# SCED 204 Sample Activity

## SCED 204: Matter and Energy in Chemical Systems

Instructor: SMATE

## Activity # 1: WHAT IS THE RELATIONSHIP BETWEEN BONDS AND ENERGY?

**Purpose:** *In Chapter 2: Activity 1, we described the forces and energy involved in bonds between two small particles in a closed system; that is, in cases where no other particles were interacting with them. In this activity, we will examine what happens to the energy of small particles when bonds are broken or formed. This will necessitate introducing a "third particle."*

**Initial ideas**

1. Which has lower electrostatic potential energy?
   a. Two hydrogen atoms involved in a bond

   b. Two separate hydrogen atoms not involved in a bond

2. Justify your choice below.

3. A chemical reaction is happening inside of a closed flask. You notice a sharp increase in the temperature of the flask and its contents. What can you attribute this increase in temperature to?

   a. Breaking of bonds in the reactants

   b. Formation of bonds in the products

   c. Both a and b

   d. Something else:_______________________________________________________.

4. Explain the reasoning behind your answer, including any everyday experiences you might have influenced your decision.

5. A chemical reaction is happening inside of a closed flask. You notice a sharp *decrease* in the temperature of the flask and its contents. What can you attribute this decrease in temperature to?

   a. Breaking of bonds in the reactants

   b. Formation of bonds in the products

   c. Both a and b

   d. Something else:_______________________________________________________.

6. Explain the reasoning behind your answer, including any everyday experiences you might have influenced your decision.

7. What would you have to do to a substance in order to make the bonds between particles that make it up, break? Add energy? Take energy away? Something else? Explain.

8. What would you have to do to a substance in order to make the bonds between particles that make it up, form? Add energy? Take energy away? Something else? Explain.

*We will first examine cases in which the third particle interacts with the bonded particles in a way that results in bond formation or breaking. In this case, our question will be "What happens to the energy in the system as a result of bond formation or breaking?" This will be called a bond-manipulated case because we are manipulating the bonding situation and observing what happens with energy as an outcome.*

*We will then examine cases in which energy is added to or taken away from the system on a macroscopic scale (i.e. we manipulate the temperature). In this case, our question will be "What happens to the bonding situation in the system as a result of energy input or output?" This will be called an energy-manipulated case because we are manipulating the energy input/output and observing what happens to the bonding situation as an outcome. The following table illustrates these two cases.*

| Case | Question | Manipulated (independent) variable | Responding (dependent) variable |
|---|---|---|---|
| Bondmanipulated | *What happens to the energy in the system as a result of bond formation or breaking?* | Bonding | Energy changes |
| Energymanipulated | *What happens to the bonding situation in the system as a result of energy input or output?* | Energy | Bonding |

**PART I - The bond-manipulated case: How bond breaking and formation affects energy**

*In this activity you will discover that other small particles have to be present to change the bonding situation between interacting small particles. Their role is to change the total energy in the 2-particle system. These small particles transfer energy to or from the 2-particle system through collisions with them, just like we saw two colliding particles do in Chapter 1: Activity* **2**. *We are first going to explore what happens when these "extra" particles are part of the system in which bonds are changing. That is, we will simply expand our system from Chapter* 2*: Activity 1 to include more particles. In this situation there is no macroscopic heat source or receiver (such as a hot plate or freezer); we are simply changing the bonding situation to see what effect that has on the energy in the system, hence the term* ***bond-manipulated case****.*

**Investigation 1**

*Evaporation in a room-temperature room is an example of a bond-manipulated case because the liquid is at the same temperature as its surroundings and there is no sun or hot plate putting more energy into the liquid, yet the bonding situation is changing. You will investigate what happens to the temperature in a liquid that is undergoing evaporation. First, let's make some predictions.*

1. During evaporation, are bonds breaking or forming? (Think back to what you learned about intermolecular bonds in Chapter 1: Activity 6 – specifically whether intermolecular bonds are present in the liquid and gas phases and how strong they are).

   ____________________________

2. Think back to your initial ideas on p. 341. Predict the temperature change you would observe in the liquid while it evaporates. Temperature would: *increase / decrease / stay the same.*

**Procedure**

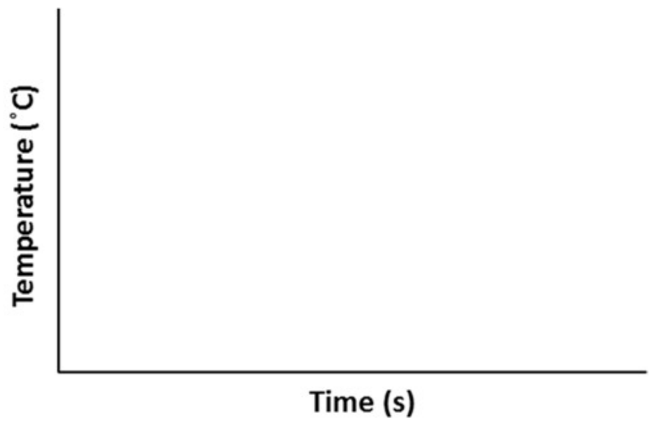
*In this investigation we will observe the evaporation of acetone instead of water, because acetone evaporates more quickly and the temperature change is more dramatic as a result.*

You will need:

- Goggles
- Temperature probe + interface + power source
- Computer with software for use with the probe
- Acetone

Chapter 4: Activity 1

1. Connect a temperature probe to a computer interface and set up the graph below. Place a drop of acetone on the temperature probe and wave it around so that the acetone evaporates quickly. Sketch the resulting time vs. temperature graph below. The specific values for the x and y axes are not important. Just capture the general shape of the curve.




2. How did the result of this experiment compare with your prediction above?

3. Did the kinetic energy of the small particles of the liquid acetone increase, decrease, or stay the same? What is your evidence?

*In Chapter 2 Activity 1, you learned that small particles can both be attractive (farther away than their bond length) and repulsive (closer together than their bond length). In this chapter we are examining bond breaking and formation. As bonds are breaking or forming, small particles are either starting at their bond length and getting farther apart, or starting farther apart than their bond length and reaching their bond length. At no time will we consider small particles closer together than their bond length, where they are repulsive. Therefore, in this and all other activities in this chapter,* ***we will consider small particles only as attractive objects.***

4. Given that we are considering the small particles of acetone (acetone molecules) to be attractive only, what happens to the potential energy of the acetone molecules as the acetone evaporates? *Increases / Decreases / Remains the same.* Explain.

**Investigation 2**

*You will now use a simulator to investigate energy transfers and transformations as a result of breaking the bond between two small particles.*

**Procedure**

1. Go to the simulator: *http://besocratic.colorado.edu/CLUE-Chemistry/activities/LondonDispersionForce/1.2-interactions-2.html*.

2. Carefully observe the two particles which are involved in a bond in the center of the screen. List all the evidence you can find from the simulator that these two particles are bonded.

3. What do you think the bonded particles represent in the investigation you just completed about evaporation?

   What do the unbonded particles represent?

Since we first want to look at a situation where there is no macroscopic heat source or receiver, set the temperature bar on the right to 11 degrees Kelvin, and keep it at that temperature. For the purposes of this investigation, ignore the temperature setting from now on, and just assume that there is no energy source or receiver keeping the system at a constant temperature.

4. Press reset and watch the simulation from the beginning, until the bond between the two small particles breaks. What had to happen to break that bond? Explain on a small particle level.

5. On average, what happened to the potential energy of the two-particle system involved in a bond, as the bond was breaking? *Increased / Decreased / Remained the same.* What is your evidence?

6. On average, did particle A get any closer to or farther away from any other particles as the simulation proceeded? *Yes / No*. What does this tell you about how, if at all, its potential energy changed with respect to all the other particles during the bond breaking event? Its potential energy: *Increased / Decreased / Remained the same.*

7. While many particles may have hit the bonded pair, we will focus on the one that finally broke the bond. Let's name this particle A. Reset the simulator and really focus on the kinetic energy of particle A before and after it breaks the bond. What happened to the kinetic energy of particle A when colliding with the two-particle bonded system to break the bond? *Increased / Decreased / Remained the same.* What is your evidence?

The table below summarizes a plausible set of energy changes that could have happened in this simulation. The shaded cell will be discussed later. The unit of energy used here is the electron volt (eV) which is just a very small unit of energy (much smaller than a Joule), appropriate for tracking energy of single small particles. Negative values indicate a decrease in energy, while positive values indicate an increase in energy (for example, we would say that the kinetic energy of particle A decreased by 45 eV).

**Changes in energy before vs. after collision: Bond breaking, bond-manipulated case**

| | Bonded pair | Particle A |
|---|---|---|
| Potential energy | + 36 eV | 0 eV |
| Kinetic energy | | - 45 eV |

8. First, make sure these values are consistent with your responses to the above questions. Ignore the shaded cell for now. Are the *directions* of changes consistent with what you reported above? What about the lack of change of potential energy of particle A? Discuss with your group, watching the simulation again if necessary.
9. Recall the law of conservation of energy: Energy cannot be created or destroyed. This is often expressed in the form of the following equation:

   Energy Input = Change in Energy + Energy Output

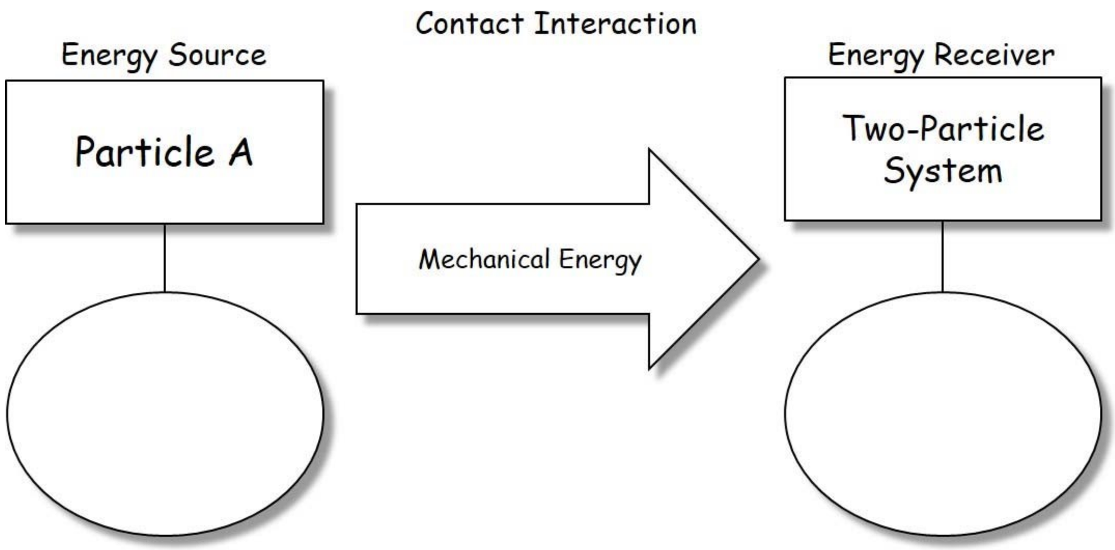
   If we isolate the moment of the collision, there is no energy input or output for the threeparticle system (bonded particles + particle A). This is because the three particles weren't in contact with any other particles the instant before the collision or after the collision. They may have been before or after that, but we are isolating the moment of the collision. Therefore, what has to be the value of the total energy change during the collision? ___ eV. Knowing this, fill out the shaded cell in the table above.

10. Is it possible for the kinetic energy of the bonded pair not to change at all during a collision in which the bond is broken? If so, how would the changes in potential energy of the bonded pair and kinetic energy of particle A compare? Explain.

**Constructing explanations**

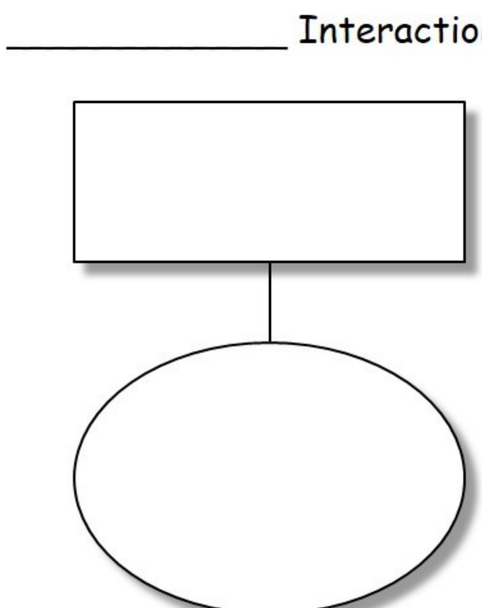
*In this bond-manipulated case, there is an energy transfer taking place. We represented transfers of kinetic energy between two particles in Chapter 1: Activity 2 using energy diagrams. In this activity we will be using energy diagrams again; however, since we now have bonded pairs, we need to consider potential energy as well as kinetic energy changes.*

1. Use your responses to the questions above to construct an energy diagram describing the energy transfer between particle A and the bonded pair.




2. Why is this a contact interaction? Why is it a mechanical energy transfer?

3. As stated earlier, in a bond-manipulated case it is most useful to consider all the particles, including those colliding with the bonded pair, as part of the same system. This is best done by combining all three particles (the bonded pair and particle A) in a single box in an energy diagram. Below draw a new diagram for the whole 3-particle system.




*Since all three particles are in the same system, we no longer think of this as an energy transfer, only as an energy transformation. This is illustrated in the energy diagram above by the lack of source, receiver, or arrow.*

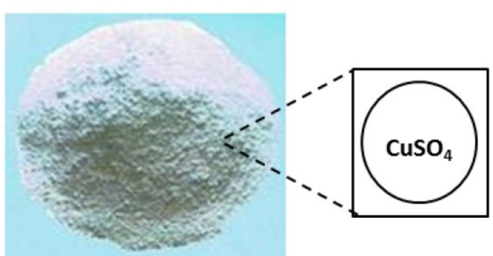
4. In bond breaking, illustrated through the energy diagram above, what type of energy is being transformed into what other type of energy? Some _______________ energy is being transformed into _______________ energy.

5. In a macroscopic system of particles, one large enough to make measurements on, a change in kinetic energy will be reflected in a change in the temperature of the system. In the process of bond breaking, will the temperature of a macroscopic system of particles that is not in contact with a macroscopic energy source or receiver increase or decrease? Explain.

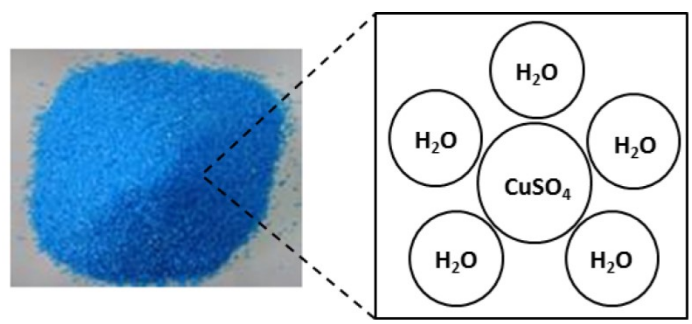
6. Is your response from the question above consistent with what you observed when acetone evaporated? If so, explain how they are consistent. If not, explain why they are inconsistent.

**Investigation 3**

*We will now examine the process of bond formation in a bond-manipulated case. Copper sulfate ($CuSO_4$) is a white substance on its own. A substance consisting of $CuSO_4$ bound to water molecules, however, is bright blue. Without the water, $CuSO_4$ is called "anhydrous." With the water, it is called "hydrated." In its hydrated form, each $CuSO_4$ unit is bound to five water molecules. Its technical name in this form is copper sulfate pentahydrate:*




Anhydrous copper sulfate
**$CuSO_4$**




Copper sulfate pentahydrate
**$CuSO_4 \cdot 5H_2O$**

*This dot represents an association between a $CuSO_4$ molecule and 5 waters. It translates as "one $CuSO_4$ makes 5 bonds (1 each) to 5 water molecules."*

*The attraction between $CuSO_4$ and water is so strong that if you simply leave anhydrous copper sulfate out in normal conditions, it will absorb water from the atmosphere and become copper sulfate pentahydrate. You will see it take on a blue color over time. We will now use this system to investigate the energy involved in bonding interactions. First, let's make some predictions.*

1. If we add water to anhydrous copper sulfate, are we breaking bonds or making bonds?

   ____________________________

2. Think back to your initial ideas on p. 341. Predict the temperature change you would observe in copper sulfate if water is added to anhydrous copper sulfate. Temperature would: *increase / decrease / stay the same.*

**Procedure**

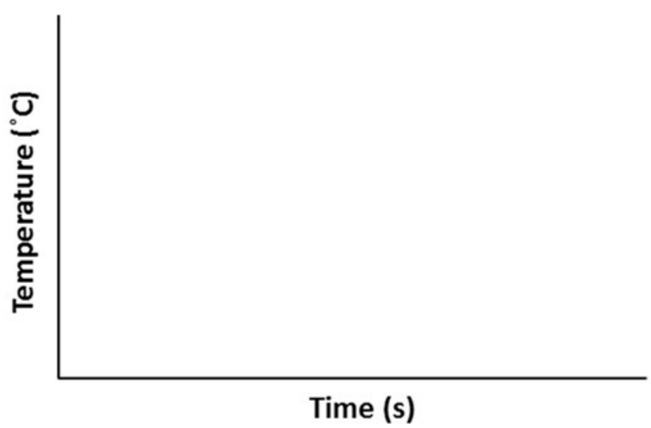
You will need:

- Goggles
- Gloves
- Temperature probe + interface + power source
- Computer with software for use with the probe
- Squirt bottle filled with DI water
- Test tube with flask to hold it

1. Place a small test tube in a rack, small beaker, or flask. Fill it about 1/4 full with anhydrous copper sulfate.
2. Insert a temperature probe into the copper sulfate.

3. With a squirt bottle, slowly add deionized water just until all the copper sulfate is submerged.

4. Adjust the y axis on your resulting time vs. temperature graph so the line fills the screen. Then sketch the general shape of your graph below. On the x axis, label the time interval during which water was added to the copper sulfate.



5. How did the result of this experiment compare with your prediction above?

6. Did the kinetic energy of the small particles of copper sulfate and water increase, decrease, or stay the same? What is your evidence?

7. How did the potential energy of the copper sulfate – water system change? What is your evidence? *(Remember we are considering these small particles to be attractive only.)*
**Investigation 4**

*Again we will use a simulator to investigate this bond-manipulated case. However, this time we will investigate bond formation. To be more precise, the simulation you will be using starts with a loosely bonded pair of small particles, so we will investigate what it takes to <u>strengthen</u> the bond. This is the same as what it takes to <u>form</u> a bond.*

1. Go to the simulator: *http://besocratic.colorado.edu/CLUE-Chemistry/activities/LondonDispersionForce/1.2-interactions-1.html*.

2. Just as in investigation 2 on p. 345, imagine that another particle (let's now call it particle B) were to enter the screen and interact with the bonded pair. What do you think that other particle would have to do to the bonded pair to *strengthen* the bond?

3. Click the box that says "lose energy." Does this strengthen the bond? What is your evidence?

4. On average, what happened to the potential energy of the two-particle system as the bond was being formed? *Increased / Decreased / Remained the same.* What is your evidence?

5. Reset the simulation. This time, prepare to pay close attention to the kinetic energy of particle B, as evidenced by its speed, before and after the collision (the bar graph shows the kinetic energy of the 2-particle system, not particle B).
6. Click "lose energy." How does the kinetic energy of particle B change as the two particles strengthen/form a bond? *Increases / Decreases / Remains the same.*

7. Fill in the tables below. First, imagine a collision in which the kinetic energy of the bonded pair changes. How must the change in potential energy of the bonded pair compare to the change in kinetic energy of particle A for this to be the case? What are the directions of change? Complete the table below with some plausible values.

**Changes in energy before vs. after collision: Bond formation, bond-manipulated case**

| | Bonded pair | Particle B |
|---|---|---|
| Potential energy | | |
| Kinetic energy | | |

8. Now imagine a collision in which the kinetic energy of the bonded pair does not change. How must the change in potential energy of the bonded pair compare to the change in kinetic energy of particle A for this to be the case? What are the directions of change? Complete the table below with some plausible values.

**Changes in energy before vs. after collision: Bond formation, bond-manipulated case**

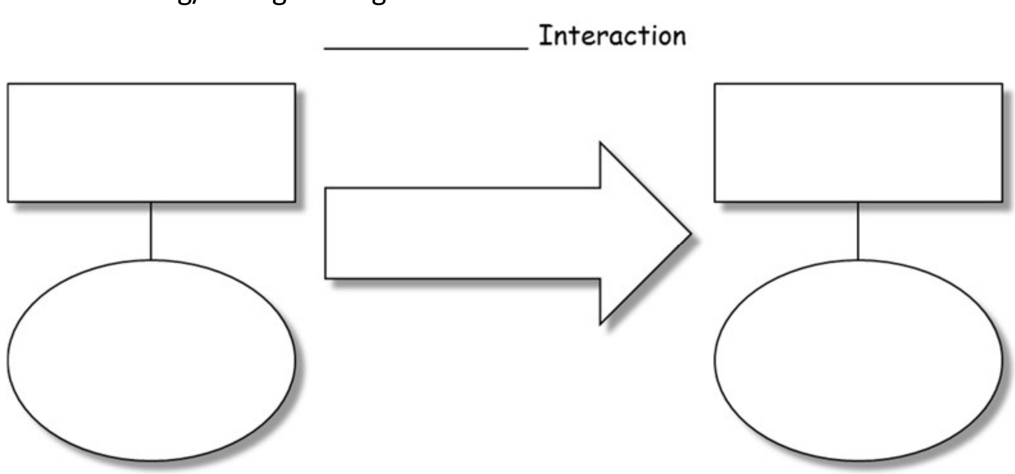
| | Bonded pair | Particle B |
|---|---|---|
| Potential energy | | |
| Kinetic energy | 0 eV | |

9. In both of the cases above, is particle B an energy source or receiver? What is your evidence?

**Constructing explanations**

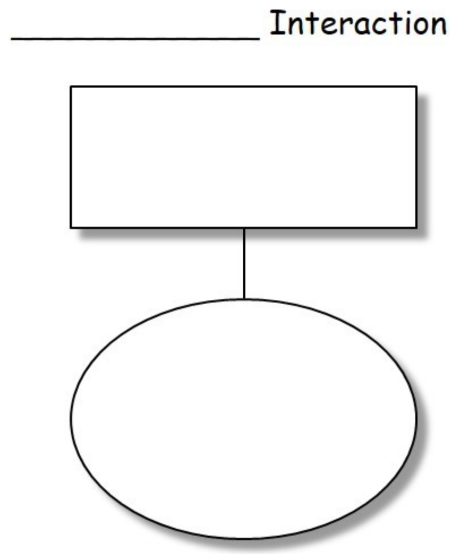
*In the above simulation you observed the strengthening of a bond, but this is the same process that causes initially unbonded particles to form a bond as well.*

1. Using your answers to the questions above, construct an energy diagram for bond formation/strengthening. In this diagram you will consider the system to contain only the two particles forming/strengthening a bond.




Write a narrative below to accompany your energy diagram.

2. Now, include particle B in the system. Complete the energy diagram below for the whole three-particle system.




3. In a macroscopic system of particles, one large enough to make measurements on, a change in kinetic energy will be reflected in a change in the temperature of the system. In the process of bond formation, will the temperature of a macroscopic system of particles that is not in contact with an energy source or receiver increase or decrease? Explain.

4. Is your response from the question above consistent with what you observed when water was added to $CuSO_4$? If so, explain how they are consistent. If not, explain why they are inconsistent.

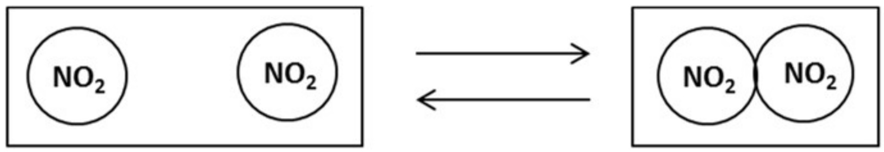
5. What do you think the third particle (particle B) represented in the $CuSO_4$/water system?

**Part II – The energy manipulated case: How energy input/output affects bonding**

*In Part I, temperature was not manipulated in any way (there was no hot place, freezer, etc.). Instead, changes in temperature were observed as a consequence of breaking or forming bonds. In this part of this activity we will manipulate the temperature and observe how it affects the bonds in a system. In order to manipulate temperature, we need to include a macroscopic energy source or receiver outside of the system – in other words, we need to add a large collection of small particles that have a higher or lower average kinetic energy than our system, so that they can change the temperature of the system. These can be atoms in a hot plate or air molecules being heated by a Bunsen burner (energy source), water molecules in an ice bath or air molecules in a freezer (energy receiver). Because we now have temperature differences between our system and the small particles outside of our system, for the purposes of this activity we are working with an* ***energy-manipulated case.***

**Investigation 5**

Consider the following chemical reaction, showing two nitrogen dioxide ($NO_2$) molecules combining to form one nitrogen tetroxide molecule ($N_2O_4$).




2 molecules of nitrogen dioxide ($NO_2$)
***brown color***

One molecule of nitrogen tetroxide ($N_2O_4$)
***colorless***

Note that there is an arrow that goes in each direction. That means this reaction is *reversible* – it can happen in either direction. In fact, both the forward and backward reactions are constantly happening at the same time. (This is very common, and in fact is true of every chemical reaction to some extent.)

1. In the direction of the forward arrow, is a bond being broken or formed? _____________

   In the direction of the backward arrow? ____________

It is very difficult to obtain pure $NO_2$ or pure $N_2O_4$ because of the back and forth of this reaction. It is much more common to obtain a mixture that has more of one than the other. Two mixtures with differing ratios of $NO_2$ to $N_2O_4$ are shown below. In both cases, the brown color is due to the $NO_2$, but there is less $NO_2$ in the bottle on the right.

More $NO_2$ in More $N_2O_4$ in
$NO_2/N_2O_4$ mixture

$NO_2/N_2O_4$ mixture

You will now manipulate the temperature of an $NO_2/N_2O_4$ system and we will observe what happens with the bonds by observing the color change. First, make some predictions.

2. Look at the equation on p. 357. Bond breaking in this system would be evidenced by a *darkening / lightening* of the brown color? What about bond formation? *darkening / lightening*
3. If we were to increase the temperature of a sealed flask of an $NO_2/N_2O_4$ mixture, what would happen to the color of the mixture? Justify your prediction below.
4. If we were to decrease the temperature of a sealed flask of an $NO_2/N_2O_4$ mixture, what would happen to the color of the mixture? Justify your prediction below.
5. Now take your bottle of $NO_2/N_2O_2$ mixture and place it alternately in a warm and cold water bath. Record your observations below.

   When the temperature of the gaseous mixture increases, it becomes: *darker / lighter.*

   When the temperature of the gaseous mixture decreases, it becomes: *lighter / darker.*

6. What happened when the temperature was increased in the $NO_2/N_2O_4$ system? Were more bonds broken or formed? What is your evidence?
7. What happened when the temperature was decreased in the $NO_2/N_2O_4$ system? Were more bonds broken or formed? What is your evidence?

**Investigation 6**

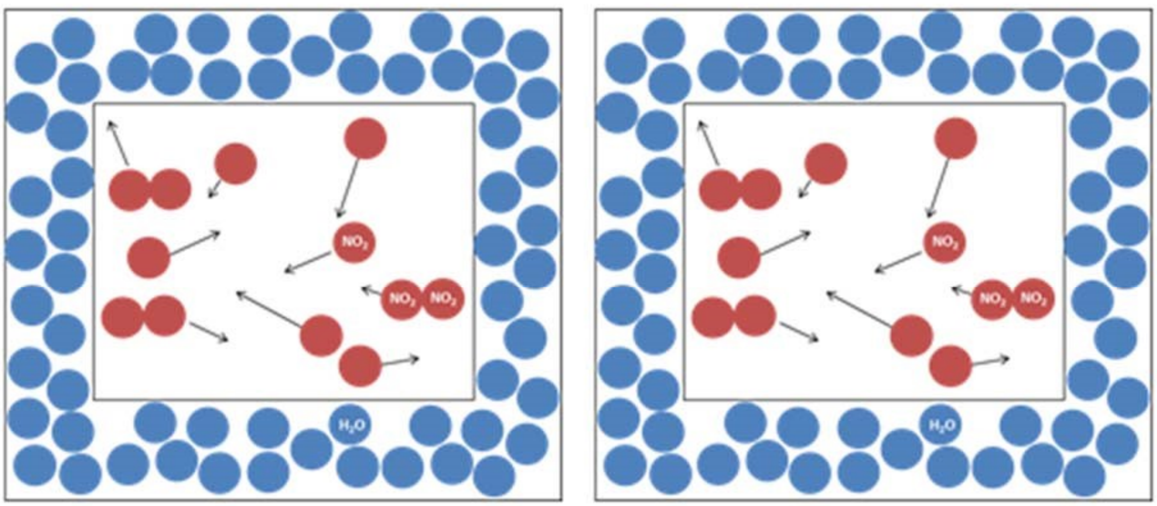
*We will again use a simulation, but this time will simulate adding or removing energy to/from a system. We will observe what happens to the bonds as a consequence.*

1. Go to the simulator: *http://besocratic.colorado.edu/CLUE-Chemistry/activities/LondonDispersionForce/1.2-interactions-2.html*. This time, you will manipulate the temperature of the system. When you increase the temperature, you are adding energy to the system. When you decrease it, you are removing energy from the system.
2. Manipulate the temperature to try to make the bond between the two particles break, and then manipulate it again to make the bond reform. What did you have to do to the temperature to make the bond break? *Increase / Decrease / Neither.* To make the bond form? *Increase / Decrease / Neither.*
3. Is your response from the question above consistent with what you observed with the $NO_2/N_2O_4$ system? If so, explain how they are consistent. If not, explain why they are inconsistent.

**Constructing explanations**

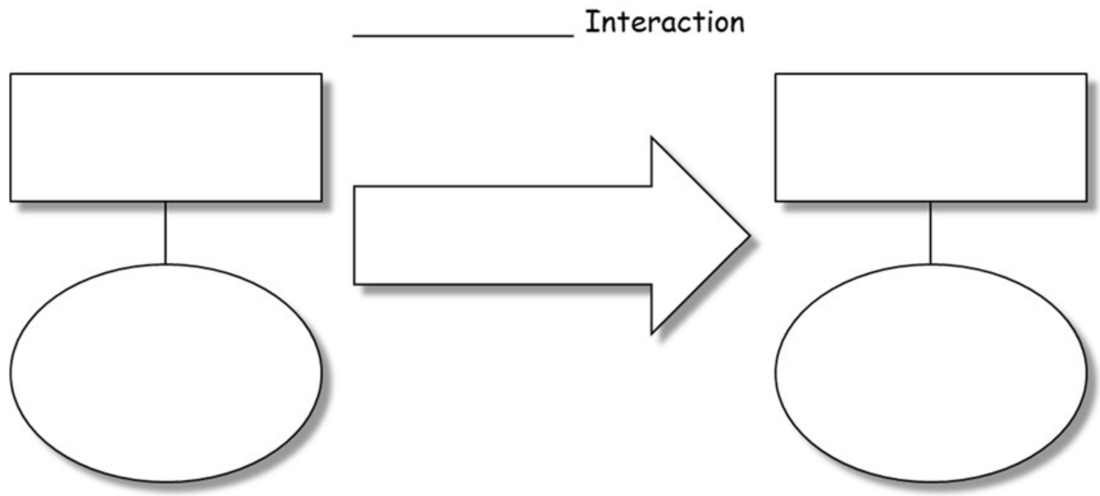
*Recall that we are now working with an energy-manipulated case in which we must consider the influence of surrounding particles on our system of small particles that are involved in bond formation and breaking processes. The surrounding particles come from the hot and cold water baths. Below are two models of the system we are considering plus the surrounding water particles. For simplicity we will disregard the barrier (flask) between the water and $NO_2$/$N_2O_4$ particles and assume the small particles are colliding directly with the $NO_2$ and $N_2O_4$ particles.*

1. Add arrows to three of the water particles (each circle represents a molecule) in each of the representations below to indicate their speed of motion relative to the $NO_2$ and $N_2O_4$ particles (the longer the arrow, the faster the speed). You may draw the arrows crossing the boundary between the water and $NO_2$ and $N_2O_4$ particles.

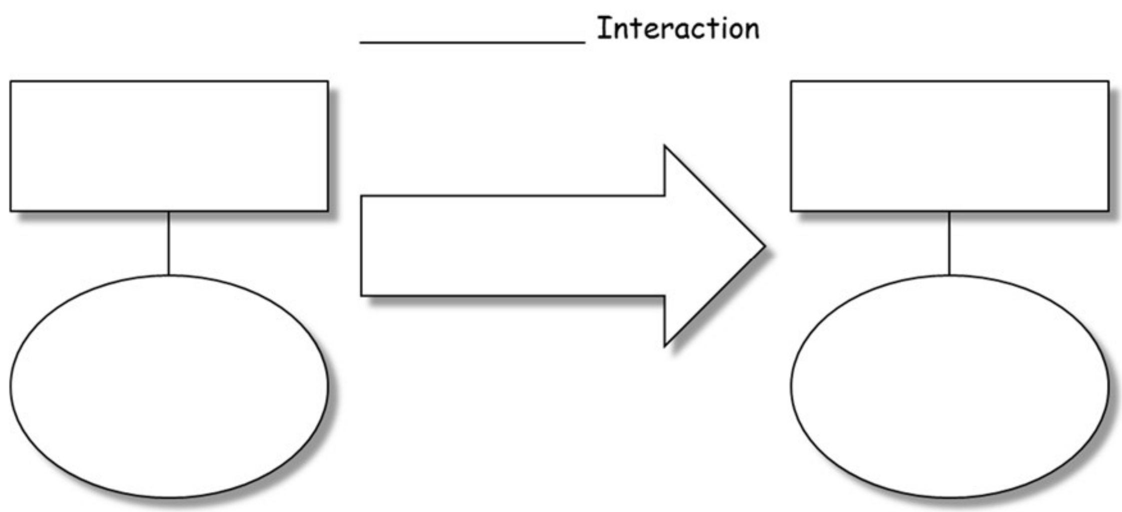


Hot water bath　　　　Cold water bath

2. Complete an energy diagram describing the energy transfer and transformation taking place as one fast-moving water molecule collides with one $NO_2$ particle that is involved in a bond with another $NO_2$ particle.




3. Complete an energy diagram describing the energy transfer and transformation taking place as one slow-moving water particle collides with an isolated $NO_2$ particle, causing it to form a bond with another $NO_2$ particle.




4. Write a narrative to accompany one of the energy diagrams above. Make it clear which scenario you are writing a narrative about.

**Part III – Bond manipulated vs. Energy manipulated cases**

Recall the definitions of bond-manipulated and energy-manipulated cases below:

| Case | Question | Manipulated (independent) variable | Responding (dependent) variable |
|---|---|---|---|
| Bondmanipulated | *What happens to the energy in the system as a result of bond formation or breaking?* | Bonding | Energy changes |
| Energymanipulated | *What happens to the bonding situation in the system as a result of energy input or output?* | Energy | Bonding |

1. Below, decide whether or not each scenario is a bond-manipulated or energy-manipulated case. In a bond-manipulated scenario, remember something changes with the bonding in the system and an energy change is observed as a result. In an energy-manipulated scenario, energy is put into or taken out of a system and a change in the bonding in the system results. Put a **B for bond manipulated** and an **E for energy manipulated.**

   a) ______ Ignoring the initial spark, gasoline burning in a car engine to make the car run.

   b) ______ Heating a pot of water to produce steam

   c) ______ Observing droplets on the underside of a lid that topped the heated pot of water

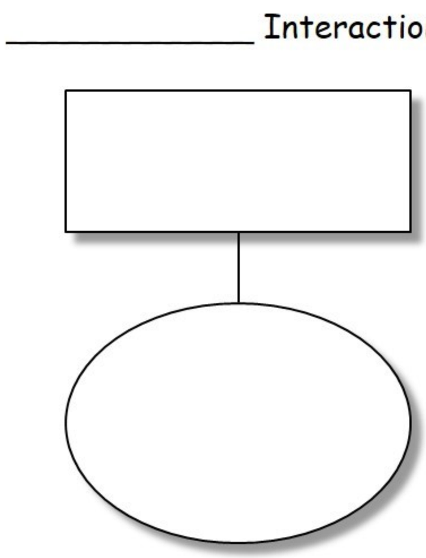
   d) ______ When sodium (Na) and chlorine ($Cl_2$) are mixed, salt is formed and the reaction container becomes hot to the touch.

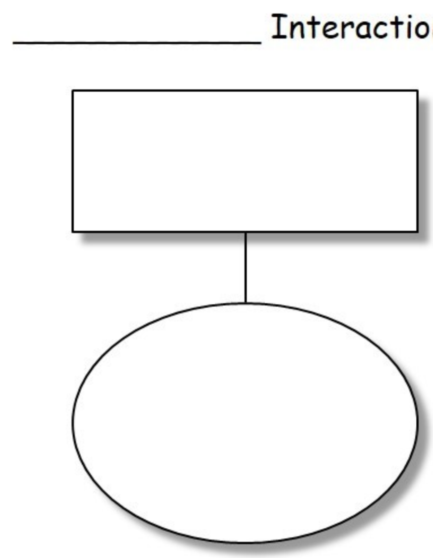
   e) ______ You notice that your shoe heats up quickly when you rest it next to a campfire.

2. The main difference between bond-manipulated and energy-manipulated cases is the location of particles A and B (the particles that collide with another pair of particles to make a bond break or form). When you measured temperature changes in the bond-manipulated cases (evaporation and hydration of copper sulfate), were particles A and B part of the system or surroundings? (Think about where the temperature decreases or increases came from, in terms of the small particles). Explain.

   When you observed the $NO_2/N_2O_4$ system, were particles A and B part of the system or surroundings? Explain.

3. Go back to your energy transformation diagrams for the bond-manipulated cases on pp. 349 and 355. Below, draw new transformation diagrams in which you label the particles according to what they were in investigations 1 and 3 (e.g. water particles, copper sulfate particles).




4. In the energy source/receiver boxes above, circle with a colored pencil the particle(s) you measured the temperature of.

5. If you were to measure the temperature of only the bonded/bonding pair, would you always record a temperature change, during a bond breaking or formation event? Why or why not? (Look at the second table on p. 354.)

6. Go back to your energy transfer diagrams for the energy-manipulated cases on p. 361. What particles must change in kinetic energy during a bond breaking or bond formation event, water, $NO_2/N_2O_4$, or both? Explain below.

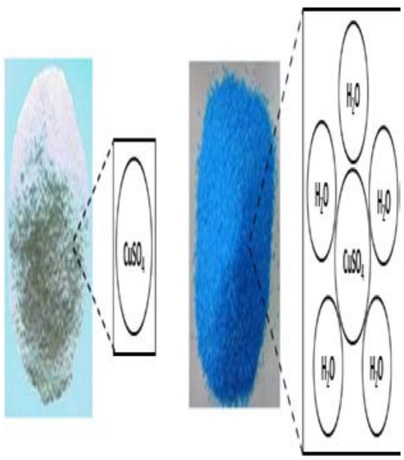
7. If you were to measure the $NO_2/N_2O_4$ system inside the flasks as they were in contact with the hot and cold water, would you expect to measure a temperature change? Why or why not?

**Summarizing Questions:**

**S1:** In Part I, which process (bond formation or breaking) was accompanied by a decrease in temperature? __________________ Explain on a small particle level what caused this temperature decrease.

**S2:** In Part I, which process (bond formation or breaking) was accompanied by an increase in temperature? _________________ Where did the energy to increase the temperature come from? Explain on a small particle level.

**S3:** A sealed syringe contains a system of $NO_2$ and $N_2O_4$ particles in equilibrium (see p. 357). A student pushes down on the syringe as quickly and hard as she can. After the plunger is in its new position, the student observes a sharp increase in temperature, along with a lightening of color of the gas inside. Create an energy transformation diagram to answer the question, **Why did the temperature of the $NO_2$/$N_2O_4$ system increase and color lighten after the plunger was pushed down?**

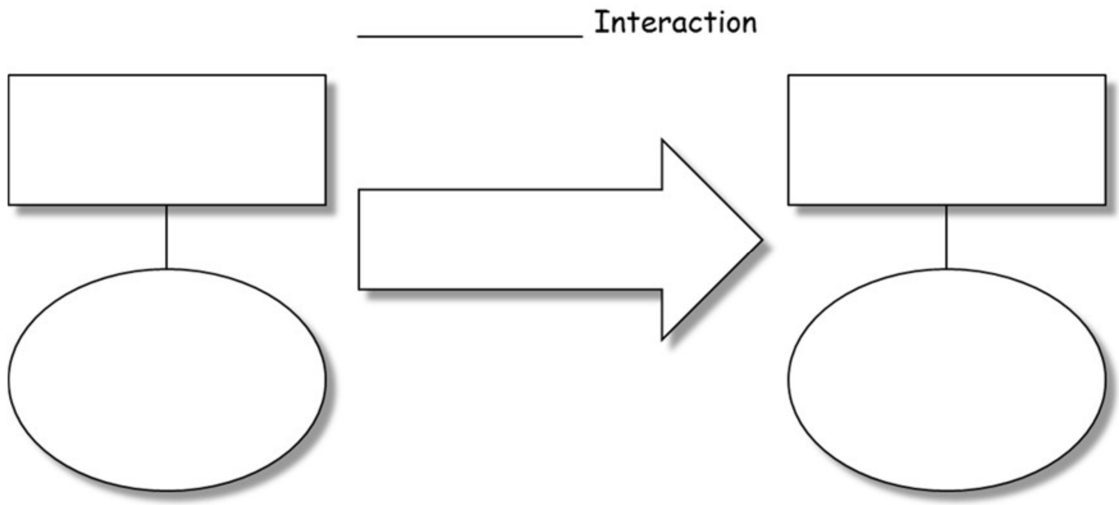



*Narrative:*

**S4:** What could you do to a substance, in terms of energy, to try to make its bonds break? Explain why this would work on a small particle level. Explain where you would see a temperature change, and whether it would increase or decrease: The system, the surroundings, or both.

**S5:** What could you do to a substance, in terms of energy, to try to make more bonds form? Explain why this would work on a small particle level. Explain where you would see a temperature change, and whether it would increase or decrease: The system, the surroundings, or both.

**S6:** You heat some water in a pan topped with a lid. After the water gets hot, you take off the lid to find water droplets on the underside of it. These droplets came from water vapor evaporating from the water and condensing onto the bottom of the lid. Create an energy diagram and accompanying narrative to answer the question, **Why do water droplets form on the bottom of the lid, in a closed pot of heated water?** Consider the bonding situation in both liquid and gaseous water, as well as the difference in temperature between the lid and the heated water.




*Narrative:*

**S7:** Kate, Devon, and Victor are thinking about how burning gasoline in a car engine results in energy to run the car. Here is part of their conversation:

**Kate:** "I think the energy comes from breaking down the gasoline molecules. As you break the bonds between the atoms, energy is released."

**Victor:** "Doesn't energy just come from the gas molecules themselves? Don't the gas molecules turn into energy?"

**Devon:** "I don't think molecules or atoms can just turn into energy, but I also don't think it can come from breaking bonds. If I want to get two magnets away from each other I have to use energy from my hands."

Respond to each student's ideas, using evidence and small particle explanations from this activity to support, refute, or add substance to them.

NAME: ___________________________

**Homework**

Whenever the system and the surroundings are at different temperatures, there will be a transfer of kinetic energy between the small particles of the system and the surroundings. If the system has a higher temperature than the surroundings, there will be a transfer of kinetic energy from the system to the surroundings. We call this type of process, in which kinetic energy leaves the system, **exothermic**. If the surroundings have a higher temperature than the system, there will be a transfer of kinetic energy from the surroundings into the system. We call this type of process, in which kinetic energy enters the system, **endothermic**. This may at first make the most sense sense for Part II, in which we used a macroscopic energy source or receiver (the water baths) as the surroundings. In this case, the $NO_2/N_2O_4$ system transferred energy to or from the water bath. In the cases of evaporation or mixing of $CuSO_4$ with water, however, we can also use these terms. Recall that in both of these cases the system and surroundings were at the same temperature before any bond breaking or formation had occurred. However, after some bond breaking or formation occurs, the system (water + immediately surrounding space or $CuSO_4$ + water) is at a different temperature than the surroundings. Kinetic energy can then be transferred to or from the surroundings.

Consider how the temperature of a macroscopic system of particles changes relative to the surroundings during bond-breaking or bond-formation to answer the following questions.

1. Would bond formation be considered an exothermic or endothermic process? Explain your answer.

2. Would bond breaking be considered an exothermic or endothermic process? Explain your answer.

3. A student makes the following statement: "As food molecules are broken down in your body, energy is released." What misconception do you think this student might have? Why is this a misconception?

**Revisiting initial ideas**

1. Review your responses to your initial ideas on p. 341. Discuss how your ideas now are similar to and/or different from these initial responses.