Water Chemistry

Be sure to attend lab THIS week
- Bring the lab manual
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- Instructors will give percent lab grade to one another

Solid, Liquid, Gas

Three Phases of Water at Earth’s Surface
- Liquid
- Solid
- Vapor
Energy captured or released upon change from one phase to another

Solid Ice

Molecular Structure of Ice

Liquid Water

Gas Steam

Water Molecule
- Bent molecule
- Covalent bonds
- Polar
- Dissolves ionic substances
Properties of Water
- Solid water floats on liquid water
- High surface tension
- ‘Universal’ solvent
- High specific heat
- High heat of vaporization

High Surface Tension
- In liquid phase, the water molecules fit closely together
- Polar nature allows them to attract one another

Liquid water and its molecules
- In liquid phase, the water molecules fit closely together
- Polar nature allows them to attract one another

Water Molecule
- Bent
- Polar

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

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

Three phases of water
- Liquid water
- Ice

High Surface Tension
- Water molecules in the ice structure
- Water molecules in the liquid state
- Water molecules in the gas state

Water Expansion
- Molecule shape fit together closer in liquid
- Open structured crystal due to hydrogen bonding of polar molecules upon freezing
Gas, Solid and Liquid

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

Gas
Steam

Water phases and molecules

Evaporation

Boiling

Water vapor

Boiling Temp vs. Pressure

Microscopic boiling
Pressure Cooker

Boiling at less than 100 °C
- Pour in hot water
- Reduce Pressure with syringe

Evaporation or Not
- 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

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

Condensation on Glass
- 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

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
Water vapor capacity of air increases with temperature. Notice how warm air has a much larger capacity for water vapor than the colder air.
Energy of Water Phase Change

- Calorie: energy to change 1 g water 1 K or 1 °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

- Convert with equations
  - Order of operations
    - Parentheses first
    - Then multiply or divide
    - Add or subtract last
  - Or use adjacent scales such as p. 142 of Conceptual Physical Science textbook
  - $C = \frac{5}{9}(F - 32)$
  - $F = \frac{9}{5}C + 32$
- Kelvin same size as degree Celsius
- ‘Absolute Zero’ is 0 K
  - (notice no degree symbol on K)
  - 0° C = 273 K
- Molecular motion ceases at absolute zero

Temperature

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

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