Using Legos® to Model Energy Transfer in Chemical Reactions – Answer Key

Define these terms:

Endothermic: refers to a process where energy (as heat) flows into the system from the surroundings

Exothermic: refers to a process where energy (as heat) flows out of the system into the surroundings

Is bond breaking endothermic or exothermic?\_\_Endothermic\_\_\_\_ How do you know?

Energy is required to overcome the strong electrostatic forces of attraction holding atoms together in the bond. This energy comes from the surroundings

*NOTE: This question is specifically checking for a misconception regarding bond breaking. It is a common misconception that bond breaking is exothermic because of a commonly taught concept in biology. In biology, students learn that ATP🡪ADP is exothermic. Overall, the process IS exothermic, but the erroneous conclusion is based upon the breaking of a phosphate bond from the adenosine molecule. In reality, the removal of the phosphate requires a certain amount of energy to make this happen in the first place. The resulting molecule, ADP does have a lower enthalpy value than ATP, hence the overall process is exothermic.*

In this activity, you will model what occurs during a chemical reaction at the submicroscopic level using tiny Lego® pieces. You will use specific pieces to represent specific aspects of bond breaking and bond formation. Here’s what each Lego® piece represents:

Brown 1x2 – atom A Light blue 1x1 – bond with energy of 100 Joules (J)

Beige 1x2 – atom B Red, round 1x1 – bond with energy of 33 Joules (J)

Pink 1x2 – atom C

Dark blue 1x2 – Atom D

You will get a bag with a small quantity of each piece that you will use to complete the activity and learn about what it means for a reaction to be truly endothermic and exothermic.

1. Build a molecule of A2 that has an overall bond energy of 200 J.
2. Build a molecule of B2 that has an overall bond energy of 167 J.
3. Break both A2 and B2 completely apart.
4. Did breaking the molecule apart require more energy to do than putting the molecule together? YES As you see, breaking bonds requires energy since the attractive force that is a bond is very strong.
5. Now make two molecules of AB. Each molecule has an overall bond energy of 100 J.
6. You should have bond energies “left over.” This adds up to 167 J of energy released to the surroundings. Therefore, this reaction is EXOTHERMIC.
7. We are going to account for the energy changes in the reaction between A2 and B2 using an energy diagram. It is a line graph that displays energy over time. In order to draw the energy diagram correctly we need to do some figuring:
   1. Total energy of reactants = 367 J
   2. Total energy of products = 200 J
   3. Total energy of products – Total energy of reactants = -167 J

The value you get in part c should be the same size as what you got in #6. What is different about what you got in c? Why is it different?

The answer in part c is negative while the answer in #6 is positive. The negative sign on the answer for c reflects the exothermic nature of the process as energy is released by the reaction to the surroundings.

1. Now let’s sketch an energy diagram. Your axes are labeled appropriately for you.

Transition state

Energy (J)

A2 + B2

A2 + B2

167 J

2AB

Time (s)

This is an energy diagram for an EXOTHERMIC reaction. Notice that the “hill” in the middle of the diagram represents the activation energy needed to break the bonds in all the reactant molecules.

1. Make two molecules: a molecule of CD that has an overall bond energy of 233 J and a molecule of AB that has an overall bond energy of 100 J.
2. What is the total energy of the reactants? 333 J
3. Break the bonds between CD and AB.
4. Make two new molecules: a molecule of AC that has an overall bond energy of 400 J and a molecule of BD that has an overall bond energy of 267 J.
5. What did you do differently this time? Why did you do it?

More bond energy blocks were pulled from the bag (surroundings) to make the bonds the right size.

Notice that you took in energy from your surroundings. This is what happens during an ENDOTHERMIC process. How much energy did you take in? 333 J (3 blue + 1 red)

1. We are going to account for the energy changes in the reaction between AB and CD using an energy diagram. It is a line graph that displays energy over time. In order to draw the energy diagram correctly we need to do some figuring:
   1. Total energy of reactants = 333 J
   2. Total energy of products = 667 J
   3. Total energy of products – total energy of reactants = 334 J

The value you get in part c should be the same size as what you got in #13. Why is the quantity of energy you got in c the same as what you got in #13?

Energy was added to the reaction, so the value for c is nearly the same as the answer to #13 in value and identical to #13 in sign.

1. Now let’s sketch an energy diagram. Your axes are labeled appropriately for you.

Transition state

Energy (J)

AC + BD

334 J

AB + CD

Time (s)

This is an energy diagram for an ENDOTHERMIC reaction. Notice that the “hill” in the middle of the diagram represents the *activation energy* needed to break the bonds in all the reactant molecules.