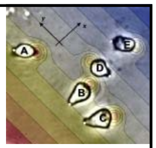
Physics 131- Fundamentals of Physics for Biologists I



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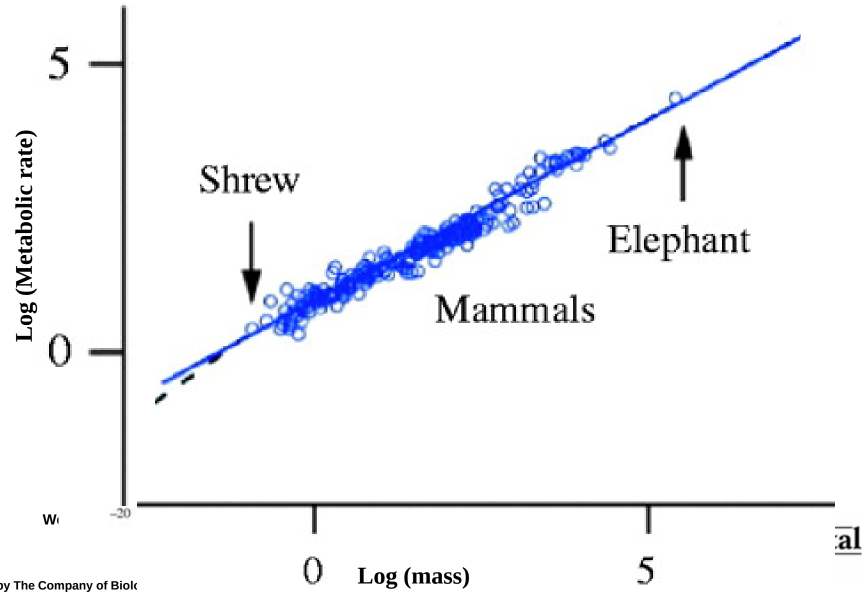
11/30/2012

Follow up on HW – an amazing example of a scaling law !

Kleiber's 3/4-power law: metabolic changes as mass to the power 3/4



Outline

Forces from PE

Bound States

Attraction of neutral objects?

Foothold ideas: Forces from PE

- For conservative forces, PE can be defined by

$$\vec{F} \cdot \Delta\vec{r} = -\Delta U$$

- If you know *U*, the force can be gotten from it via

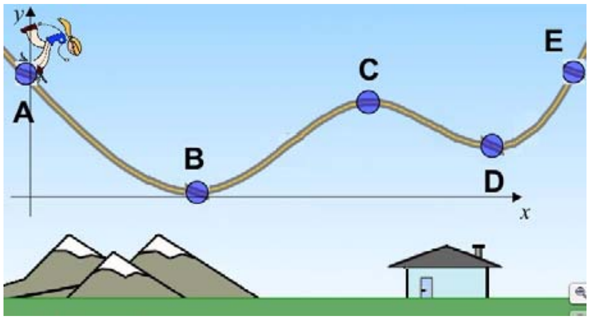
$$F_{\parallel}^{type} = -\frac{\Delta U_{type}}{\Delta r} = -\frac{dU_{type}}{dr}$$

- In more than 1D need to use the *gradient*

$$\vec{F}^{type} = -\vec{\nabla} U_{type}$$

- The force always points down the PE hill.

If we have a complicated potential energy – and a mass at rest in it – can we tell where it will go when released?



How do you know?
What are the conditions under which this works?

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Moving to molecules

- Apply our framework for forces and energies to atoms and molecules.
- See what goes over directly, what we have to add.
- Can we integrate what we know about atoms and molecules from chemistry with the physics we have learned?

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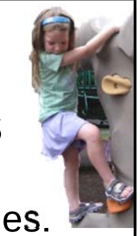
Foothold ideas: Energies between charge clusters



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

$$U_{12}^{elec} = \frac{k_C Q_1 Q_2}{r_{12}}$$

No vectors!

- The potential energy between many charges is

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

Just add up all pairs!

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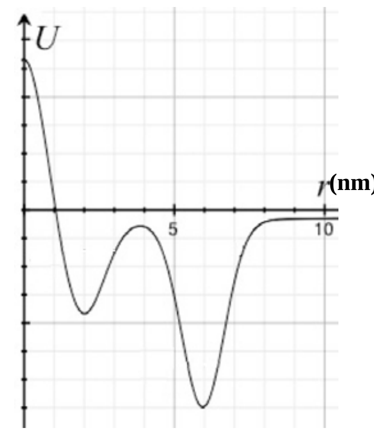
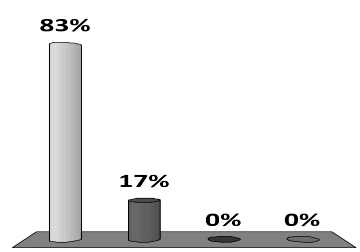
The figure below shows the interaction potential between two molecules (along a particular orientation of the two molecules). The units are in nm (r) and eV (U).



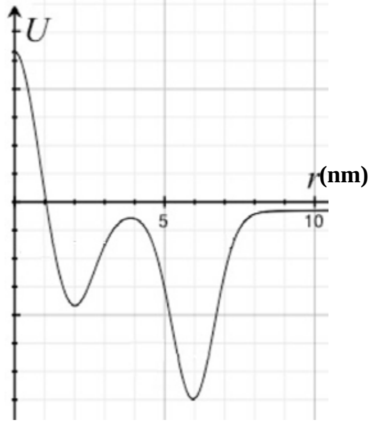
When the molecules are separated by 7 nm the force between them is

1. Attractive
2. Repulsive
3. Zero
4. Cannot be determined from the figure.



The figure below shows the interaction potential between two molecules (along a particular orientation of the two molecules). The units are in nm (r) and eV (*U*).

When the molecules are separated by 2 nm the force between them is



1. Attractive
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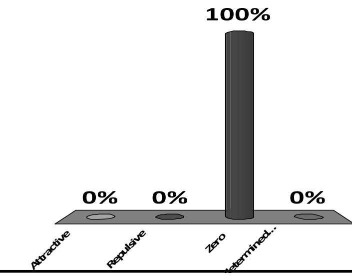
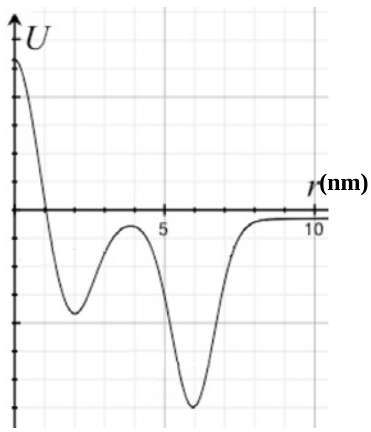
3. Zero
4. Cannot be determined from the figure.

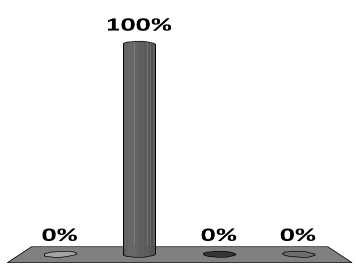


The figure below shows the interaction potential between two molecules (along a particular orientation of the two molecules). The units are in nm (r) and eV (*U*).

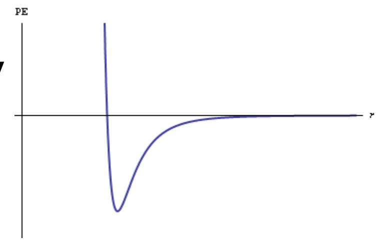
When the molecules are separated by 0.5 nm the force between them is



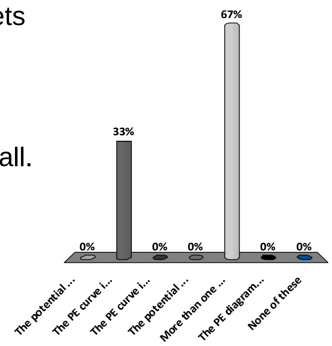
1. Attractive
2. Repulsive
3. Zero
4. Cannot be determined from the figure.



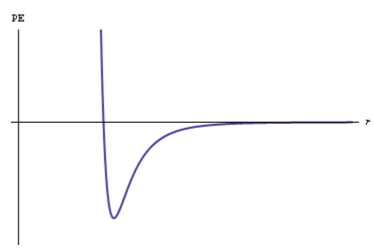
You know that two atoms that are far apart are barely interacting. How is this represented visually in the PE diagram?



1. The potential energy approaches zero as r gets large.
2. The PE curve is close to horizontal as r gets large.
3. The PE curve is close to vertical as r gets small.
4. The potential energy has a minimum.
5. More than one of these
6. The PE diagram doesn't demonstrate this information
7. None of these



These two atoms can exist in a stable bound state. How is this represented visually in the PE diagram?



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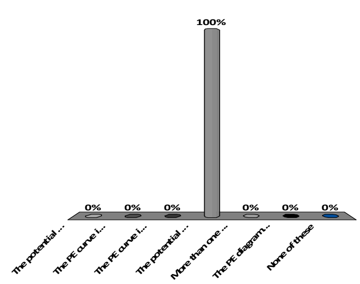
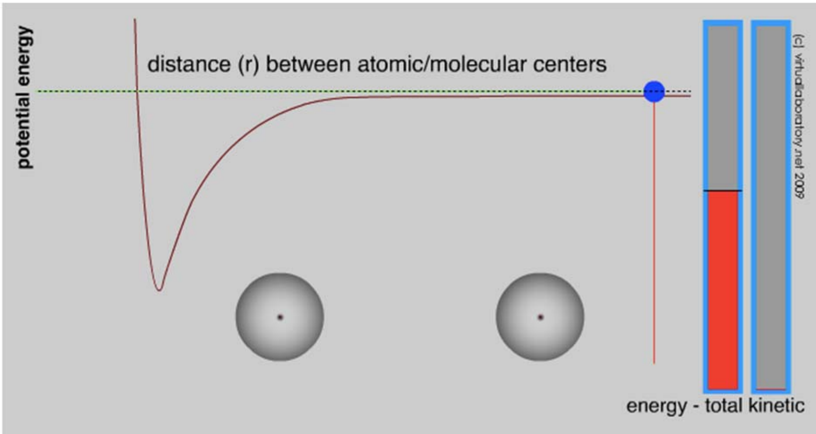


Molecular forces



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

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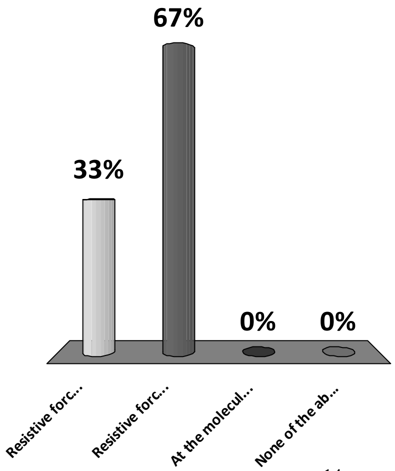
In the presence of resistive forces, the total energy is no longer conserved.

1. Resistive forces are dominant at the scales of molecules
2. Resistive forces are negligible at the scale of molecules
3. At the molecular scales, we can see that resistive forces are really kinetic and potential energy of molecules
4. None of the above



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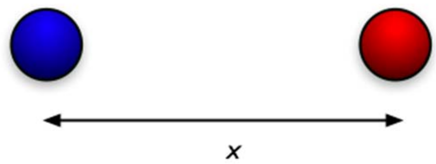
What does the potential look like?



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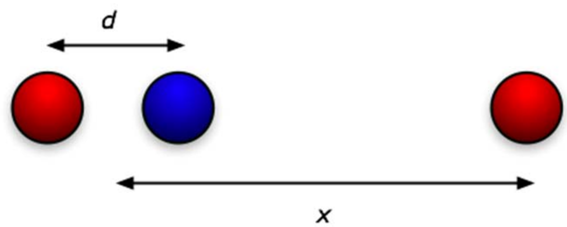

What does the potential look like?