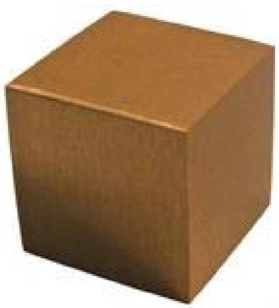
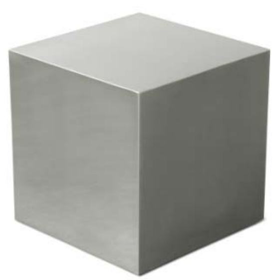
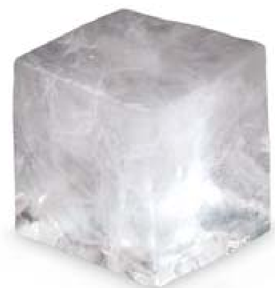
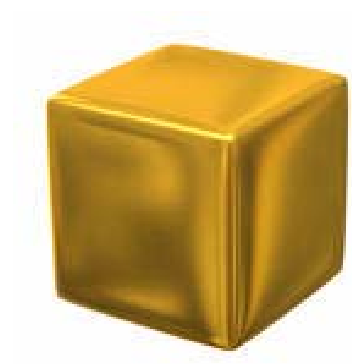
Specific Heat Capacity









Slide Summary

- Specific Heat Capacity
  - What it is and example of values
  - Solving a sample problem
- Heat Capacity
  - What it is
  - Heat capacity of a system
  - Solving a sample problem
- Exit Ticket Question

Heat

- Remember that Thermal Energy depends on
  - Temperature difference between the bodies
  - Mass of the bodies
  - **Materials' properties** ←

These lesson will look at this this variable

Specific Heat Capacity

- Definition:
  - The amount of thermal energy needed to raise the temperature of one kilogram of a substance by one kelvin.
- Symbol
  - c (lower case c)
- Units
  - J / kg · K
- Each material has a different value

Specific Heat Capacity

- Example of values

Substance	Specific Heat Capacity (J/kg ·K)
Lead	130
Silver	234
Copper	390
Iron	470
Marble	880
Aluminum	910
PET	1000
Air	1000
Ethanol	2430
Water	4200

Specific Heat Capacity

- The amount of thermal energy is calculated as follows

$$Q = m \cdot c \cdot \Delta T$$

Thermal Energy
(J)

Mass of substance
(kg)

Specific Heat Capacity
(J/kg K)

Change in temperature
$T_2 - T_1$
(K)

Specific Heat Capacity

- Calculate the following
  - How much energy is required to increase the temperature of 500g of lead from 25°C to 60°C? The specific heat capacity of lead is 130 J/kg·K.

$$Q = m \cdot c \cdot \Delta T$$

$$Q = 0.5 \cdot 130 \cdot (60 - 25)$$

$$\mathbf{Q = 2275\ J}$$

Note that ΔT (°C) = ΔT (K). Ask yourself why!

Heat Capacity

- Definition
  - The amount of thermal energy required to change the temperature of a body by one kelvin
- Symbol
  - C (upper case C)
- Units
  - J / K
- $C = m \cdot c$
- Therefore **$Q = C \cdot \Delta T$**

Heat Capacity

- From the previous problem
  - 500g of lead (which has a specific heat capacity of 130 J/kg·K) will have a heat capacity of

$$\mathbf{C = m \cdot c}$$

$$C = 0.5 \cdot 130$$

$$\mathbf{C = 65\ J/K}$$

Heat Capacity

- The sum of the individual heat capacities of all the objects in a system is the heat capacity of the system.

$$C_{system} = m_1 \cdot c_1 + m_2 \cdot c_2 + \ldots + m_n \cdot c_n$$

Heat Capacity

- Consider a 500mL bottle of water at 25°C. It is put into the fridge. What temperature would it be if it loses 10kJ to the air in the fridge.
  - Specific heat of water is 4200J/kg·K
  - The plastic bottle is 10g with c=1000J/kg·K.

$C = m_{bottle} \cdot c_{bottle} + m_{water} \cdot c_{water}$

$C = 0.01 \cdot 1000 + 0.5 \cdot 4200$

$\mathbf{C = 2110\ J/K}$

$Q = -C \cdot \Delta T$

$10{,}000 = -2110 \cdot (T_2 - 25)$

$\mathbf{T_2 = 20.3\ °C}$

Exit Ticket Question

- 50 kJ is added to 1.5 L of water. If the water was originally 5°C, what is the final temperature?
  - The specific heat capacity of water is 4,200 J/kg•K
  - The density of water is 1 kg/L

Additional Question

- A 50 g cube of Aluminum at 500°C is immersed into a 2 L container of water at 15°C. What is the final temperature at thermal equilibrium.
  - The specific heat capacity of water is 4,200 J/kg·K
  - The specific heat capacity of aluminum is 910 J/kg·K
  - The density of water is 1 kg/L

Additional Question Solution

- The energy lost by the Al cube ($-Q_{Al}$) must equal to the energy gained by the water (Q_{H20})
- At thermal equilibrium, $T_{2\text{-}H2O} = T_{2\text{-}Al} = T_2$

$$Q_{H20} = m_{H20} \cdot c_{H2O} \cdot \Delta T$$
$$Q_{H20} = m_{H20} \cdot c_{H2O} \cdot (T_2 - T_{1\text{-}H20})$$
$$Q_{H20} = 2 \cdot 4{,}200 \cdot (T_2 - 15)$$

$$Q_{Al} = m_{Al} \cdot c_{Al} \cdot \Delta T$$
$$Q_{Al} = m_{Al} \cdot c_{Al} \cdot (T_2 - T_{1\text{-}Al})$$
$$Q_{Al} = 0.05 \cdot 910 \cdot (T_2 - 500)$$

$$Q_{H20} = -Q_{Al}$$
$$2 \cdot 4{,}200 \cdot (T_2 - 15) = -\ 0.05 \cdot 910 \cdot (T_2 - 500)$$
$$T_2 = 18\ °C$$