Physics 131- Fundamentals of Physics for Biologists I

Office Hours:
12/6 Friday 5pm-6pm AV Williams 3341
12/9  Monday 3-4pm AV Williams 3341
12/10 Tuesday 1-2pm AV Williams 3341
12/12 Thursday 2pm-3.30pm Course Center
How many interactions in the system hold potential energy?

6 interactions hold potential energies
4 kinetic energies
Energies between charge clusters

- Atoms and molecules are made up of charges.
- The potential energy between two charges is

\[ U_{12}^{\text{elec}} = \frac{k_C Q_1 Q_2}{r_{12}} \]

- No vectors!

- The potential energy between many charges is

\[ U_{12\ldots N}^{\text{elec}} = \sum_{i<j=1}^{N} \frac{k_C Q_i Q_j}{r_{ij}} \]

\[ U_{\text{tot}}^{\text{elec}} = \frac{k_C q_1 q_2}{r_{12}} - \frac{k_C q_1 Q_3}{r_{13}} - \frac{k_C q_1 Q_4}{r_{14}} - \frac{k_C q_2 Q_3}{r_{23}} - \frac{k_C q_2 Q_4}{r_{24}} + \frac{k_C Q_3 Q_4}{r_{34}} \]

- Just add up all pairs!
How many of the energies change when **ONLY** the charge \( Q_4 \) moves far to the right, nothing else moves?

\[
U_{\text{tot}}^{\text{elec}} = \frac{k_C q_1 q_2}{r_{12}} - \frac{k_C q_1 Q_3}{r_{13}} - \frac{k_C q_1 Q_4}{r_{14}} + \frac{k_C q_2 Q_3}{r_{23}} - \frac{k_C q_2 Q_4}{r_{24}} + \frac{k_C Q_3 Q_4}{r_{34}}
\]
Balance of kinetic and potential energy in a molecule

[Graph showing potential energy vs. distance (r) between atomic/molecular centers]

http://besocratic.colorado.edu/CLUE-Chemistry/activities/LondonDispersionForce/1.2-interactions-0.html

Page 3 of the interactive Demo!

Energy Bargraphs!
Now all four charges are allowed to move

6 potential energies
4 kinetic energies

When the charges move, energy is exchanged between ALL 10 “bins”

Total energy is conserved!
Hidden Energy Inside Objects

- Each atom can have kinetic energy
- Each interaction between atoms can store potential energy
  - Interactions between atoms can be modeled as springs
  - More realistic: Lenard-Jones Potential
Temperature

- **Temperature**: Measures the amount of energy in each atom or interaction – the key concept is that thermal energy is **on average** equally distributed among all these possible “bins” where energy could reside.
If you lower the temperature of object A, what happens to the energy?

1. Fewer “bins”, but each carries same energy independent of temperature
2. Smaller amount of energy in each bin
3. Both fewer “bins” and smaller amount of energy in each bin
Object A at 80 C temperature, touches object B at 20 C temperature. The system will exchange energy. What will happen

The temperature of the system will be:
1. pretty close to 50 C
2. pretty close to 80 C
3. pretty close to 20 C
4. greater than 80 C
5. less than 20 C
Critical Experiment 1

If we have **equal** amounts of the **same** kinds of materials at different temperatures and put them together, what happens?

1. pretty close to 50°C
2. pretty close to 80°C
3. pretty close to 20°C
4. greater than 80°C
5. less than 20°C