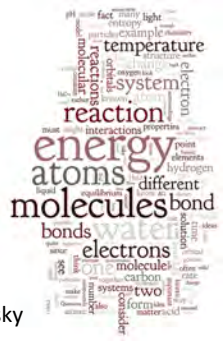
Phase changes and bonding



Chemistry, Life, the Universe & Everything – Cooper & Klymkowsky

Emergent properties

- When atoms interact to form larger molecules or structures – they have emergent properties
- How many atoms must interact to provide these properties
- Does the size of the "clumps" of atoms affect the properties?

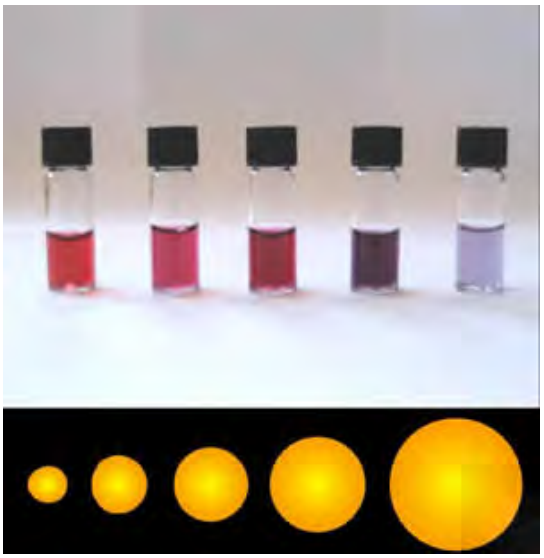
nanoparticles

Gold nano-particles interact with light differently depending on the size of the particle

Nanoparticles ~ 1- 100 nm (many biomolecules fall into this range)

They have different properties than bulk materials

Depend on surface area to size ratio



http://www.webexhibits.org/causesofcolor/9.html

Discrete vs continuous materials

elemental form	H_2	He	Li(c)	Be(c)	B(c)	C(c)	N_2	O_2	F_2	Ne
melting point	13.81 K	0.95 K	453.65 K	1560 K	2348 K	3823 K	63.15 K	54.36 K	53.53 K	24.56 K
boiling point	20.28 K	4.22 K	1615 K	2744 K	4273 K	4098 K	77.36 K	90.20 K	85.03 K	27.07 K
bp-mp	6.47 K	3.27 K	1161 K	1184 K	1925 K	275 K	14.21 K	35.84 K	31.5	2.51 K
name	hydrogen	helium	lithium	beryllium	boron	carbon	nitrogen	oxygen	fluorine	neon

What trends or patterns can you see here?

Changes of state

- To go from solid → liquid → gas phase requires energy, where does it come from?
- To go from gas→ liquid → solid phase releases energy, where does it go?
- What is the energy used for? (To overcome attractions between particles)

Effect of temperature

- The melting point of molecular hydrogen is 14K
  - What is making the molecules stick together?
- The boiling point of molecular hydrogen is ~20K
  - What interaction is overcome when H_2 boils?
- At ~6000K molecular hydrogen dissociates
  - What interaction is overcome at 6000K?

Melting and boiling

- When a substance melts, the interactions between the particles have to be overcome – so that they can move relative to each other (that's what allows a liquid to flow).
- The magnitude of the melting point provides an estimate of the strength of the interactions between particles.
- The mp (and bp) of Li, Be, B, and C are much higher because chemical bonds (rather than intermolecular interactions) are broken when these substances melt.

What is the difference between a covalent bond and LDF

- Covalent bond
  - Strong (require a lot of energy to break)
  - Caused by attraction of electrons from one atom to nuclei from another atom
  - Hard to predict bond strength
  - Present only when atomic orbitals interact **constructively**
  - Within molecules or networks
- LDF/van der Waals interaction
  - Relatively weak
  - Caused by fluctuating charge distribution
  - Increase (predictably) with size of electron cloud
  - Present between all molecular level species
  - Between separate molecules