Biothermal physics

First lecture

Introduction to Heat

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Third Stage

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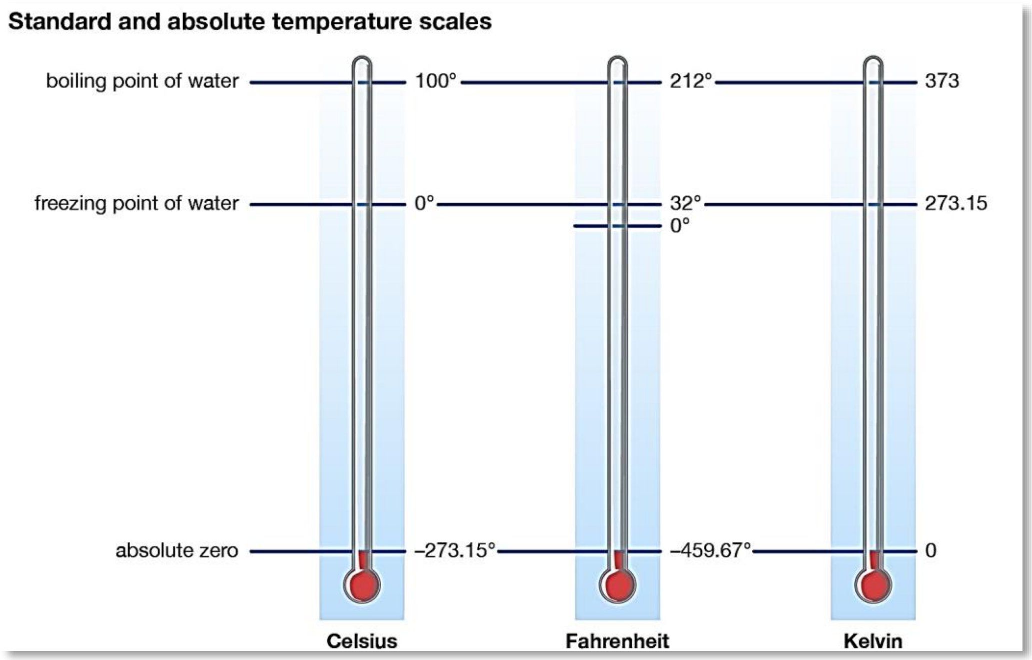
1. *What is Heat?*

- ***Heat*** is the form of energy that is transferred between two materials of different temperature.
- This transfer of energy occurs because of differences in the average translational kinetic energy per molecule in the two materials.
- Heat flows from the material with higher temperature to the material with lower temperature.
- The SI unit of heat is the joule, where 1 joule = 1 newton × meter.

2. *What is Temperature?*

Temperature is a measure of average translational kinetic energy per molecule in a substance.

Temperature scales are Fahrenheit, Celsius and Kelvin.



- In Fahrenheit scale, water freezes at 32° and boils at 212°.
- On the Celsius scale, water freezes at 0°and boils at 100 °.
- The scientific standard, is the Kelvin scale. 0 Kelvin is equal to -273.15° Celsius.

Converting Between Celsius, Kelvin, and Fahrenheit Scales

To Convert From…	**Use This Equation**
Celsius to Fahrenheit	$T_{°F} = 9/5\ T_{°C} + 32$
Fahrenheit to Celsius	$T_{°C} = 5/9\ (T_{°F} - 32)$
Celsius to Kelvin	$T_K = T_{°C} + 273.15$
Kelvin to Celsius	$T_{°C} = T_K - 273.15$
Fahrenheit to Kelvin	$T_K = 5/9\ (T_{°F} - 32) + 273.15$
Kelvin to Fahrenheit	$T_{°F} = 9/5\ (T_K - 273.15) + 32$

- ✓ Atoms and molecules are constantly in motion, bouncing off one another in random directions. Recall that kinetic energy is the energy of motion, and that it increases in proportion to velocity squared.
- ✓ Thermal energy is the energy associated with heat is the average kinetic energy of the particles (molecules or atoms) in a substance.
- ✓ Faster moving molecules have greater kinetic energies, and so the substance has greater thermal energy, and thus a higher temperature.
- ✓ The total internal energy of a system is the sum of the kinetic and potential energies of its atoms and molecules.
- ✓ Thermal energy is one of the subcategories of internal energy, as is chemical energy.

Q: 1. What is 12.0 °C in kelvins?

2. What is 32.0 °C in degrees Fahrenheit?

3. What is used to measure temperature?

4. what the difference between heat and temperature?

3. Types of heat

There are three types of heat:

1. Perceptible heat is the heat that can cause a change and a difference in the temperature of a substance.

2. Latent heat, a specific amount of energy is required to change the solid form of a particular substances into a liquid or the liquid into a gas. It is energy required for change of state

3. Specific heat the quantity of heat required to raise the temperature of one gram of a substance by one Celsius degree. The units of specific heat are usually calories or joules per gram per Celsius degree. example, the specific heat of water is 1 calorie (or 4.186 joules) per gram per Celsius degree.

$$c = \frac{\Delta E}{m\Delta\theta}$$

$$\Delta E = mc\Delta\theta$$

m = mass (kg)
c = specific heat capacity (J/kg°C)
ΔE = change in thermal energy (J)
$\Delta\theta$= change in temperature (°C)

Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

Example

A 250g copper pipe is heated from 10°C to 31°C. What is the energy needed to heat the pipe? The specific heat capacity of copper is 390 $J/kg^{-1}°C^{-1}$.

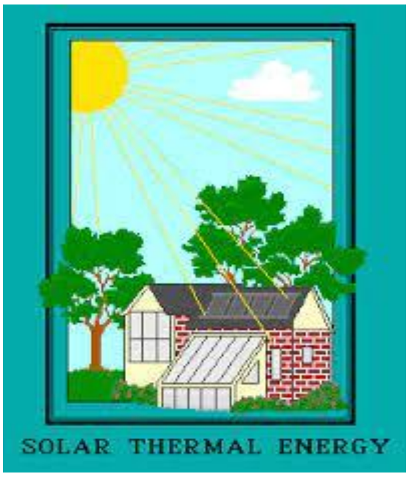
$$\Delta E = mc\Delta\theta$$

$m = 250g \times 10^{-3} = 0.25$ kg, $\Delta\theta = 31 - 10 = 21°C$

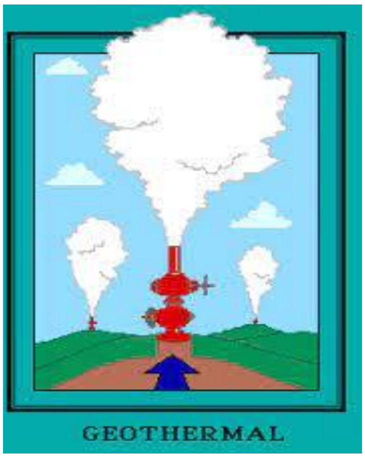
$\Delta E = 0.25 \text{ kg} \times 390\ J/kg^{-1}°C^{-1} \times 21°C = 2048J$

4. Natural Sources of Heat Energy

- Solar Energy: The sun's energy travels to Earth as electromagnetic radiation.

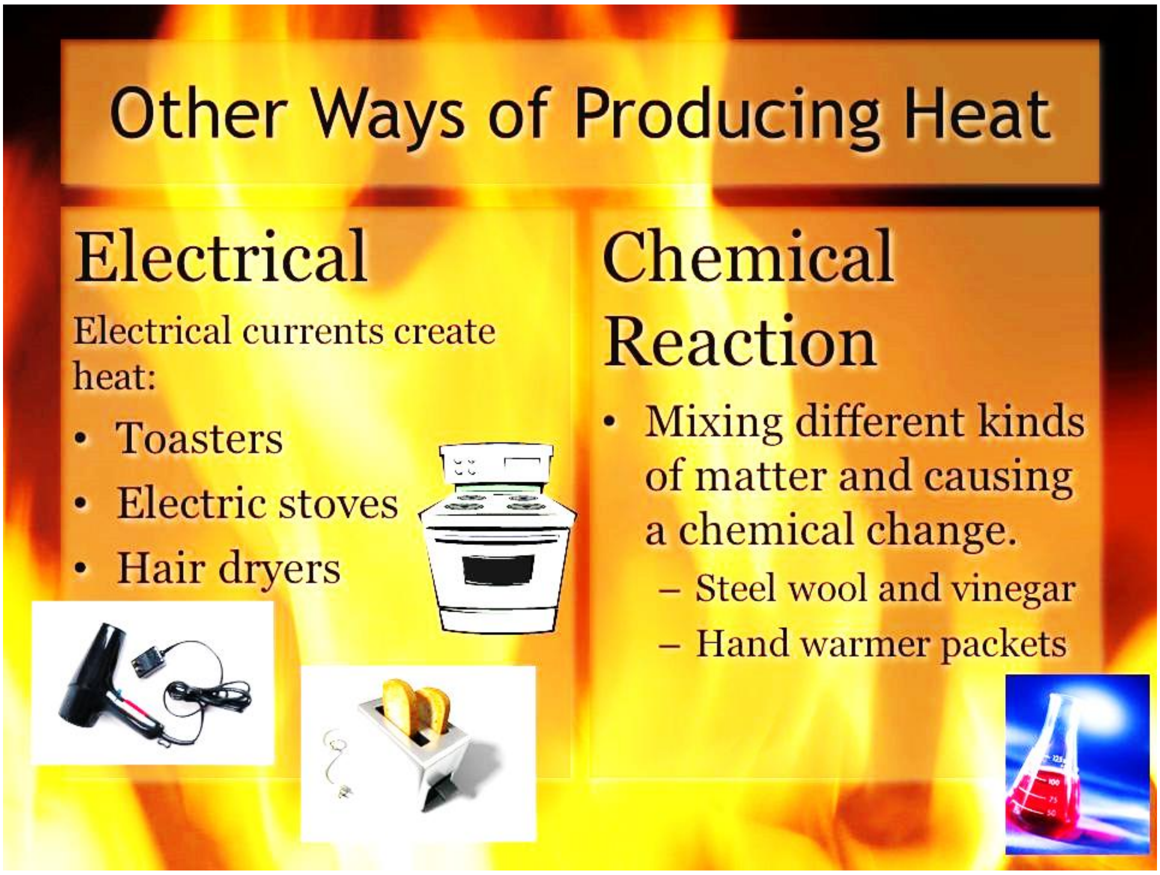


- Geothermal Energy: The heat is produced within Earth's core, which is made of solid iron surrounded by molten lava. The core is hotter than the surface of the sun. The energy is produced by the radioactive decay of particles of rocks, creating the magma.



- Biomass: Animal and plant products give us natural heat energy. When we eat hamburgers, an animal source, or salad, a plant source, we get heat energy in the form of calories, which fuels us. When we burn types of plant products, such as trees, heat energy is created. Heat energy from biomass-plant and animal products-is originally from the sun. Plants use heat energy directly from the sun to grow through the process of photosynthesis. Animals eat the plants to get energy. Humans eat plants as well as animals for energy.

- Fossil Fuels: Solid fuel, such as coal, and gaseous fuel, such as petroleum, are natural sources of heat energy. These fuels are created over millions of years from the remains of plants and animals. We find them in deposits beneath the surface of the earth. When humans ignite fossil fuels, the fuels combust, creating heat energy.


Other Ways of Producing Heat
Electrical
Electrical currents create heat:
• Toasters
• Electric stoves
• Hair dryers
Chemical Reaction
• Mixing different kinds of matter and causing a chemical change.
– Steel wool and vinegar
– Hand warmer packets