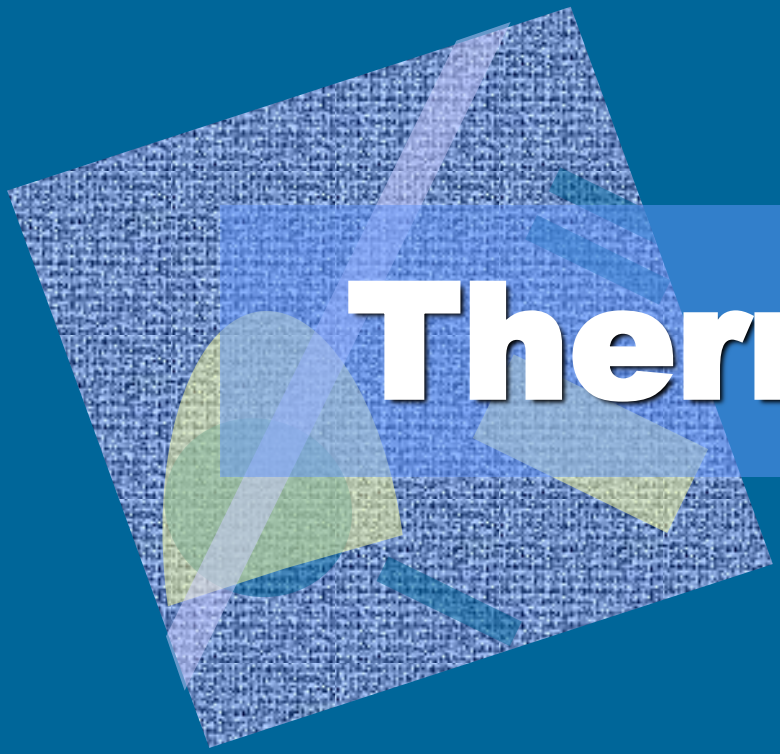


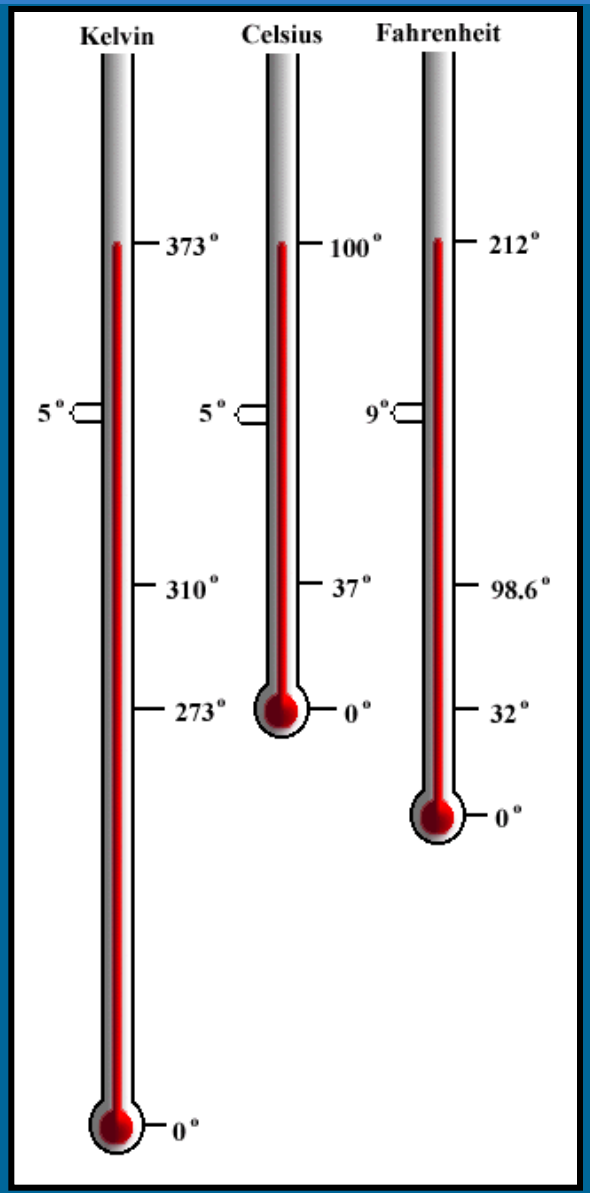
Thermal Energy

Thermal Energy

- Temperature
- Thermal Energy
- Heat Transfer

A. Temperature

- **Temperature**
  - measure of the average KE of the particles in a sample of matter

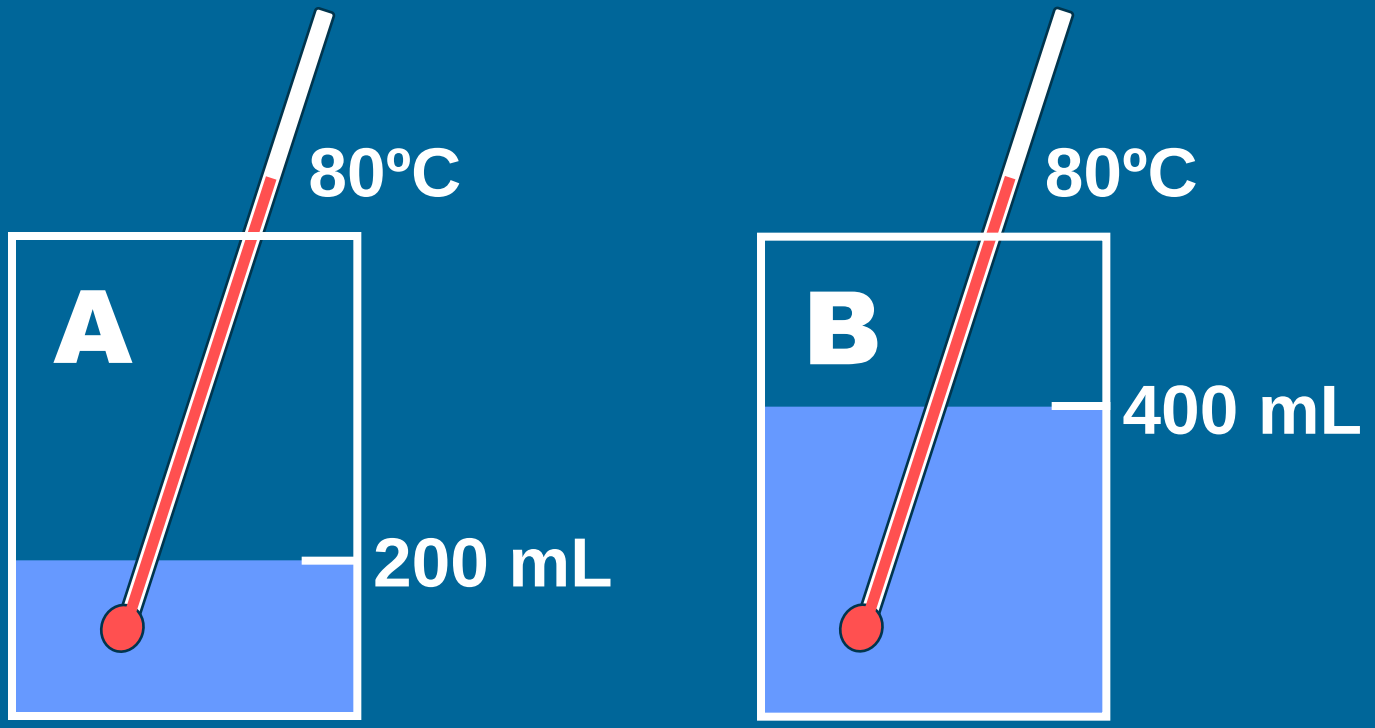


B. Thermal Energy

- **Thermal Energy**
  - the total energy of the particles in a material
  - **KE** - movement of particles
  - **PE** - forces within or between particles due to position
  - depends on temperature, mass, and type of substance

B. Thermal Energy

- Which beaker of water has more thermal energy?
  - B - same temperature, more mass

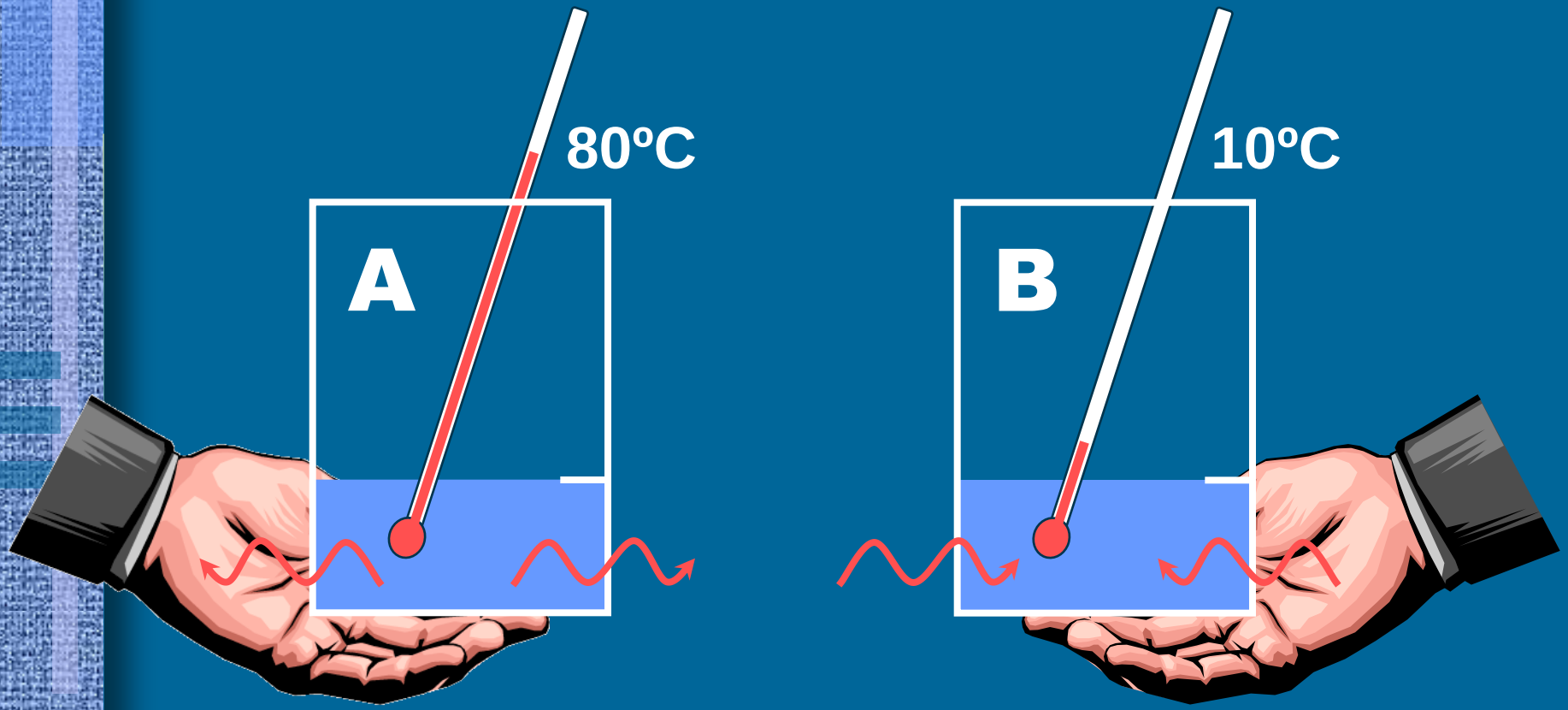


C. Heat Transfer

- **Heat**
  - thermal energy that flows from a warmer material to a cooler material
- Like work, heat is...
  - measured in joules (J)
  - a transfer of energy

C. Heat Transfer

- Why does A feel hot and B feel cold?
  - Heat flows from A to your hand = hot.
  - Heat flows from your hand to B = cold.



C. Heat Transfer

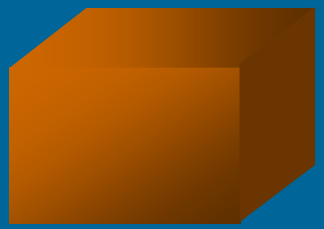
- **Specific Heat (C_p)**
  - amount of energy required to raise the temp. of 1 kg of material by 1 degree Kelvin
  - units: J/(kg·K) or J/(kg·°C)

Specific Heat Values (J/(kg·K))	
Water	4184
Alcohol	2450
Aluminum	920
Carbon (graphite)	710
Sand	664
Iron	450
Copper	380
Silver	235

C. Heat Transfer

- Which sample will take longer to heat to 100°C?

50 g Al



50 g Cu

Specific Heat Values (J/(kg·K))	
Water	4184
Alcohol	2450
Aluminum	920
Carbon (graphite)	710
Sand	664
Iron	450
Copper	380
Silver	235

- Al - It has a higher specific heat.
- Al will also take longer to cool down.

C. Heat Transfer

$$Q = m \times \Delta T \times C_p$$

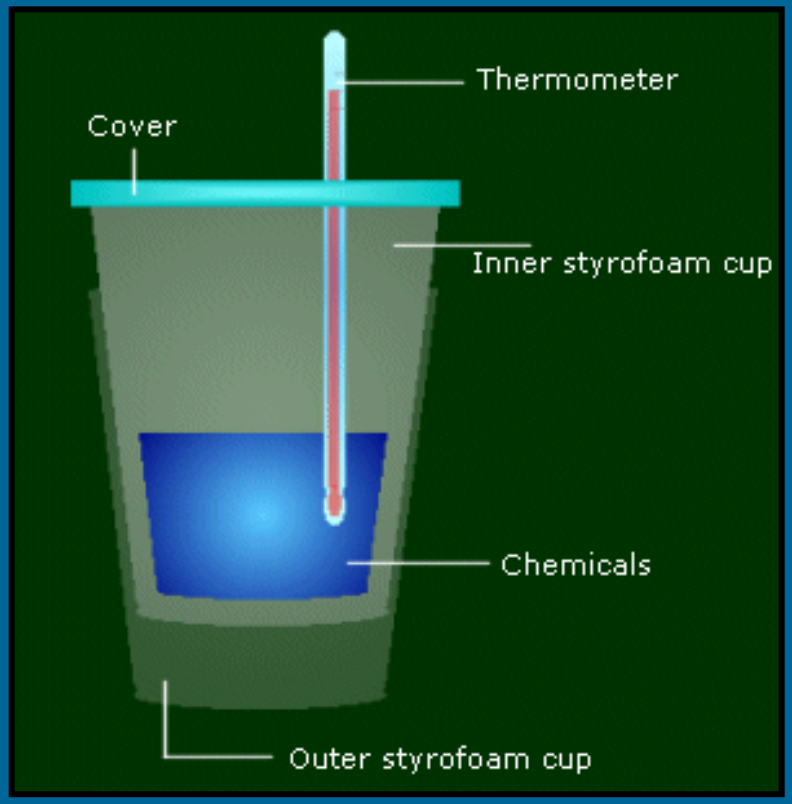
Q: heat (J)
m: mass (kg)
ΔT: change in temperature (K or °C)
C_p: specific heat (J/kg·K)

$\Delta T = T_f - T_i$

– Q = heat loss
+ Q = heat gain

C. Heat Transfer

- **Calorimeter**
  - device used to measure changes in thermal energy
  - in an insulated system,



Coffee cup Calorimeter

heat gained = heat lost

C. Heat Transfer

- A 32-g silver spoon cools from 60°C to 20°C. How much heat is lost by the spoon?

GIVEN:	WORK:
$m = 32\ g$	$Q = m \cdot \Delta T \cdot C_p$
$T_i = 60°C$	$m = 32\ g = 0.032\ kg$
$T_f = 20°C$	$\Delta T = 20°C - 60°C = -40°C$
$Q = ?$	$Q = (0.032kg)(-40°C)(235J/kg \cdot K)$
$C_p = 235\ J/kg \cdot K$	**$Q = -301\ J$**

C. Heat Transfer

- How much heat is required to warm 230 g of water from 12°C to 90°C?

GIVEN:	WORK:
$m = 230\ g$	$Q = m \cdot \Delta T \cdot C_p$
$T_i = 12°C$	$m = 230\ g = 0.23\ kg$
$T_f = 90°C$	$\Delta T = 90°C - 12°C = 78°C$
$Q = ?$	$Q = (0.23kg)(78°C)(4184\ J/kg \cdot K)$
$C_p = 4184\ J/kg \cdot K$	**$Q = 75{,}061\ J$**