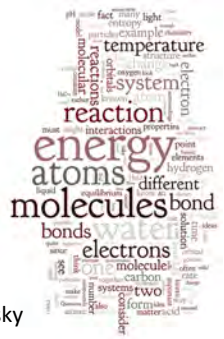
Bonding



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

Isolated atoms

- How do we know atoms exist?
- Do they have properties we can directly observe in the real world?
- Do isolated atoms or molecules have melting points or boiling points?
- Do isolated atoms/molecules exist in a state (solid, liquid or gas)?

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?

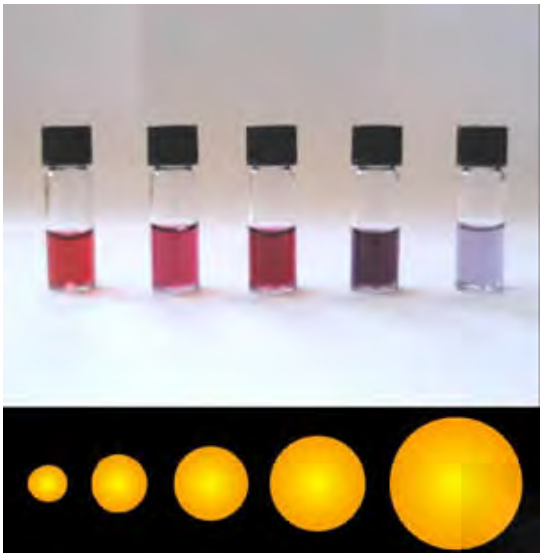
nanoparticles

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

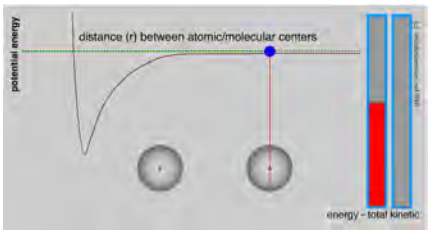
Depend on surface area to size ratio



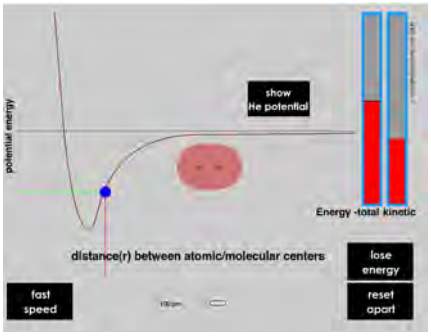
http://www.webexhibits.org/causesofcolor/9.html

Lets look again at atomic interactions

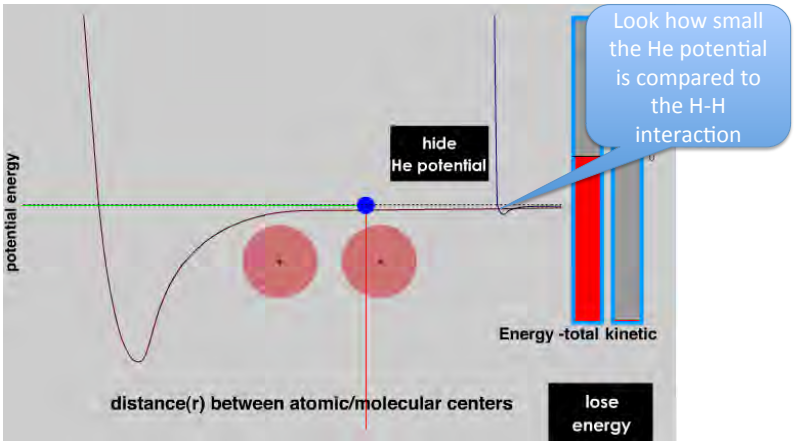
Helium (no bond forms)



Hydrogen forms a stable bond



The interaction between two Hydrogens is much stronger than two Heliums



Why?

- Two hydrogen atoms interact and form a covalent bond.
- (valence) Electrons from one atom become attracted the the other nucleus
- Each nucleus is attracting both electrons (a tug of war)
- Bond length is most stable - ie lowest potential energy

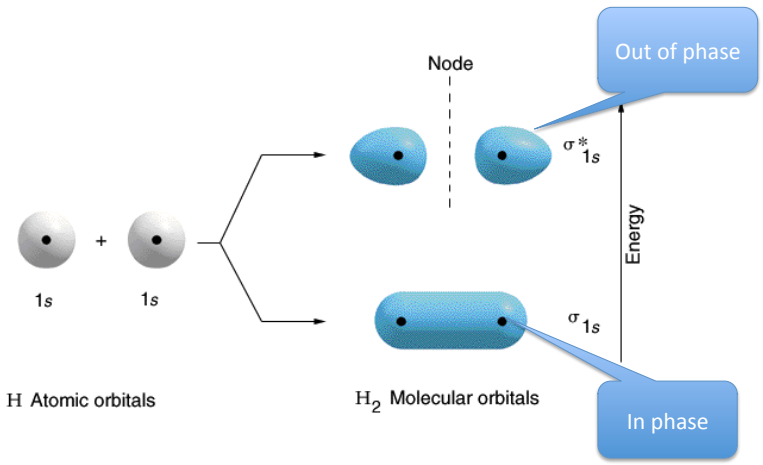
Covalent Bonds

- Attraction between atoms caused by attraction between electron of one atom and nucleus of the other atom.
- The atoms are not so much sharing electrons as fighting over them!
- (see bonding simulation on Blackboard)

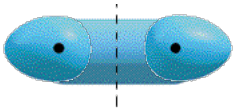
Molecular Orbital Theory

- Combine n atomic orbitals → n molecular orbitals
- Bonding orbitals are of lower energy than the atomic orbitals (typically) - stabilizing
- Antibonding orbitals are of higher energy – and destabilizing
- Electrons in bonding orbitals make the species more stable
- Electrons in antibonding orbitals – make the species less stable

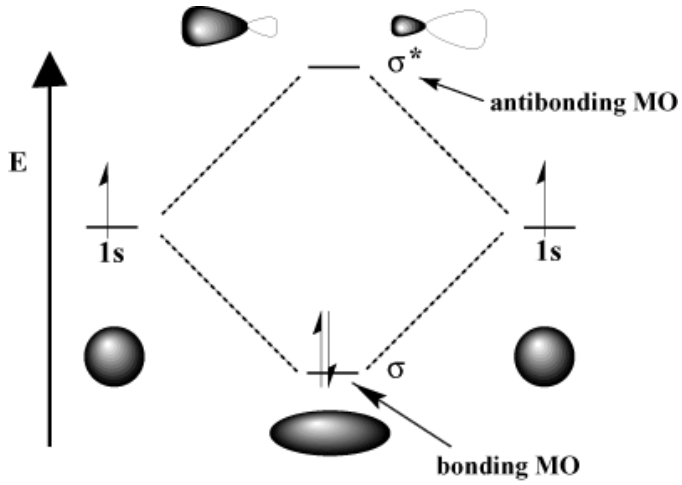
Covalent bonds



Both orbitals are in the same place in space – just at different energies



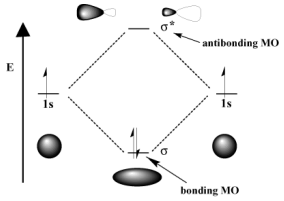
Why doesn't helium form bonds?



Covalent Bonds

- Two electrons in a bonding molecular orbital make up one bond
- Two electrons in an antibonding orbital cancel out the stabilization from one bond

Bonding in helium and hydrogen



In helium-helium, both bonding and antiboding molecular orbitals are occupied. Because their energies (negative for the bonding orbital and positive for the anti-bonding orbital) are equal and opposite, there is no net stabilization of the interaction

In hydrogen-hydrogen, only the bonding molecular orbital is occupied, leading to a net stabilization of the interaction.

To break the bond, enough energy has to be added to raise an electron to the anti-bonding orbital.