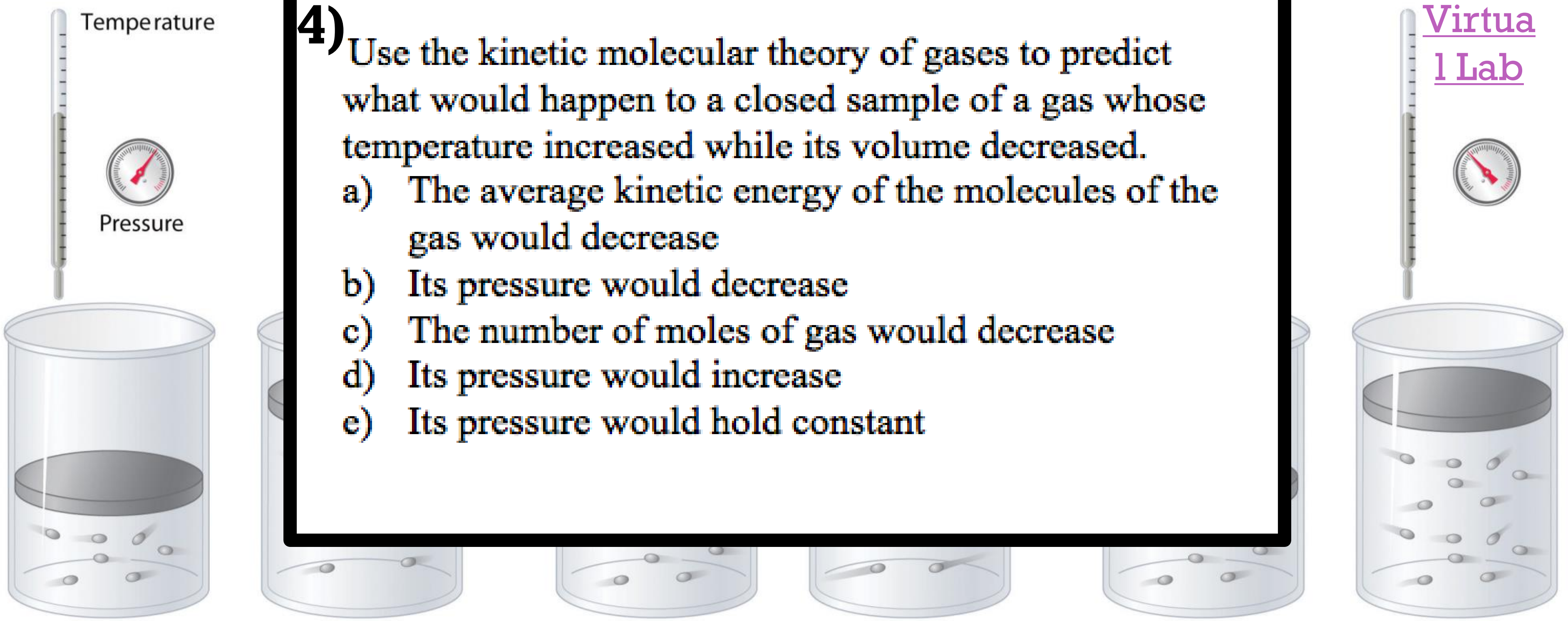

4) Use the kinetic molecular theory of gases to predict what would happen to a closed sample of a gas whose temperature increased while its volume decreased.

a) The average kinetic energy of the molecules of the gas would decrease
b) Its pressure would decrease
c) The number of moles of gas would decrease
d) Its pressure would increase
e) Its pressure would hold constant

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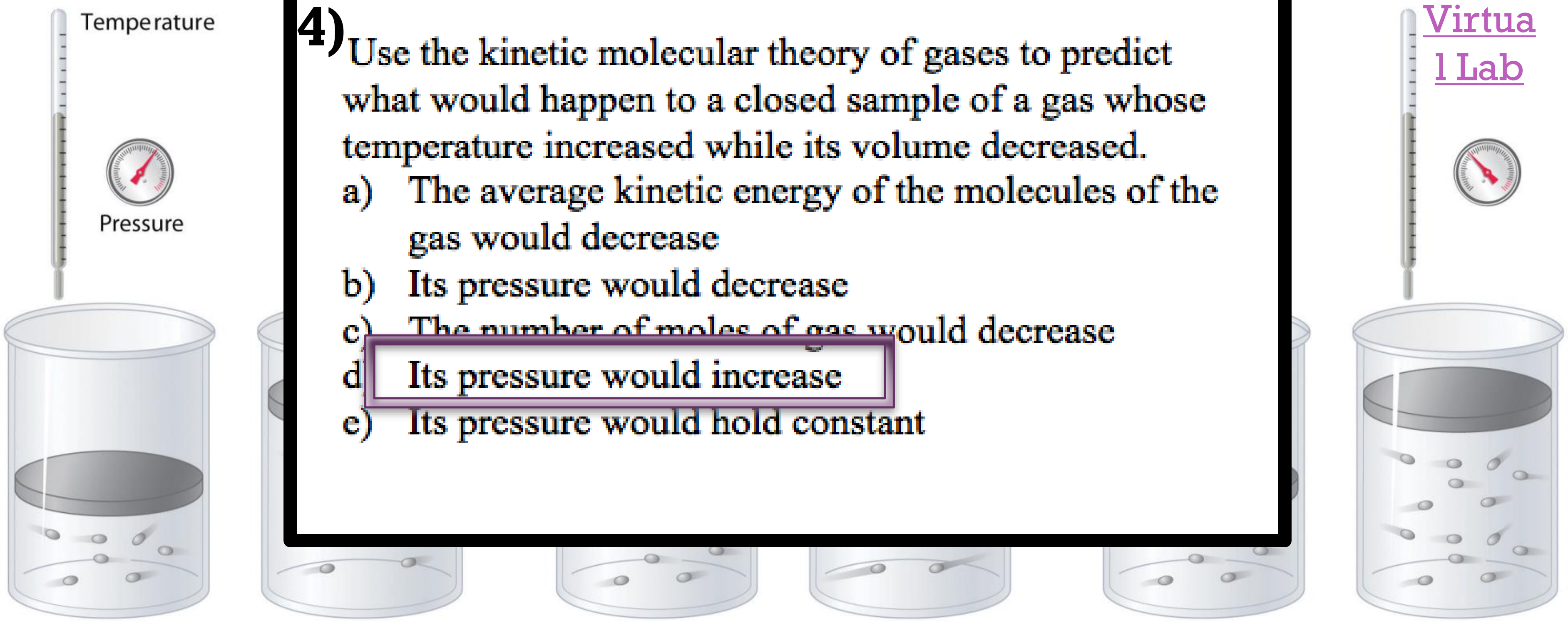

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LO 2.5: Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample

+

The Ideal Gas Law

Source

Question: 5)

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

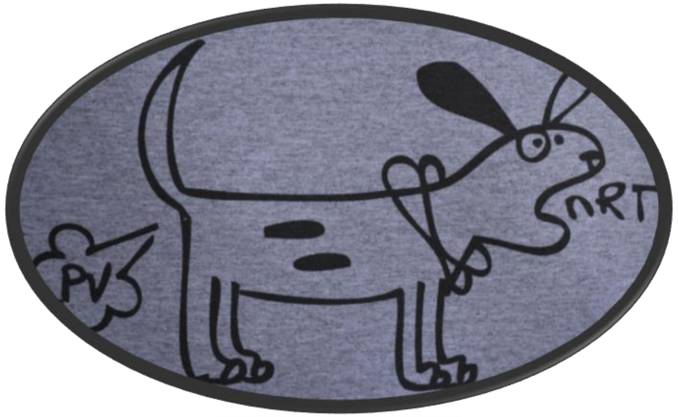
b. $\frac{5.00L \cdot 1.10atm}{0.0821 \frac{atm}{mol} \frac{L}{K} \cdot 150K}$

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

+

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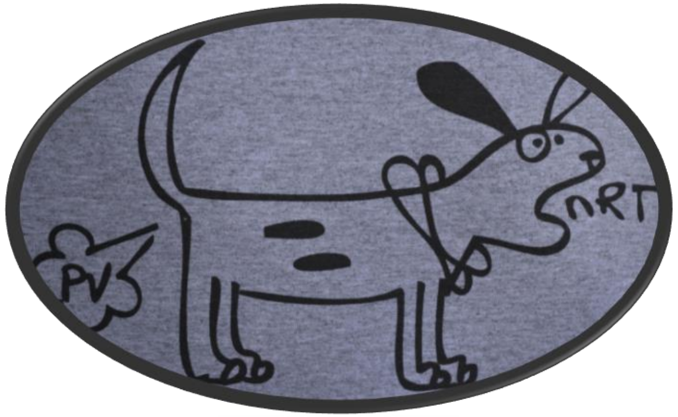


Video

Answer:

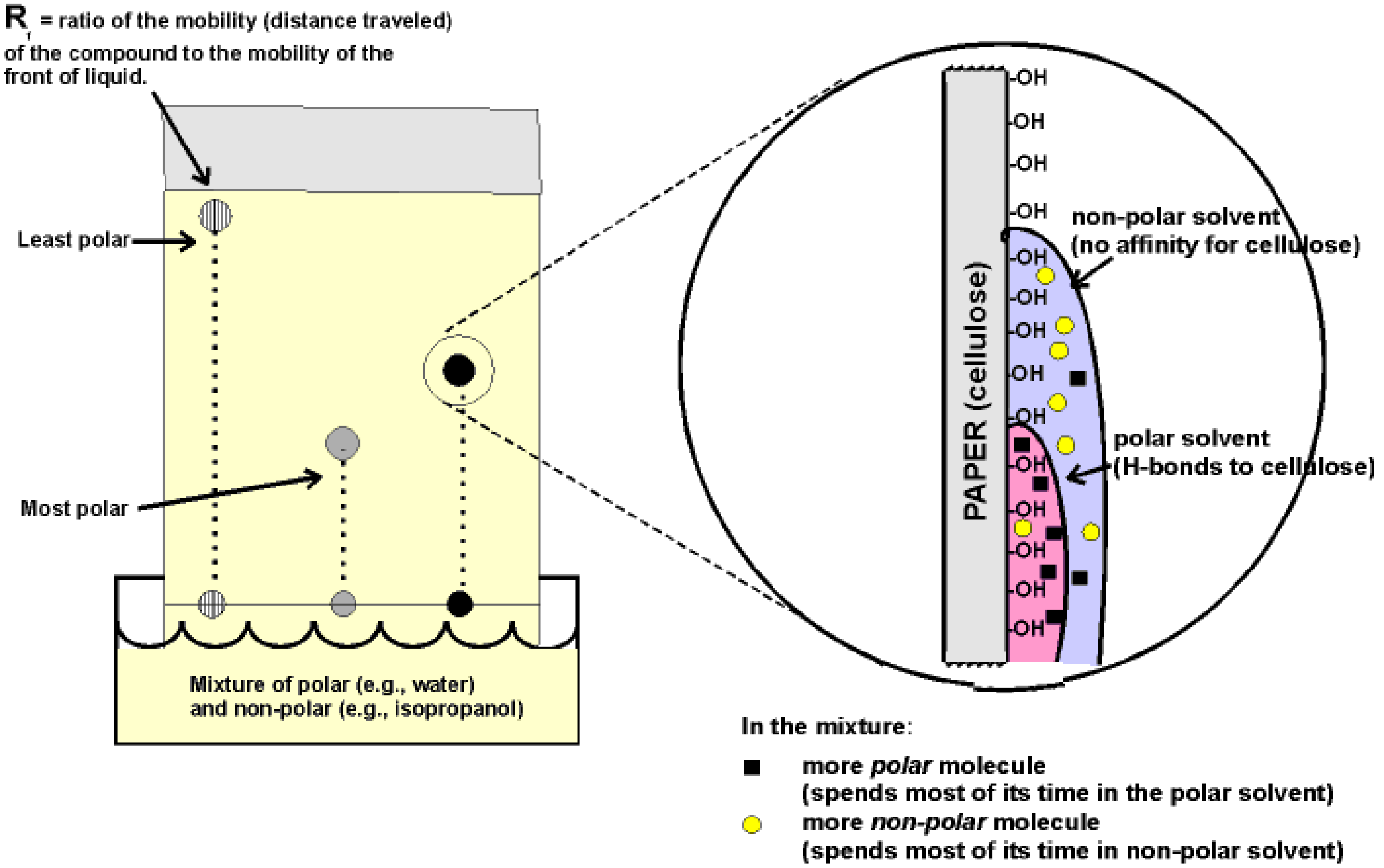
The correct answer is "e", $\dfrac{15.5g \cdot 0.0821 \frac{atm \ L}{mol \ K} \cdot 423K}{5.00L \cdot 1.10atm}$. To calculate the molar mass we need to take the grams of the unknown(15.5g) and divide by how many moles of unknown there are. We can use the ideal gas law to determine the moles of unknown by taking the pressure multiplied by the volume and dividing by R multiplied by the temperature in kelvins, this gets inverted when we divide, giving us the answer above.

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

Chromatography

[Source]

[Video]

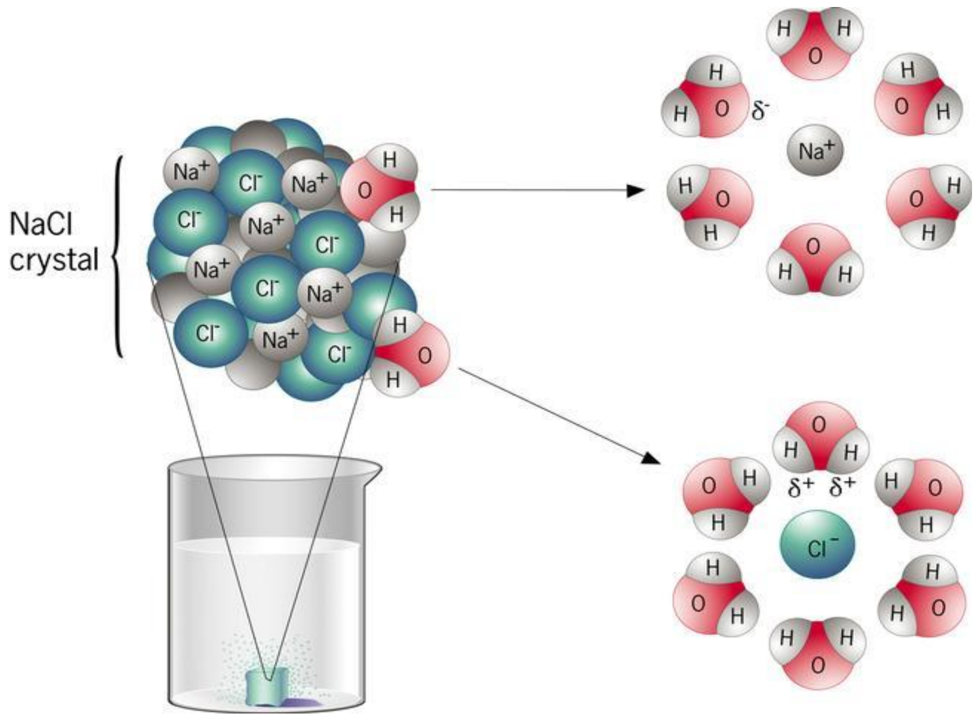


LO 2.7: The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions.

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 positive dipoles (H side) points towards the anion

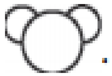
LO 2.8: The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.

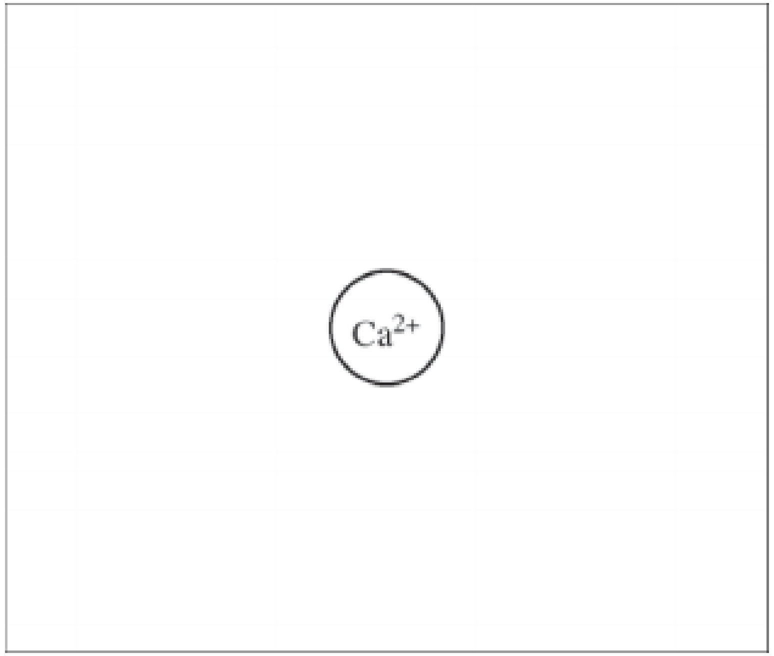
Source

Dissolving/Dissociation: Solute and Solvent

6)

(c) In the box below, complete a particle representation diagram that includes four water molecules with proper orientation around the Ca^{2+} ion.

Represent water molecules as .



NaCl
crysta

o

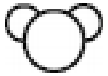
points towards the anion

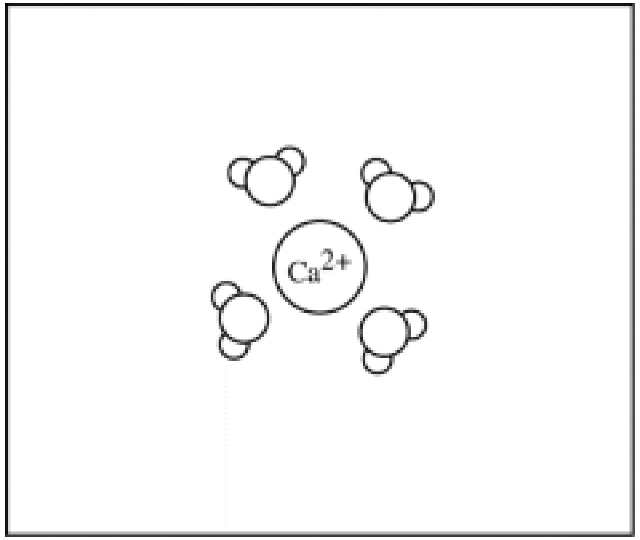
LO 2.8: The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.

Source

+ Dissolving/Dissociation: Solute and Solvent

6) (c) In the box below, complete a particle representation diagram that includes <u>four</u> water molecules with proper orientation around the Ca^{2+} ion.

Represent water molecules as 



[The diagram should show the oxygen side of the water molecules oriented closer to the Ca^{2+} ion.]	1 point is earned for a correct diagram that shows at least three of the four water molecules oriented as described.

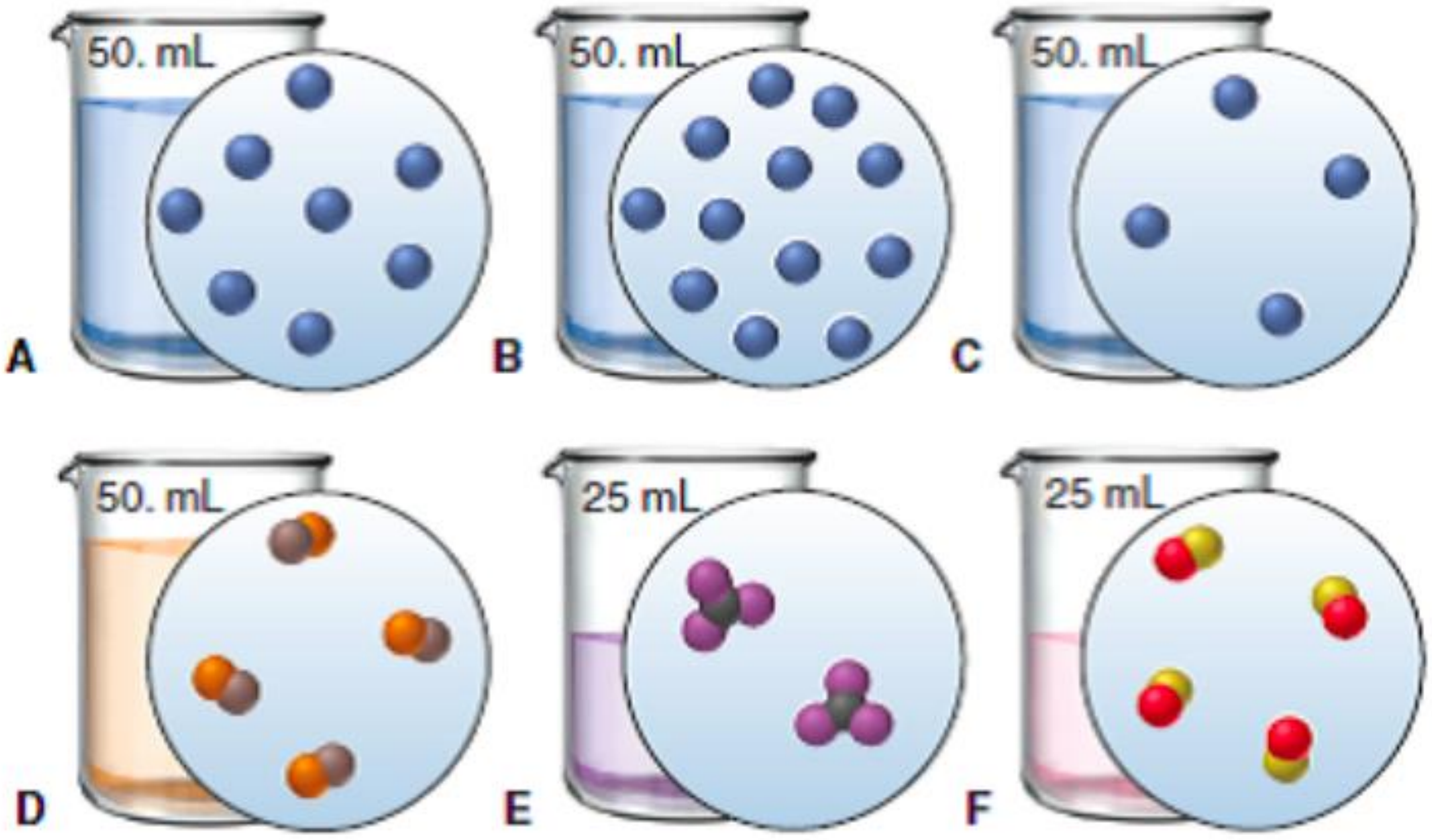
points towards the anion

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

+

Molarity and Particle Views

Source



Video

7)

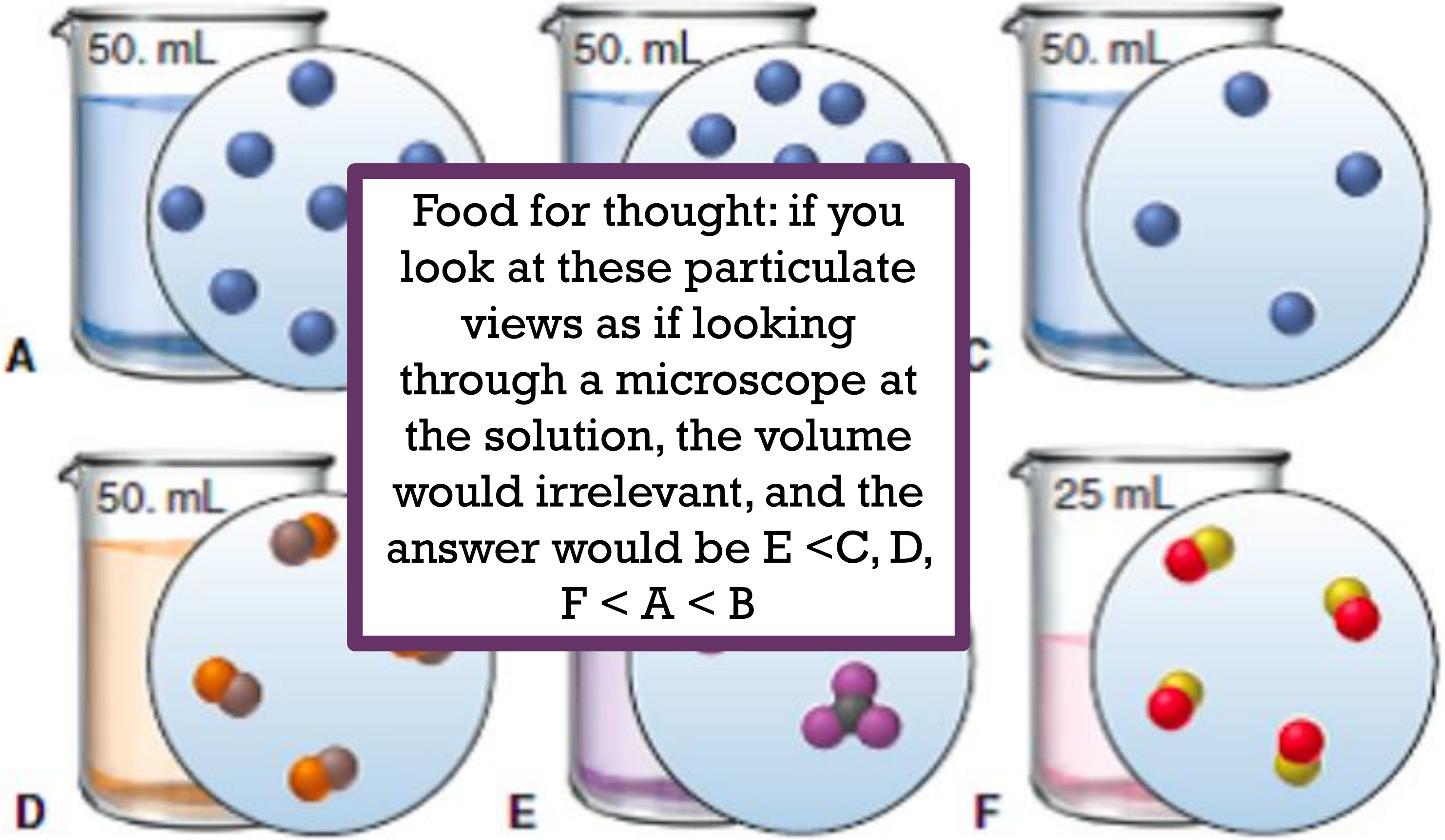
- QUESTION: Rank the six solutions above in order of increasing molarity. Pay attention to volume, and some have equal concentration

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

Molarity and Particle Views

[Source](#)



Food for thought: if you look at these particulate views as if looking through a microscope at the solution, the volume would irrelevant, and the answer would be E <C, D, F < A < B

[Video](#)

7)

- QUESTION: Rank the six solutions above in order of increasing molarity. Pay attention to volume, and some have equal concentration
- C,D, and E (tied); A and F (tied); most concentrated is B

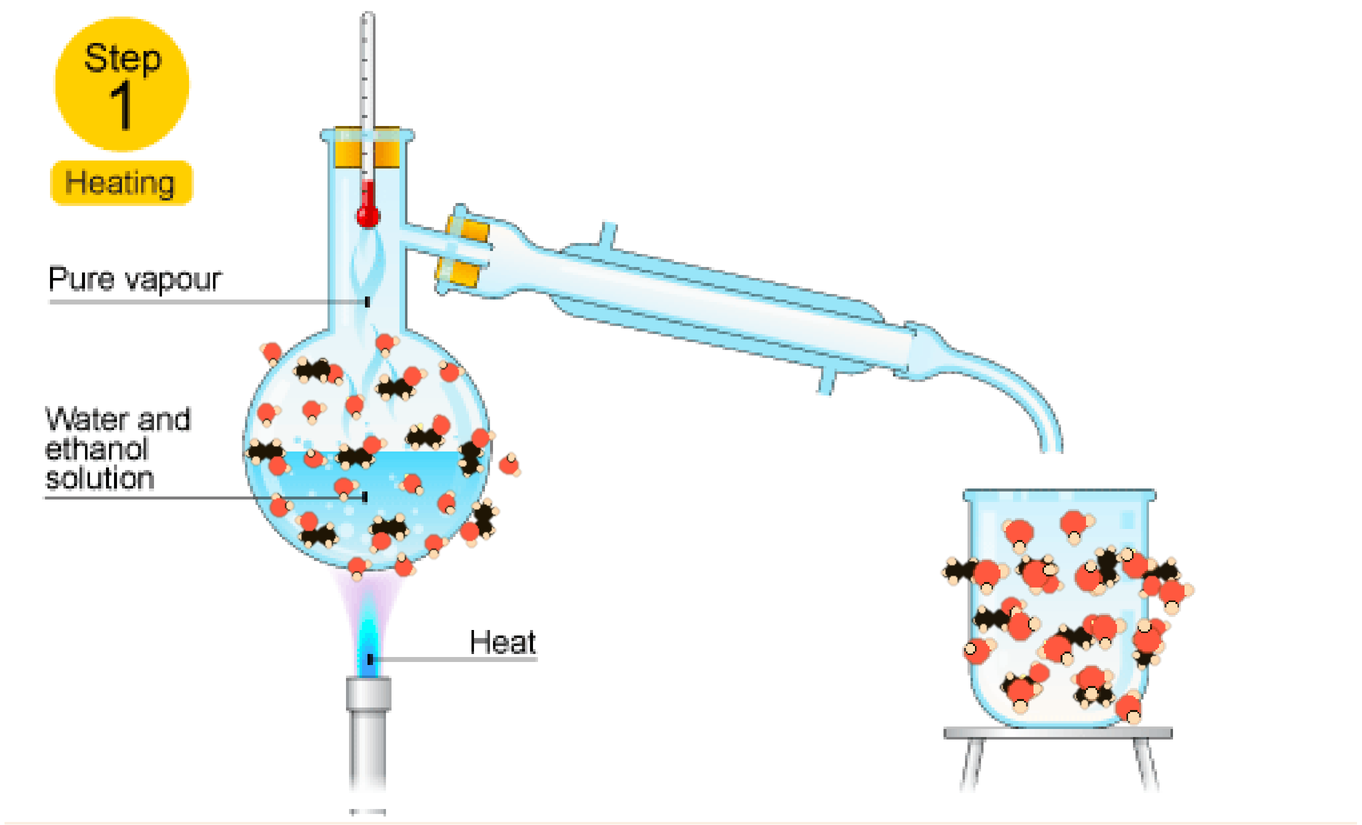
LO 2.9: The student is able to create or interpret representations that link the concept of molarity with particle views of solutions

+

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 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

8)

Question:
Which of the following would have the highest boiling point?

a. He
b. Ne
c. Xe
d. Kr

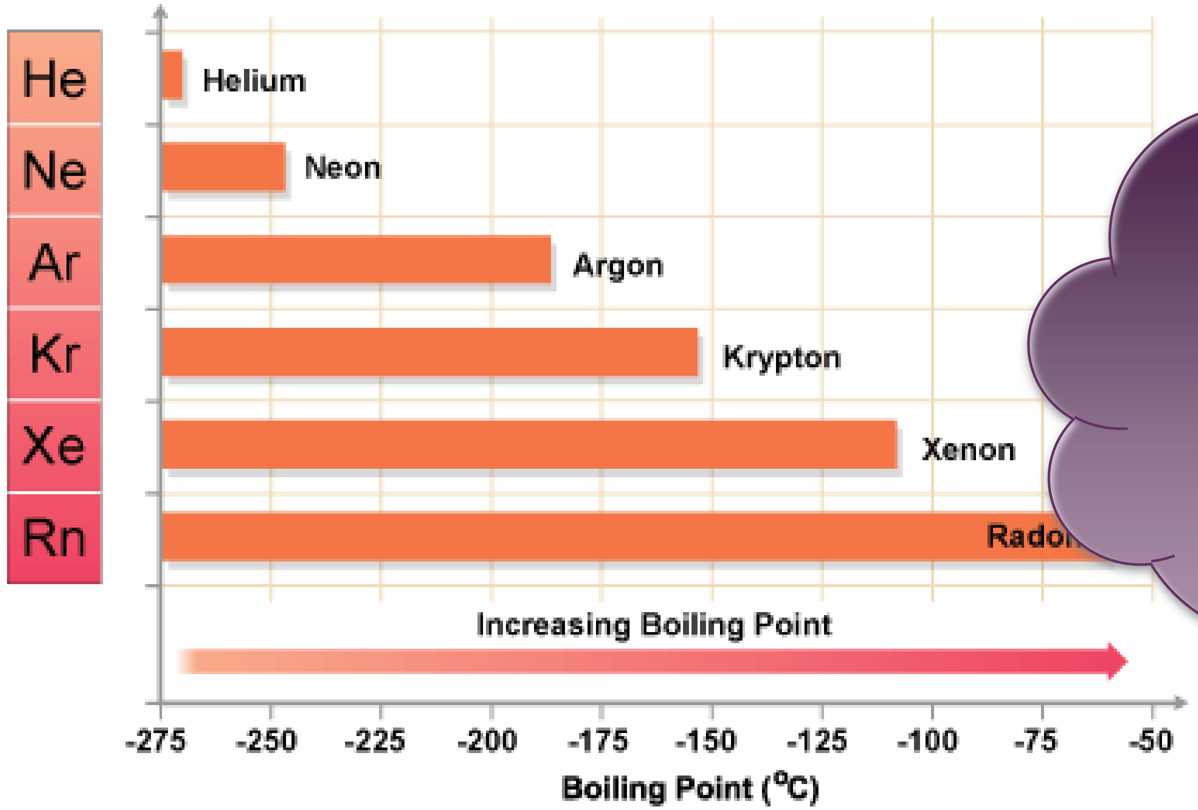
Video

Click reveals answer and explanation.

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

8)



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

.com

Answer:
The correct answer is "c". All of the choices are non-polar noble gasses. The only intermolecular forces present are London dispersion forces. The strength of the LDFs are determined by the polarizability of the atoms. The atom with the greatest number of elections will be the most polarizable, having the strongest intermolecular forces and consequently the highest boiling point.

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

9) **Question:**

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

Video

	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 Waals – 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

+

Deviations from Ideal Gas Behavior

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

Video

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

Answer:
The correct answer is "a", 100K and 100 atm. The ideal gas law works best at high temperatures and low pressures. When a gas is at low temperatures and high pressures a gas will behave least like an ideal gas.

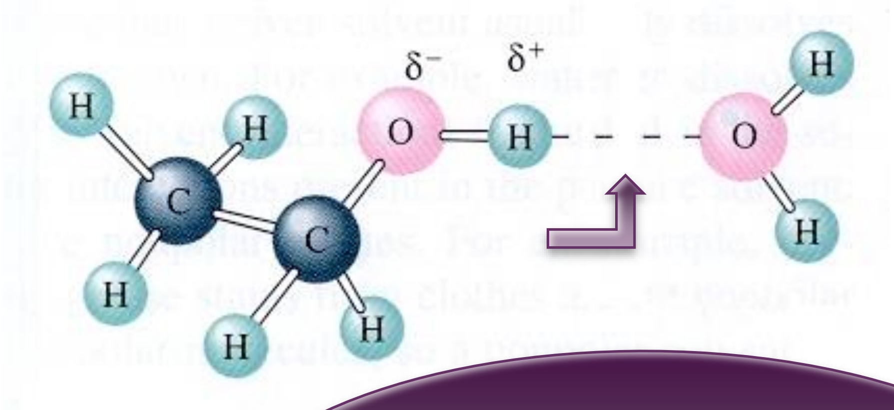
LO 2.12: The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions

Hydrogen Bonding

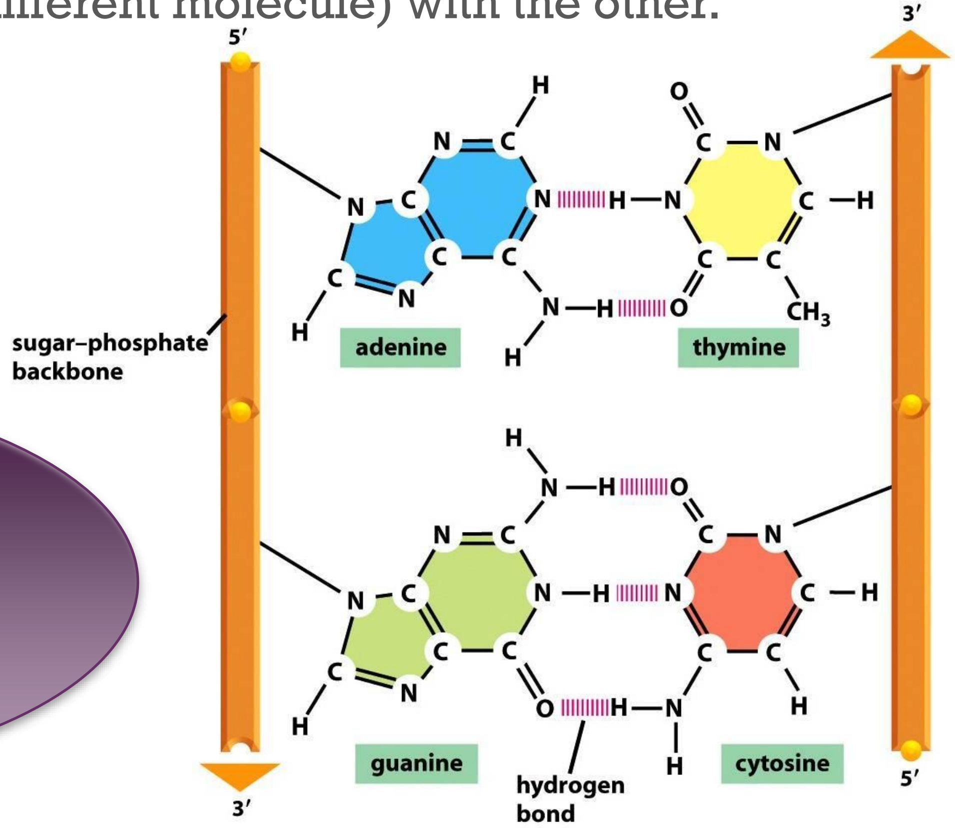
[Source]

- 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 <u>FON</u>

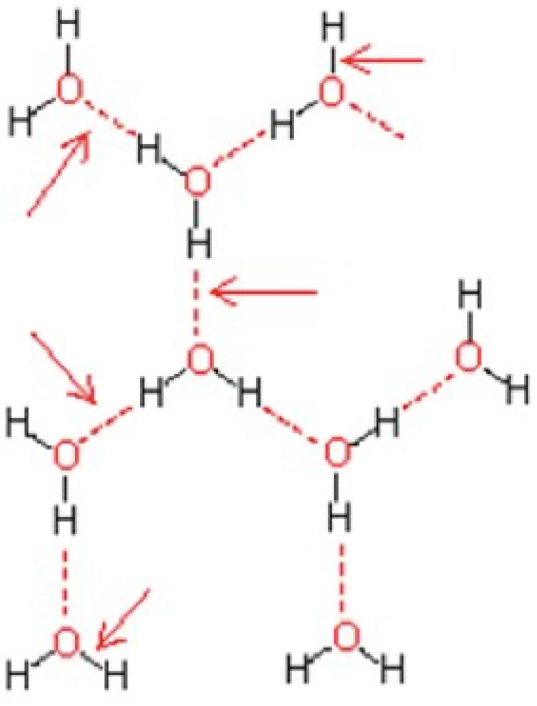


LO 2.13: The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.

Hydrogen

10)

Water molecules are depicted in the diagram below, along with five arrows that show some kind of interaction between molecules or atoms. Which of the following statements true?

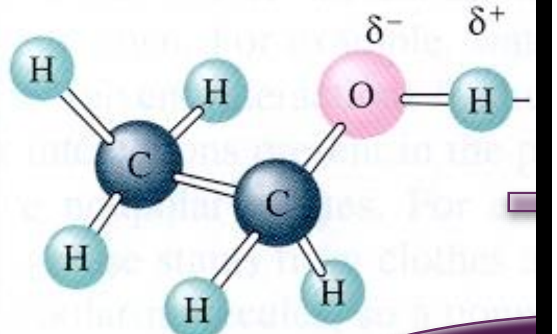


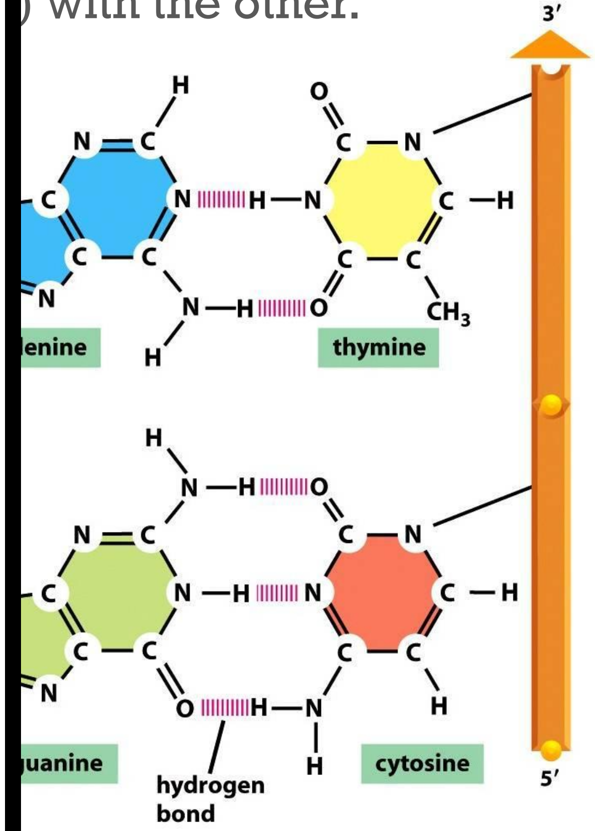
A. Two of the arrows point to hydrogen bonds.
B. Three of the arrows point to intermolecular bonds.
C. Three of the arrows point to interactions that are significantly stronger than the other two interactions.
D. Two of the arrows point to non-polar covalent bonds.

[Source](#)

- Hydrogen bonding is s… …ter, DNA, ammonia, HF, and alcoh… …orce not a true intramolecular bond.
- Hydrogen bonds are lik… …s the bread. H will be in a intramolecu… …e N, O, and/or F and have an intermolec… …) with the other.

[Video](#)





Remem…
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LO 2.13: The student is ab… …etween the structural features of polar molecul… …een the particles.

+ Hydrogen

Source

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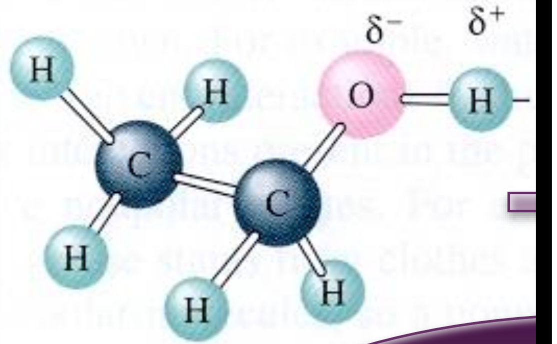

Remem…
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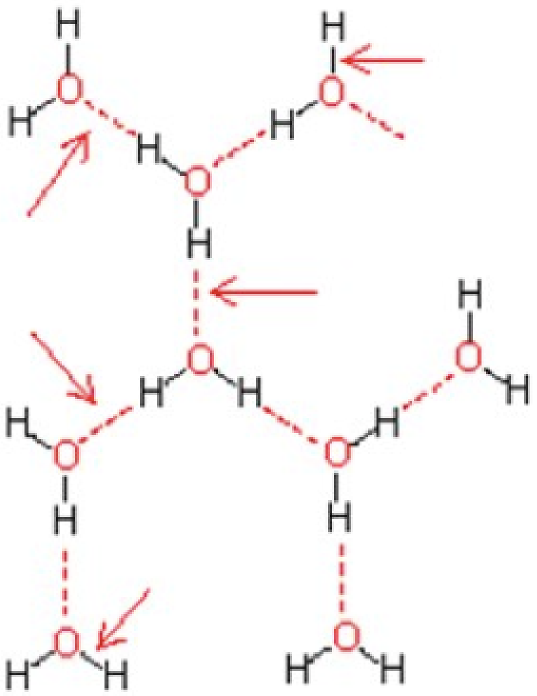
10)

Water molecules are depicted in the diagram below, along with five arrows that show some kind of interaction between molecules or atoms. Which of the following statements true?

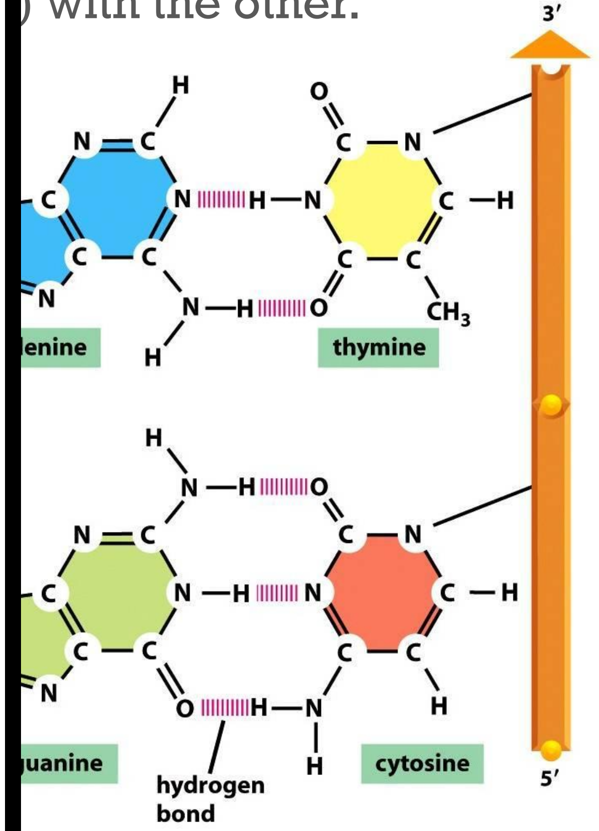


A. Two of the arrows point to hydrogen bonds.

B. Three of the arrows point to intermolecular bonds.

C. Three of the arrows point to interactions that are significantly stronger than the other two interactions.

D. Two of the arrows point to non-polar covalent bonds.



LO 2.13: The student is ab… etween the structural features of polar molecul… een the particles.

Source

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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.

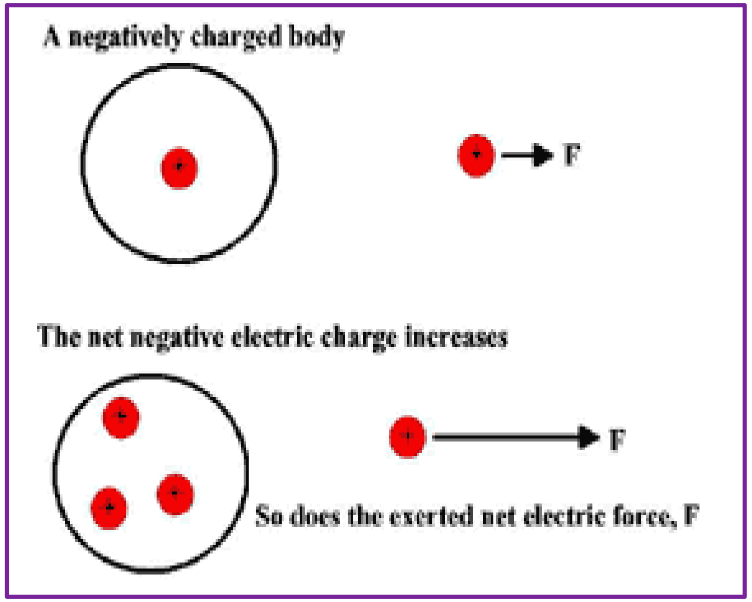
- There is a sort of tug-of-war involved with species dissolved in water. The water pulls individual ions away from the solid. The solid is pulling individual ions back out of the water. There exists an equilibrium based on how strongly the water attracts the ions, versus how strong the ionic solid attracts the ions.

Video

- 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.

11) 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



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

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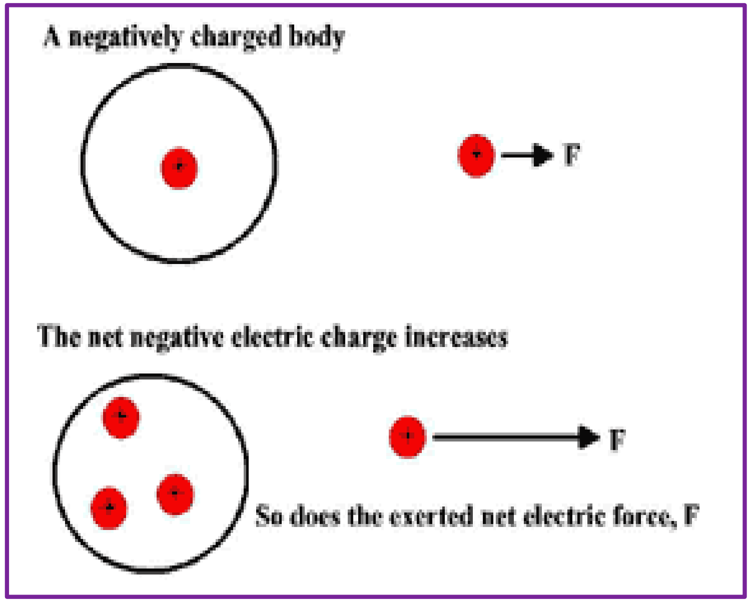

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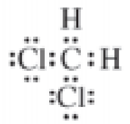
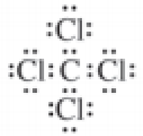
Generally speaking. There are exception

Use the information in the following table to answer parts (c) and (d).

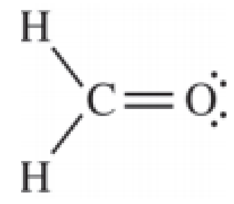
12)

Name	Lewis Electron-Dot Diagram	Boiling Point (°C)	Vapor Pressure at 20°C (mm Hg)
Dichloromethane		39.6	353
Carbon tetrachloride		76.7	89

(c) Dichloromethane has a greater solubility in water than carbon tetrachloride has. Account for this observation in terms of the intermolecular forces between each of the solutes and water.

(d) In terms of intermolecular forces, explain why dichloromethane has a higher vapor pressure than carbon tetrachloride.

(e) The complete Lewis electron-dot diagram of methanal (formaldehyde) is shown in the box below. Molecules of methanal can form hydrogen bonds with water. In the box below, draw a water molecule in a correct orientation to illustrate a hydrogen bond between a molecule of water and the molecule of methanal. Use a dashed line to represent the hydrogen bond.



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12)

Use the information in the following table to answer parts (c) and (d).

Name	Lewis Electron-Dot Diagram	Boiling Point (°C)	Vapor Pressure at 20°C (mm Hg)

(c) Dichloromethane has a greater solubility in water than carbon tetrachloride has. Account for this observation in terms of the intermolecular forces between each of the solutes and water.

CH_2Cl_2 is polar, whereas CCl_4 is not. Therefore, CH_2Cl_2 interacts with H_2O via dipole-dipole forces, while CCl_4 only interacts with water via dipole/induced dipole forces or LDFs, which would be weaker. As a result, CH_2Cl_2 has a greater solubility.	2 points are earned for a rationale that references the types of IMFs between each compound and water.

(d) In terms of intermolecular forces, explain why dichloromethane has a higher vapor pressure than carbon tetrachloride.

Because CH_2Cl_2 has the higher vapor pressure, the combination of LDFs and dipole-dipole forces in CH_2Cl_2 must be weaker than the strong LDFs in CCl_4.	2 points are earned (1 point for referencing the type(s) of IMFs in each of the two compounds).

H

LO 2.15: ... er and other sol... ects.

12)

Use the information in the following table to answer parts (c) and (d).

Name	Lewis Electron-Dot Diagram	Boiling Point (°C)	Vapor Pressure at 20°C (mm Hg)

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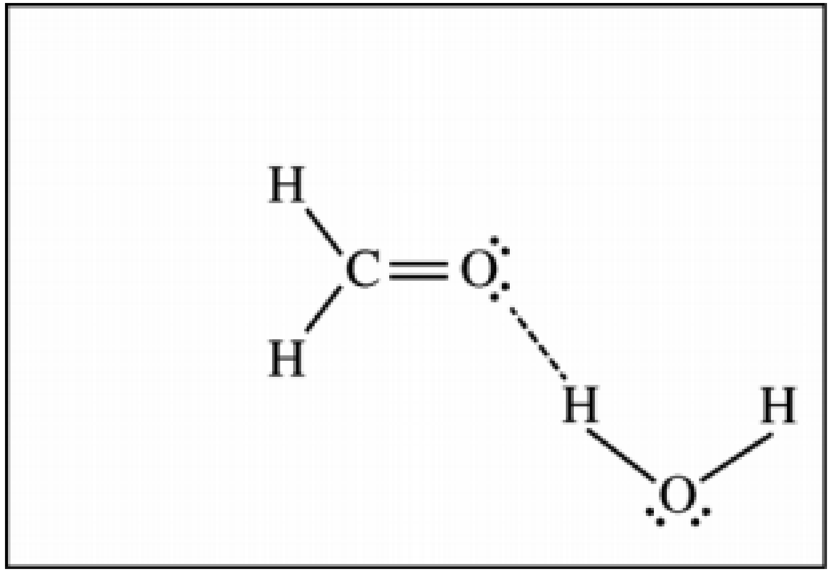

See diagram above.	1 point is earned for a correct diagram.

LO 2.15: ... er and

other sol... ects.

Source

Physical Properties and IMF's

13)

Question:
Which of the following substances would have the highest vapor pressure at 25°C?

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

Click reveals answer and explanation.

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

Physical Properties and IMF's

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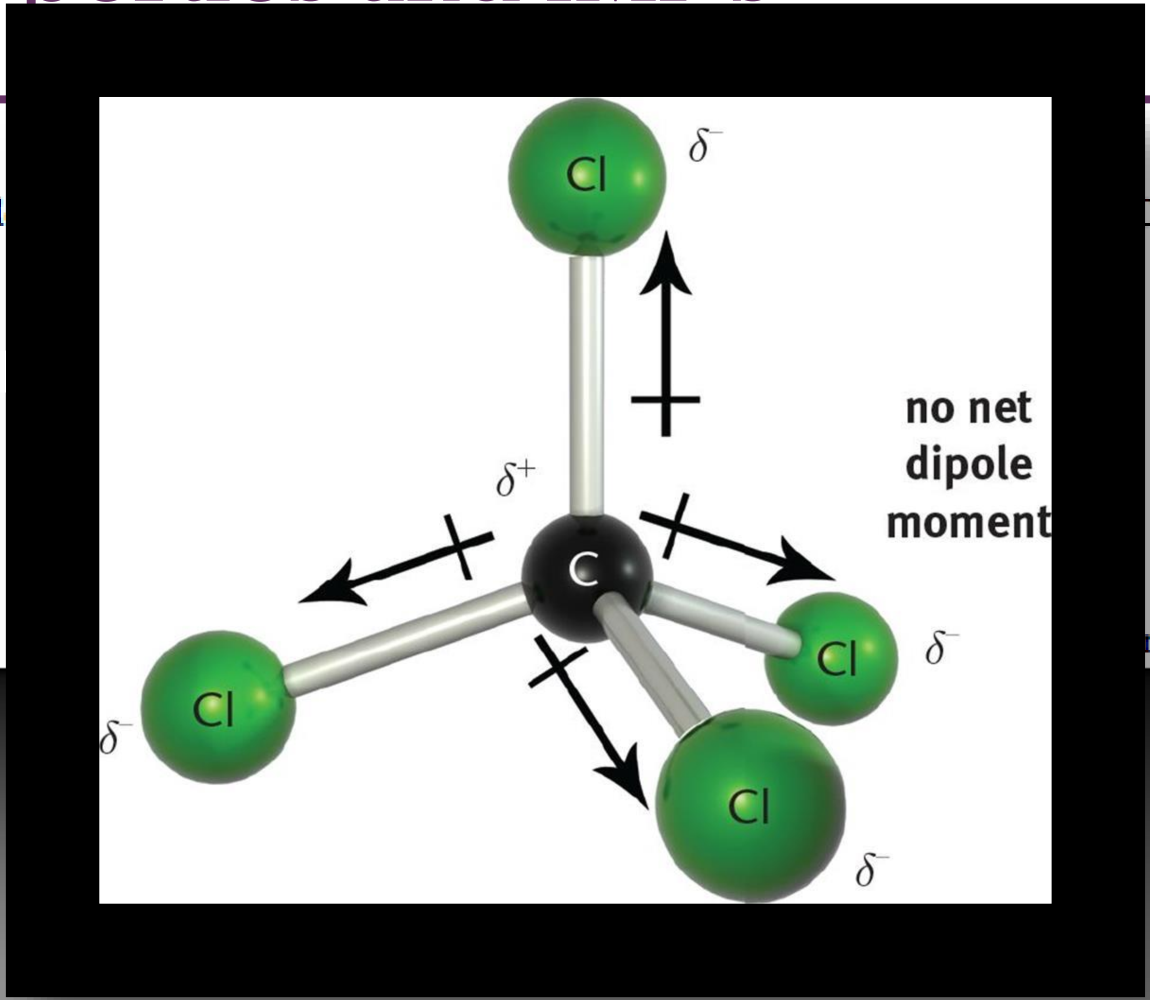


Video

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

+

Physical Properties and IMF's

13)

The box below is an image of a question card:

Question:

Which of the following substances would have the highest vapor pressure at 25°C?

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

Answer:

The correct answer is "c", CCl_4. The highest vapor pressure will be the substance that have the weakest intermolecular forces. The smallest non-polar molecule will generally have the weakest intermolecular forces and therefor the highest vapor pressure.

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.

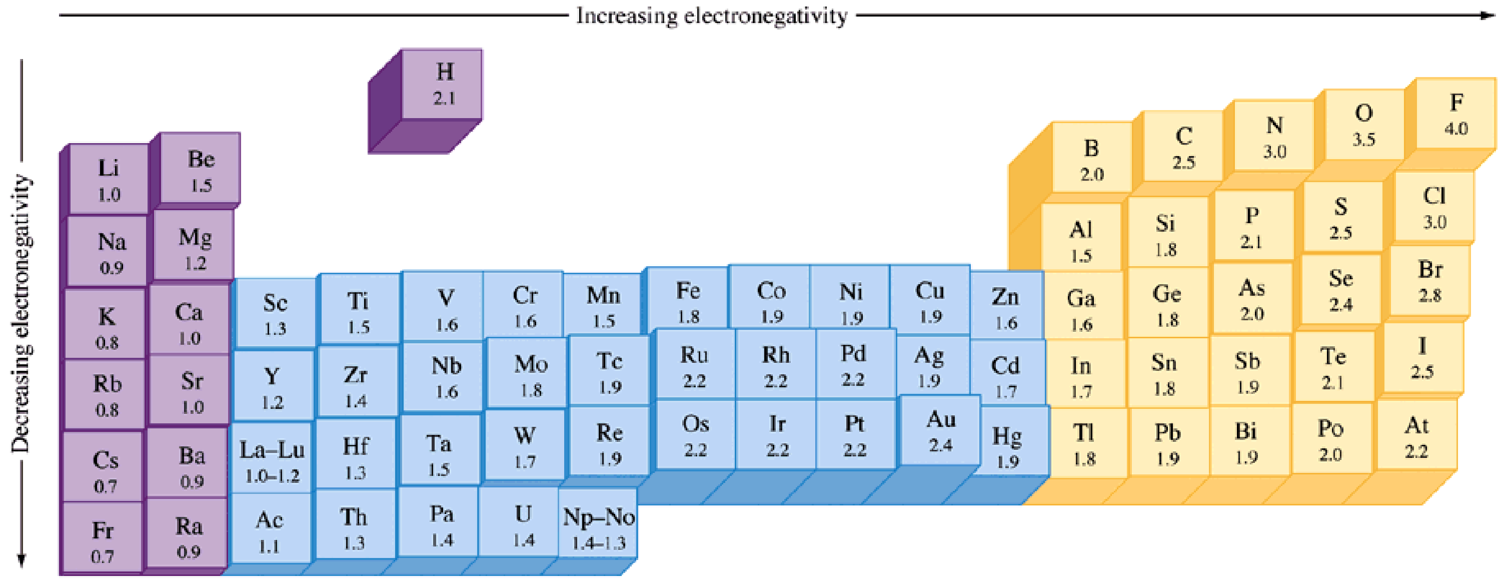
+ Bonding and Electronegativity

[Source](#)

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

[Video](#)



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.

+

Bonding and Electronegativity

[Source]

[Video]

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0.0 – 0.4 ... onpolar

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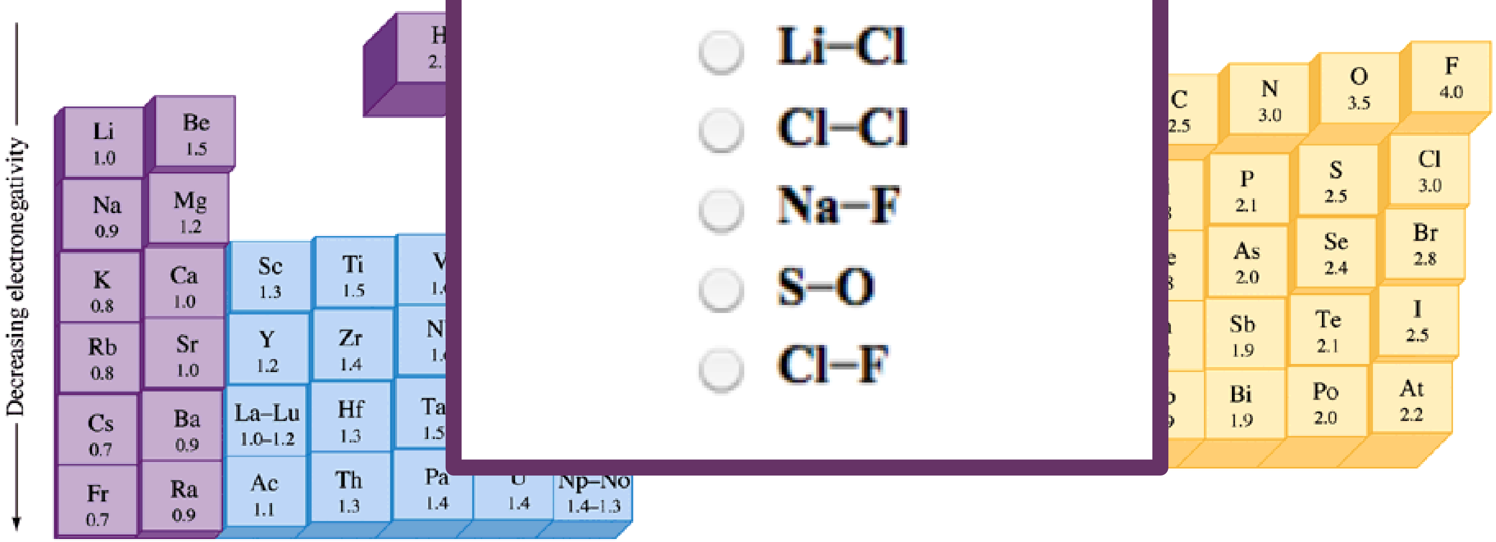
> 1.7 ... onic

14) Which bond has the most ionic character?

- Li–Cl
- Cl–Cl
- Na–F
- S–O
- Cl–F



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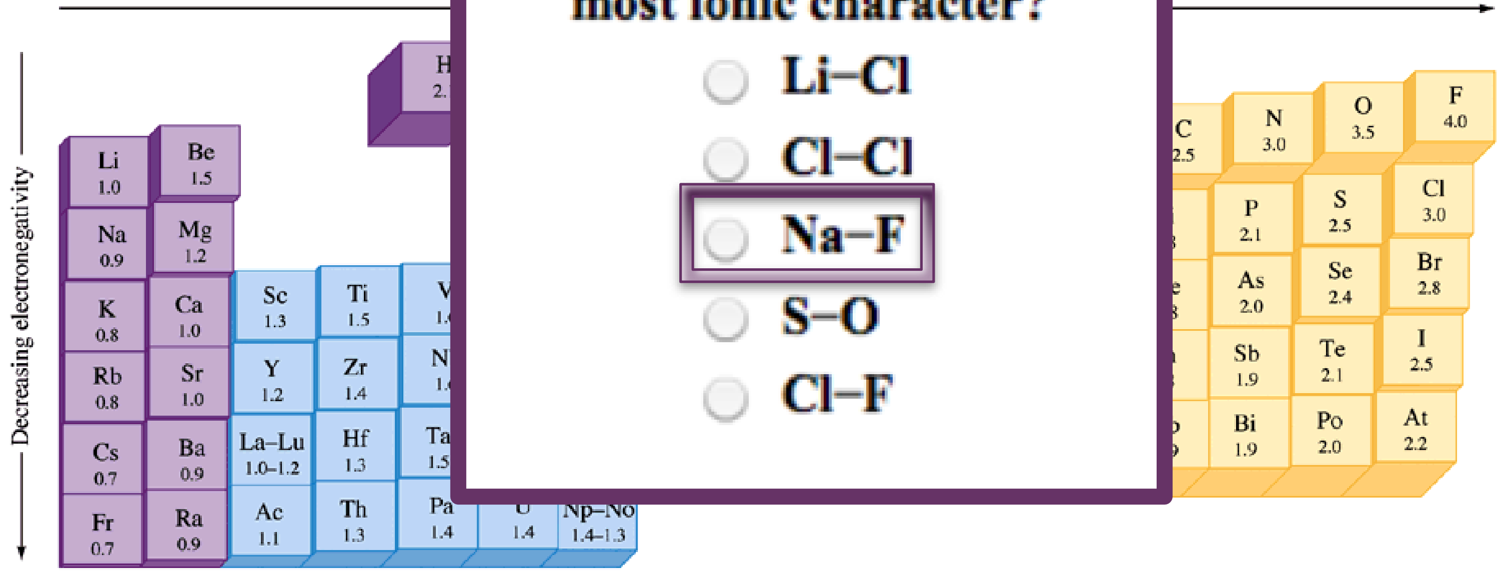

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+

Ranking Bond Polarity

Source

Video

Question: 15)

Which of the following bonds would be MOST polar?

a. C—O
b. H—O
c. H—F
d. C—N
e. F—O

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.

Ranking Bond Polarity

Source

Video

Question: **15)**
Which of the following bonds would be MOST polar?

a. C—O
b. H—O
c. H—F
d. C—N
e. F—O

Answer:
The correct answer is "c", H—F. The polarity of a bond is determined by the difference in the electronegativity between the two atoms. Atoms that are far apart on the periodic table will have a greater difference in electronegativity. H and F are the furthest apart in this list, and will have the biggest difference.

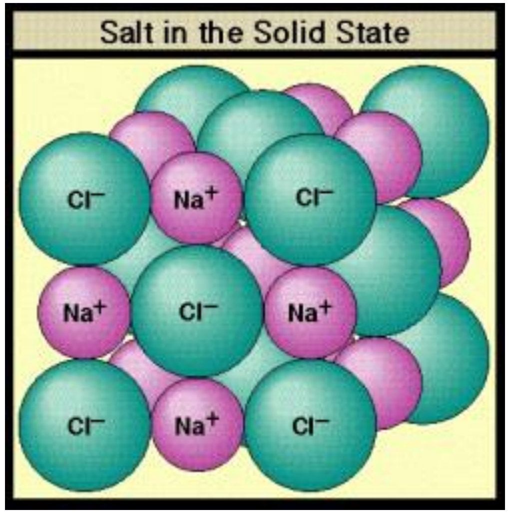
LO 2.18: The student is able to rank and justify the on the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table.

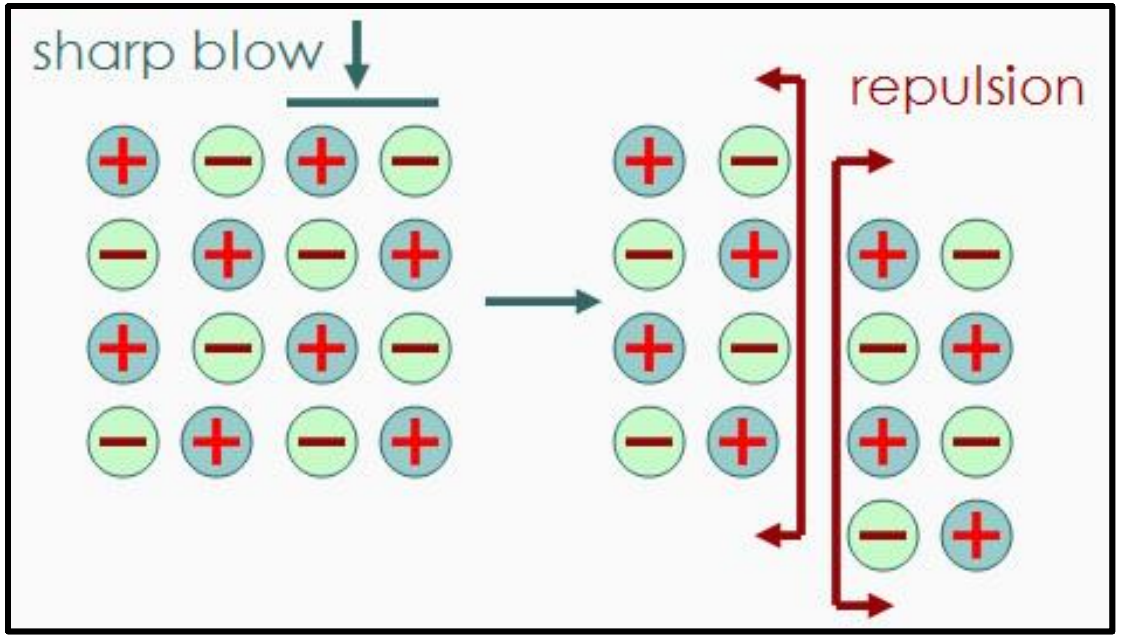
Source

Ionic Substances and their Properties

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

Video





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

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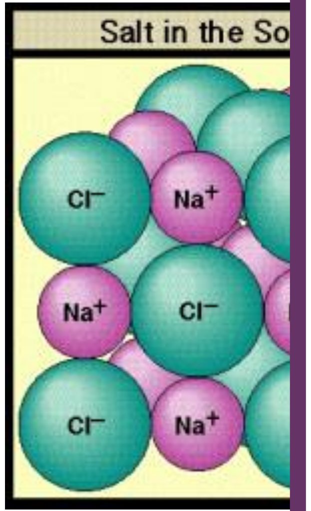

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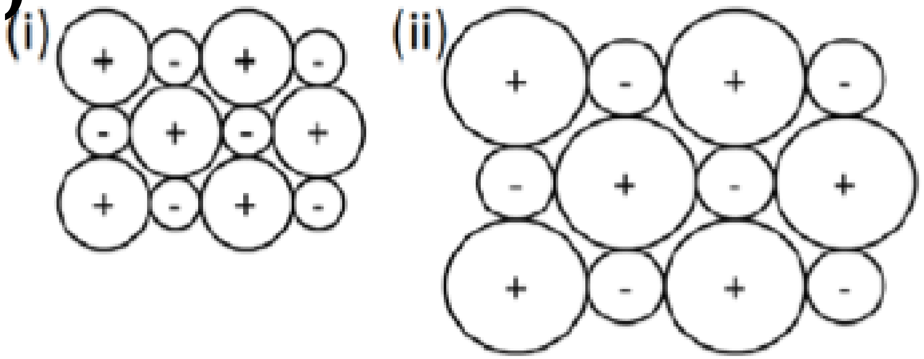
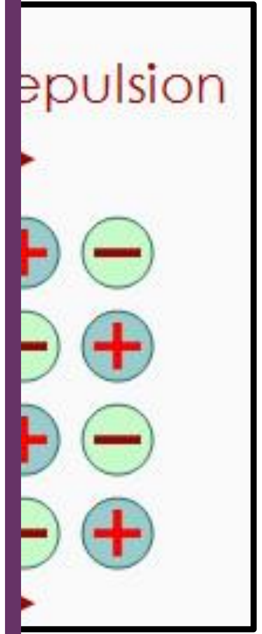


Which of the following statements regarding the above ionic solids are true?

1. Both are malleable
2. Both are ductile
3. Substance (i) has a higher boiling point
4. Substance (ii) has a higher boiling point

a. 1 and 3
b. 2 and 4
c. 3 only
d. 4 only



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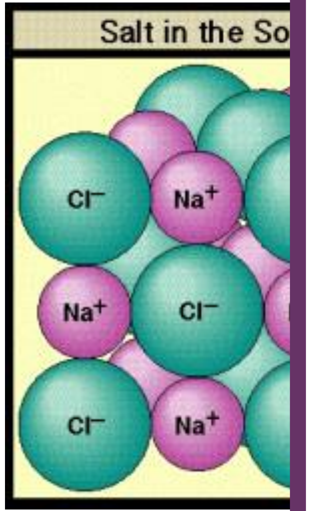

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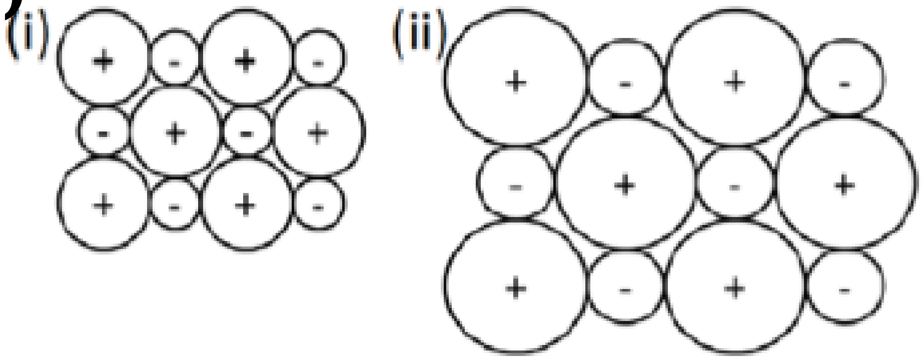

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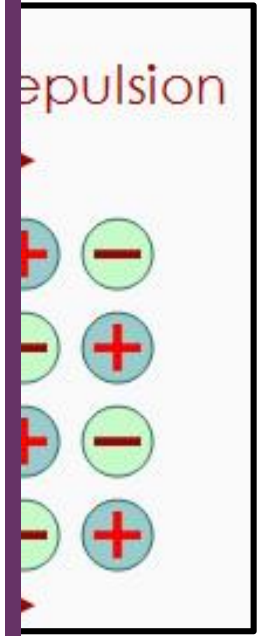

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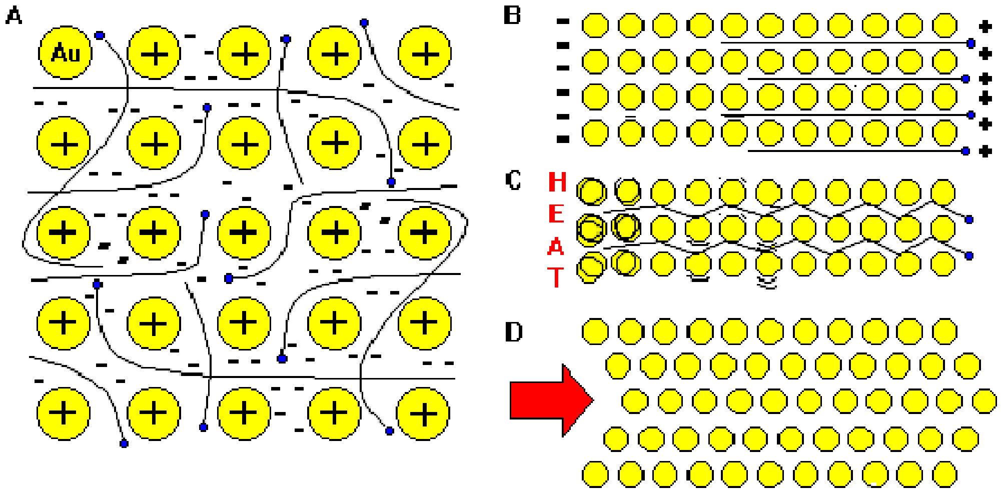
Metallic Properties – Sea of

Source



"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."

Video

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.

+

Metallic Properties – Sea of

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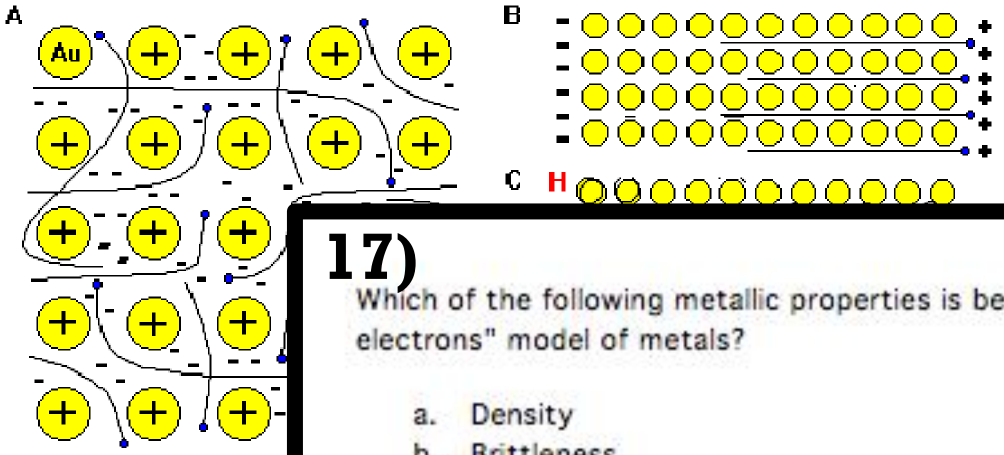
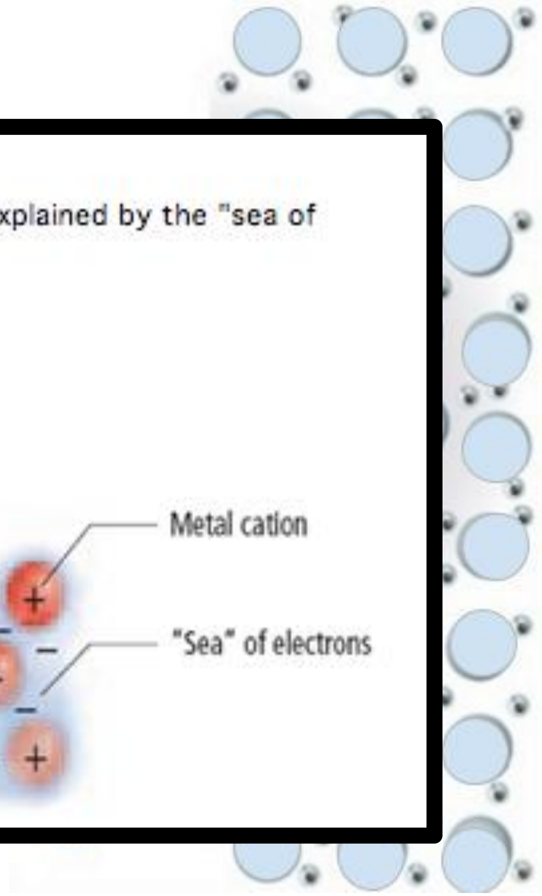


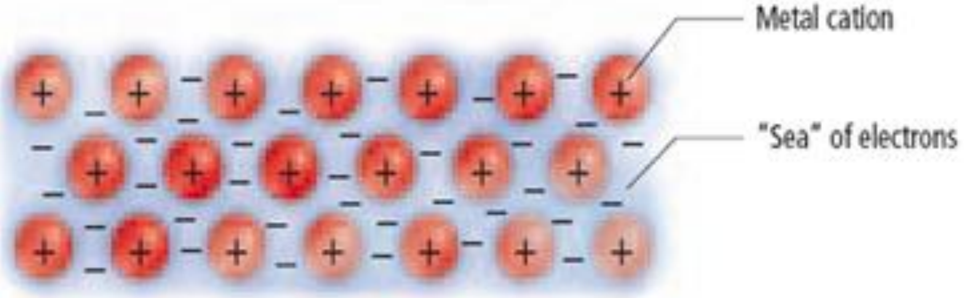


Video

17)

Which of the following metallic properties is best explained by the "sea of electrons" model of metals?

a. Density
b. Brittleness
c. Atomic Mass
d. Electrical Conductivity



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Metallic Properties – Sea of

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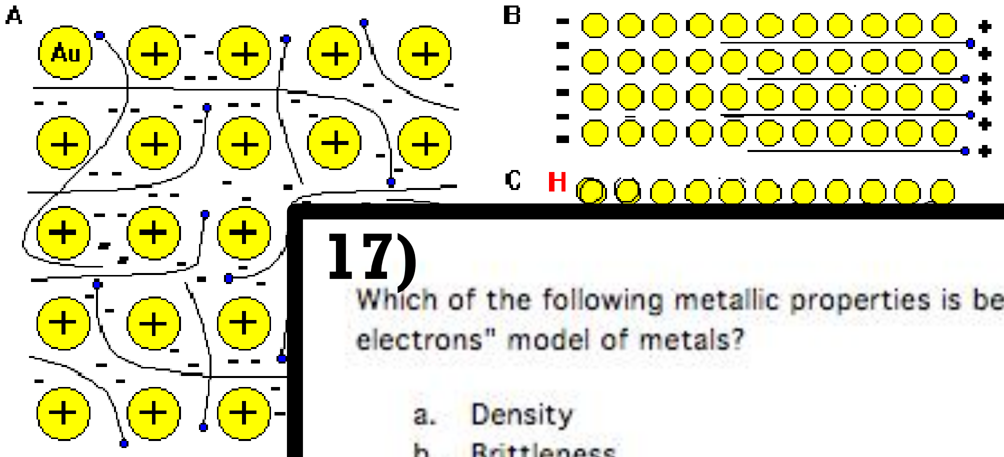
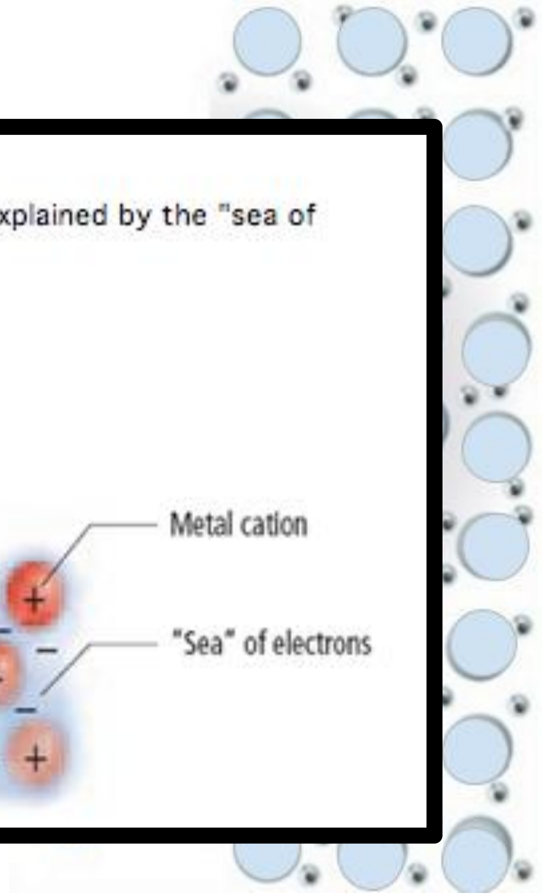
[Video](#)





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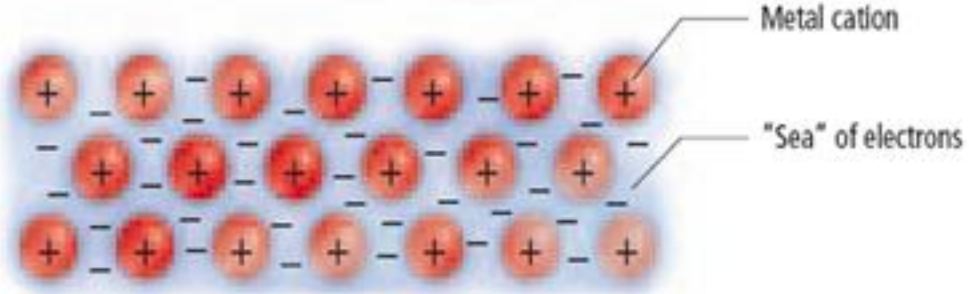

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+

[Source](#)

Question: **18)**

Which of the following molecules has a tetrahedral shape?

a. NH_3
b. H_2O
c. BH_3
d. CH_4
e. HF

[Video](#)

LO 2.21: The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

+

[Source](#)

[Video](#)

Question: **18)**

Which of the following molecules has a tetrahedral shape?

a. NH_3
b. H_2O
c. BH_3
d. CH_4
e. HF

Answer:

The correct answer is "d", CH_4. For a molecule to have a tetrahedral shape the central atom needs to have 4 bonds and no un-bonded electron pairs. Only CH_4 has 4 bonds with no un-bonded pairs.

LO 2.21: The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

Source

+

Lewis Diagrams / VSEPR

Video

Question: 19)

Which of the following molecules has polar bonds but is a non-polar molecule?

a. O_2
b. NH_3
c. HF
d. H_2CO
e. CCl_4

LO 2.21: The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

Source

+ # Lewis Diagrams / VSEPR

Video

Question: **19)**

Which of the following molecules has polar bonds but is a non-polar molecule?

a. O_2
b. NH_3
c. HF
d. H_2CO
e. CCl_4

Answer:

The correct answer is "e", CCl_4. For a molecule to be non-polar either the bonds in the molecule need to be non-polar or the polar bonds in the molecule need to be symmetrically arranged so that they cancel out. The CCl_4 molecule has polar C–Cl bonds that are arranged symmetrically so that the dipole moment cancels out.

LO 2.21: The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

Lewis Diagrams / VSEPR

Source

Video

Question: 20)

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 is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

Source

Lewis Diagrams / VSEPR

Video

Question: **20)**

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

Answer:

The correct answer is "c", sp^3. The oxygen atom has 4 electron pairs around it, 2 bonds and 2 non-bonding pairs. When there are four pairs the hybridization is sp^3.

LO 2.21: The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.

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 differ!

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	Click to view results	Click to view results	n/a
Sodium chloride (NaCl)		Solid	808	Click to view results	Click to view results	yes
Potassium Iodide (KI)		Solid	680	Click to view results	Click to view results	yes
Sucrose ($C_{12}H_{22}O_{11}$)		Solid	186	Click to view results	Click to view results	yes
Olive Oil		Liquid	-6	Click to view results	Click to view results	no
Ethanol (C_2H_6O)		Liquid	-114	Click to view results	Click to view results	yes
Corn Starch		Solid	Decomposes at high temperatures	Click to view results	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

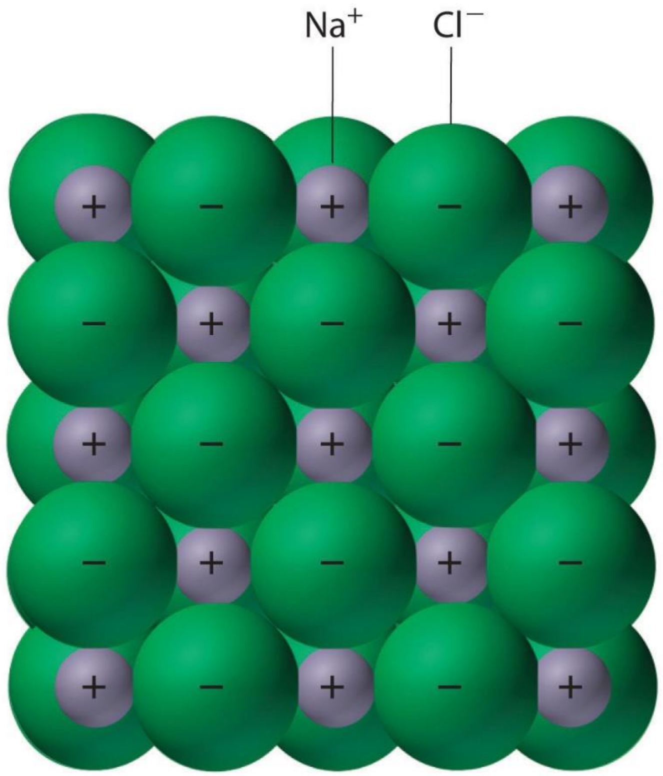
Use properties of compounds to differentiate them from one another. Other tests may be performed to positively identify the compound, but are not necessary to observe types of bonds present.

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.

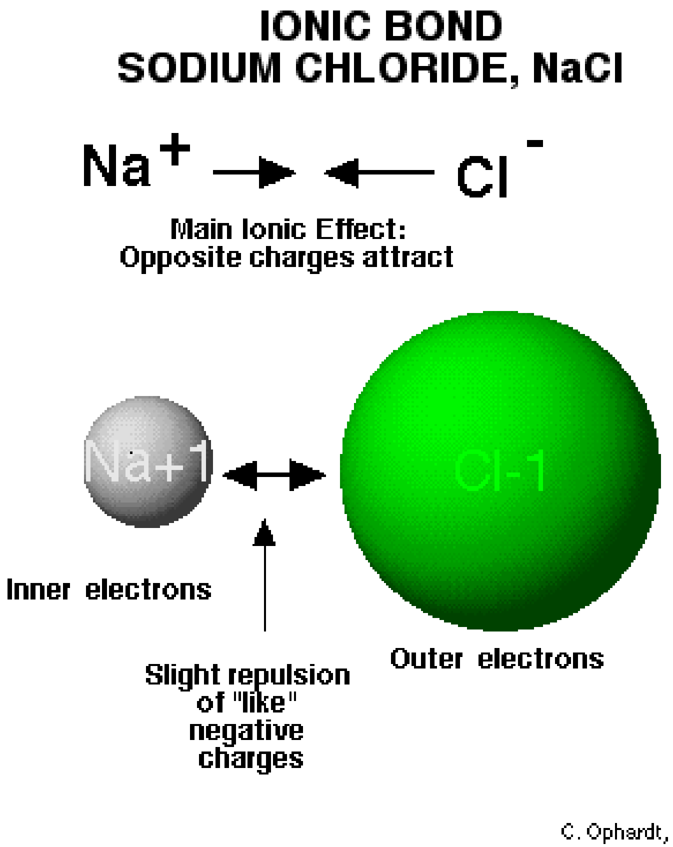
Source

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.

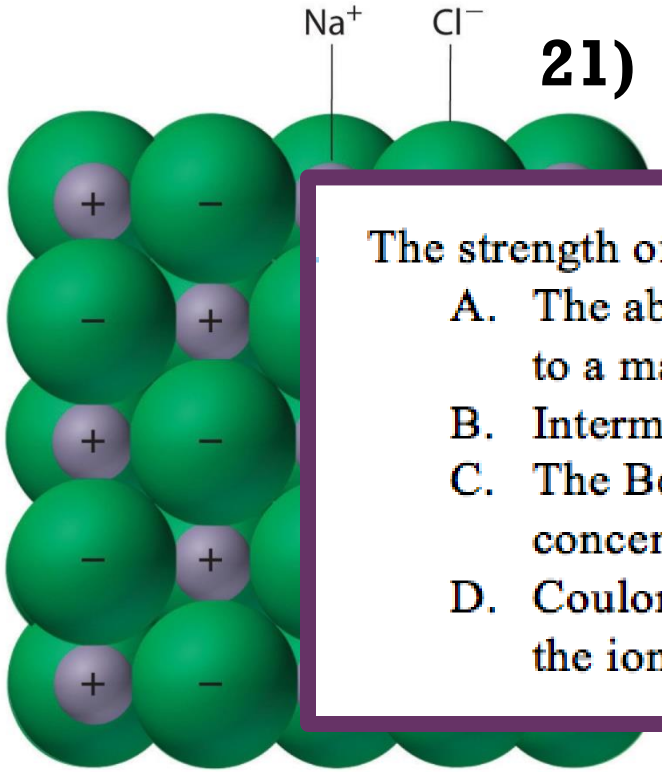
Source

Crystal Structure of Ionic Compounds

21)

The strength of an ionic bond is related to

A. The ability of the ions to be attracted to a magnet
B. Intermolecular forces between the ions
C. The Beer-Lambert law and the concentration of ions
D. Coulomb's law, the distance between the ions and the charges of the ions



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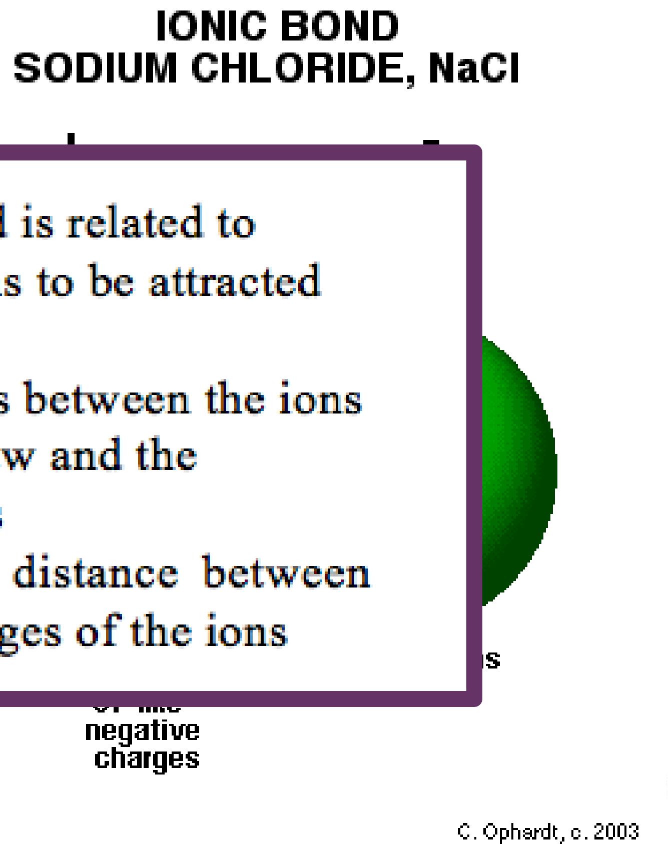
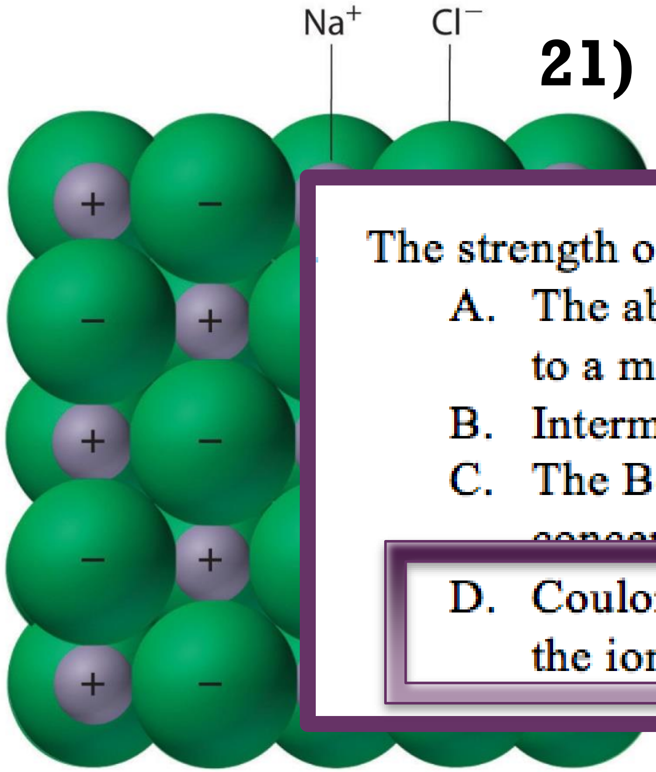


LO 2.23: The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.

Source

Crystal Structure of Ionic Compounds

21)



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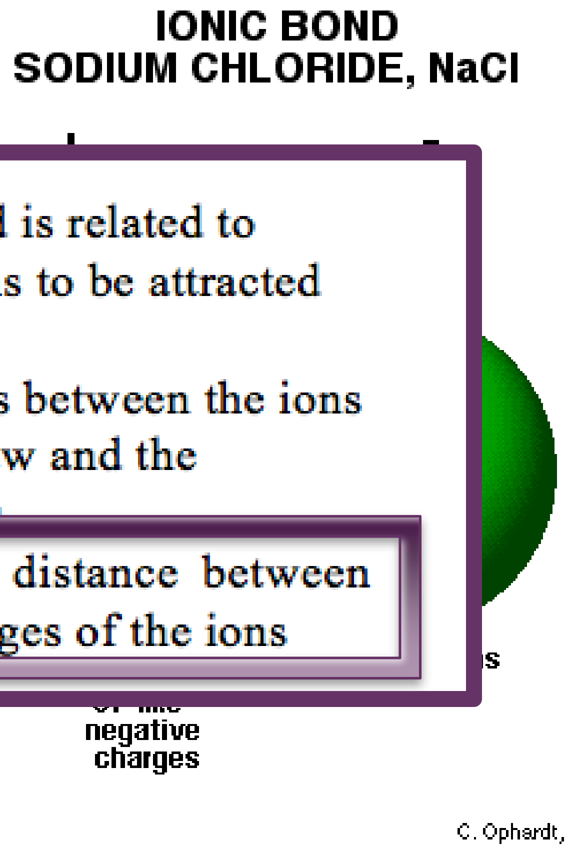

Video

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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

22)

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.

Video

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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

+

Crystal Structure of Ionic Compounds

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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.

Video

The +2 and -2 ions attract each other more strongly than +1 attracts -1.

The ions Mg^{+2} and O^{-2} are smaller than Na^{+1} and Cl^{-1}, therefore the ions can get closer together, increasing their electrostatic attractions.

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.

Alloys and their Properties

Source

+

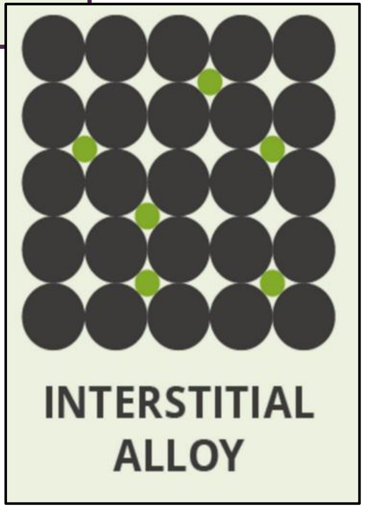
Question: 23)

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.

Video



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.

+

Alloys and their Properties

Source

Video

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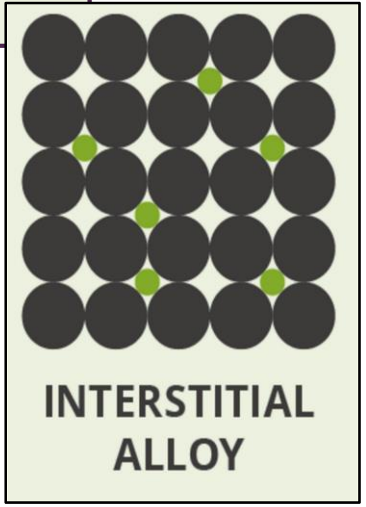
d. Copper and gold do not have any oxidation states in common, making the alloy much softer.

Answer:
The correct answer is "c". When there is a significant difference in the size of the atoms in an alloy the crystal lattice will become distorted, making it more difficult for the crystal structure to shift making the alloy harder. The added copper atoms in the silver lattice pin the lattice in place around the copper atoms preventing movement and making the alloy harder.



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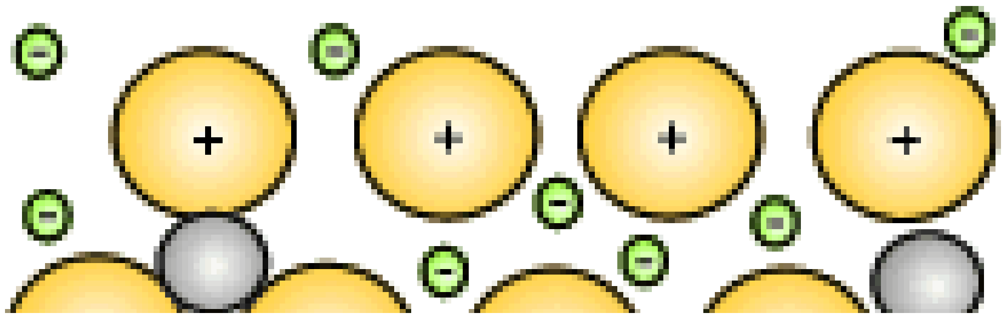
Source

+ # 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.

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Alloys!

[Source](#)

[Video](#)

Type of All	
substitutio	stal structure[1] srruption
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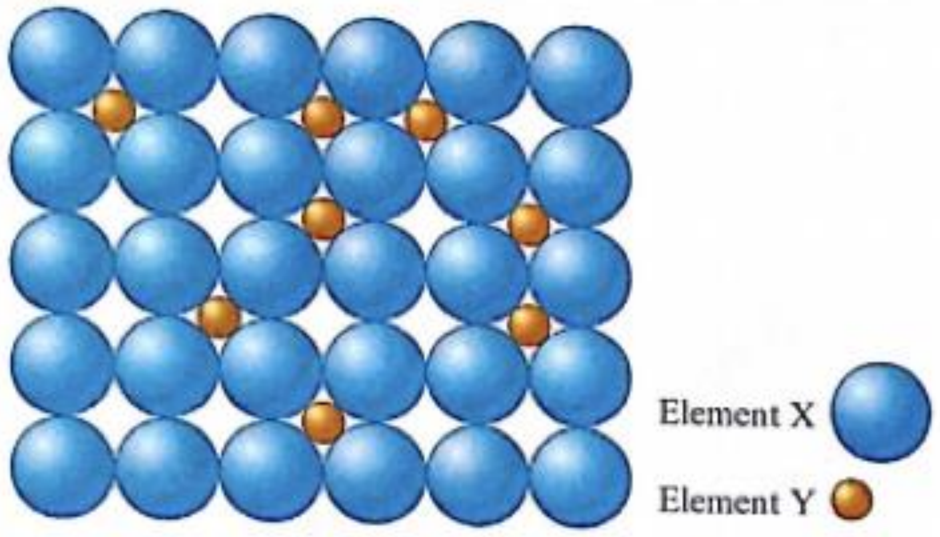
* intermeta ... ble metals

24) An example of an alloy is shown in the diagram below. Compared with the pure metal X, how would you expect the properties of the alloy to vary?



A. The alloy has higher malleability and higher density
B. The alloy has lower malleability and lower density
C. The alloy has higher malleability and lower density
D. The alloy has lower malleability and higher density

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

+ Alloys!

Video

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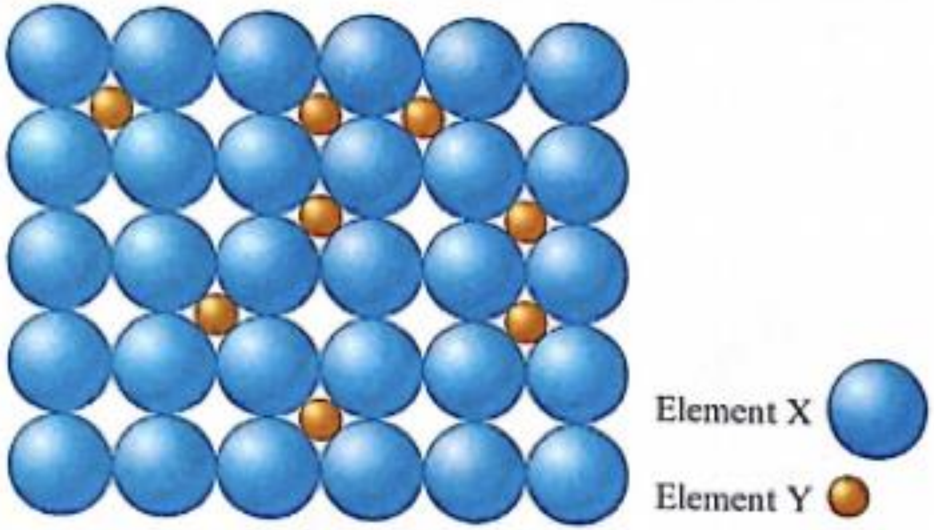

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LO 2.26: Students can use the electron sea model of metallic bonding to predict or make claims about macroscopic properties of metals or alloys.

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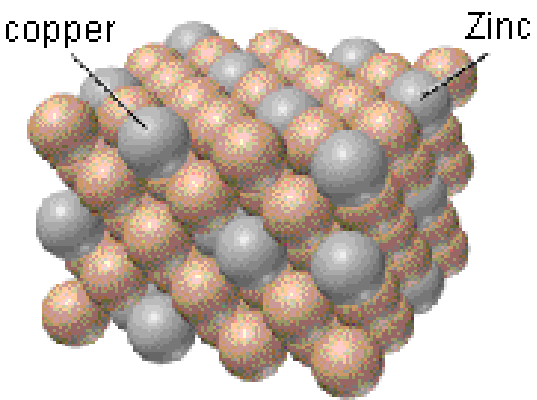
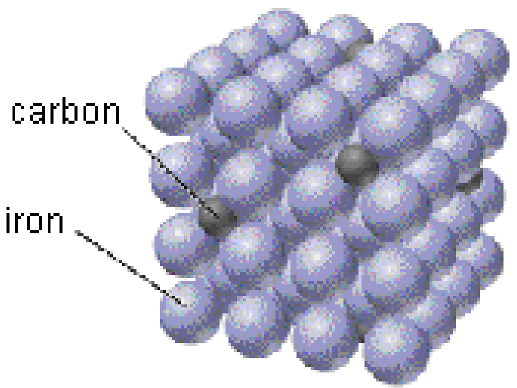
Metallic Solids - Characteristics

Source

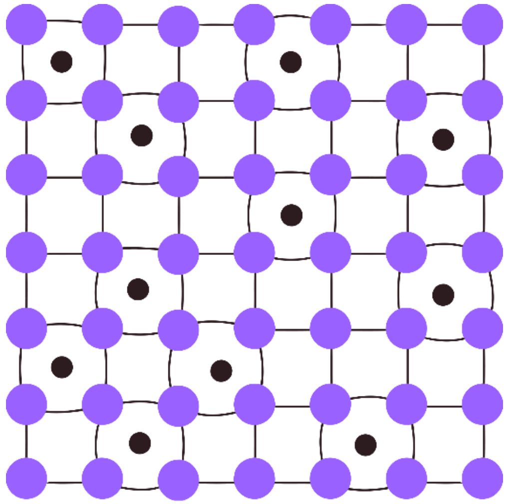
Video

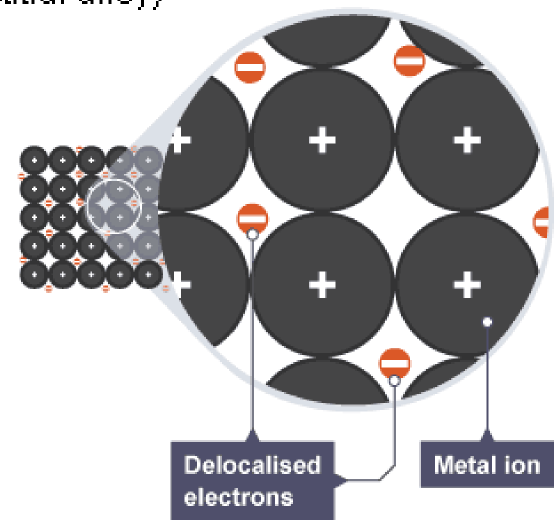


Brass (substitutional alloy)



Carbon steel (interstitial alloy)





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: 25)

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.

Source

Properties of Metallic Solids

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

Answer:
The correct answer is "d". A P-type semiconductor has been doped with the addition of an element with fewer electrons than the element that makes up the crystal matrix. germanium has four valence electrons, only the gallium has fewer that 4 valance electrons.

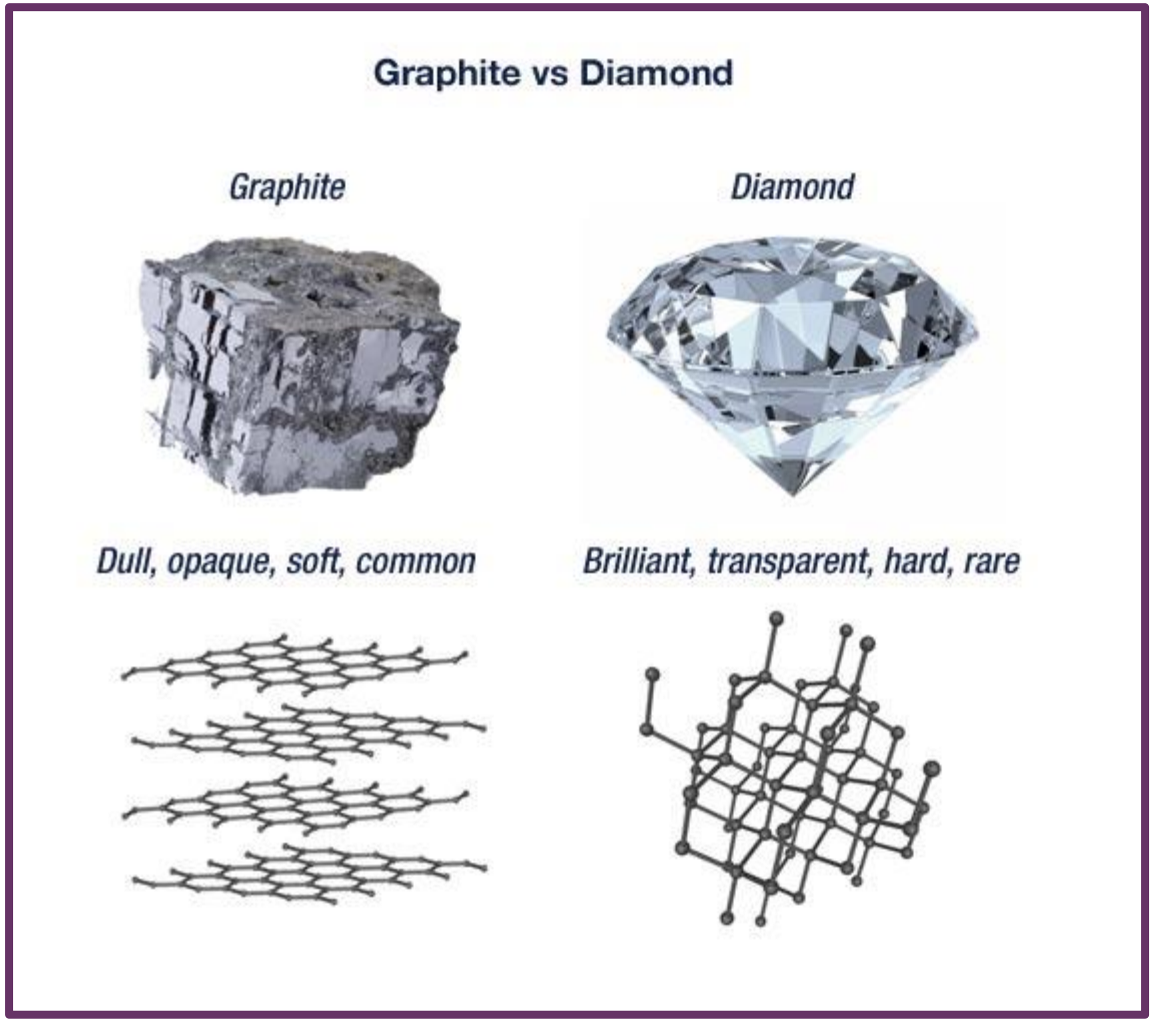
Video

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.

+

Source

Covalent Compounds - Interactions



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.

+

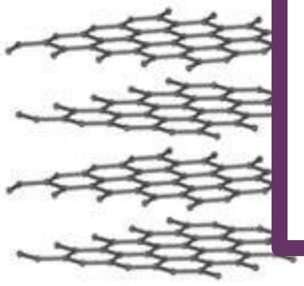
Covalent Compounds - Interac

Source

26)

Graphite

Dull, opaque, soft, co



Diamond has a high melting point and is extremely hard. Which characteristic of diamond's bonding and structure accounts for these observations?

A. Diamond is ionic and ionic bonds are strong

B. Diamond's discrete molecules are held together by relatively strong intermolecular forces

C. Diamond has a layered structure where three carbon atoms are joined to one another with strong covalent bonds

D. Diamond forms a giant covalent network where all of the atoms are joined to one another with very strong covalent bonds

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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.

[Source](#)

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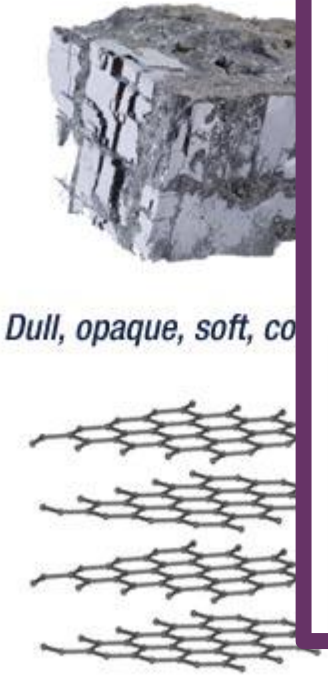
Covalent Compounds - Interacti

26) C

Graphite



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[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.

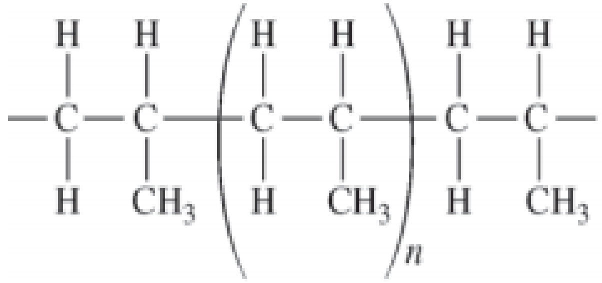
Source

+

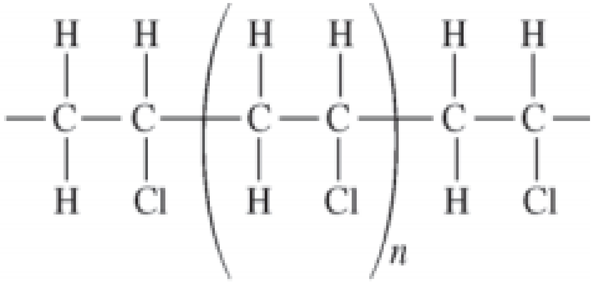
Covalent Solids

27)

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.



PP



PVC

(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.

Source

+

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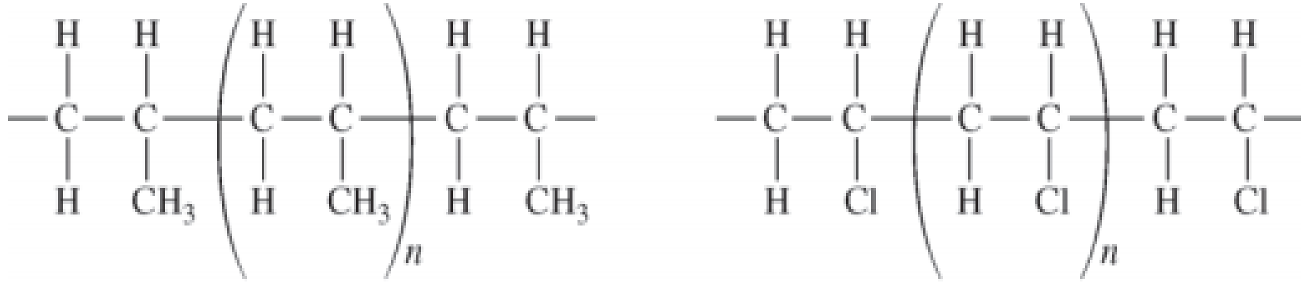


PP PVC

(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

The PVC beads sink. The spacing between chains is similar, but a Cl atom has a greater mass than CH_3 .

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.

+

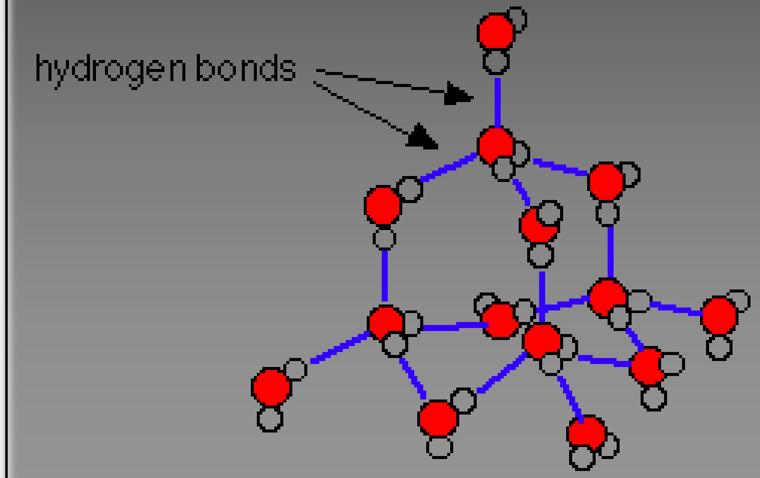
Molecular Compounds - Interactions

Source

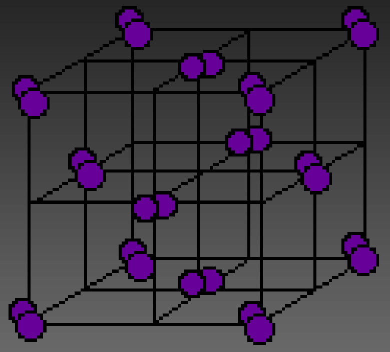
Video

Water (H_2O)

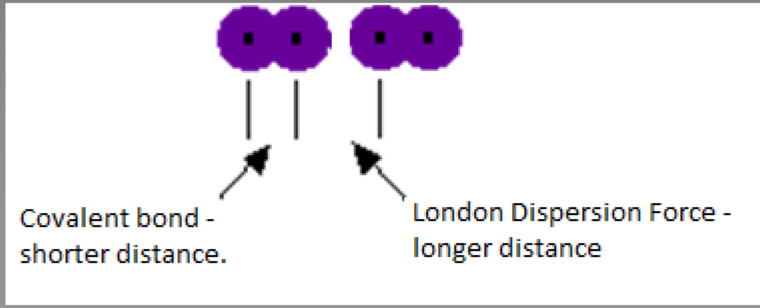
Polar Covalent compounds align according to dipole-dipole interactions.



Iodine (I_2)



Non-Polar Covalent compounds align according to LDF's as a solid.



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?

28)

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.

Molecular Compound Interactions

Source

Which of the following are broken when water boils?

28)

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

Video

All of these are broken *except* covalent bonds.

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.

Iodine consists of I_2 molecules, and the only attractions between the molecules are van der Waals dispersion forces. There are enough electrons in the I_2 molecule to make the temporary dipoles creating the dispersion forces strong enough to hold the iodine together as a solid. But they aren't all that strong, and so the solid has a low melting point and boiling point.

It is almost insoluble in water because the only attractions between water molecules and iodine molecules are dispersion forces. But in order to get the iodine molecules in between the water molecules you would have to break hydrogen bonds in the water. This costs too much energy which can't be recovered from the new attractions between water and iodine.

It dissolves in organic solvents such as hexane because, in this case, all you have to do is break the dispersion forces in the iodine and the hexane, and replace them by similar forces between the iodine and hexane.

Iodine doesn't conduct electricity because it doesn't have any mobile delocalised electrons.

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.