July 16, Week 7

Today: Temperature and Heat, Chapter 11

Final Homework #7 now available. Due Monday at 5:00PM.

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

<u>Temperature</u> - A measure of the average kinetic energy of the molecules

“Measure” $\Rightarrow$ A number directly proportional to the average kinetic energy

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

Temperature - A measure of the average kinetic energy of the molecules

"Measure" $\Rightarrow$ A number directly proportional to the average kinetic energy

In the U.S. there are currently three temperature scales used:

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

Temperature - A measure of the average kinetic energy of the molecules

"Measure" $\Rightarrow$ A number directly proportional to the average kinetic energy

In the U.S. there are currently three temperature scales used:

Celsius scale

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

<u>Temperature</u> - A measure of the average kinetic energy of the molecules

"Measure" $\Rightarrow$ A number directly proportional to the average kinetic energy

In the U.S. there are currently three temperature scales used:

<u>Celsius scale</u> - Pure water at sea level freezes at $0^\circ C$ and boils at $100^\circ C$

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

Temperature - A measure of the average kinetic energy of the molecules

"Measure" $\Rightarrow$ A number directly proportional to the average kinetic energy

In the U.S. there are currently three temperature scales used:

Celsius scale - Pure water at sea level freezes at $0^\circ C$ and boils at $100^\circ C$

Fahrenheit scale

Temperature

In all phases, the molecules have random speeds. (In liquids and gases, the molecules have random directions too.)

Temperature - A measure of the average kinetic energy of the molecules

"Measure" $\Rightarrow$ A number directly proportional to the average kinetic energy

In the U.S. there are currently three temperature scales used:

Celsius scale - Pure water at sea level freezes at $0^\circ\, C$ and boils at $100^\circ\, C$

Fahrenheit scale - Pure water at sea level freezes at $32^\circ\, F$ and boils at $212^\circ\, F$

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

On the Kelvin scale, absolute zero $= 0\,K$ (No degree sign.)

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

On the Kelvin scale, absolute zero $= 0\,K$ (No degree sign.)

The spacing on the Kelvin scale was chosen to be the same as the Celsius scale

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

On the Kelvin scale, absolute zero $= 0\,K$ (No degree sign.)

The spacing on the Kelvin scale was chosen to be the same as the Celsius scale $\Rightarrow$

$$\boxed{\Delta T(K) = \Delta T(^\circ C)}$$

So any equation with ΔT can use either Kelvin or Celsius

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

On the Kelvin scale, absolute zero $= 0\,K$ (No degree sign.)

The spacing on the Kelvin scale was chosen to be the same as the Celsius scale $\Rightarrow$

$$\boxed{\Delta T(K) = \Delta T(^\circ C)}$$

So any equation with ΔT can use either Kelvin or Celsius

From experiment, $0\,K = -273^\circ C$

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

On the Kelvin scale, absolute zero $= 0\,K$ (No degree sign.)

The spacing on the Kelvin scale was chosen to be the same as the Celsius scale $\Rightarrow$

$$\boxed{\Delta T(K) = \Delta T(^\circ C)}$$

So any equation with ΔT can use either Kelvin or Celsius

From experiment, $0\,K = -273^\circ C \Rightarrow \boxed{T(K) = T(^\circ C) + 273}$

Kelvin Scale

The Kelvin scale is based on the physical definition of temperature.

Lower temperature $\Rightarrow$ lower kinetic energy $\Rightarrow$ slower speeds

<u>Absolute Zero</u> - The lowest possible temperature. At absolute zero, all molecular motion would stop.

On the Kelvin scale, absolute zero $= 0\,K$ (No degree sign.)

The spacing on the Kelvin scale was chosen to be the same as the Celsius scale $\Rightarrow$

$$\boxed{\Delta T(K) = \Delta T(^\circ C)}$$

So any equation with ΔT can use either Kelvin or Celsius

From experiment, $0\,K = -273^\circ C \Rightarrow \boxed{T(K) = T(^\circ C) + 273}$

Also, $\boxed{T(^\circ C) = \frac{5}{9}\left(T(^\circ F) - 32^\circ\right)}$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

(b) $100°F$, $100°C$, $100\,K$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

(b) $100°F$, $100°C$, $100\,K$

(c) $100\,K$, $100°C$, $100°F$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

(b) $100°F$, $100°C$, $100\,K$

(c) $100\,K$, $100°C$, $100°F$

(d) $100\,K$, $100°F$, $100°C$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

(b) $100°F$, $100°C$, $100\,K$

(c) $100\,K$, $100°C$, $100°F$

(d) $100\,K$, $100°F$, $100°C$

(e) $100°C$, $100\,K$, $100°F$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

(b) $100°F$, $100°C$, $100\,K$

(c) $100\,K$, $100°C$, $100°F$

(d) $100\,K$, $100°F$, $100°C$

(e) $100°C$, $100\,K$, $100°F$

Temperature Exercise

Which of the following is the correct ranking of temperatures from coldest to hottest?

(a) $100°C$, $100°F$, $100\,K$

(b) $100°F$, $100°C$, $100\,K$

(c) $100\,K$, $100°C$, $100°F$

$$100\,K = -173°C = -279°F$$

(d) $100\,K$, $100°F$, $100°C$

$$100°C = 212°F = 373\,K$$

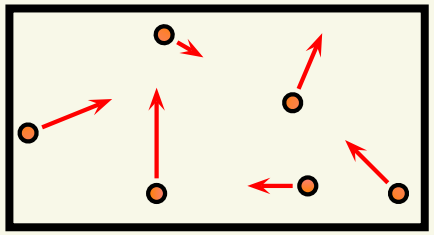
(e) $100°C$, $100\,K$, $100°F$

Ideal Gas

In the case of an Ideal Gas, the relationship between the average kinetic energy of the molecules and the temperature was discovered by Ludwig Boltzmann.

Ideal Gas

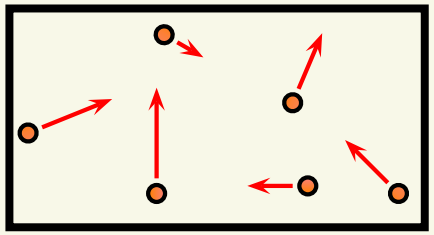
In the case of an Ideal Gas, the relationship between the average kinetic energy of the molecules and the temperature was discovered by Ludwig Boltzmann.



Ideal Gas - A gas with no interaction between the molecules except for their random, elastic collisions.

Ideal Gas

In the case of an Ideal Gas, the relationship between the average kinetic energy of the molecules and the temperature was discovered by Ludwig Boltzmann.



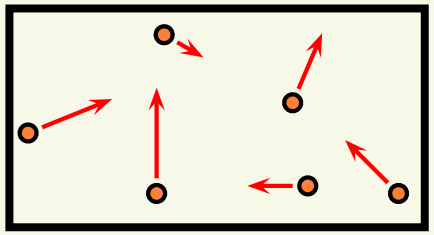
Ideal Gas - A gas with no interaction between the molecules except for their random, elastic collisions.

$$K_{av} = \frac{3}{2} k_B T$$

Average kinetic energy for a single molecule in an ideal gas

Ideal Gas

In the case of an Ideal Gas, the relationship between the average kinetic energy of the molecules and the temperature was discovered by Ludwig Boltzmann.



Ideal Gas - A gas with no interaction between the molecules except for their random, elastic collisions.

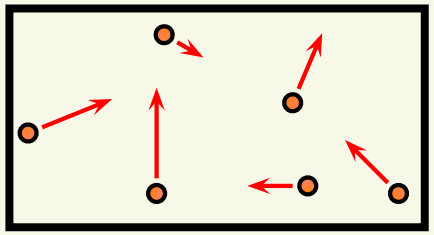
$$K_{av} = \frac{3}{2} k_B T$$

Average kinetic energy for a single molecule in an ideal gas

$k_B = 1.38 \times 10^{-23}\ J/K =$ the Boltzmann constant

Ideal Gas

In the case of an Ideal Gas, the relationship between the average kinetic energy of the molecules and the temperature was discovered by Ludwig Boltzmann.



Ideal Gas - A gas with no interaction between the molecules except for their random, elastic collisions.

$$K_{av} = \frac{3}{2} k_B T$$

Average kinetic energy for a single molecule in an ideal gas

$k_B = 1.38 \times 10^{-23}\ J/K =$ the Boltzmann constant

$$E_{th} = \frac{3}{2} N k_B T$$

Thermal energy of an ideal gas with N total molecules

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

(b) $\Delta E_{th} = \frac{3}{2} N k_B (20)$

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

(b) $\Delta E_{th} = \frac{3}{2} N k_B (20)$

(c) $\Delta E_{th} = \frac{3}{2} N k_B (30)$

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

(b) $\Delta E_{th} = \frac{3}{2} N k_B (20)$

(c) $\Delta E_{th} = \frac{3}{2} N k_B (30)$

(d) $\Delta E_{th} = \frac{3}{2} N k_B (50)$

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

(b) $\Delta E_{th} = \frac{3}{2} N k_B (20)$

(c) $\Delta E_{th} = \frac{3}{2} N k_B (30)$

(d) $\Delta E_{th} = \frac{3}{2} N k_B (50)$

(e) There is not enough information since I don't have my calculator and so can't convert Celsius into Kelvin

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

(b) $\Delta E_{th} = \frac{3}{2} N k_B (20)$

(c) $\Delta E_{th} = \frac{3}{2} N k_B (30)$

(d) $\Delta E_{th} = \frac{3}{2} N k_B (50)$

(e) There is not enough information since I don't have my calculator and so can't convert Celsius into Kelvin

Ideal Gas Exercise

An ideal gas has its temperature increased from $20°C$ to $50°C$, without gaining or losing molecules. What was the change in the gas's thermal energy, ΔE_{th}?

(a) $\Delta E_{th} = 0$

(b) $\Delta E_{th} = \frac{3}{2} N k_B (20)$

$$\Delta E_{th} = \frac{3}{2} N k_B \Delta T$$

$$\Delta T(K) = \Delta T(°C)$$

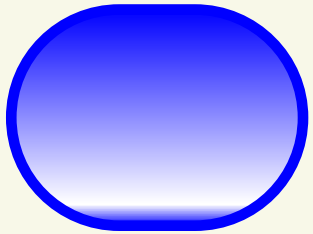
(c) $\Delta E_{th} = \frac{3}{2} N k_B (30)$

(d) $\Delta E_{th} = \frac{3}{2} N k_B (50)$

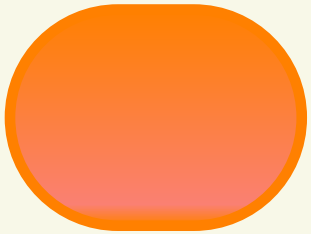
(e) There is not enough information since I don't have my calculator and so can't convert Celsius into Kelvin

Heat

<u>Heat</u> - Transfer of energy between the molecules of two different temperature objects that results in a change in the thermal energy of both.



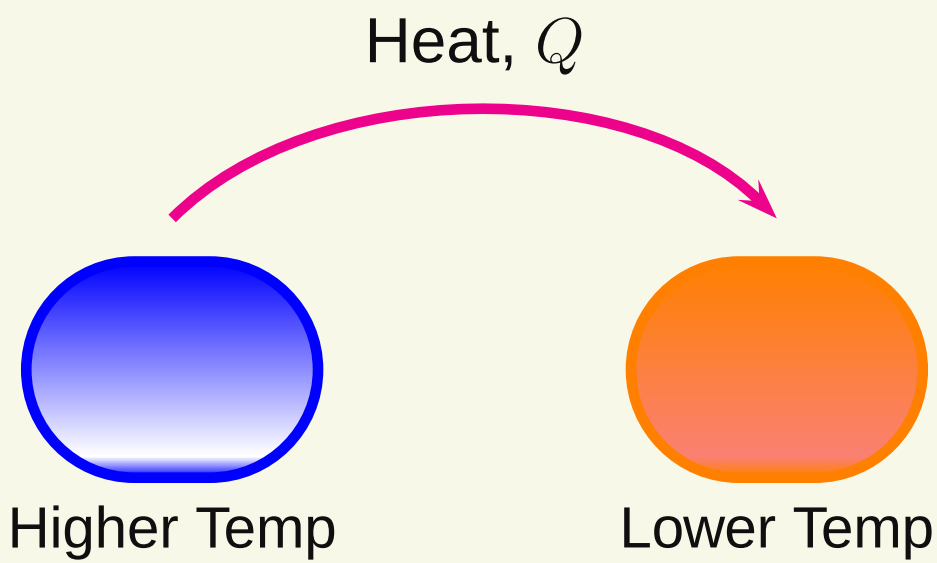
Higher Temp



Lower Temp

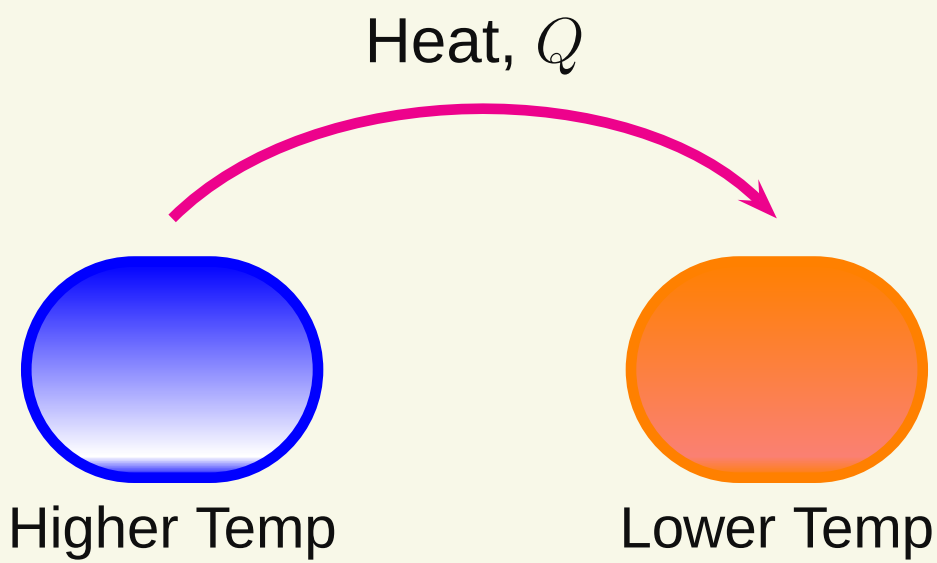
Heat

<u>Heat</u> - Transfer of energy between the molecules of two different temperature objects that results in a change in the thermal energy of both.



Heat

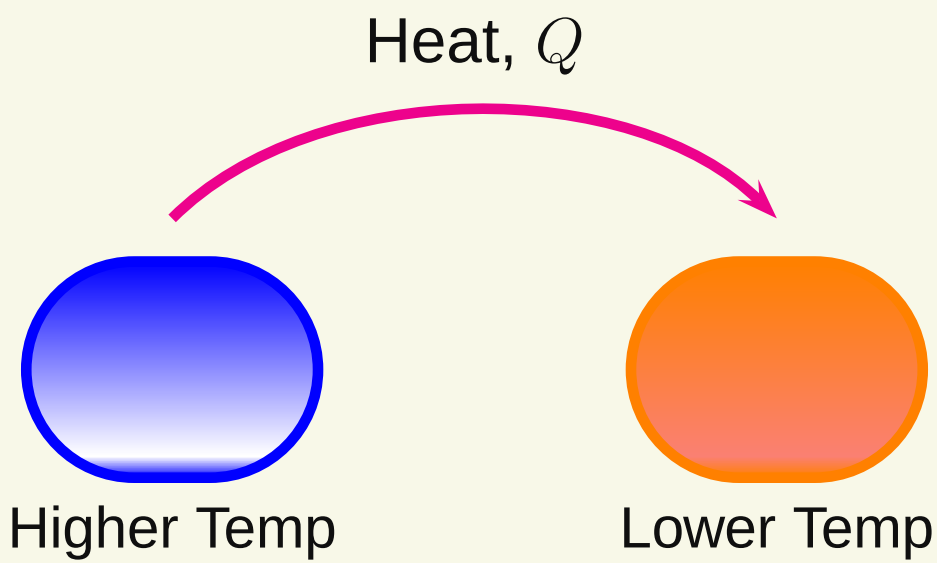
<u>Heat</u> - Transfer of energy between the molecules of two different temperature objects that results in a change in the thermal energy of both.



The higher temperature object has more energy so conservation $\Rightarrow$ heat spontaneously flows from higher to lower temperature

Heat

Heat - Transfer of energy between the molecules of two different temperature objects that results in a change in the thermal energy of both.



The higher temperature object has more energy so conservation $\Rightarrow$ heat spontaneously flows from higher to lower temperature

Thermal Equilibrium - The net heat transfer stops when two objects reach the same temperature

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Just the thermal energy of one object

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Positive $Q \Rightarrow$ increase in thermal energy so on left side

Just the thermal energy of one object

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

W_{other} is just called W here

Positive $Q \Rightarrow$ increase in thermal energy so on left side

Just the thermal energy of one object

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Speed of the center of gravity

W_{other} is just called W here

Positive $Q \Rightarrow$ increase in thermal energy so on left side

Just the thermal energy of one object

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Speed of the center of gravity

W_{other} is just called W here

Positive $Q \Rightarrow$ increase in thermal energy so on left side

Just the thermal energy of one object

For an object that has no change in potential energy or kinetic energy of its center: $v_i = v_f$, $y_i = y_f$, $s_i = s_f$

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Speed of the center of gravity

W_{other} is just called W here

Positive $Q \Rightarrow$ increase in thermal energy so on left side

Just the thermal energy of one object

For an object that has no change in potential energy or kinetic energy of its center: $v_i = v_f$, $y_i = y_f$, $s_i = s_f$

First Law of Thermodynamics: $\boxed{W + Q = \Delta E_{th}}$

Thermodynamics

In 1840, James Joule discovered that work being done to an object can also cause a change in thermal energy

$$\frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}ks_i^2 + W + Q = \frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}ks_f^2 + \Delta E_{th}$$

Speed of the center of gravity

W_{other} is just called W here

Positive $Q \Rightarrow$ increase in thermal energy so on left side

Just the thermal energy of one object

For an object that has no change in potential energy or kinetic energy of its center: $v_i = v_f$, $y_i = y_f$, $s_i = s_f$

First Law of Thermodynamics: $\boxed{W + Q = \Delta E_{th}}$

"Motion" of Heat

First Law of Thermodynamics

First Law of Thermodynamics: $\boxed{W + Q = \Delta E_{th}}$

First Law of Thermodynamics

First Law of Thermodynamics: $\boxed{W + Q = \Delta E_{th}}$

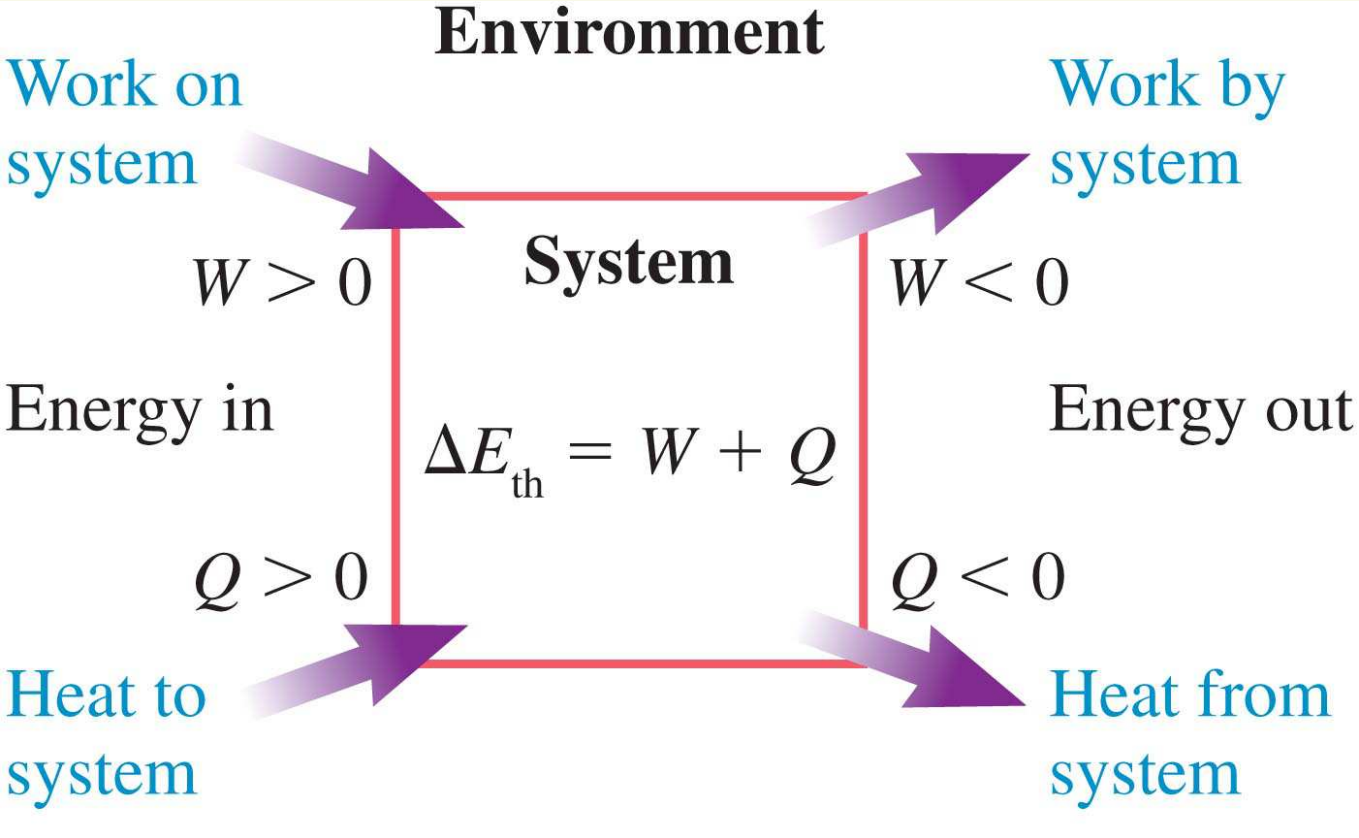
There are two ways to change the thermal energy of on object - Work being done to the object (W) and heat (Q)

First Law Signs

In applying the first law of thermodynamics, we have to think about the “system” = the object that is of interest. Everything else is called the <u>environment</u>

First Law Signs

In applying the first law of thermodynamics, we have to think about the “system” = the object that is of interest. Everything else is called the <u>environment</u>



First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(a) <u>Steam</u> is used to spin a turbine. (Assume the turbine's temperature remains constant.)

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(a) <u>Steam</u> is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) <u>Ice</u> is removed from the freezer and sits on a counter.

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

(d) After 30 minutes of baking, a pan is removed from the oven and sits on a counter.

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

(d) After 30 minutes of baking, a pan is removed from the oven and sits on a counter.

(e) A nail is struck repeatedly with a hammer.

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

(d) After 30 minutes of baking, a pan is removed from the oven and sits on a counter.

(e) A nail is struck repeatedly with a hammer.

First Law Exercise

For which of the following situations is the work positive and the heat zero? In each case, the system has been underlined.

(e) A <u>nail</u> is struck repeatedly with a hammer.

First Law: $W + Q = \Delta E_{th} \Rightarrow W + 0 = \Delta E_{th} \Rightarrow W = \Delta E_{th}$

W is positive $\Rightarrow$ E_{th} will increase $\Rightarrow$ the nail's temperature will increase

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(a) <u>Steam</u> is used to spin a turbine. (Assume the turbine's temperature remains constant.)

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(a) <u>Steam</u> is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) <u>Ice</u> is removed from the freezer and sits on a counter.

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

(d) After 30 minutes of baking, a pan is removed from the oven and sits on a counter.

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

(d) After 30 minutes of baking, a pan is removed from the oven and sits on a counter.

(e) A nail is struck repeatedly with a hammer.

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(a) Steam is used to spin a turbine. (Assume the turbine's temperature remains constant.)

(b) Ice is removed from the freezer and sits on a counter.

(c) An expanding gas inflates a balloon.

(d) After 30 minutes of baking, a pan is removed from the oven and sits on a counter.

(e) A nail is struck repeatedly with a hammer.

First Law Exercise II

For which of the following situations is the work zero and the heat positive? In each case, the system has been underlined.

(b) Ice is removed from the freezer and sits on a counter.

First Law: $W + Q = \Delta E_{th} \Rightarrow 0 + Q = \Delta E_{th} \Rightarrow Q = \Delta E_{th}$

Q is positive $\Rightarrow$ E_{th} will increase $\Rightarrow$ the ice will melt and then increase temperature

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT
Steam is used to spin a turbine. (Assume the turbine's temperature remains constant)				

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT
Steam is used to spin a turbine. (Assume the turbine's temperature remains constant)	$-$	0	$-$	$-$

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT
Steam is used to spin a turbine. (Assume the turbine's temperature remains constant)	$-$	0	$-$	$-$
An expanding gas inflates a balloon				

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT
Steam is used to spin a turbine. (Assume the turbine's temperature remains constant)	$-$	0	$-$	$-$
An expanding gas inflates a balloon	$-$	0	$-$	$-$

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT
Steam is used to spin a turbine. (Assume the turbine's temperature remains constant)	$-$	0	$-$	$-$
An expanding gas inflates a balloon	$-$	0	$-$	$-$
After 30 minutes of baking, a pan is removed from the oven and sits on a counter				

First-Law Followup

Process	W	Q	ΔE_{th}	ΔT
Steam is used to spin a turbine. (Assume the turbine's temperature remains constant)	$-$	0	$-$	$-$
An expanding gas inflates a balloon	$-$	0	$-$	$-$
After 30 minutes of baking, a pan is removed from the oven and sits on a counter	0	$-$	$-$	$-$