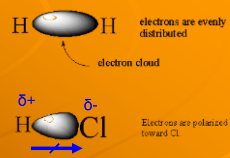
Chemistry SOL Review— Phases of Matter

COVALENT BOND POLARITY

- non-polar covalent bonds: bonding electrons shared equally between two atoms
  - Example: H_2
- polar covalent bonds (polar bonds): bonding electrons shared unequally.
  - Example: HCl



BOND POLARITY BASED ON ATOMS' ELECTRONEGATIVITY

- the more electronegative atom acquires a slight negative charge (δ-).
- the less electronegative atom acquires a slight positive charge(δ+).

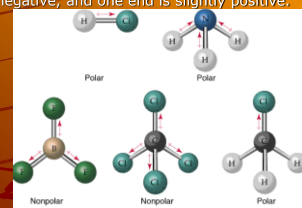
The unequal sharing creates "polarized" bonds with opposite charges.
Two ways to show polarity in structural formulas.
δ- and δ+ or a slashed arrow pointing toward electronegative element

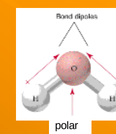
http://jchemed.chem.wisc.edu/JCESoft/CCA/pirelli/pages/cca2like.html

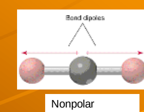
Chemistry SOL Review— Phases of Matter

Intermolecular Forces

- **POLAR MOLECULES**
- Polar Molecules: One end of the molecule is slightly negative, and one end is slightly positive.







Symmetric molecules are usually **nonpolar**. The polarities all cancel out. The CO_2 molecule is nonpolar.
When the arrows do not cancel the molecule is polar as in water. Unsymmetrical molecules are polar if there are polar bonds in the structure.

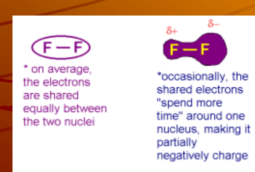
- **In chemical compounds, covalent bonds form when —**
  - **A** the electronegativity difference between two atoms is very large
  - **B** electrons are completely transferred between two metals
  - **C** pairs of electrons are shared between two nonmetal atoms
  - **D** two nonmetal ions are attracted to each other by opposite charges
- **The type of bond found in magnesium chloride is —**
  - **A** covalent
  - **B** nonpolar
  - **C** ionic
  - **D** metallic

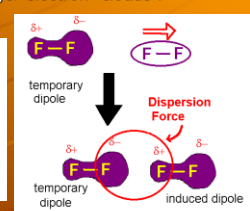
Chemistry SOL Review— Phases of Matter

Intermolecular Forces

Intermolecular Attractions are attractions between molecules due to three forces

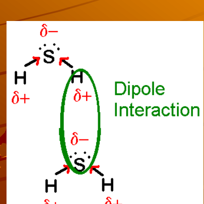
1. Dispersion forces (weakest) are temporary attractions between molecules due to temporary dipoles due to shifting electron clouds. Dispersion forces are greater in larger molecules with larger electron "clouds".

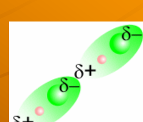




2. Dipole interactions: polar molecules are attracted to each other. The positive dipole of one molecule is attracted to the negative dipole of another.

Example: HCl molecules





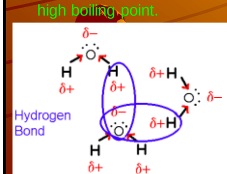
Chemistry SOL Review— Phases of Matter

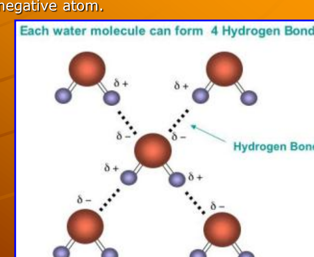
Intermolecular Forces

Intermolecular Attractions are attractions between molecules due to three forces

3. Hydrogen bond: hydrogen that is covalently bonded to a very electronegative atom is also weakly bonded to the unshared pair of another electronegative atom.

Hydrogen bonding is the strongest intermolecular force. This explains water's high boiling point.





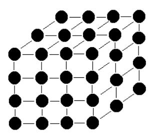
Chemistry SOL Review— Phases of Matter

Intermolecular Forces

Intermolecular Attractions and Molecular Properties

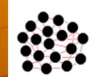
As intermolecular forces increase, the molecules are held more strongly together.

Solids resist melting because melting requires breaking intermolecular attractions and reforming new ones as the molecules slide past each other.



Solid
* low KE
*all IMF inplace
*molecules attached to each other

Liquids resist boiling because the liquid molecules will have to overcome the intermolecular attraction of the other liquid molecules to enter the gas phase.



Liquid
*some IMF overcome
* intermediate KE
*atoms slide past each other

As more and more heat energy is added to the system, some molecules begin to vibrate so strongly (achieve a high kinetic energy) that they overcome all intermolecular attractions and escape from the influence of other molecules. Thus, the molecules enter the gas phase.

Gas
*no IMF
* no connection to other molecules
*high KE

- **What probably causes water to have the highest specific heat of the substances listed above?**
  - A Molecule size
  - B Molecular mass
  - C Strong hydrogen bonds
  - D High density of ice

Specific Heat Capacities of Some Common Substances

Substance	Specific Heat Capacity (cal/g • °C)
Aluminum	0.21
Alcohol	0.58
Water	1.00
Wood	0.42

- **Water has several unique properties such as high boiling point, high surface tension, and low vapor pressure. The type of attraction that *best* accounts for these unique properties is —**
  - A dispersion forces
  - B coordinate covalent bonding
  - C hydrogen bonding
  - D ionic bonding

Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

Kinetic Molecular Theory:

1. The tiny particles in all forms of matter are in constant motion.
2. As kinetic energy increases, temperature increases.
3. Kinetic Energy is directly proportional to the Kelvin temperature scale.
4. At zero Kelvin, K, all molecular motion theoretically stops.

0°C = 273K

Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

GASES

Gas pressure is measured in atmospheres, kilopascals (kPa), or mm Hg

One atmosphere = 101.3 kPa = 760 mm Hg

Assumptions relating to gases:

1. Gas particles have negligible volume compared to container size
2. Gas particles do not attract or repel each other*
3. Gas particle move constantly, rapidly and randomly
4. All collisions are perfectly elastic (particles collide like billiard balls, not marshmallows)

However, gas particles really do attract each other due to intermolecular forces

Chemistry SOL Review— Phases of Matter

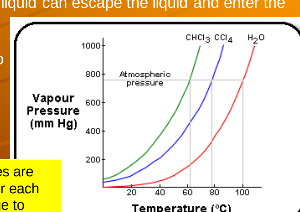
Kinetic Molecular Theory

LIQUIDS

When gas molecules lose kinetic energy (cool and slow down) then intermolecular forces can cause the molecules to stick together and liquify.

Evaporation: molecules with enough kinetic energy to overcome the intermolecular attractions in a liquid can escape the liquid and enter the gas phase.

Vapor Pressure: the force due to the gas above a liquid. This increases as temperature increases.



The curves are different for each liquid due to intermolecular forces

Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

LIQUIDS

Boiling Point: the temperature where a liquid's vapor pressure equals the external pressure or atmospheric pressure.

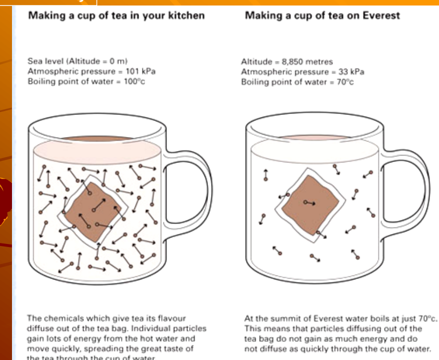
Boiling Point increases as external/atmospheric pressure increases.

Boiling Point decreases as external/atmospheric pressure decreases.

Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

LIQUIDS



Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

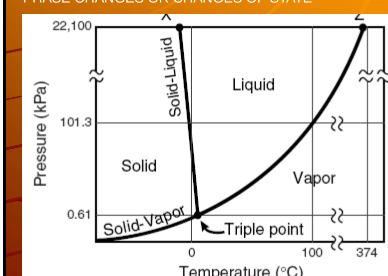
SOLIDS

1. Particles in liquids are free to slide past each other
2. Particles in solids do not slide past each other, but vibrate in place.
3. Melting point: temperature where a solid becomes a liquid.

Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

PHASE CHANGES OR CHANGES OF STATE

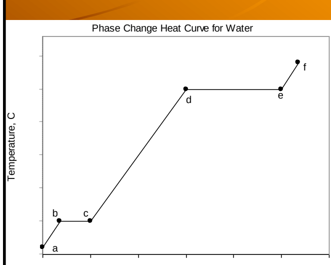


Triple Point—combination of temperature and pressure where all three phases coexist

Chemistry SOL Review— Phases of Matter

Kinetic Molecular Theory

PHASE CHANGES OR CHANGES OF STATE



a to b: solid increases in temperature.

b to c: solid melts to liquid at a constant temperature

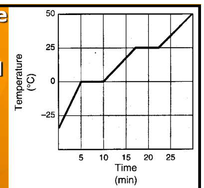
c to d: liquid increases in temperature

d to e: liquid vaporizes to gas at a constant temperature

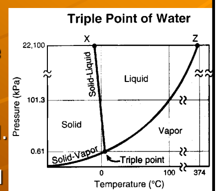
e to f: gas increases in temperature

- **The average kinetic energy of a sample of water molecules is —**
  - **A** increased as the temperature is decreased
  - **B** increased as the temperature is increased
  - **C** unaffected by temperature changes
  - **D** always equal to zero
- **One of the main assumptions of the kinetic molecular theory of gases is that the particles of an ideal gas —**
  - **A** must be single atoms instead of molecules
  - **B** are in constant motion
  - **C** must be maintained at very high pressures
  - **D** must be highly chemically reactive
- **Water molecules have the *greatest* kinetic energy in —**
  - **A** ice at 0º C
  - **B** water at 373 K
  - **C** water at 98º C
  - **D** steam at 150º C

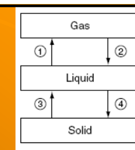
- An experiment yielded the above temperature and time information. What is the freezing point of the material in this experiment if the material is a solid at time zero?
  A -25° C
  B 0° C
  C 25° C
  D 50° C



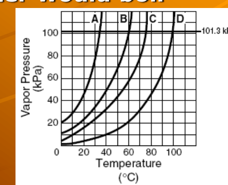
- According to the graph above, what happens at the triple point of water?
  A Only ice and liquid water exist in equilibrium.
  B Water exists only as a solid.
  C Water exists only as a gas.
  D Ice, water vapor, and liquid water exist in equilibrium.



- Which numbered process represents condensation?
  A 1
  B 2
  C 3
  D 4

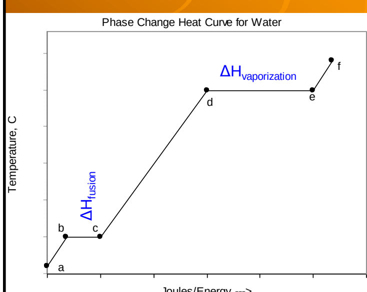


- Line D represents water. If the atmospheric pressure in a flask is lowered to 70 kPa, water would boil at what temperature?
  A 32° C
  B 70° C
  C 92° C
  D 100° C



Chemistry SOL Review— Phases of Matter

Molar Heats of Fusion and Vaporization



Molar heat of fusion: the energy required to melt one mole of a substance. (ΔH_{fusion})

Molar heat of vaporization: the energy required to vaporize one mole of a substance. ($\Delta H_{vaporization}$)

Chemistry SOL Review— Phases of Matter

Molar Heats of Fusion and Vaporization

Calculations

Example 1: How much energy is required to melt 10.0 grams of ice into water? The heat of fusion of ice is 80.0 calories/(gx°C).

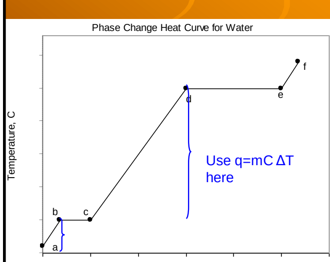
$$\frac{10.0\text{ g } H_2O}{} \times \frac{80.0\text{ calories}}{1\text{ g } H2O} = 800.\text{ calories}$$

Example 2: How much energy is required to vaporize 36.02 grams of water to steam at 100°C? Water's molar heat of vaporization is 6.01 kJ per mole.

$$\frac{36.02\text{ g } H_2O}{} \times \frac{1\text{ mol } H_2O}{18.01\text{ g } H_2O} \times \frac{6.01\text{ kJ}}{1\text{ mol } H_2O} = 12.02\text{ kJ}$$

Chemistry SOL Review— Phases of Matter

Specific Heat Capacity Calculations



Specific Heat Capacity:

The amount of energy needed to raise one gram of a substance by 1°C.

Units = J/(gx°C)

Memorize

$q = mC\Delta T$

Chemistry SOL Review— Phases of Matter

Specific Heat Capacity Calculations

$q = mC\Delta T$

q = heat in joules, J
m = mass in grams
C = specific heat capacity
$\Delta T = T_{final} - T_{initial}$

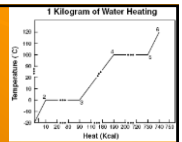
Example 1: A 15 gram sample of water is warmed from 45° to 65°C. The specific heat capacity of water is 4.18 J/(gx°C). How much energy was required to warm the water?

Answer: q = (15)(4.18)(65-45) = (15)(4.18)(20) = 1254 Joules

Example 2: A 2.0 gram sample of metal requires 5.0 Joules of energy to warm from 10 to 20°C. What is the metal's specific heat capacity?

Answer: 5.0=(2.0)(C)(20-10) or 5.0=(2.0)(C)(10) and C = 0.25 J/(gx°C).

- **Between points 2 and 3, energy is being used to —**
  - A melt ice
  - B heat water
  - C evaporate water
  - D heat water vapor



- **The amount of energy needed to raise one gram of a substance one degree Celsius is a characteristic property known as —**
  - A heat of formation
  - B heat of vaporization
  - C molar heat of fusion
  - D specific heat capacity
- **If the heat of fusion of water is 80 cal/g, the amount of heat energy required to change 15.0 grams of ice at 0° C to 15.0 grams of water at 0° C is—**
  - A 80 cal
  - B 560 cal
  - C 1200 cal
  - D 2400 cal

- **If the heat of fusion is 32.2 kJ/mol, the amount of heat energy required to melt 5.67 grams of FeO is —**
  - A 2.54 kJ
  - B 3.26 kJ
  - C 5.32 kJ
  - D 18.3 kJ
- **The specific heat capacity of a substance is the quantity of heat required to change the temperature of 1 gram of a substance by —**
  - A 1° C
  - B 5° C
  - C 10° C
  - D 20° C
- **Solid magnesium has a specific heat of 1.01 J/g • °C. How much heat is given off by a 20.0 gram sample of magnesium when it cools from 70.0° C to 50.0° C?**
  - A 202 J
  - B 404 J
  - C 808 J
  - D 1010 J

Chemistry SOL Review— Phases of Matter

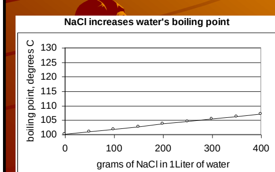
Colligative Properties

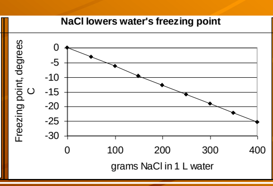
Adding impurities to a liquid increases the boiling point and decreases the freezing point (widens the liquid temperature range)

Examples:

Adding antifreeze to the water in the radiator to prevent boiling in summer and freezing in winter.

Putting salt on the road to prevent the road from icing up.





- **An ice-skating rink has tubes under its floor to freeze the water. Salt water is cooled well below the freezing point of water and pumped through the tubes to freeze the water in the rink. Why can the salt water be cooled so low without freezing?**
  - A Salt has a very low freezing point.
  - B Adding salt to water lowers its freezing point.
  - C Movement of the salt water through the tubes keeps it in the liquid state.
  - D The salt water is constantly absorbing energy from its surroundings.
- **Water can be made to boil *above* its normal boiling point of 100° C by —**
  - A decreasing the air pressure
  - B increasing the air pressure
  - C increasing the heat being applied
  - D decreasing the volume of the container
- **The freezing point and the boiling point of water can be altered by a variety of techniques. Which of the following has little or no effect on the boiling point of water?**
  - A Increasing the air pressure above the liquid
  - B Adding alcohol to the water
  - C Adding sodium chloride to the water
  - D Increasing the amount of water

Chemistry SOL Review— Molar Relationships

Gas Laws

1. General Properties of Gases
   There is a lot of "free" space in a gas.
   Gases can be expanded infinitely.
   Gases fill containers uniformly and completely.
   Gases diffuse and mix rapidly.

The Gas Laws

The Combined Gas Law $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Always use degrees Kelvin

°C + 273 = K

Boyle's Law
Inverse relationship $P_1V_1 = P_2V_2$

http://www.grc.nasa.gov/WWW/K-12/airplane/aboyle.html

Charles Law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Chemistry SOL Review— Molar Relationships

Gas Laws

Some Problems

A balloon contains 8.0 liters of gas at 100 K. What is the balloon's volume at 200K?

Answer: $\frac{8}{100} = \frac{V_2}{200}$ = 16 Liters

A balloon contains 10. Liters at 3 atmospheres and 275 K. What is the volume of the balloon at 0.50 atmospheres and 200K?

Answer: $\frac{(3.0)(10)}{275} = \frac{(0.50)V_2}{200}$ = 45 Liters

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$P_1V_1 = P_2V_2$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Chemistry SOL Review— Molar Relationships

Gas Laws

The Ideal Gas Law

Memorize: PV = nRT

- •P= pressure in kPa
- •V= liters
- •N= moles
- •T= temperature in Kelvin
- •R = universal gas law constant = 8.31 $\frac{\text{kPa x L}}{\text{Moles x K}}$

•The SOL test uses $R = 8.31 \frac{\text{kPa} \cdot \text{dm}^3}{\text{moles} \cdot \text{K}}$

Chemistry SOL Review— Molar Relationships

Gas Laws

The Ideal Gas Law

Memorize: PV = nRT

R = 8.31 $\frac{\text{kPa x L}}{\text{Moles x K}}$

$R = 8.31 \frac{\text{kPa} \cdot \text{dm}^3}{\text{moles} \cdot \text{K}}$

Example 1:A 15 liter tank contains 2.0 moles of nitrogen gas at 27 °C. What is the pressure of nitrogen inside the tank?

Answer:

P=?, V=15 L, n=2.0, T=300K (remember to convert)

P(15)=2.0(8.31)(300) so P = 332.4 kPa

You try: How many moles of Hydrogen gas are in a 20. L tank pressurized to 1000. kPa at 300K?

Answer:

P=1000., V=20. L, n=? T=300K

(1000.)(20) = n(8.31)(300) so n = 8.0 moles Hydrogen

Chemistry SOL Review— Molar Relationships

Gas Laws

Dalton's Law of Partial Pressures

Memorize: $P_{total} = P_1 + P_2 + P_3 + \ldots$

Example A tank containing nitrogen, hydrogen and ammonia gas has a total pressure of 12 atmospheres. The partial pressure of the hydrogen is 6 atmospheres, the partial pressure of the ammonia is 4 atmospheres. What is the partial pressure of the nitrogen?

Answer:

P_{total} = 12 atm, P_{N2}=?, P_{H2}=6, P_{NH3}=4

12 = P_{N2} + 6 + 4 so P_{N2} = 2

http://video.google.com/videosearch?q=gas+laws&sourceid=ie7&rls=com.microsoft:en-US&oe=utf8&safe=active&um=1&ie=UTF-8&sa=N&hl=en&tab=wv#q=gas+law+demonstration&hl=en&emb=0&start=10

- **A gas cylinder is filled with 4.00 moles of oxygen gas at 300.0 K. The piston is compressed to yield a pressure of 400.0 kPa. What is the volume inside the cylinder?**
  A 3.19 dm3
  B 6.25 dm3
  C 24.9 dm3
  D 31.5 dm3

$R = 8.31 \frac{\text{kPa} \cdot \text{dm}^3}{\text{moles} \cdot \text{K}}$

- **A sample of hydrogen gas is collected over water at 25° C. The vapor pressure of water at 25° C is 23.8 mmHg. If the total pressure is 523.8 mmHg, what is the partial pressure of the hydrogen?**
  A 23.8 mmHg
  B 47.6 mmHg
  C 500.0 mmHg
  D 523.8 mmHg
- **A gas cylinder with a volume of 3.00 dm3 contains 8.00 moles of oxygen gas at a temperature of 50.0 K. What is the pressure inside the cylinder?**
  A 504 kPa
  B 1110 kPa
  C 2220 kPa
  D 3320 kPa

$R = 8.31 \frac{\text{kPa} \cdot \text{dm}^3}{\text{moles} \cdot \text{K}}$

- **A tank contains N2 at 1.0 atm and O2 at 2.0 atm. Helium is added to this tank until the total pressure is 6.0 atm. What is the partial pressure of the helium?**
  A 4.0 atm
  B 3.0 atm
  C 2.0 atm
  D 1.0 atm
- **If the pressure exerted on a confined gas is doubled, then the volume of the gas —**
  A increases four times
  B decreases by one-fourth
  C is doubled
  D is halved
- **A sample of oxygen gas is collected over water at 22° C and 98.67 kPa pressure. If the partial pressure of the water is 2.67 kPa, the partial pressure of the oxygen is —**
  A 93.33 kPa
  B 96.00 kPa
  C 98.66 kPa
  D 101.33 kPa
- **A sample of nitrogen occupies 10.0 liters at 25C and 98.7 kPa. What would be the volume at 20C and 102.7 kPa?**
  A 7.87 L
  B 9.45 L
  C 10.2 L
  D 10.6 L

- **Equal quantities of different liquids are plac[ed] in closed manometers at 20° C. Which liqui[d] has the highest vapor pressure?**

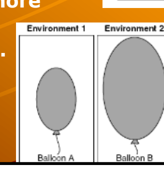
- **Each balloon was filled with an identical number of moles of gas. Which of the following best explains why balloon B is larger than balloon A?**

A The gas in balloon A is under less pressure.

B The gas in balloon A is warmer.

C The gas in balloon B is under more pressure.

D The gas in balloon B is warmer.



- **Charles' Law states that if a given quantity of gas is held at a constant pressure, then its volume is directly proportional to the absolute temperature. This law explains why —**

  A the pressure of a gas increases when volume decreases
  B a gas-filled balloon expands when it is heated
  C solids require heat in order to change into gases
  D some gases only react with each other at high temperatures

- **According to Boyle's law, the relationship between the pressure and volume of a gas at constant temperature is —**

  A numerically equivalent
  B inversely proportional
  C positively correlated
  D totally unrelated

- **The total pressure of an O2-Ar-He gas mixture is 755 mm Hg. If the partial pressure of Ar is 174 mm Hg and the partial pressure of He is 389 mm Hg, then the partial pressure of O2 is —**

  A 192 mm Hg
  B 282 mm Hg
  C 366 mm Hg
  D 563 mm Hg