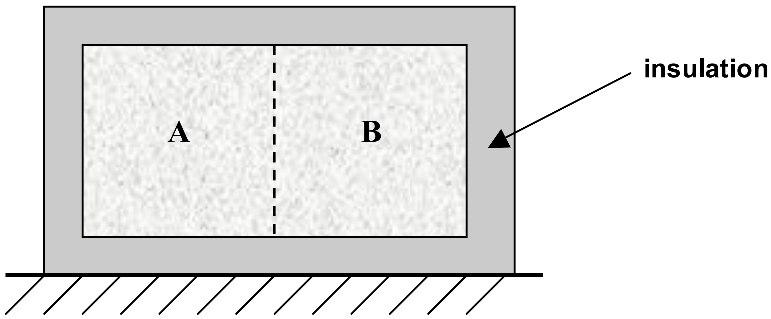
Ideal-Gas Worksheet

The thermal energy [symbol: E_{th}*] of an ideal gas is equal to the total kinetic energy of all of the molecules in the gas. According to the kinetic theory of gases, the absolute temperature* T *of an ideal gas is proportional to the average kinetic energy of the molecules contained within the gas. That is,* $T \propto \frac{E_{th}}{N}$ *where* N *represents the number of molecules of gas.*

1. Suppose we have two samples, *A* and *B*, of an **ideal gas** placed in a partitioned insulated container which neither absorbs energy nor allows it to pass in or out. The gas in Sample *A* is the **same gas** that is in Sample *B*. Sample *A* has the **same mass** as sample *B* and each side of the partition has the same volume**.** Energy but no material can pass through the conducting partition; the partition is rigid and cannot move.



a. Consider the two equal masses of ideal gas, *A* and *B*:

i. If the thermal energy of *A* is equal to the thermal energy of *B* ($E_{thA} = E_{thB}$), will the temperature of *A* be the same as the temperature of *B*, or will it be different?

ii. Suppose the ratio of internal energies is $\left(\frac{E_{th\,A}}{E_{th\,B}}\right)$; would the value of the ratio $\left(\frac{T_A}{T_B}\right)$ be *greater than*, *less than*, or *equal to* $\left(\frac{E_{th\,A}}{E_{th\,B}}\right)$?

On the bar chart on the next page, the values of the samples' thermal energy are shown at some initial time ("Time Zero"); "Long After" refers to a time long after that initial time. Refer to the set of three bar charts to answer the following questions.

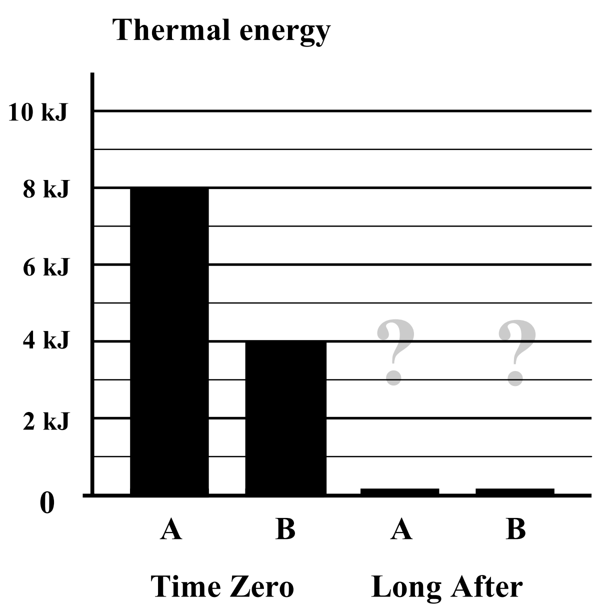
b. Find the absolute temperature of sample *A* at time zero (the initial time), and plot it on the chart.

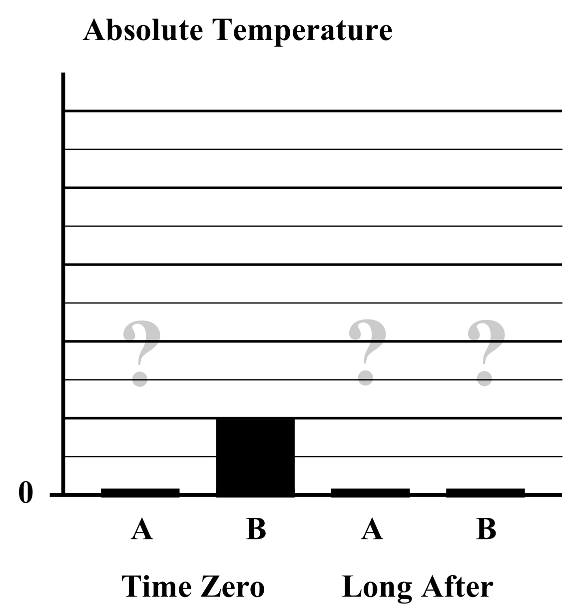
c. After the initial time, would you expect to see any changes in the temperatures of samples *A* and *B*? If yes, describe the changes (i.e., increases or decreases), and explain your answer. If you don't expect to observe any changes, explain why.

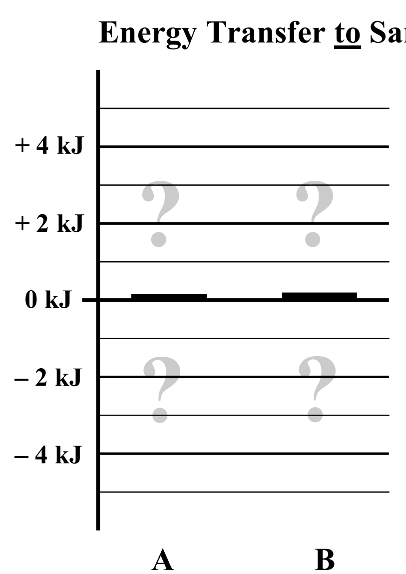
d. A long time after time zero, what ratio do you expect for the temperatures of the two samples? $\frac{T_A}{T_B}$ = _____?

e. A long time after time zero, what ratio do you expect for the thermal energies of the two samples? $\frac{E_{th\,A}}{E_{th\,B}}$ = ______? Explain.

f. Complete the bar charts by finding the "Long After" values for temperature and thermal energy, and also the amounts of energy transferred to each sample. (This is the net transfer that occurs between time zero and the time "long after.") If any quantity is zero, label that quantity as zero on the bar chart. Explain your reasoning below. *NOTE: The missing values (indicated by a thick line on the horizontal axis) are* *not* *necessarily zero – you need to determine whether or not they are actually zero!*







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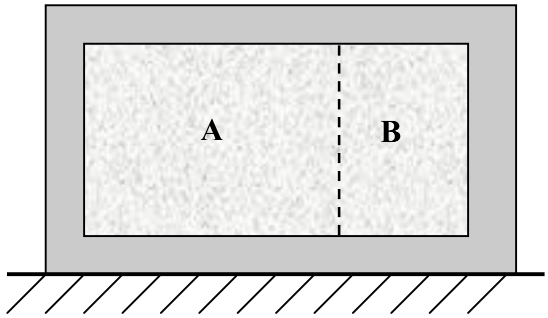
2. Suppose we again have two samples, *A* and *B*, of an **ideal gas** placed in a partitioned insulated container. The gas in Sample *A* is the **same gas** that is in Sample *B*; however, Sample *A* now has **twice the mass** of sample *B* **(**and the volume of sample *A* is twice the volume of sample *B*). Energy but no material can pass through the conducting partition; the partition is rigid and cannot move.



a. Consider the two ***unequal*** masses of ideal gas, *A* and *B*:

i. If *A* and *B* have the same thermal energy, will their temperature be the same, or different? (Is the average kinetic energy *per molecule* the same, or different?)

ii. After the initial time, would you expect to see any changes in the temperatures of samples *A* and *B*? If yes, describe the changes (i.e., increases or decreases). If you don't expect to observe any changes, explain why.

On the bar chart on the next page, the values of the samples' thermal energy are shown at some initial time ("Time Zero"); "Long After" refers to a time long after that initial time. ***In this case,* A *and* B *do NOT have the same* initial *thermal energy.*** *Refer to the set of three bar charts to answer the following questions.*

b. Find the absolute temperature of sample *A* at time zero (the initial time), and plot it on the chart.

c. A long time after time zero, what ratio do you expect for the temperatures of the two samples? $\frac{T_A}{T_B}$ = _____?

d. A long time after time zero, what ratio do you expect for the thermal energies of the two samples? $\frac{E_{th\,A}}{E_{th\,B}}$ = _____? Explain.

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e. Complete the bar charts by finding the "Long After" values for temperature and thermal energy, and also the amounts of energy transferred to each sample. (This is the net transfer that occurs between time zero and the time "long after.") If any quantity is zero, label that quantity as zero on the bar chart. Explain your reasoning below. *NOTE: The missing values – indicated by a thick line on the horizontal axis – are* <u>*not*</u> *necessarily zero – you need to determine whether or not they are actually zero!*