SLIDE 35

Initial $\theta_{if} = -5°C$

Freezing point $\theta = -10°C$

$$X_{ice} = X'_w \left[1 - \frac{\theta_{if}}{\theta} \right]$$

$X'_w = X_w - BW = 40\%$

$$X_{ice} = \underset{0.4}{X'_w} \Big[1 - \overset{0.5}{\frac{-5°C}{-10°C}} \Big] = 0.4 \times 0.5$$

$$dh = c\, d\theta \quad \text{[Specific Enthalpy)}$$

θ = temperature in °C

$$C = \frac{dh}{d\theta}$$

T = temperature in K

$$C_{app}(\theta) = C_{\substack{\text{sensible} \\ \text{heat}}} + C_{\text{latent heat}}$$

$$\left.\frac{dh}{d\theta}\right)_{\substack{\text{sensible} \\ \text{heat}}} \qquad \left.\frac{dh}{d\theta}\right|_{\substack{\text{latent} \\ \text{heat}}}.$$

$$dh = c\,d\theta$$ (2)

For pure water above freezing point $c \approx$ constant $\simeq 4.2 \frac{kJ}{kg\,K}$.

What happens if we want to calculate change in enthalpy from 20°c to 60°c

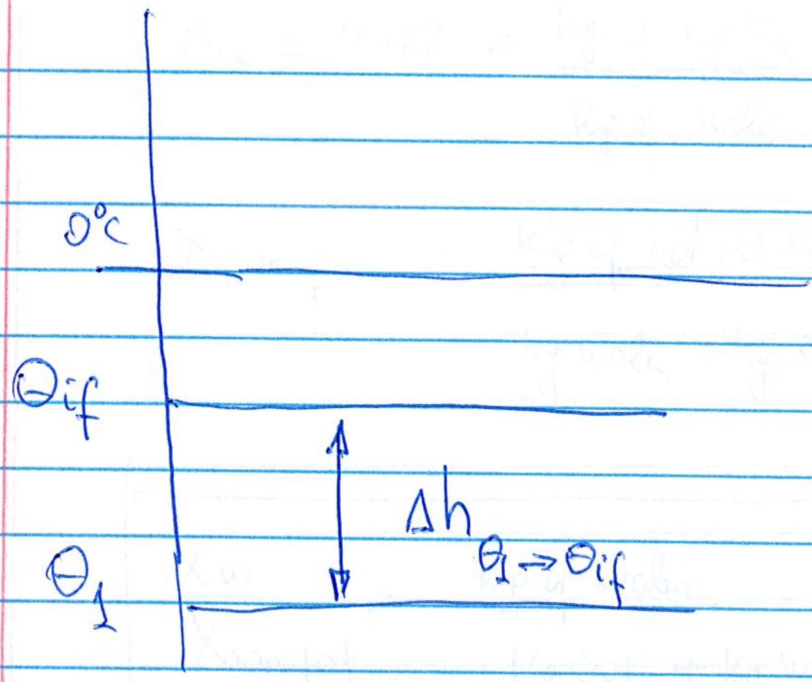
$$\int_{h_1}^{h_2} dh = \Delta h = \int_{\theta_1}^{\theta_2} c\,d\theta \approx c[\theta_2 - \theta_1] = c\Delta\theta$$

Below freezing point for a biomaterial

$$c(\theta) \longleftarrow \text{STRONG FUNCTION OF TEMPERATURE } \theta$$

$$dh = c_{app}(\theta)\,d\theta$$

I want to calculate the enthalpy change [HEAT = HOW MUCH] From a temperature θ_1 below initial freezing point (θ_{if}) and the initial freezing point

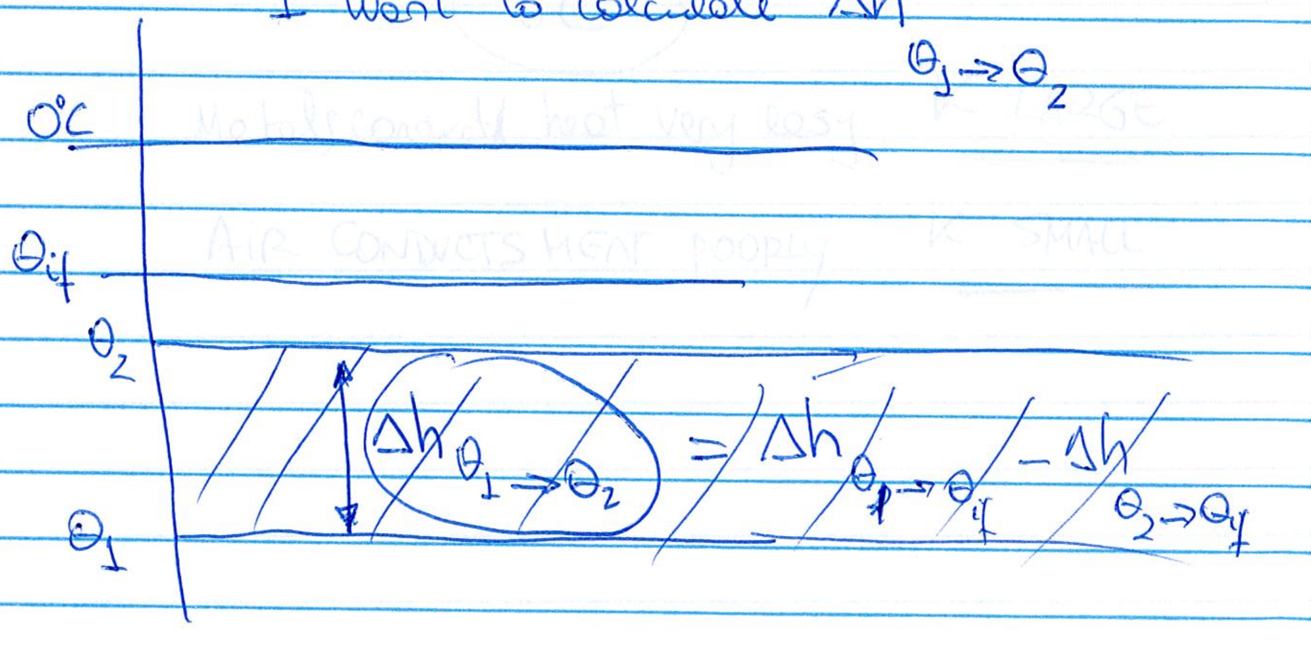


$$\boxed{\Delta h_{\theta_1 \to \theta_{if}} = \int_{\theta_1}^{\theta_{if}} C_{app}(\theta)\, d\theta}$$

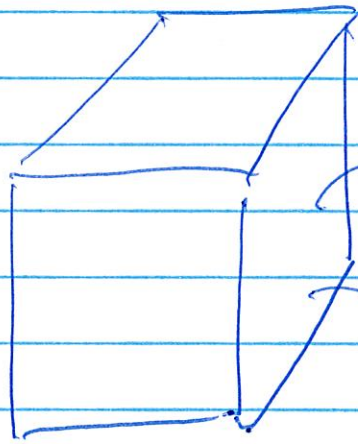
Equation that will be in your list

<u>Question</u>

I want to calculate $\Delta h_{\theta_1 \to \theta_2}$



$$\Delta h_{\theta_1 \to \theta_2} = \Delta h_{\theta_1 \to \theta_{if}} - \Delta h_{\theta_2 \to \theta_{if}}$$



$V = 1\,m^3$

ρ DENSITY kg/m^3

C HEAT CAPACITY $\frac{kJ}{kg\,K}$

HEAT BLOCK FROM ~~[illegible]~~ 0°C to 1°C

AND I WANT TO HAVE AN IDEA ON TIME.

$$\frac{\Delta T}{\Delta t}$$

$$\boxed{Q = \rho C V \frac{\Delta T}{dt}} = \frac{\cancel{kg}}{\cancel{m^3}} \times \cancel{m^3} \times \frac{kJ}{\cancel{kg}\,\cancel{°C}} \frac{\cancel{°C}}{sec.} = kW$$

Power [in kW] to change the temperature of the block 1°C in 1s

$$\boxed{Q \propto \rho C}$$ For $\frac{\Delta T}{\Delta t} = \frac{1°C}{1sec}$ and $V = 1\,m^3$

$Q = \rho C$ for $V = 1 m^3$ (6)

$\frac{\Delta T}{\Delta t} = \frac{1°C}{1 Se.}$

METAL $\rho = 5{,}000 \ Kg/m^3$

$C = 2 \frac{KJ}{Kg.}$

$\boxed{Q = 10{,}000 \ Kwatts}$ Power.

WATER $\rho = 1{,}000 \ kg/m^3$

$C = 4.2$

$\boxed{Q = 4{,}200 \ Kwatts}$ Power.

Air $\rho = 1 \ Kg/m^3$

$C \cong 2 KJ/Kg.$

$\boxed{Q = 2 \ Kwatts}$ Power.

MATERIAL ABILITY TO CONDUCT HEAT

$$\alpha = \frac{K}{\underbrace{\rho c}_{\text{THERMAL INERTIA}}}$$