Unit 2.2 – Temperature, Thermal Energy, and Heat
We Already Know About This!

- This unit is so that you know there is a difference among the words TEMPERATURE, HEAT, AND THERMAL ENERGY!
Temperature

- **Temperature** – a measure of the average kinetic energy of the individual particles in matter

- When talking about temperature, we usually use the adjective “hot” or “cold.”

- We will begin as scientists to use “high average kinetic energy” or “low average kinetic energy.”
Measuring Temperature

- **Thermometer** – a tool used to measure temperature which consists of a liquid (such as alcohol or mercury) sealed inside a narrow glass tube.

- When the tube is heated, liquid particles heat up and spread out (taking up more space or volume).

- When the tube is cooled, liquid particles cool down and move closer (taking up less space or volume).
Temperature Scales

- **Fahrenheit Scale** – (°F) – in the U.S., Belize, Bahamas, Palau, and the Caymen Islands, Fahrenheit is the official scale. Based on the freezing and boiling point of water, it was created in 1756 by physicist Daniel Gabriel Fahrenheit. 32°F is freezing point of water and 212°F is the boiling point.

- **Celsius Scale** – (°C) – official scale of most countries. Developed by astronomer Anders Celsius in 1743. He made the freezing point of water 0°C and the boiling point 100°C. Improved the Fahrenheit scale by making sure it doesn’t vary at different elevations.

- **Kelvin Scale** – (K) – used in physical sciences. William Thomson, 1st Baron Kelvin created the scale in 1848. Celsius and Kelvin are based on the same scale but K= °C + 273.
  - **Absolute zero** – the temperature where no more energy can be removed from matter. (0 on the Kelvin Scale and -273°C)
<table>
<thead>
<tr>
<th></th>
<th>Kelvin</th>
<th>Celsius</th>
<th>Fahrenheit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute zero</td>
<td>0 K</td>
<td>−273°C</td>
<td>−460°F</td>
</tr>
<tr>
<td>Melting point of H₂O</td>
<td>273 K</td>
<td>0°C</td>
<td>32°F</td>
</tr>
<tr>
<td>Normal Human Body Temperature</td>
<td>310 K</td>
<td>37.0°C</td>
<td>98.6°F</td>
</tr>
<tr>
<td>Water's boiling point</td>
<td>373 K</td>
<td>100 °C</td>
<td>212 °F</td>
</tr>
</tbody>
</table>

Especially Know What is in **BOLD**. It will be on the test.
Converting Fahrenheit to Celsius

- To convert a Fahrenheit temperature to a Celsius temperature, use the following formula:
  \[ °C = \frac{5}{9} (°F - 32) \]
- For example, if the temperature in your classroom is 68°F, what is the temperature in degrees Celsius?
  \[ °C = \frac{5}{9} (68 - 32) \]
  \[ °C = \frac{5}{9} \times 36 \]
  \[ °C = 20 \]
- The temperature of your classroom is 20°C.
- Anytime you leave this country, you can convert the temperature outside to a scale you understand.
Thermal Energy

- **Thermal Energy** – the total energy of all the particles in an object

- The thermal energy of an object depends on 3 measurements:
  1. The number of particles in an object
  2. The temperature of the object
  3. The arrangement of the object’s particles

- The more particles an object has at a given temperature, the more thermal energy.
  - Example: You have a 1 Liter pot of hot chocolate compare to a 0.2 Liter mug of hot chocolate at 75 K. Which has more thermal energy?
Heat

- Heat – thermal energy transferred from matter at a higher temperature to matter at a lower temperature.

- In simpler terms, HEAT IS THERMAL ENERGY MOVING FROM A WARMER OBJECT TO A COOLER OBJECT.

- When you hold an ice cube in your hand, the ice cube melts because thermal energy is transferred from your hand to the ice. Your hand feels cold since it is losing thermal energy.
Specific Heat

- Specific heat – the amount of energy required to raise the temperature of 1 kg of a material by 1 Kelvin. (units J/ (kg*K))

- If you are running on sand on a beach toward the water, you probably noticed that the sand is always hotter than the water. The specific heat of water is higher than the specific heat of sand.

- Every different material on the Earth has a different specific heat or the amount of heat required to raise the temperature of an object.
## Specific Heat of Common Material

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Heat (J/(kg*K))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>4180</td>
</tr>
<tr>
<td>Ice</td>
<td>2060</td>
</tr>
<tr>
<td>Aluminum</td>
<td>903</td>
</tr>
<tr>
<td>Glass</td>
<td>837</td>
</tr>
<tr>
<td>Sand</td>
<td>800</td>
</tr>
<tr>
<td>Iron</td>
<td>450</td>
</tr>
<tr>
<td>Copper</td>
<td>385</td>
</tr>
<tr>
<td>Silver</td>
<td>235</td>
</tr>
</tbody>
</table>

- A material with a high specific heat can absorb a great deal of thermal energy without a great change in temperature.

- The specific heat of water is 4180 J/(kg*K). That means it takes 4180 Joules of energy to raise 1 kilogram of water 1 degree Kelvin.

Water has the highest specific heat which means it takes a high amount of energy to raise the temperature of water.
Specific Heat

- There is an equation to calculate the amount of energy gained or lost by a material.

- You will need the mass of the material, the change in temperature, and the specific heat of the object.

- Example: How much heat is required to raise the temperature of 5 kilograms of water by 10 Kelvin? (specific heat of water is 4180 J from table on previous slide)

\[
\Delta E = (\text{mass}) \times (\text{specific heat}) \times (\text{change in temperature})
\]

\[
\Delta E = (5 \text{ kg}) \times (4180 \text{ J/ (kg*K)}) \times (10 \text{ K})
\]

\[
\Delta E = 209,000 \text{ J}
\]
# Temperature, Thermal Energy, and Heat Comparison

<table>
<thead>
<tr>
<th>Energy Measured</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>Temperature</td>
<td>Average kinetic energy of particles</td>
</tr>
<tr>
<td>Thermal Energy</td>
<td></td>
</tr>
<tr>
<td>Heat</td>
<td></td>
</tr>
</tbody>
</table>