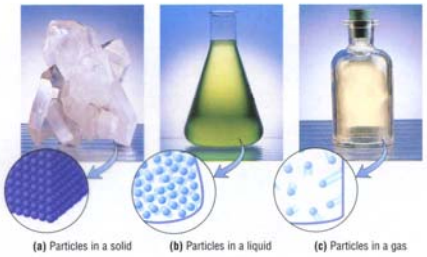
Water Properties

Properties of Water

- Solid water floats on liquid water
- High surface tension
- ‘Universal’ solvent
- High specific heat
- High heat of vaporization

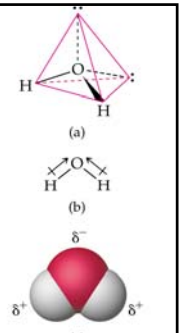
Solid, Liquid, Gas



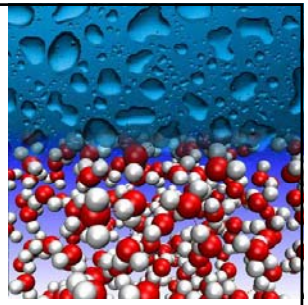
http://www.uni5.org/christjs/Matter%20and%20Energy/Unit%202%20PP_files/frame.htm

Water Molecule

- Bent molecule
- Covalent bonds
- Polar
- Dissolves ionic substances

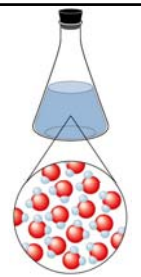


- In liquid phase, the water molecules fit closely together
- Polar nature allows them to attract one another
- Most dense at 4°C



http://www.chemlin.net/news/2007/mar2007/water.htm

Liquid Water

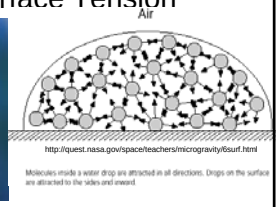


$H_2O(l)$ Water

http://www.uni5.org/christjs/Matter%20and%20Energy/Unit%202%20PP_files/frame.htm

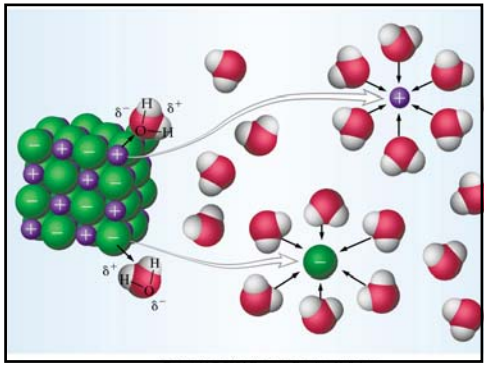
High Surface Tension

http://www.webelements.com/nexus/node/786



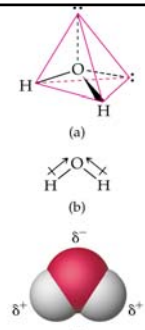
http://quest.nasa.gov/space/teachers/microgravity/tlsurf.html

Molecules inside a water drop are attracted in all directions. Drops on the surface are attracted to the sides and inward.

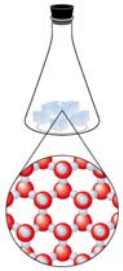


Water Molecule

- Bent
- Polar



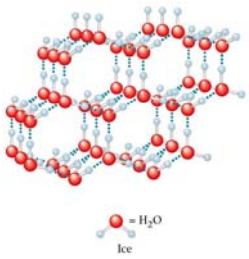
Solid Ice



$H_2O(s)$ Ice

http://www.unit5.org/christjs/Matter%20and%20Energy/Unit%202%20PP_files/frame.htm

Molecular Structure of Ice



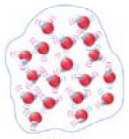
Ice

Zumdahl, Zumdahl, DeCoste, World of Chemistry 2002, page 455

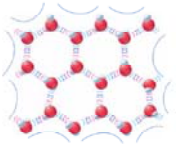
http://www.unit5.org/christjs/Matter%20and%20Energy/Unit%202%20PP_files/frame.htm

Water Expansion

- Molecule shape fit together closer in liquid
- Open structured crystal due to hydrogen bonding of polar molecules upon freezing



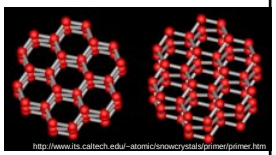
Liquid water (dense)



Ice (less dense)

Crystal structure of ice

- In solid phase of water, arrangement becomes more open, less dense
- Ice floats because of this
- Expansion of 9% upon freezing



http://www.its.caltech.edu/~atomic/snowcrystals/primer/primer.htm

Three phases of water

http://www.cdli.ca/CITE/glaciers.htm

Three Phases of Water at Earth's Surface

- Liquid
- Solid
- Vapor

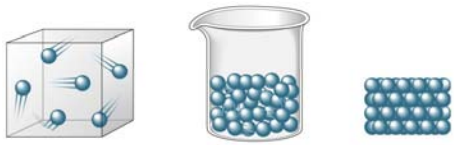
Energy captured or released upon change from one phase to another

Gas Steam

$H_2O(g)$ Steam

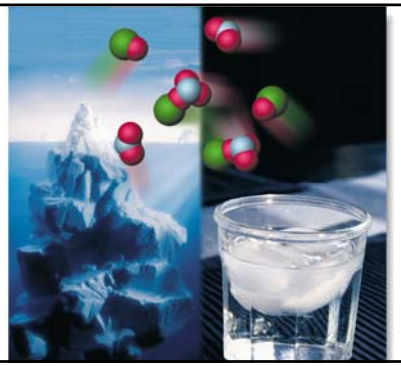
http://www.unit5.org/christjs/Matter%20and%20Energy/Unit%202%20PP_files/frame.htm

Gas, Solid and Liquid



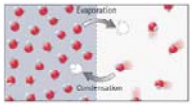
Zumdahl, Zumdahl, DeCoste, World of Chemistry 2002, page 441

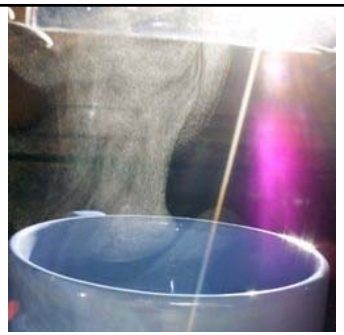
http://www.unit5.org/christjs/Matter%20and%20Energy/Unit%202%20PP_files/frame.htm



Evaporation

- Kinetic energy of molecules great enough to escape surface
- Energy is taken from liquid—cools it
- Gaseous phase or vapor phase



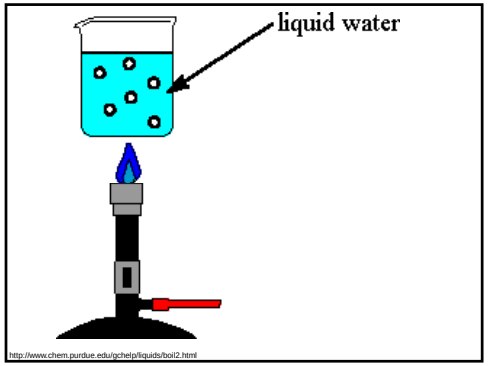


http://en.wikipedia.org/wiki/Water_vapor

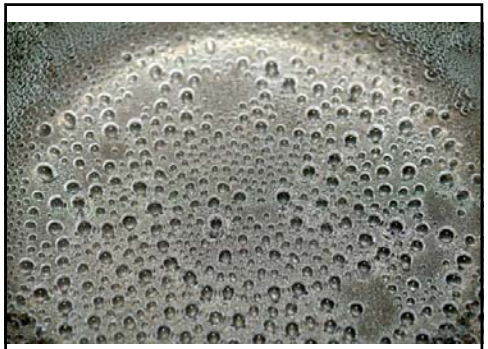
Evaporation or Not

http://www.geology.sdsu.edu/classes/geol351/01watercycle/watercycleflgs.htm

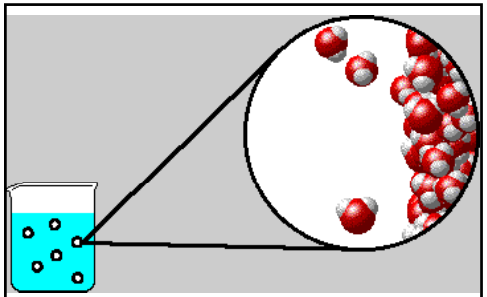
- Air inside glass become saturated with water and no more water can evaporate from the surface
- Outside glass is open system that is not saturated



http://www.chem.purdue.edu/gchelp/liquids/boil2.html



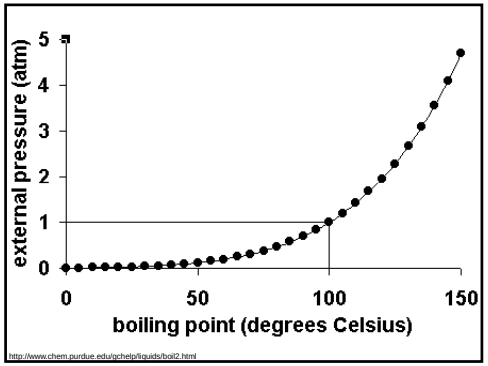
http://www.deepseaimages.com/dsilibrary/showphoto.php?photo=2912&password=&sort=1&size=medium&cat=853&page=1



http://www.chem.purdue.edu/gchelp/liquids/boil2.html

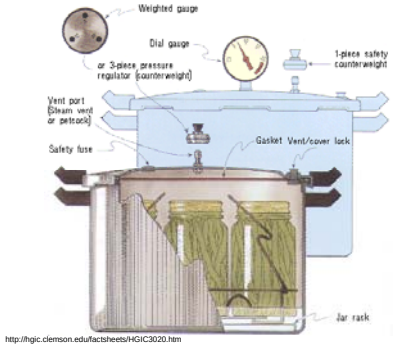
Boiling Temperature

- For any given pressure, there is a temperature at which water boils
- The temperature of the water remains at that temperature until all of the water has been changed from liquid to vapor
- The length of time for this to occur does not have an effect on this temperature



http://www.chem.purdue.edu/gchelp/liquids/boil2.html

http://www.goodmans.net/pet_item_ma-6qt_maitres-806212-6-qt-cooker.htm



http://hgic.clemson.edu/factsheets/HGIC3020.htm

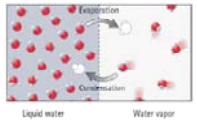
Boiling at less than 100 ^{o} C

- Pour in hot water
- Reduce Pressure with syringe

http://www.micrecol.de/air2.html

Condensation

- Opposite of evaporation
- Kinetic energy of molecules running into surface of liquid and joining it
- Heats environment



Condensation on Glass

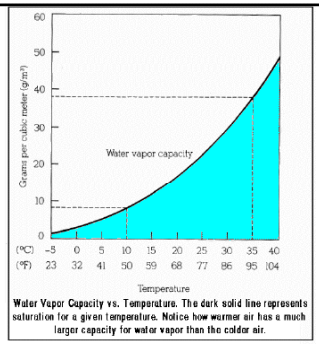
http://www.geology.sdsu.edu/classes/geol351/01watercycle/watercyclefigs.htm

Atmosphere

- Evaporation
  - Energy goes into air
  - Cools remaining water
- Condensation
  - Energy goes from air to surface
  - Warms local environment

Atmosphere

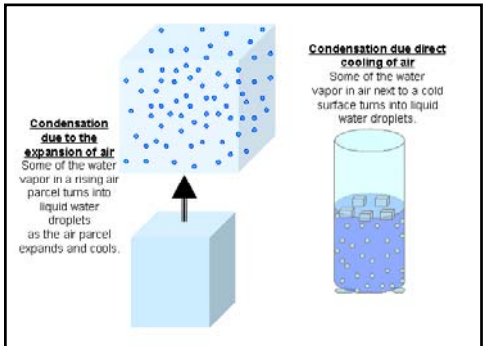
- Warm air has greater capacity for holding water in the vapor phase
- Saturation = at capacity
- Relative Humidity—percent of water contained compared to saturated amount at that temperature



Water Vapor Capacity vs. Temperature. The dark solid line represents saturation for a given temperature. Notice how warmer air has a much larger capacity for water vapor than the colder air.

http://www.wdtv.com/weather/images/Weather_Review/humidity.htm

http://observe.arc.nasa.gov/nasa/earth/hydrocycle/graphics/condensation.jpg



http://weatherstreet.com/weatherquestions/What_is_condensation.htm

http://www.anythingmarine.co.uk/anything/met.htm

http://www.victoriaweather.ca/clouds.php?image=fog

Energy of Water Phase Change

- Calorie:
  energy to change 1 g water 1 K or 1 ^{o}C
- Also need energy to change to different state of matter
- Energy of vaporization/condensation
  - ➢540 calories per gram of water = 2256 J/g
- Energy of melting/freezing
  - ➢80 calories per gram= 334 J/g

Temperature

- Measure of hotness
- Celsius
  - ➢0^{o} freezing point of pure water at standard pressure
  - ➢100^{o} boiling point at standard pressure
- Fahrenheit
  - ➢0^{o} was lowest attained
  - ➢32 was his age when he performed experiments
  - ➢212 is boiling point in those increments

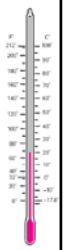
Temperature

- **Convert with equations**
  - ➢Order of operations
    - Parentheses first
    - Then multiply or divide
    - Add or subtract last

$$C = \frac{5}{9}(F - 32)$$

- **Or use adjacent scales such as p. 142 of *Conceptual Physical Science* textbook**

$$F = \frac{9}{5}C + 32$$



Temperature

- Kelvin same size as degree Celsius
- ‘Absolute Zero’ is 0 K
  - ➢(notice no degree symbol on K)
- 0^{o} C = 273 K
- Molecular motion ceases at absolute zero