Chapter 21: Temperature, Heat & Expansion

Review from the Video:

**Temperature** is the average kinetic energy of one molecule

**Heat** is energy in motion (flows from hot to cold)

**Thermal energy** is the total internal kinetic energy of a given quantity of a certain substance.
Review from the Video:

Lakes can not start to freeze until all the water (top to bottom) drops down to 4° C (or 39° f).
4° water is the most dense, this is because ice crystals start to form in liquid water at 4° C (or 39° f).
• Boiling 100° C
• Body Temperature 37 ° C
• Room Temperature 21 ° C
• Freezing 0 ° C
• Same Temperature -40 ° C (-40°F)
• Absolute Zero -273 ° C
#1 Freezing: 0° C  Boiling: 100° C

in C, F & K

On your calculator:

Apps

Sci Tools

Unit Converter

Temp

Highlight given, enter value, hit ENTER

Chose the Unknown hit ENTER

Try -40 C to F
\[ T_f = \frac{9}{5} \cdot T_c + 32 \]

\[ T_K = T_c + 273 \]

\[ T_c = \frac{5}{9} \cdot (T_f - 32) \]
#3 Calibrating a thermometer using ice water and boiling water:

From Lab
Heat energy vs Food energy

calories or Calories?

We use calories, (with a small case c or cal.)

a unit of thermal energy that can raise the temperature of 1 gram of liquid water 1°C
#8 Food Calories are equal to 1,000 (science) calories.

Pecans have about 10 food Calories of energy. So where did Calorie come from?

A common unit of energy in science is the kilocalorie (or 1,000 calories), so kilocalorie = Calorie = 1,000 calories.
#8 How about Joules?

1 calorie = 4.184 Joules

Joules are a measure of energy, in this case Kinetic energy (J), or energy of motion.

How about BTU or British thermal unit? Unit of heat energy that can change the temperature of 1 pound of liquid water 1° F
Heat always goes from areas of high temperature to areas of lower temperature until the two substances reach thermal equilibrium.

(thermometer measures their own temperatures)
Law of Conservation of Energy: energy is never created or destroyed, just transferred.
#5 Which feels hotter at 2 pm, the sand or the water, why?

Which feels hotter at midnight, the sand or the water, why?
<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Heat (cal/ g.°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>.216</td>
</tr>
<tr>
<td>Beryllium</td>
<td>.47</td>
</tr>
<tr>
<td>Brass</td>
<td>.09</td>
</tr>
<tr>
<td>Cadmium</td>
<td>.055</td>
</tr>
<tr>
<td>Copper</td>
<td>.091</td>
</tr>
<tr>
<td>Gold</td>
<td>.031</td>
</tr>
<tr>
<td>Iron</td>
<td>.11</td>
</tr>
<tr>
<td>Lead</td>
<td>.031</td>
</tr>
<tr>
<td>Mercury</td>
<td>.033</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>.25</td>
</tr>
<tr>
<td>Silver</td>
<td>.056</td>
</tr>
<tr>
<td>Tin</td>
<td>.054</td>
</tr>
<tr>
<td>Zinc</td>
<td>.093</td>
</tr>
<tr>
<td><strong>Glass</strong></td>
<td><strong>.20</strong></td>
</tr>
<tr>
<td>Ice</td>
<td>.50</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>.90</td>
</tr>
<tr>
<td>Human Body (average)</td>
<td>.85</td>
</tr>
<tr>
<td>Steam</td>
<td>.48</td>
</tr>
<tr>
<td>Sugar</td>
<td>.27</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td><strong>1.0</strong></td>
</tr>
<tr>
<td>Wood</td>
<td>.42</td>
</tr>
</tbody>
</table>

**Specific heat** refers to the quantity of energy (cal) required to raise the temperature 1° C of 1 gram of that substance.
Which city has the highest average winter temperature, Seattle or Sioux Falls, why?

Seattle: 42° F (200 miles north of us)
Sioux Falls: 17° F

Which city has the highest average summer temperature, Seattle or Sioux Falls, why?

Seattle: 65° F
Sioux Falls: 73° F
How many calories of heat energy does it take to heat my 300 ml of water for tea from 10° C to 90° C?
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\[ Q = \text{heat to change temperature} \]

\[ m = \text{mass} \]

\[ c = \text{specific heat} \]

\[ \Delta T = \text{change in temperature} \]

\[ Q = m \cdot c \cdot \Delta T \]

\[ 24,000 \text{ cal} = 300 \text{ g} \cdot 1 \text{ cal/g}^\circ \text{C} \cdot 80.0^\circ \text{C} \]
How many calories of heat energy does it take to heat my 400 g glass tea mug from 10° C to 90° C?

\[
Q = \text{heat to change temperature} \\
m = \text{mass} \\
c = \text{specific heat} \\
\Delta T = \text{change in temperature}
\]
How many calories of heat energy does it take to heat my 400 g glass tea mug from 10°C to 90°C?

\[ Q = \text{heat to change temperature} \]

\[ m = \text{mass} \]

\[ c = \text{specific heat} \]

\[ \Delta T = \text{change in temperature} \]

\[
6,400 \text{ cal} = 400 \text{ g} \cdot 0.20 \text{ cal/g}^{°}\text{C} \cdot 80.0
\]

How many Joules? \[ 6,400 \cdot 4.184 = 26,800 \]
#6 If I only would have added 5,000 calories of heat energy to my 400 g glass tea mug, what would be the temperature change?

\[ Q = m \cdot c \cdot \Delta T \]

\[ \Delta T = \frac{Q}{m \cdot c} \]

\( Q = \) heat to change temperature
\( m = \) mass
\( c = \) specific heat
\( \Delta T = \) change in temperature
\[ Q = \text{heat to change temperature} \quad \text{GIVEN} \]

\[ m = \text{mass} \quad \text{GIVEN} \]

\[ c = \text{specific heat} \quad \text{GIVEN} \]

\[ \Delta T = \text{change in temperature} \quad \text{UNKNOWN} \]

\[ \Delta T = \frac{Q}{m \cdot c} \]

\[
\begin{align*}
62.5^\circ &= 5,000 \text{ cal} \\
&\quad / (400 \text{ g } \cdot 0.20 \text{ cal/g}^{\circ}\text{C})
\end{align*}
\]

or, the cup would have warmed up from \(10^\circ\text{ C to 72.5}^\circ\text{ C}\)
Thermal energy is the internal kinetic energy associated with the random motion of the submicroscopic particles.

We do not measure thermal energy directly, but a characteristic of it: heat.

Heat is the energy of motion transported by way of contact, from one group of randomly moving particles to another, exclusively as a result of a temperature difference. The energy carriers are most often atoms, molecules, ions, or free electrons. Measured in calories or Joules.
Homework questions

1-5 due today

6-15 work on