Supplemental Activities

Module: Thermodynamics

Section: Second Law of Thermodynamics

Spontaneity

Activity 1

The purpose of this activity is to practice your understanding of the concept of spontaneous change.

1. A ___________change is defined as one that happens in only one direction in ___________, which means on its own with no outside influences.

2. Give two examples of processes that are spontaneous at room temperature and pressure – provide one physical change and one chemical change.

3. Can spontaneous reactions ever be reversed? Does temperature ever play a role in the spontaneity of a reaction?

Activity 2

The purpose of this activity is to consider again the law that governs spontaneous processes.

1. The second law of thermodynamics states that all spontaneous changes are accompanied by an ___________ in ___________entropy.

2. The change in entropy of the universe takes into account the change in entropy of the ___________ and the change in entropy of the ___________.

3. Entropy is a ___________ function that is a measure of the ___________of energy.

4. In thermodynamics, the word "___________" indicates a specifically defined path for some process.

5. Give an equation for the change in entropy using heat and absolute temperature. Explain the equation in words.

ACTIVITY 3

The purpose of this activity is to practice thinking about the sign and magnitude of changes in entropy.

1. When dry ice sublimes, the sign of the change in entropy for the system must be _____, the sign of the change in entropy of the surroundings must be _____. The overall change in entropy of the universe must be _____. Given this situation what must be the relationship of the magnitude of the values for the system and the surroundings?

2. Consider the dissolution of a small amount of table salt into water at room temperature. Define the system and the surroundings. Is the ΔS_{sys} > or < 0 or is there no way to know? Is the ΔS_{sur} > or < 0 or is there no way to know? Please justify your answer.

3. Consider a chemical reaction in which a solid metal is placed into a beaker of water. Upon mixing, a gas is released as well as light and heat. Define the system and the surroundings. Is the ΔS_{sys} > or < 0 or is there no way to know? Is the ΔS_{sur} > or < 0 or is there no way to know? Please justify your answer.

Change in Entropy

ACTIVITY 1

The purpose of this activity is to recall your conceptual understanding of the change in Entropy of a system, ΔS_{sys}.

1. What are the five things that will lead to a change in entropy of the system.

2. Describe how each of the five things you listed above could change to result in a decrease in entropy for a system.

3. How could a sample increase in positional disorder without increasing in thermal disorder?

ACTIVITY 2

The purpose of this activity is to practice your ability to quantify the change in entropy of a physical system.

1. Write three equations for the change in entropy of a system when it experiences a change in temperature, a change in volume and or a change in phase. Define each of the variables and give the units for each.

2. Calculate the change in entropy for 4.8 moles of H_2O gas when it increases in temperature from 400 K to 500 K. The heat capacity for H_2O gas is 36.57 J/molK.

3. Calculate the change in entropy of fusion for one mole of mercury. The melting point of mercury is –37.9˚C.

4. Calculate the change in entropy of fusion for 63 grams of mercury.

ACTIVITY 3

The purpose of this activity is to recall your conceptual and quantitative understanding of the change in Entropy of the surroundings, ΔS_{sur}.

1. Write the equation for the change in entropy of the surroundings. Define each of the variables and give the units for each.

2. If you know the heat flow in or out of the system at constant pressure, could you calculate the change in entropy of the surroundings (given the temperature of the surroundings)?

3. Calculate the ΔS_{sur} for the vaporization of 216 g of benzene (C_6H_6) if the surrounding temperature is 25.0 °C.

ACTIVITY 4

The purpose of this activity is to recall your conceptual and quantitative understanding of the change in Entropy of the universe for a common physical change.

1. Imagine you start with a beaker that has **45 g** of liquid nitrogen. The initial temperature of the liquid nitrogen is 77 K. If you leave this beaker in a room that has a constant temperature of 25 °C, the liquid nitrogen will *spontaneously* boil and you will end up with all gaseous nitrogen at 25 °C. Here we will calculate the entropy change for the process of the liquid nitrogen boiling and increasing in temperature to 25 °C.
   a. First identify what the system and surroundings are. (what are they composed of, what is their temperature, etc…) Often it is helpful to make a sketch or diagram.

b. Now identify what the initial and final states of the system are. Again a diagram, equation, or sketch can be helpful. You should break this down into two steps: liquid nitrogen boiling, then the nitrogen gas warming up.

c. Now look at the energy change for this process. Does energy flow into or out of the system? If so, as heat or work?

d. Given that $\Delta H°_{vap}$=5.92 $kJmol^{-1}$ and that the heat capacity for nitrogen gas is 1.04 $Jg^{-1}°K^{-1}$. How much heat flows into the system for this process (in kJ)?

e. What is the change in entropy for the boiling of the liquid nitrogen? What is the change in entropy for the warming of the nitrogen gas? What is the change in entropy for the system?

2. Now let's consider the surroundings for this particular system.
   a. Did heat flow into or out of the surroundings during this change?

   b. What is the entropy change for the surroundings?

3. Now let's consider the entropy change for the universe for this process.
   a. What is the entropy change for the universe?

   b. Did you expect this process to have a + or – ΔS_{univ}? Why?

   c. Is there a condition in which you would expect this process to not be spontaneous? If so what effect would such a condition have on the ΔS_{surr}?