Chapter 15 and 16

Water and Solutions

Water Molecules

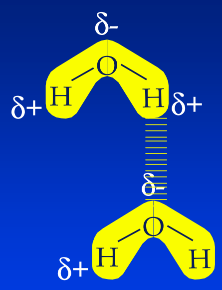
- O is more electronegative than H
- Gives O a partial negative charge
- Bent shape makes molecule polar
- Strong hydrogen bonds
- Water molecules are attracted to one another better than other molecules its size

Surface Tension

- liquid water acts like it has a skin.
- Water forms round drops.
- All because water hydrogen bonds.

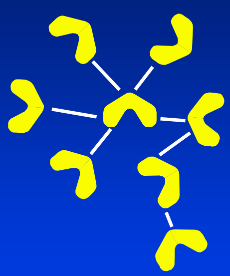
Surface Tension

- One water molecule H-bonds to another.
- Can H bond to molecules all around.



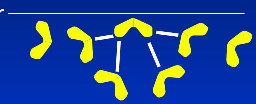
Surface Tension

- A water molecule in the middle of solution is pulled in all directions.



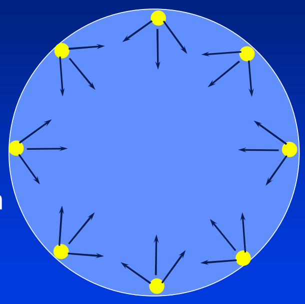
Surface Tension

- Not at the surface.
- Only pulled into water and close together
- Holds the molecules together.
- Causes surface tension.



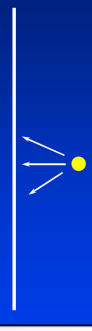
Surface Tension

- Water drops are round because all the molecules on the edge are pulled to the middle.
- Gravity can flatten them out on a surface



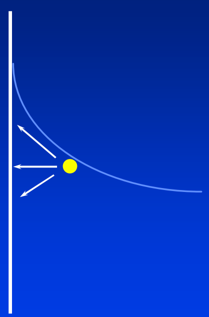
Adhesive Force

- Glass has polar molecules.
- Attracts the water molecules.
- Some of the pull is up.

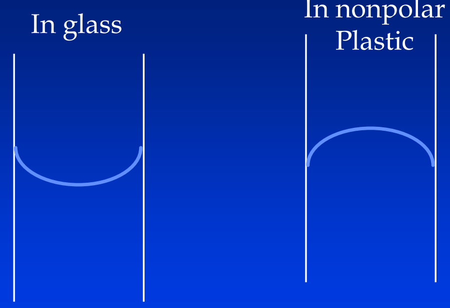


Meniscus

- Water curves up along the side.
- This makes the meniscus.



Meniscus



Heat Capacity

- Water has a high heat capacity
- It takes more energy to get its molecules moving faster
- Water 4.18 J/g°C - Iron only 0.447 J/g°C.
- Q = Mass x ΔT x C
  - Q is heat C is heat capacity
- How much heat is needed to raise the temperature of 25g of iron and water by 75°C

Intermolecular Forces

The forgotten part of Chapter 8

Polar Bonds

- When the atoms in a bond are the same, the electrons are shared equally.
- This is a nonpolar covalent bond.
- When two different atoms are connected, the electrons may not be shared equally.
- This is a polar covalent bond.
- How do we measure how strong the atoms pull on electrons?

Electronegativity

- A measure of how strongly the atoms attract electrons in a bond.
- Use table 6.2 Pg. 177

Table 6.2

Electronegativity Values for Selected Elements

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	Tl 1.8	Pb 1.9	Bi 1.9		

Electronegativity

- The bigger the electronegativity difference the more polar the bond.
- SUbtract
- 0.0 - 0.4 Covalent nonpolar
- 0.5 - 1.0 Covalent moderately polar
- 1.0 -2.0 Covalent polar
- >2.0 Ionic

How to show a bond is polar

- Isn't a whole charge just a partial charge
- $\delta+$ means a partially positive
- $\delta-$ means a partially negative

$$\overset{\delta+}{H}-\overset{\delta-}{Cl}$$

$$+\!\!\longrightarrow$$

- The Cl pulls harder on the electrons
- The electrons spend more time near the Cl

Polar Molecules

Molecules with ends

Polar Molecules

- Molecules with a partially positive end and a partially negative end
- Requires two things to be true

① The molecule must contain polar bonds

This can be determined from differences in electronegativity.

②Symmetry can not cancel out the effects of the polar bonds.

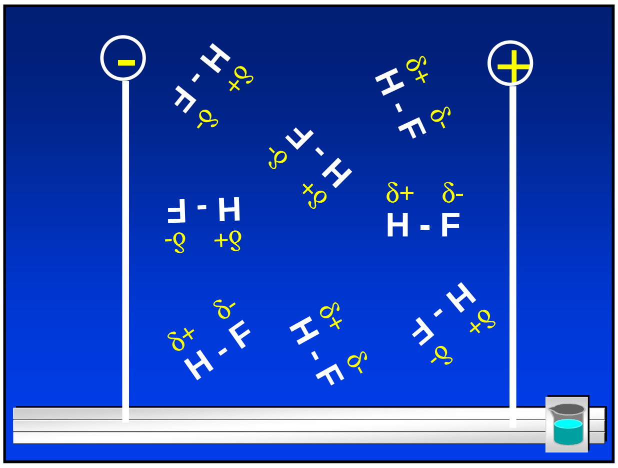
Must determine shape first.

Polar Molecules

- Symmetrical shapes are those without lone pair on central atom
  - Tetrahedral
  - Trigonal planar
  - Linear
- Will be nonpolar if all the atoms are the same
- Shapes with lone pair on central atom are not symmetrical
- Can be polar even with the same atom

Is it polar?

- HF
- H_2O
- NH_3
- CCl_4
- CO_2
- CH_3Cl



Intermolecular Forces

What holds molecules to each other

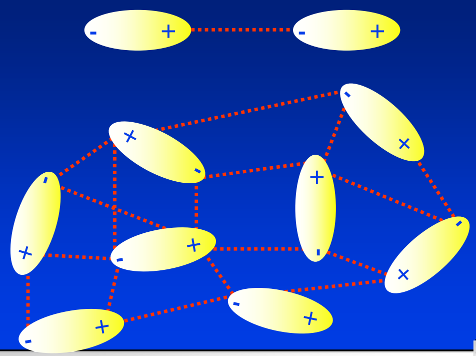
Intermolecular Forces

- They are what make solid and liquid molecular compounds possible.
- The weakest are called van der Waal's forces - there are two kinds
  - Dispersion forces
  - Dipole Interactions

Dipole interactions

- Occur when polar molecules are attracted to each other.
- Partial positive on one molecule attracted to partial negative on another
- Opposites attract but not completely hooked like in ionic solids.

$$\overset{\delta^+}{H}-\overset{\delta^-}{F} \longleftrightarrow \overset{\delta^+}{H}-\overset{\delta^-}{F}$$



Dispersion Force

- Electrons are not evenly distributed at every instant in time.
- Temporary partial charges
- An momentary dipole.
- Affects the electrons ion the molecule next to it.
- Called induced dipole
- Momentarily attracted

Dispersion force

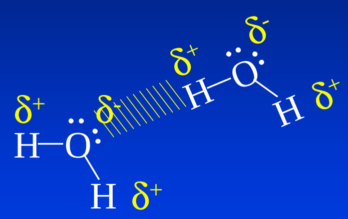
Dispersion Force

- Depends only on the number of electrons in the molecule
- Bigger molecules more electrons
- More electrons stronger forces
  - F_2 is a gas
  - Br_2 is a liquid
  - I_2 is a solid

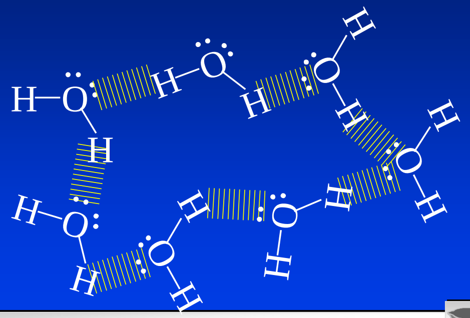
Hydrogen bonding

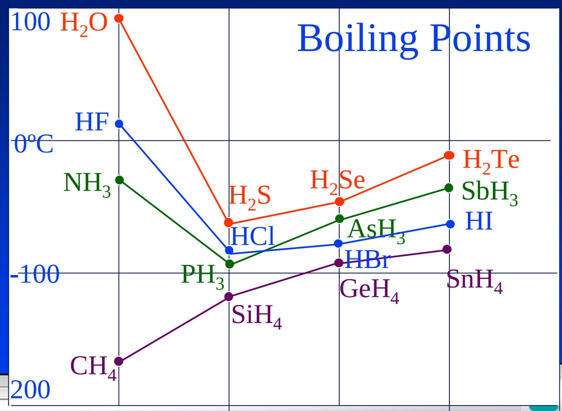
- Are the attractive force caused by hydrogen bonded to F, O, or N.
- F, O, and N are very electronegative so it is a very strong dipole.
- They are small, so molecules can get close together
- The hydrogen partially share with the lone pair in the molecule next to it.
- The strongest of the intermolecular forces.

Hydrogen Bonding



Hydrogen bonding





Vapor Pressure

- The pressure caused by the vapor above a liquid at equilibrium
- Caused by molecules that escape
- Water has a low vapor pressure for a small molecule
- Hydrogen bonding keeps molecules from escaping.

What happens to the vapor pressure of water as the temperature increase.

A. It increase because more molecules have the energy to escape

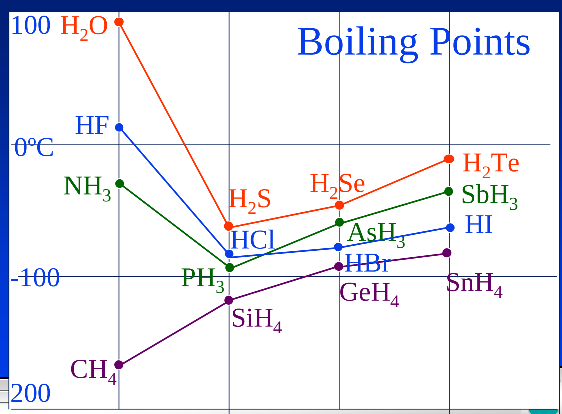
B. It decreases because the hydrogen bonds get stronger

C. It increase because the hydrogen bond gets weaker

D. It does not change because the strength of the hydrogen bond doesn’t change.

Boiling point

- When vapor pressure equals external pressure.
- Strong hydrogen bonds make it hard for water to become a gas.
- High boiling point 100 ºC



Heat of vaporization

- Because of the strong hydrogen bonds it takes a large amount of energy to change water from a liquid to a gas.
- 2260 J/g is the heat of vaporization.
- It takes this much energy to boil water.
- You get this much energy back when it condenses.
- Steam burns, but heats things well.

Which of these gets smaller because of water's strong hydrogen bonding?

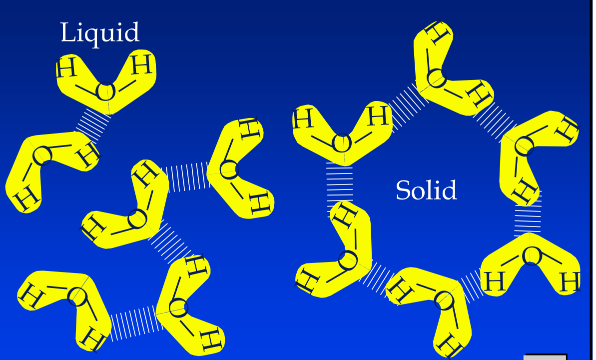
A) Boiling point
B) Vapor pressure
C) Amount of curve to the meniscus
D) Surface tension
E) Heat capacity
F) Heat of vaporization

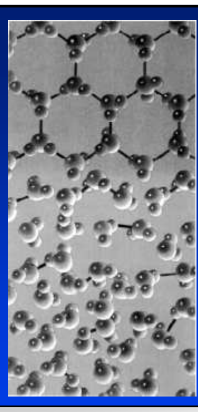
Ice

- Most liquids contract (get smaller) as they are cooled.
- They get more dense.
- When they change to solid they are more dense than the liquid.
- Solid metals sink in liquid metal.
- Ice floats in water.
- Why?

Ice

- Water becomes more dense as it cools until it reaches 4ºC.
- Then it becomes less dense.
- As the molecules slow down they arrange themselves into honeycomb shaped crystals.
- These are held together by H-bonds.
- Freezes at 0ºC, which is high for a small molecule





Snow

Ice

- 10% less dense than water.
- Water freezes from the top down.
- It takes a great deal of energy to turn solid water to liquid water.
- Heat of fusion is 334 J/g.

What is most responsible for water's special properties?

A. The two hydrogen atoms, because they are small
B. The oxygen atom because it is electronegative
C. Hydrogen has a partially positive charge
D. The attraction of one water molecule for another

Which of the following is NOT high for water

A. Melting point
B. Boiling point
C. Vapor Pressure
D. Heat capacity
E. Heat of Fusion

Aqueous Solutions

- Solution - a homogenous mixture mixed molecule by molecule.
- Solvent - the stuff that does the dissolving.
- Solute -the stuff that is dissolved.
- Exist in all phases, solvent, solute and solutions
- Aqueous solution- a solution with water as the solvent.

Aqueous Solutions

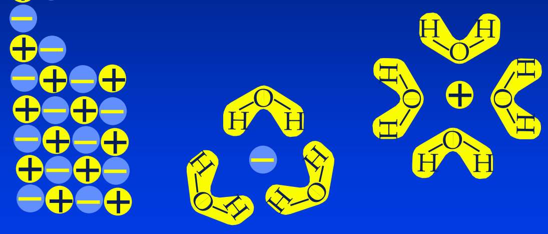
- Water dissolves ionic solids and polar covalent solids best.
- The rule is "like dissolves like"
- Polar dissolves polar.
- Nonpolar dissolves nonpolar.
- Oil is non polar.
- Oil and water don't mix.
- Salt is ionic- salt water.

How Ionic solids dissolve

- Called solvation.
- Water breaks the + and - charged pieces apart and surround them.

How Ionic solids dissolve

Animation



- Solids will dissolve if the attractive force of the water molecules is stronger than the attractive force of the crystal.
- If not the solids are insoluble.
- Water can do the same things to polar molecules.
- Other polar molecules can do the same thing
- Molecules that can hydrogen bond are very soluble in water.

- Water doesn't dissolve nonpolar molecules because they have no charges to attract water molecules .
- The water molecules attract each other and separate from the nonpolar molecules.
- Nonpolar molecules are held together by dispersion forces
- Nonpolar dissolves nonpolar because they attract each other the same amount as they attract themselves

Water or Oil?

- $CaCl_2$
- CH_4
- NH_3
- K_2SO_4
- H_2S
- Cl_2
- CH_3OH

Electrolytes

- Substances that conduct electricity when melted or dissolved in water.
- Conducting is charged pieces moving
- Ionic compounds are electrolytes
  - Fall apart into ions
    - When dissolved
    - When melted

Nonelectrolytes

- Substances that don't conduct electricity when melted or dissolved in water.
- Most molecular compounds.
- Dissolve because they are polar
- Don't have to ionize to dissolve
- Don't make charges

Weak electrolytes

- Substances that conduct electricity slightly when dissolved in water.
- Some molecular compounds.
- When dissolve they partially fall apart
- Make a few ions
- Don't make ions when melted

Animation

Hydrates

- Ionic compounds that trap water in their crystal structure
- Always the same number of water molecules
- Number of molecules written after a dot in the formula
- $CoCl_2 \cdot 6H_2O$
- In the name use prefix for number of water molecules
- Cobalt (II) chloride hexahydrate

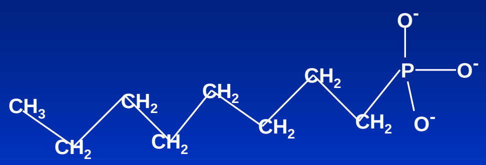
Hydrates

- Heating will force water to leave
- $CoCl_2 \bullet 6H_2O(s) \underset{\text{-heat}}{\overset{\text{+heat}}{\rightleftharpoons}} CoCl_2(s) + 6H_2O(g)$
- When water returns heat released
- Efflorescent hydrates will lose moisture to the air
- if their vapor pressure is more than pressure of water in the air

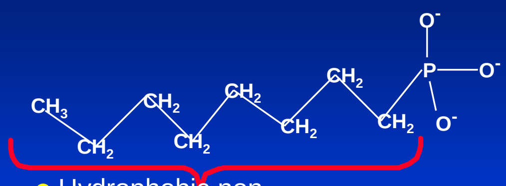
Hydrates

- Hygroscopic hydrates pull moisture from the air
- Used to remove moisture from packages
- Called a dessicant
- Deliquescent Hydrates remove so much moisture that they get wet
- Form aqueous solutions from water in the air

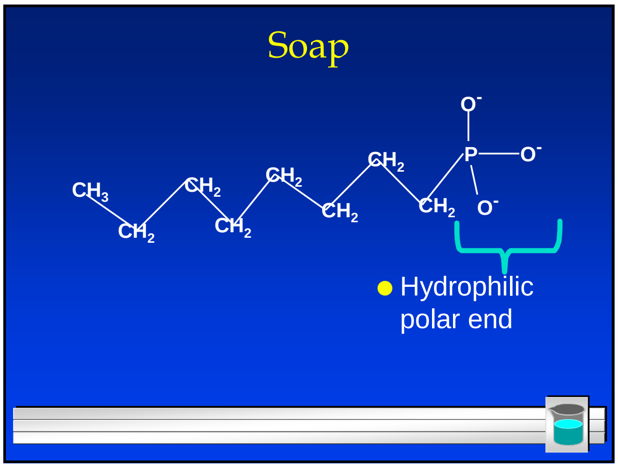
Soap

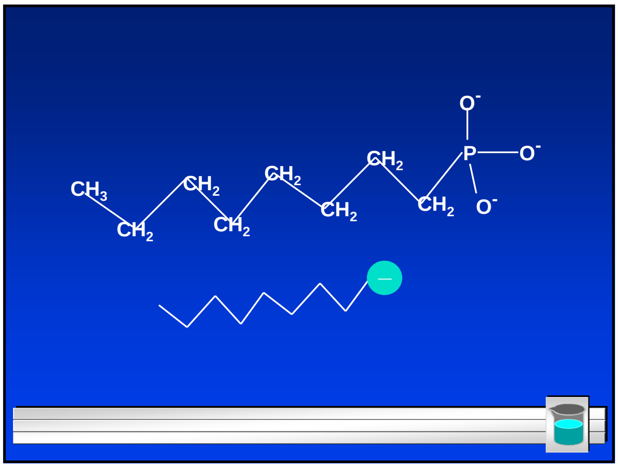


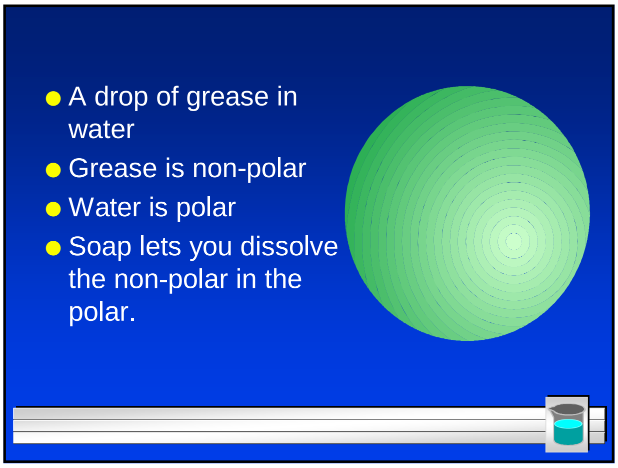
Soap

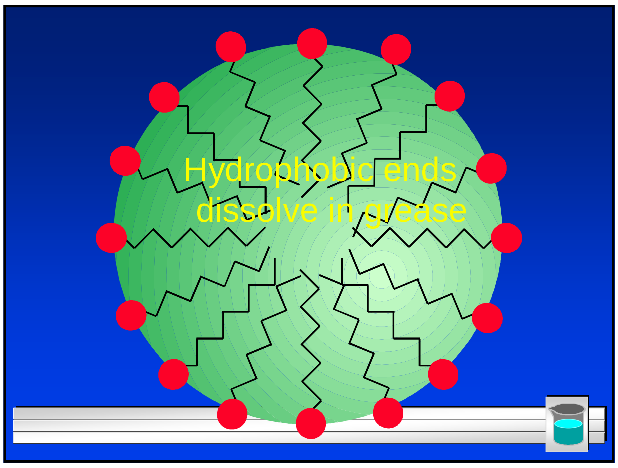


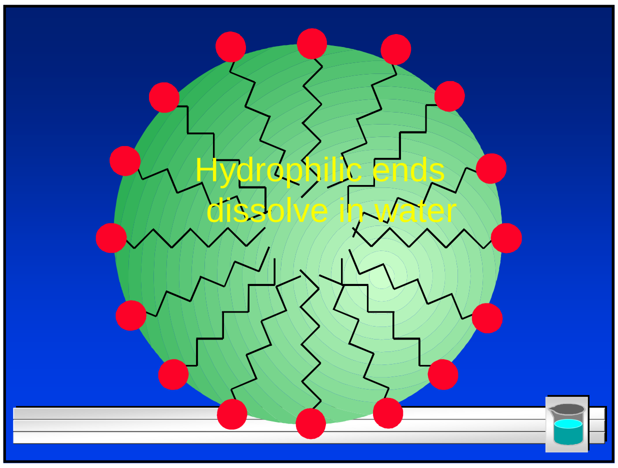
- Hydrophobic non-polar end

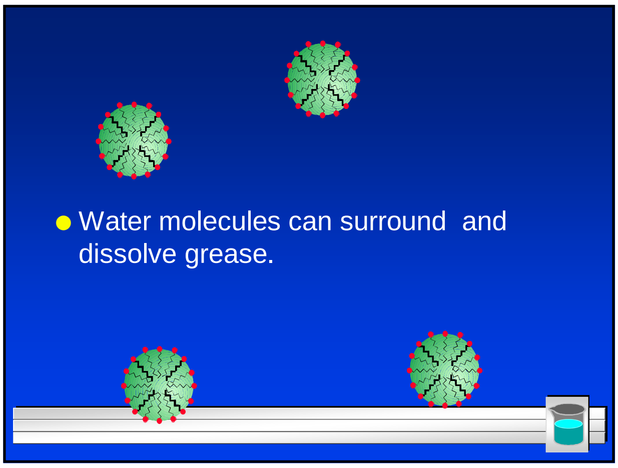

Soap
Hydrophilic polar end

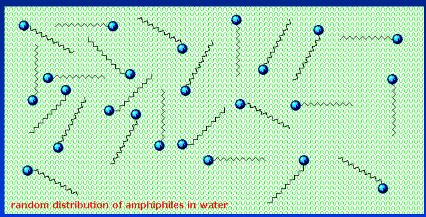



A drop of grease in water
Grease is non-polar
Water is polar
Soap lets you dissolve the non-polar in the polar.


Hydrophobic ends dissolve in grease


Hydrophilic ends dissolve in water


Water molecules can surround and dissolve grease.

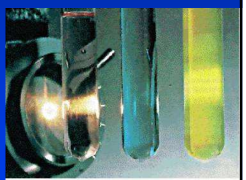


Mixtures that are NOT Solutions

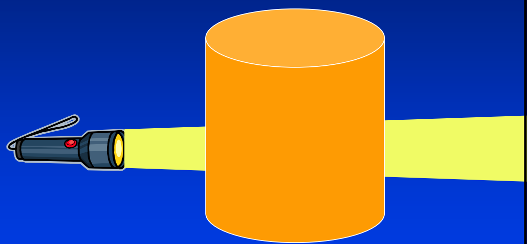
- Suspensions are mixtures that slowly settle upon standing.
- Particles of a suspension are more than 100 times bigger than that of a solution.
- Can be separated by filtering.
- Colloids particles are between the size of a suspension and that of a liquid.
- Don't settle or filter
- Emulsions are colloids of liquids in liquids.

Tyndall Effect

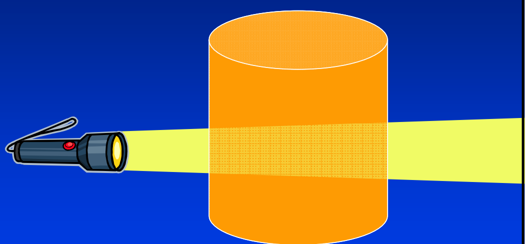
- Put a beam of light through a mixture
- Reflection of light off undissolved particles
- Solution- no Tyndall effect- can't see the beam
- Suspensions- sparkle off big particles
- Colloids- continuous beam



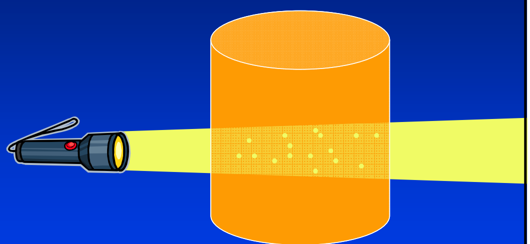
Solution



Colloid



Suspension



Math in chapter 15

- $Q = m \Delta T C$
- Q is heat
- m is mass
- ΔT is change in temperature
- C is heat capacity-
  - for water 4.18 J/g°C
- Use when the temperature changes
- 0 °C - 100 °C

Math Practice

- How much heat will it take to heat 23 g of water from 23º to 79ºC?

Math in chapter 15

- $Q = \Delta H_{fus}\, m$
- ΔH_{fus} is heat of fusion – energy to melt
  - For water 334 J/g
  - Use at 0 °C
  - No temperature change

Math Practice

- How much heat does it take to melt 23 g of ice at 0ºC?

Math in chapter 15

- $Q = \Delta H_{vap}\, m$
- ΔH_{vap} is heat of vaporization – energy to turn liquid to gas
- For water 2260 J/g
  - Use at 100 °C
  - No temperature change

Math Practice

- How much heat does it take to boil 23 g of water at 100ºC?

Please make your selection

Which takes the most energy?

A. Melting 10 g of ice at 0ºC.

B. Heating 10 g of water from 0ºC to 100ºC

C. Boiling 10 g of water at 100ºC