EXTRAORDINARY WATER

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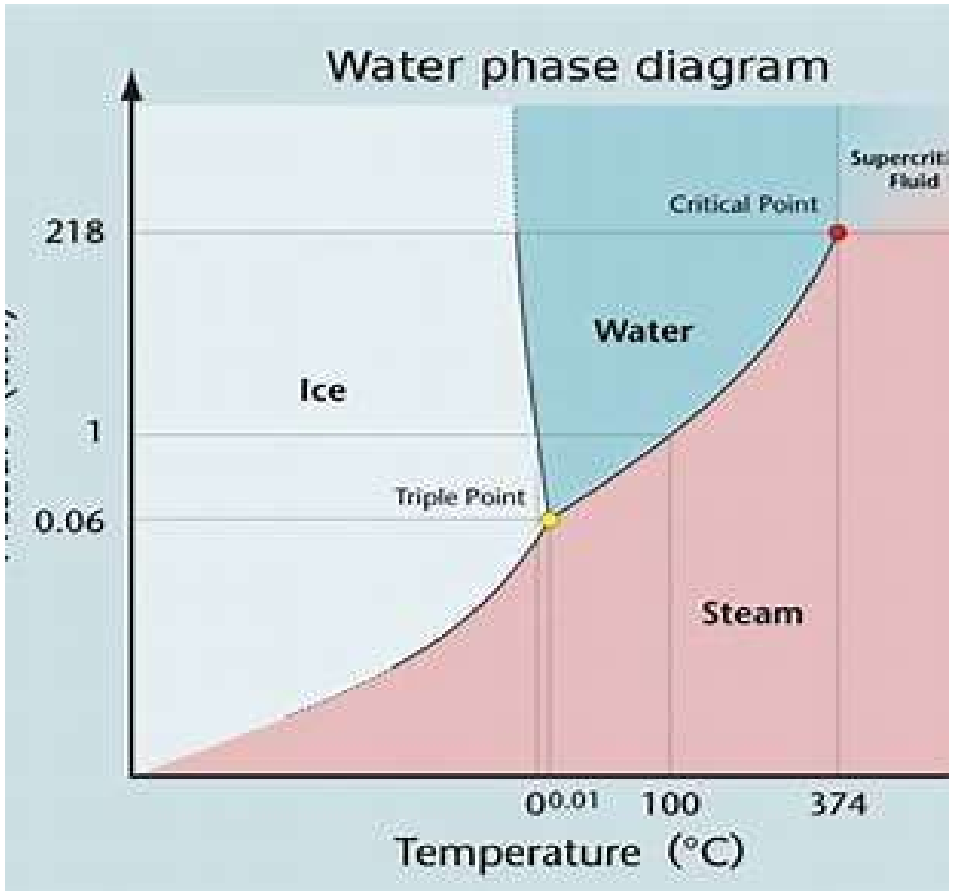
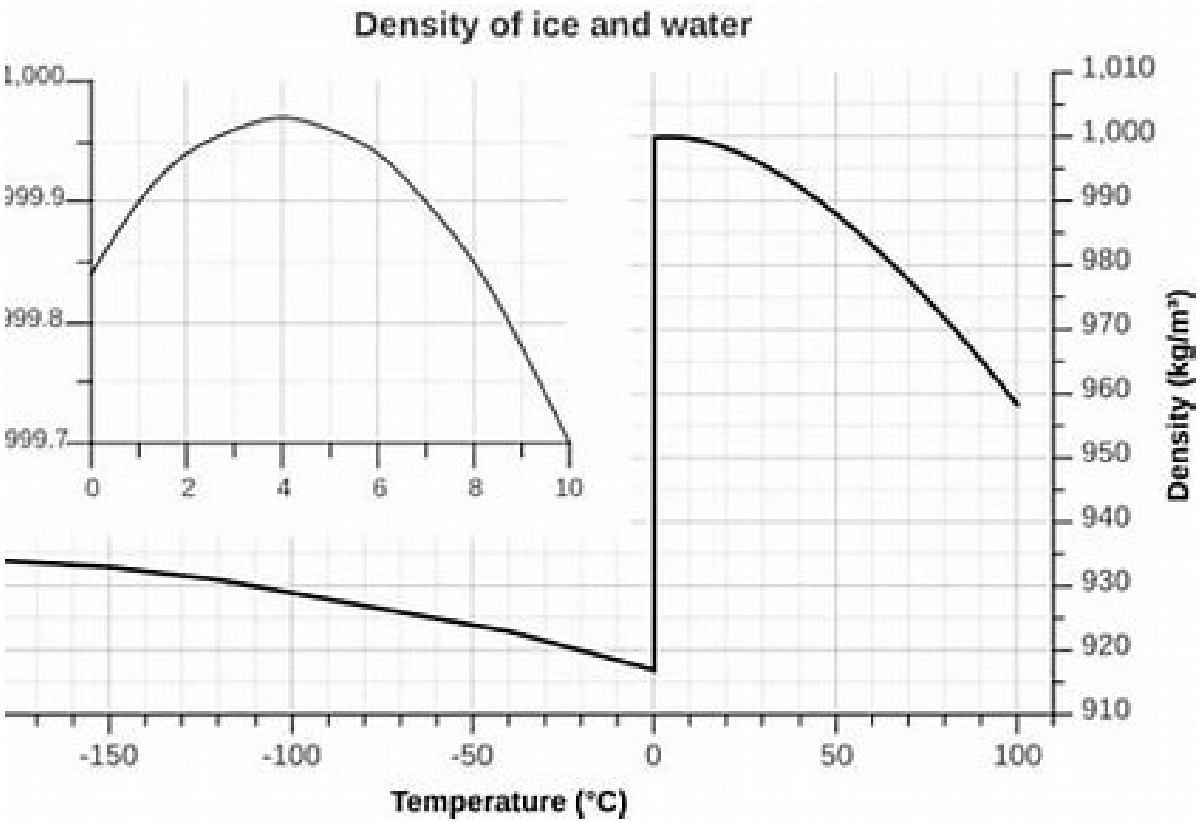
Water, water everywhere

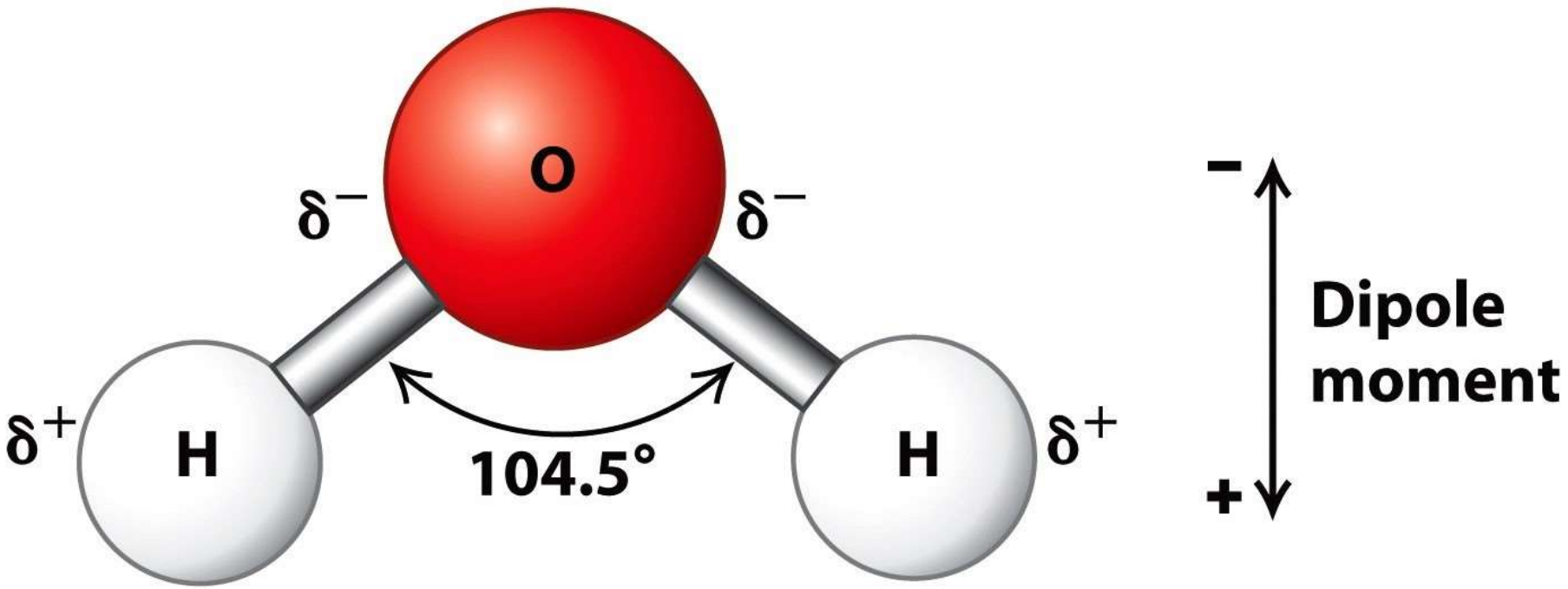
Phase Diagram



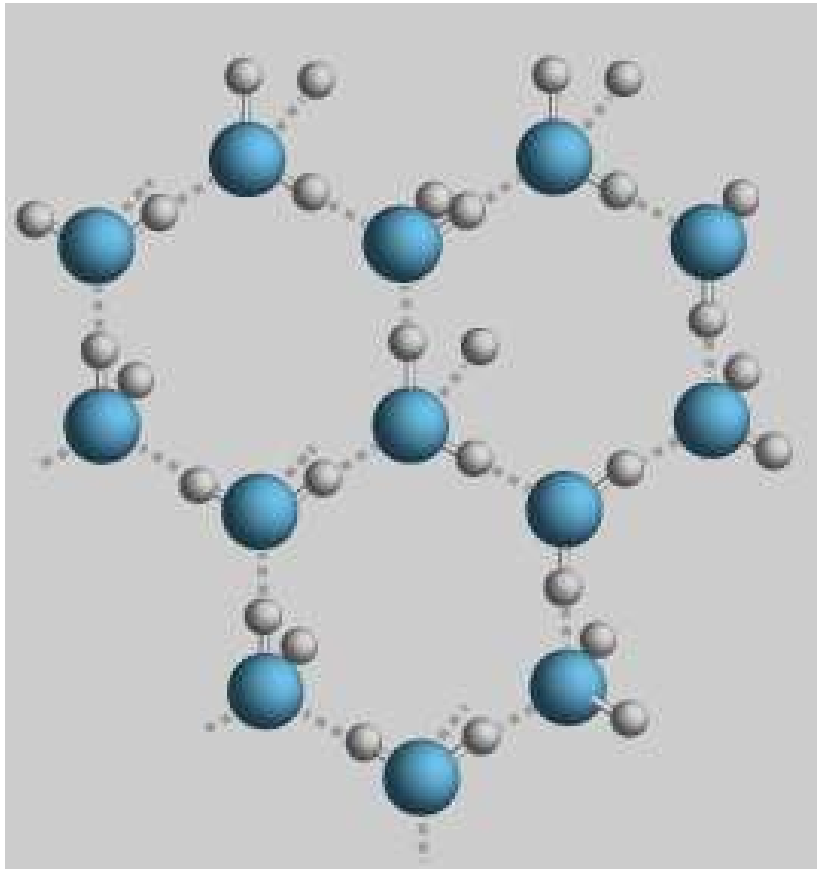
Density vs Temperature



Water Molecule Structure



Water Crystal structure



Consequence of inverse thermal contraction

- Water freezes from the top down
- Oceanic heat loss reduced by insulating blanket of ice
- Ocean depths never freeze
- Fish & aquatic creatures can survive at the bottom of ponds

The very best heat transfer medium?

Specific Heat

- Water - 1 kcal/kg/^{0}C
- Ethanol - 0.68 kcal/kg/^{0}C
- Octane - 0.505 kcal/kg/^{0}C
- Ammonia - 1.05 kcal/kg/^{0}C
- Copper - 0.092 kcal/kg/^{0}C
- Air - 0.238 kcal/kg/^{0}C

That's why a hottie is so good at making your bed warm!

And water is the best liquid in your central heating system

Phase Transition

- Ice -> Liquid Water Latent Heat of freezing 80 kcal/kg
  (to cool 8g of water from 10^0c to 0^0c only needs 1g of ice)
  For comparison: Ethanol 25.8, Toluene 17.2 kcal/kg

- Liquid water > Steam Latent Heat of boiling 540 kcal/kg
  For comparison Ethanol 204 kcal/kg
  Ammonia 327 kcal/kg
  Toluene 83.4 kcal/kg
- That's why steam is the best industrial heating medium
- That's why water is really good for fire fighting

Surface Tension

- Water has highest Surface Tension of any liquid at ambient temperatures other than Mercury
- Readily forms stable droplets that resist tendency to fragment as they fall through air
- Small rain droplets evaporate faster as they fall meaning less water reaches the ground
- Easy to make a surface waterproof

Viscosity

Liquid	Viscosity N s/m^2
Acetone	300
Petrol	600
Water	1000
Beer	1800
Olive Oil	40,000
Honey	10,000,000

Thermal Conductivity

- Water is not a good conductor of heat, but its not bad either

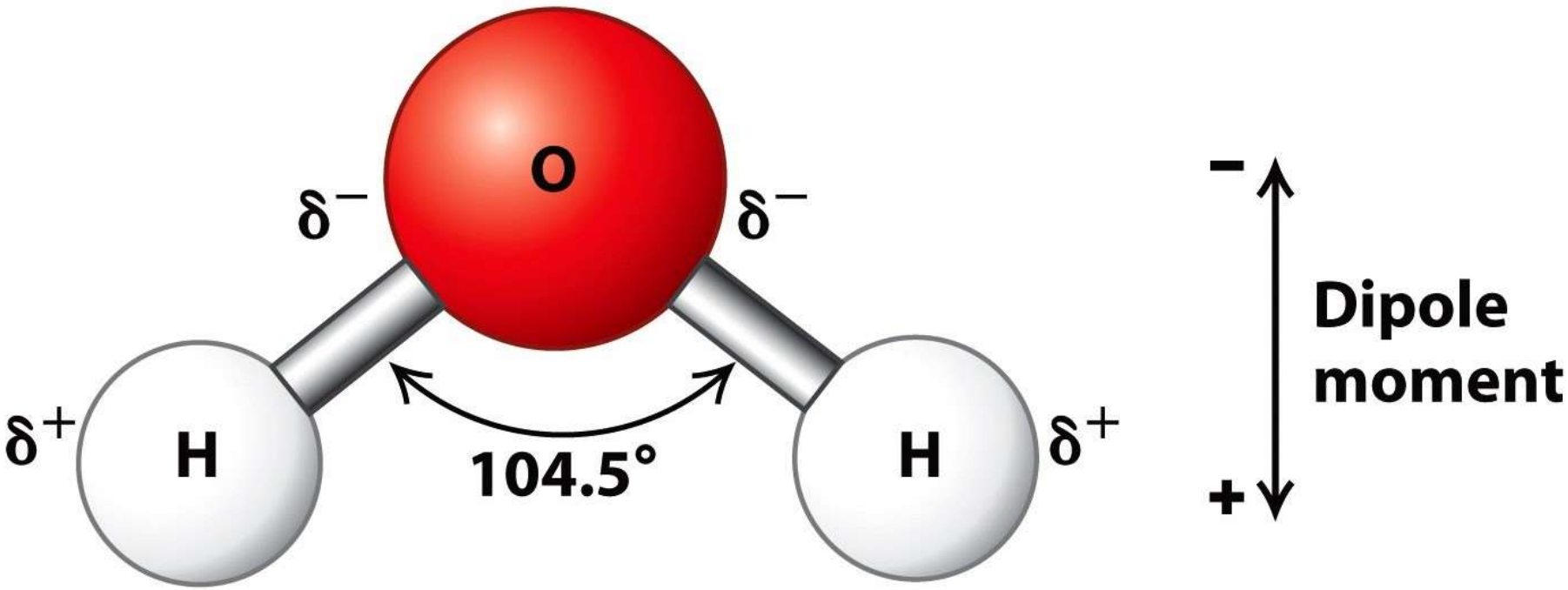
Liquid	Conductivity BTU/hr/ft/^{O}F
Sodium	49
Mercury	4.83
Water	0.34
Ammonia	0.29
Ethyl alcohol	0.104
Petrol	0.086

Electrical Conductivity

- Water is not a good conductor of electrical currents!
- Pure water has an electrical conductivity of 0.05 μS/cm
- By comparison tap water is 200 – 600 μS/cm and seawater is 50,000 μS/cm
- Petroleum 0.0000003 μS/cm

Why does a bit of salt make such a difference?

- Molecular structure makes it a polar solvent



Polar Solutions

- Ionic molecules, e.g. NaCl, dissolved in a polar solvent get separated into ionic species (anions & cations) which can carry an electrical charge facilitating the passage of an electrical current through the fluid
- The ability of a polar solvent to dissolve and polarise a solute depends on its' Dielectric Constant and Dipole Moment
- Water Dielectric Constant 80
  Dipole Moment 1.85
- Makes water the Ultimate polar solvent within which all biochemical reactions take place

Gaseous Solutions

- Many gases undergo ionic dissociation on solution in water e.g. for ammonia $NH_3 + H_20 <=> NH_4^+ + OH^-$
- Oxygen does not hence solubility in water is relatively low, at atmospheric pressure: in fresh water 9-11mg/l
  in sea water 8-9 mg/l
- But it is sufficient for marine creatures to extract in order to breath.