PHYSICS

The Two Laws of Thermodynamics

- _____ **…** means "movement of heat" in Greek. This branch of science was actually started in the early 1800's before atomic theory was prevalent. Therefore macroscopic ideas like: mechanical work, pressure, and temperature held sway – ideas like microscopic analysis of molecules and atoms did not yet come into play.

- **Temperatures …**

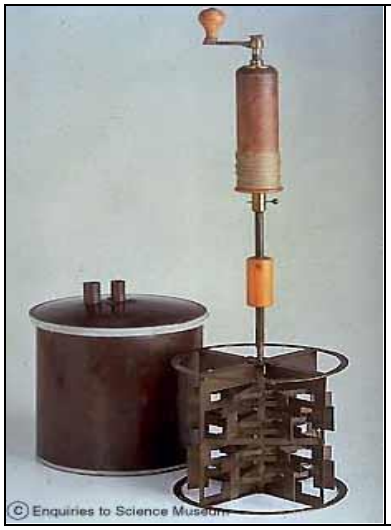
Substance	**Temperature in °K**
• Fusion Reactor	• °K
• Center of Sun	• °K
• Surface of a Hot Star	• °K
• Plasma	• °K
• Surface of the Sun	• °K
• Hot enough to break up all molecules	• °K
• Iron melts	• °K
• Water Boils	• °K
• Ice Melts	• °K
• Dry Ice Vaporizes	• °K
• Nitrogen Boils	• °K
• ABSOLUTE ZERO	• °K

- **The First Law of Thermodynamics:**
  _____
  _____

  (in simple terms) _____ = HEAT GAINED

  (in quantitative terms) heat added to a system = _____ + _____

- **Joule's Experiment …**



As the paddle wheel turned, *mechanical energy* turned into *heat*.

- _____ **…** have expanding or compressing gases that cool or warm up – but do not leave the closed system.
  [Cold air adiabatically expands about 10°C for each km of the upper atmosphere.]

- _____ **…** occurs when air is cooled at a low altitude and stays beneath warmer air above. This can trap smoke, smog, or clouds in flat layers.
  [Smog at Los Angeles or Denver is an example.]

- **QUESTION: If a parcel of air that is 20°C rises 6 km, what will its temperature be?**

- **The Second Law of Thermodynamics:**
  _____

  (in simple terms) HEAT GOES FROM _____

  (in qualitative terms) high energy goes to low energy – _____

- **Heat Engines … change _____ *energy* into _____ *work.***
  [Examples are: refrigerator, air conditioner, steam turbine, car engine, jet engine.]

- **Carnot's Efficiency of a Heat Engine …**

  _____ = ($T_{hot} - T_{cold}$) / T_{hot} *(where T_{hot} and T_{cold} are in Kelvin degrees)*

DERIVATION

- BY DEFINITION: EFFICIENCY = $\frac{\text{WORK OUT}}{\text{HEAT IN}}$
- FROM CONSERVATION OF ENERGY: HEAT IN = WORK OUT + HEAT OUT
- SO ∴: WORK OUT = HEAT IN − HEAT OUT
- SO EFFICIENCY IS: $\frac{(\text{HEAT IN} - \text{HEAT OUT})}{\text{HEAT IN}}$

FOR EXAMPLE:
A STEAM ENGINE AT 400°K WITH A SINK AT 300°K IS 1/4 EFFICIENT — OR 25%.

$$\frac{400-300}{400} = \frac{100}{400} = \frac{1}{4} \text{ or } 25\%$$

(IF YOU COULD RUN THIS ENGINE AT 600°K, YOU'D GET 50% EFFICIENCY!)

- **QUESTION: Which of the two Laws of Thermodynamics is Quantitative (numerically measurable) and which is Qualitative (describing the nature of phenomena)?**

- **_____ … the amount of disorder in a system.**
  Put Laws 1 and 2 together …
  1 says that all of the heat that leaves one area goes to another area, and
  2 says that the heat flow is one way: high to low.
  Therefore, it looks like things are running down – _____ *energy &* _____ *order*.

  Entropy Increasing (_____ order):
  - waterfalls fall (to lower energy)
  - crystals come apart
  - stars cool (and so do planets)
  - engines are inefficient
  - buildings fall
  - energy resources deplete
  - gases spread out to fairly even distribution – not ordered congregations

  Entropy Decreasing (_____ order):
  - a birth
  - the process of life
  - Emerson said that human thought is evolving toward more order.

- **Actual Thinking *through* Thermodynamics**

  - **Since *Heat* can be converted to any other form of _____ and back …**
    - The 1st Law intimates ENERGY IS ALWAYS _____

  - **Since the 2nd Law is a 1 WAY STREET**
    - No *Perpetual Motion* Machines
    - The Universe is _____
    - The Universe is _____ *Down*

  - **At a molecular / atomic level**
    - everything appears to be coming _____
    - everything appears to be decreasing in _____
    - everything appears to be increasing in _____

  - **Even our psychological sense of _____ is based on the 2nd Law**
    - rocks rolling down mountains
    - a water balloon bursting apart
    - try running a movie backwards

- **So is everything obeying *ENTROPY* ??????????????????**
  Paul G. Hewitt, author of the Physics textbook, *Conceptual Physics* writes … "Interestingly enough, the American writer Ralph Waldo Emerson, who lived during the time the second law of thermodynamics was the new science topic of the day, philosophically speculated that not everything becomes more disordered with time and cited the example of human thought. Ideas about the nature of things grow increasingly refined and better organized as they pass through the minds of succeeding generations. Human thought is evolving toward order."

- **Reading into Emerson …**
  - it appears that if ideas "pass through the minds of succeeding generations" … that we may have a _____
  - and it begs the question, where did order come from in the first place?
  - where did diamonds and roses come from? – they are highly _____
  - is it possible that physical things with order come from _____?

Calculations (Advanced Level: Sig Figs & Sci Not)

[For rules on Sig Figs, see http://www.bickart.com/heart/general/ref_significant_figures.html.]

1) **How many calories must a 1.0 gram drop of water be heated to go from 23°C to 87°C?**

2) **How many calories must 150.00 ml of water be heated to go from 23.00°C to 87.00°C?**

3) **How many calories must come out of 1.000 liter of water to cool down from 20.000°C to 19°C?**

4) **How many calories must a .001 gram drop of water be heated to go from -2.00°C to 10.0°C?**

5) **How many calories would a 1.5 liter bottle of water that has been frozen (right at 0.0°C) take to melt?**

6) **How many calories would it take to boil a 400 ml beaker full of 20°C water?**

7) **How many calories would it take to turn a gram of ice (at 0.0000°C) into steam?**

8) *****TUIT*** If you threw a 5.25 kg block of ice at Absolute Zero into a Nuclear Fusion Reactor, how much heat would be absorbed?**

Thermodynamics Worksheet

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• **Iron melts**	• **°K**
• **Water Boils**	• **°K**
• **Ice Melts**	• **°K**
• **Dry Ice Vaporizes**	• **°K**
• **Oxygen Boils**	• **°K**
• **ABSOLUTE ZERO**	• **°K**

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- **the process of life**
- **Emerson said that human thought is evolving toward more order.**

<u>Calculations</u> (Advanced Level: Sig Figs & Sci Not)

9) How many calories must a 5.01 gram drop of water be heated to go from 24.02°C to 87.03°C?

10) How many calories must 350. ml of water be heated to go from 23°C to 89°C?

11) How many calories must come out of 6 liter of water to cool down from 40°C to 19°C?

12) How many calories must a 34.99 gram drop of water be heated to go from -9.07°C to 10°C?

13) How many calories would a 7.2 liter bottle of water that has been frozen (right at 0.0000000°C) take to melt?

14) How many calories would it take to boil a 400. ml beaker full of 30.0°C water?

15) How many calories would it take to turn a gram of ice (at 0.00000°C) into steam?