Thermal Properties Module

Outline

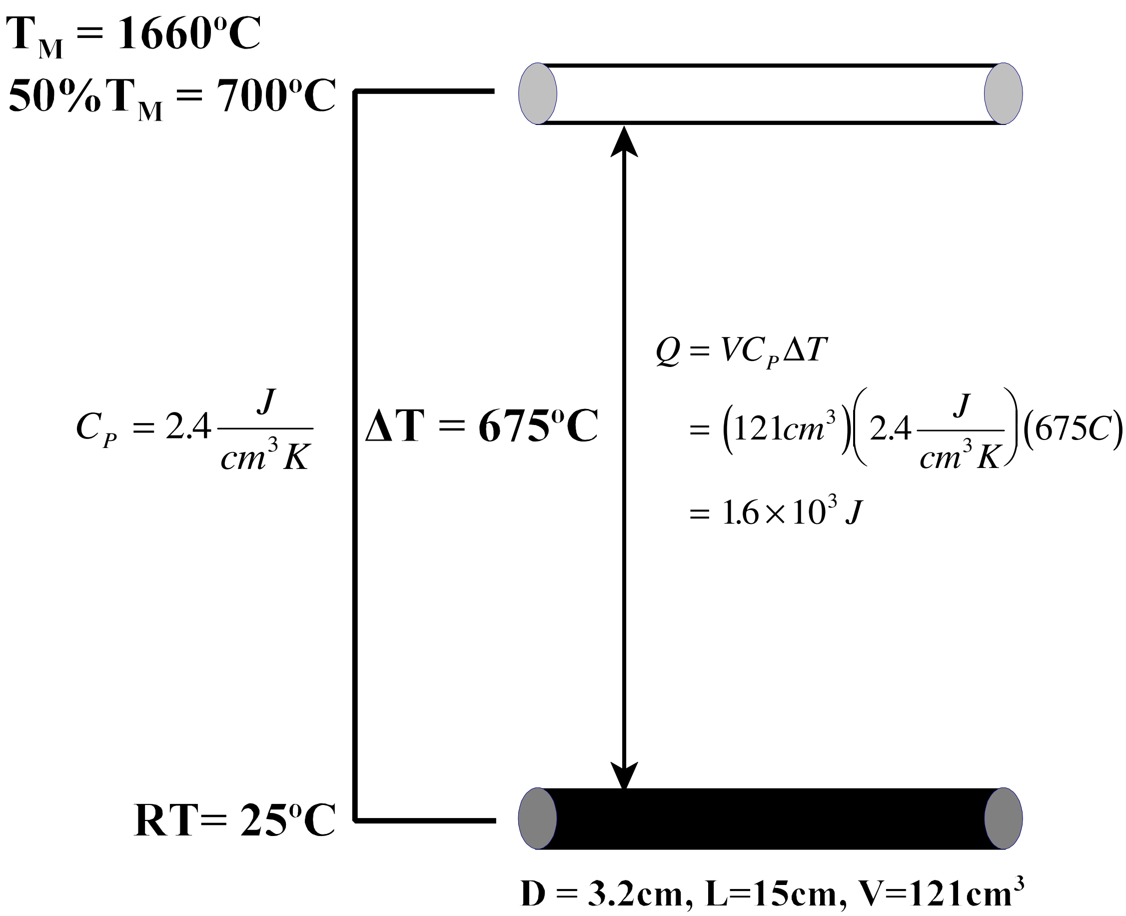
- Heat of Fusion
- Heat Capacity
- Thermal Expansion
- Thermal Conductivity
- Thermal Diffusivity

Heat Capacity

- Heat Per Degree
  - Can Be Based on Mass, Moles, Volume.

$$C_P = \frac{dQ}{dT}$$

Titanium (Ti) is Basis for This Example



<u>Heat of Fusion ΔH_F</u>

- First Law of Thermodynamics
  - Heat at Constant Pressure Required to Melt a Given Amount of Material at T_M
  - Heat at Constant Pressure Expelled When a Given Amount of Solidifies at T_M

$$T_M = 660^{o}C$$

$$V = 1953\ cm^3$$

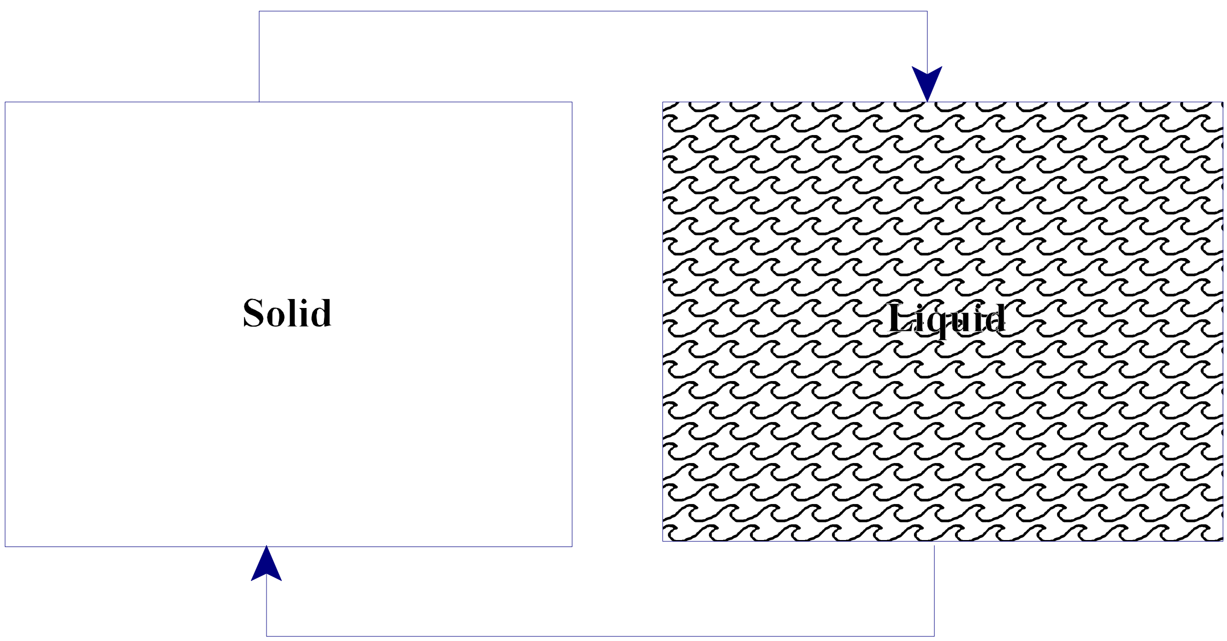
$$\Delta H_F = 1080 \frac{J}{cm^3}$$

$$Q = V \Delta H_F$$

$$= \left(1953 cm^3\right)\left(1080 \frac{J}{cm^3}\right)$$

$$= 2.1 \times 10^6\ J$$

2.1×10^6 J Required



2.1×10^6 J Given Off

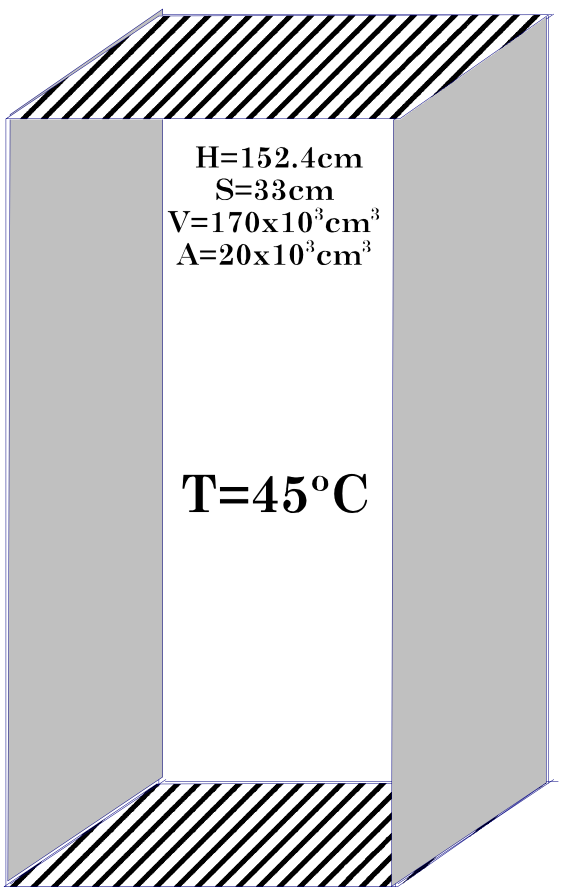
**Aluminum (Al)
is Basis for
This Example**

Thermal Conductivity

- Thermal Conductivity

$$\frac{Power}{Area} = -k\frac{dT}{dx}$$

Copper (Cu) is Basis for This Example



45°C

$$\frac{dT}{dx} = \frac{30C}{3.5cm} = 8.6\frac{C}{cm}$$

$$\kappa = 4\frac{W}{cmK}$$

$$\frac{Power}{Area} = -k\frac{dT}{dx}$$

$$\frac{P}{A} = 34.4\frac{W}{cm^2}$$

$$P_{Loss} = 688kW$$

15°C

3.5cm

Thermal Diffusivity

- Definition

$$\alpha = \frac{k}{C}$$

- Unit Analysis

$$\alpha = \frac{k}{C} = \frac{\dfrac{J}{(s)(cm)(K)}}{\dfrac{J}{(cm^3)(K)}} = \frac{cm^2}{s}$$

- Implications

$$\frac{\partial T}{\partial t} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right)$$

Thermal Expansion

- Thermal Expansion or Contraction

$$\varepsilon = \frac{\Delta L}{L_0} = \alpha \Delta T$$

94% T_M = 200°C

T_M = 232°C

$\alpha = 23.0 \times 10^{-6} K^{-1}$

50.2 cm

$$\varepsilon = \alpha \Delta T = \left(23.0 \times 10^{-6} K^{-1}\right)\left(175C\right)$$
$$= 0.4\%$$

$$\varepsilon = \frac{\Delta L}{L_0}$$

$$\Delta L = L_0 \varepsilon = \left(50cm\right)\left(0.004\right) = 0.2cm$$

RT= 25°C

50 cm

Tin (Sn) is Basis for This Example

Summary and Wrap Up

- Heat of Fusion
- Heat Capacity
- Thermal Expansion
- Thermal Conductivity
- Thermal Diffusivity