STEM Sims™

Forces and Atoms

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Do you need an idea for a scientific study?
Try out one of our ideas or make one of your own.

Understanding the relationship between chemical bonds and potential energy is one of the most common difficulties for students studying chemistry. Take the following brief quiz to see how much you already know about potential energy. See the bottom of page 4 to check your answers.

1. A typical vehicle tire consists of how many molecules?
   a. one
   b. thousands
   c. millions
   d. billions

2. Two atoms are at some distance away from each other and begin moving towards each other. As the atoms move closer to each other, the potential energy:
   a. increases.
   b. decreases.
   c. remains the same.

3. A molecule undergoes a chemical reaction and breaks apart into the two atoms that make up the molecule. For this process to occur,
   a. energy must be added.
   b. energy must be released.
   c. energy is not required.

4. Acetylene (C_2H_2) is used as a welding gas and has a triple bond between the two carbon atoms. How does the potential energy of the triple bond in acetylene compare to the potential energy of a single bond between carbon atoms in the ethane molecule (C_2H_6)?
   a. The potential energy in the triple bond is greater than the single bond.
   b. The potential energy in the triple bond is less than the single bond.
   c. The potential energy in the triple bond is the same as the single bond.

5. A low potential energy chemical bond would be the chemically *least* stable.
   a. true
   b. false

Bond, Chemical Bond

What's the difference between a polar and a nonpolar chemical bond? In this activity, you'll conduct a simulation to illustrate how electrons are impacted in each type of bond. Get started now.

Materials

2 – rubber bands of equal length and elasticity
1 – shorter and less elastic rubber band
2 – large paper clips (~2 inches)
masking tape and pen

Procedure

Part I. Assembling the Nonpolar Bond

1. Connect the two paperclips end to end.
2. Place one rubber band on the end of one of the paperclips.
3. Place the other identical rubber band on the end of the other paperclip.
4. Place a small piece of masking tape on each of the paperclips and label them with "e-" to represents electrons. See Figure 1 below."
5. Grab each end of the rubber bands and pulling the assembly apart gently with the same force on each rubber band.
6. In Table 1 below, describe the results.

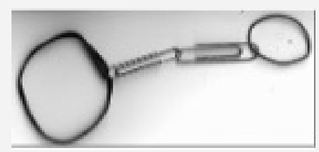

Figure 1.

Part II. Assembling the Polar Covalent Bond

7. Remove one rubber band from the assembly.
8. Replace that rubber band with the shorter and less elastic rubber band.
9. Grab each end of the rubber bands and pulling the assembly apart gently with the same force on each rubber band.
10. In Table 1 below, describe the results.

Table 1. Investigation Results

Experiment	Observations
Equal Elasticity Rubber Bands	
Unequal Elasticity Rubber Bands	

Questions

1. What was the rubber band's elasticity representing with respect to an atom?

2. What was your pulling on the end of the rubber band representing with respect to an atom?

3. How did the potential energy of the different elasticity rubber bands compare when you pulled on the rubber bands? Provide a reason to support your response.

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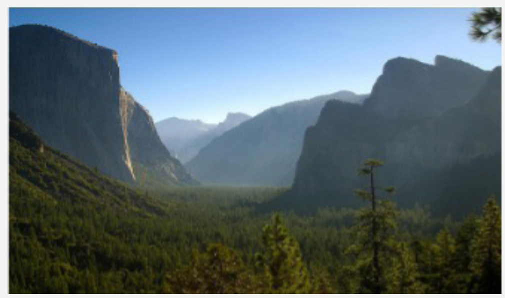
The Big Valley Analogy

Imagine a person is walking along a flat plain and suddenly encounters a large valley. This is much like two atoms being separated by a great distance. When stationary on the flat land the person has no net attraction for the bottom of the valley, just as the atoms have little attraction for each other. However, once entering the valley the likelihood for moving to the bottom of the valley becomes greater since it is much easier to move downhill than uphill. The attractive force of gravity has not changed, but the resistance offered by the ground has since the ground is now pushing upward at an angle instead of directly up. This is slightly different than two atoms approaching each other because the attractive electrostatic force between the two atoms is increasing. The lower the person moves down in the valley, the smaller the person's potential energy.

Now when the person reaches the bottom of the valley, the person's potential energy with respect to the valley has reached a minimum or in this case zero. When the two atoms reach an ideal distance apart, their potential energy also reaches a minimum value. This position is called the equilibrium bond length of the two atoms.



If the person tries to walk upward on the opposite side of the valley, the walk becomes very difficult and requires much energy to increase the person's potential energy. If the two atoms move too close together, the repulsive electrostatic force increases over the attractive force and the potential energy of the atoms becomes greater. So, the next time you must study bond lengths and potential energy, take a walk into the big valley.

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Answers: Page 2 Answers: 1) a, 2) b, 3) a, 4) b, 5) b. **Page 3 Answers:** Bond, Chemical Bond 1) The difference in elasticity was representing the difference in electronegativity of the atoms. 2) The pull of the positively charged nucleus on the electrons. 3) Answers will vary. Since $PE = 1/2kx^2$, the greater stretch was probably associated with a greater PE.