Atom interactions

Claims, and evidence for the existence

- Claim:
  - Atoms are divisible, they contain small negatively charged particles
- Evidence:
  - A beam of negatively charged particles is emitted from the cathode and it does not depend on the nature of the cathode (element from which it is made)
- Data:
  - How the beam is deflected by magnetic and electric fields. The charge to mass ratio of the particles
- Theory/model
  - The plum pudding

Claims, and evidence: (Rutherford)

- Claim:
  - Atoms have a small positively charged nucleus
- Evidence:
  - A very small number of positively charged particles do not go straight through the gold foil
- Data:
  - measurements about how many go through
- Theory:
  - The planetary model of the atom

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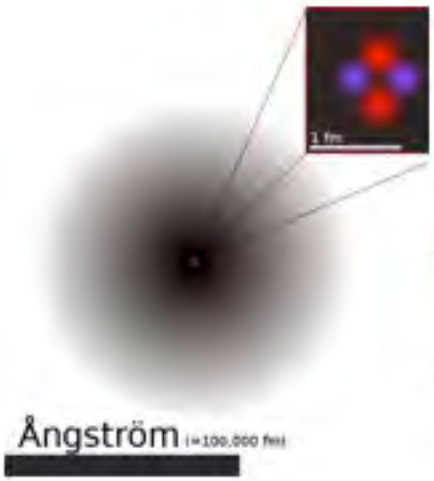
Model of atom



- Electrically neutral
- Very small nucleus (~ 2 x 10^{-15} m)
- Nucleus contains protons (+1 charge, 1 amu) and neutrons (0 charge. 1 amu)
- "cloud" of electrons – takes up most space (~ 20 – 200 x 10^{-12} pm)
- Electrons (–1 charge, mass ~ 1/3000 amu)

Questions to ponder

- Why don't the protons within a nucleus repel one another?
- Why don't the electrons and protons come together within the nucleus? (Why don't atoms collapse?)
- Do the electrons within an atom repel each other?

To understand how atoms interact we

But First...

What is Energy?

- "...**in physics today, we have no knowledge of what energy *is*.**" ... *"we know how to calculate its value for a great variety of situations, but beyond that it's just an abstract thing which has only one really important property. If we add up all the values before something happens and then add them up after it happens the two values will be exactly the same. (We must be sure to include every object affected.) This is the law of conservation of energy".*
- *The Feynman Lectures on Physics* Vol I, p 4-1
- http://www.pacifier.com/~ppenn/whatis.html
- Feynman's Lectures

What is energy?

- Any change in matter is accompanied by a change in energy
- Energy is conserved (cant create or destroy)

Thermodynamics

- Study of energy changes and transfers.
- Two basic types of energy: (can you give examples?)
  - Kinetic
  - Potential

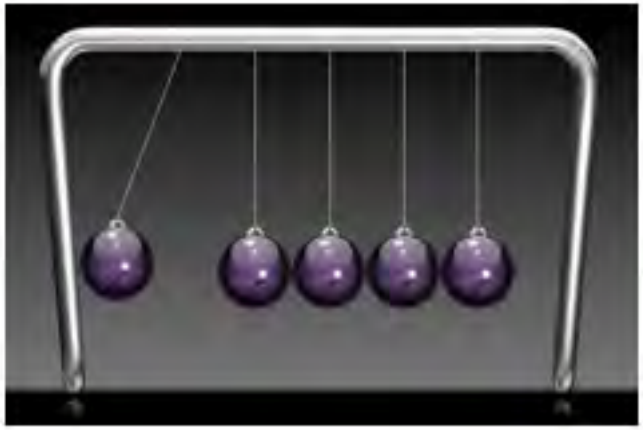
Energy

- Capacity to supply heat or to do work
  - Energy = heat +work
- Kinetic energy - energy of motion ($1/2mv^2$)
  - On the molecular level - Thermal Energy
- Potential Energy - stored energy
  - Potential energy must be stored in a system (an isolated object cannot have potential energy)
  - Chemical energy is potential energy – it is determined by arrangements of atoms in systems
- Units SI - Joule ($kg/m^2.s^2$)
  - 1 Calorie = 4.184 J

Energy can be transferred (from one object to another)

and transformed (eg from potential to kinetic energy and back)

Newton's Balls



Systems

- To study energy changes we need to define what we are studying.
- System – part of the universe you are looking at
- Can monitor energy changes between system and surroundings
- Energy is never lost (First Law of Thermodynamics)

What happens when two helium atoms approach each other?

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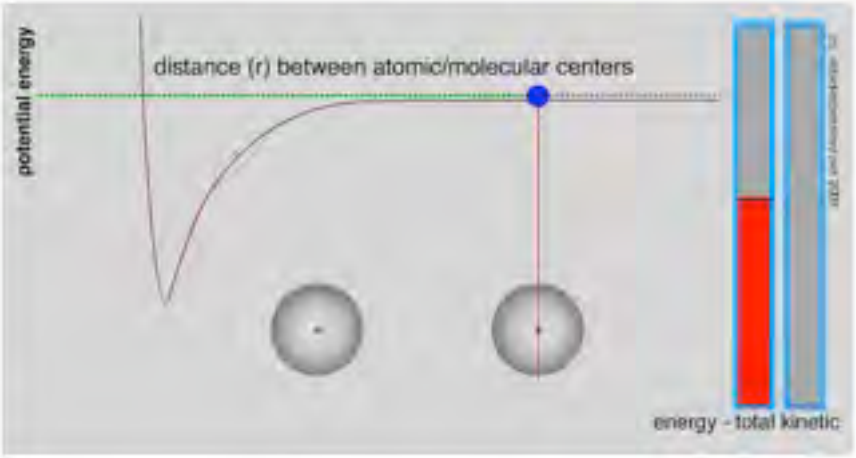
What happens as two helium atoms get closer to each other?



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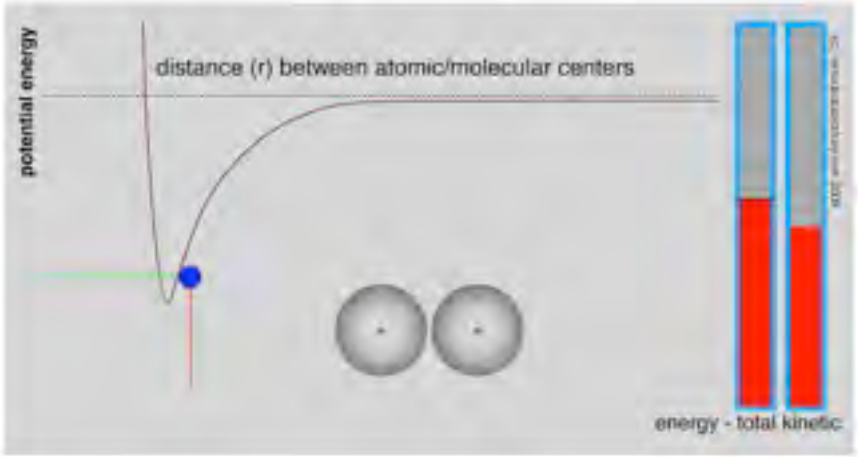
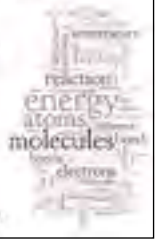


Helium interactions

- Why do the atoms move toward each other?
- Where does the energy come from to start that motion?
- Why do they oscillate?
- What does it take to form a stable (non-oscillatory) interaction?
- When you use the cursor, how does that influence the total energy of the system?
- In the "real world", how would energy normally removed from the two atoms?
- Where would it go?



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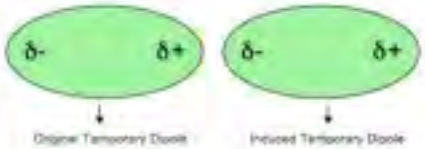
London Dispersion Forces

- Present between ALL molecules (neutral species)
- Caused by fluctuations of electron density in the molecule (or atom)
- Adjacent molecule – gets induced dipole



Interactions and temperature (next

- What happens to atoms/molecules when the temperature is raised?
- How does this occur? (how do the molecules "know" the temperature has been changed?)