SLIDE 3

$$A(r) = 2\pi r L$$

↑ changing

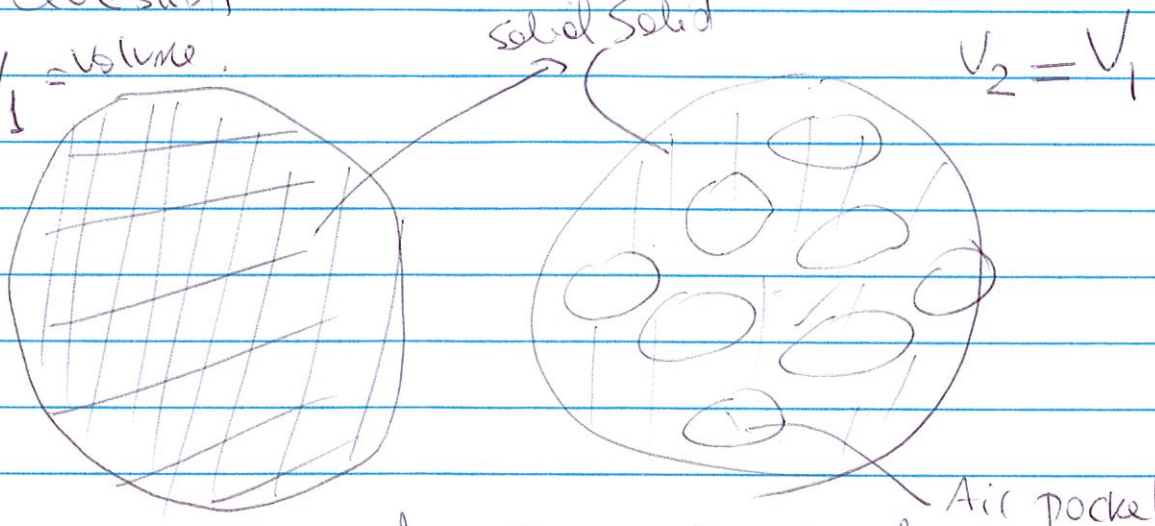
$$Q = -K\, 2\pi r L \frac{d\theta}{dr}$$

↑ ↑

by integration → $\ln \frac{r_2}{r_1}$ ∴

Question

V_1 = volume



K_1 : thermal conductivity of material 1 > K_2 : thermal conductivity of material 2

MATERIAL 2 HAS AIR POCKETS AND CONDUCTS HEAT SLOWLY

(2)

$$\alpha = \frac{K}{\rho C}$$

K ← ABILITY OF THE MATERIAL TO CONDUCT HEAT

ρC ← THERMAL INERTIA

— MORE AIR IN THE MATERIAL

$K \downarrow \Longrightarrow$ MATERIAL TRANSFER HEAT SLOWLY

$\rho C \Longrightarrow C$ does not change $\Longrightarrow \rho \downarrow$

$\rho C \downarrow$

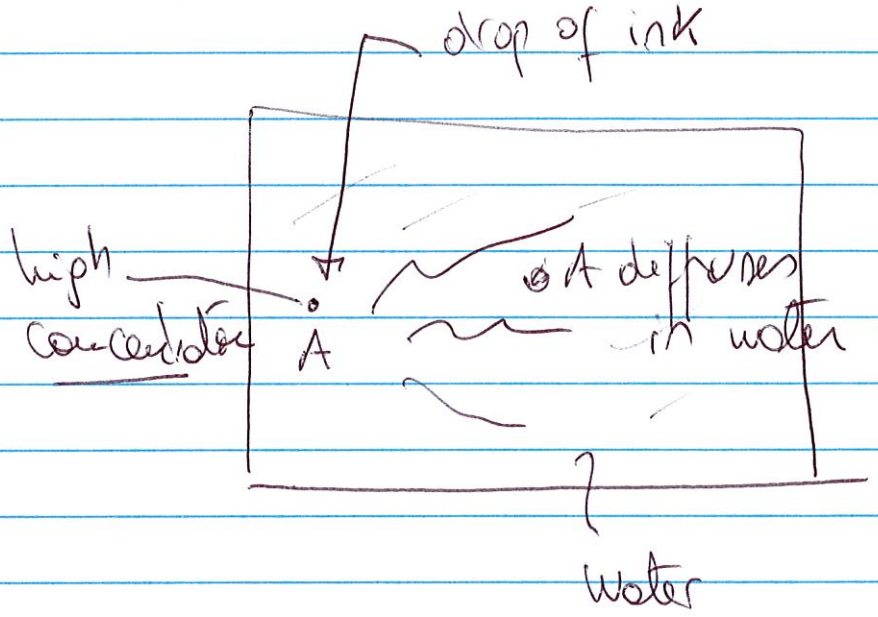
MATERIAL HEAT FASTER IN TIME

VALUES OF α ?

$$\alpha = \frac{K}{\rho C} \cong \frac{0.01 \ W/m.K}{1000 \ kg/m^3 \times 4.2 \times 10^3 \ J/kg.K} =$$

$$\alpha \cong \frac{0.01 \times 10^{-6}}{\sim 4} \frac{W \, m^{-2}}{J/m^3} \cong 0.2 \times 10^{-8} \ m^2/s$$

Why α is ~~thermal~~ called thermal diffusivity ?



LAW TO MODEL DIFFUSION OF INK IN WATER

THE LAW IS CALLED THE FICK LAW

FOR 1-D DIFFUSION

$$N = -D_{A,W} A \frac{dC_A}{dX}$$

C_A: concentration of component A (ink)

$$C_A = \frac{\text{mol of A}}{m^3}$$

N: DIFFUSION RATE OF INK

$D_{A,W}$: DIFFUSION COEFFICIENT OF A IN WATER. $\left[\frac{m^2}{s}\right]$

FOURIER LAW

$$Q = -\frac{K}{\rho C} A \frac{d\theta(\rho C)}{dX}$$

$$Q = -\alpha A \frac{d(\rho C \theta)}{dX}$$

THERMAL DIFFUSIVITY $\frac{m^2}{s}$

$$\rho C \theta = \frac{kg}{m^3} \times \frac{J}{kg\,K} \times K = \frac{J}{m^3}$$

concentration of energy.

$$\varepsilon_i = \frac{\text{Volume of Component } i}{\text{TOTAL Volume}}$$

i CAN BE WATER, PROTEIN, POLYSACCHARIDE etc, AND CAN BE AIR

(4)

$$\varepsilon_i = \frac{\rho_s \times X_i}{\rho_i}$$

ε_i: Volume fraction of component i

$$\varepsilon_i = \frac{\text{mass of solid}}{\text{Volume of material}} \times \frac{\text{mass of } i}{\text{mass of solid}}$$

$$\frac{\text{mass of component } i}{\text{Volume of component } i}$$

$$\boxed{\varepsilon_i = \frac{\text{Volume of component } i}{\text{Volume of material}}}$$

Question

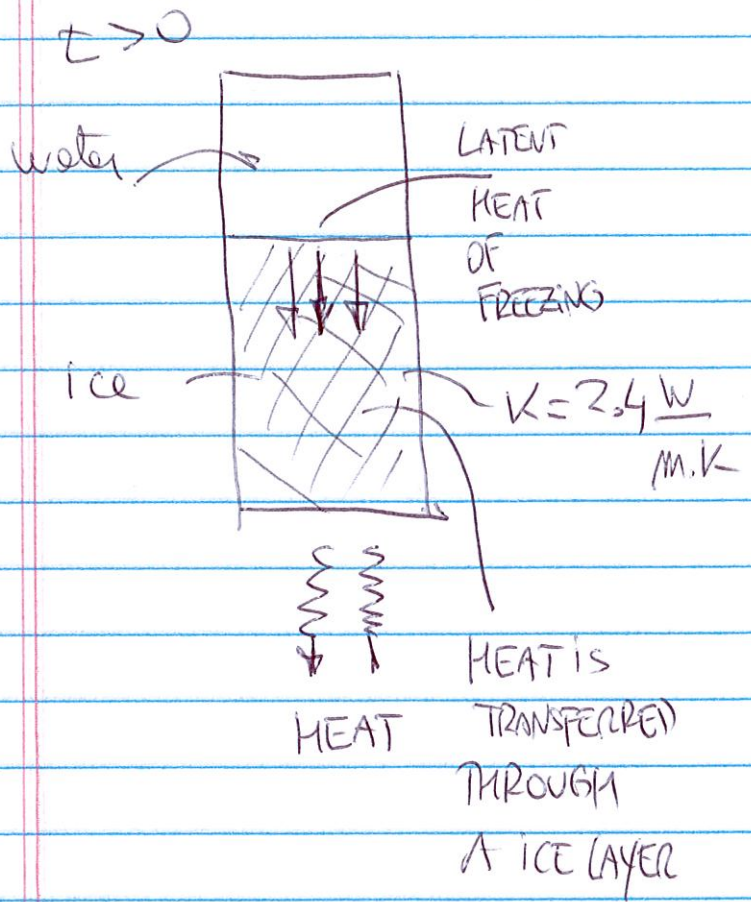
Based on $K_{ice} \cong 2.4\ W/m.K$

$K_{water} \cong 0.5\ W/m.K$

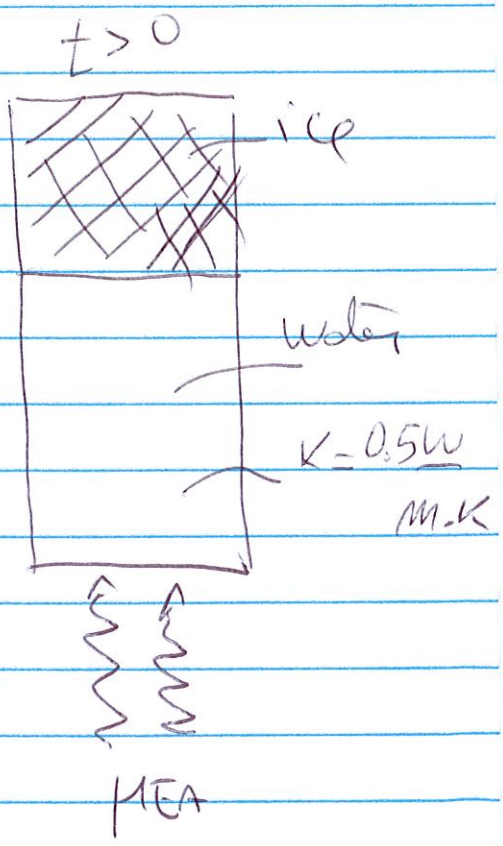
What is taking longer Freeze or Thaw a biomaterial?

FREEZING PROCESS

1D - HEAT TRANSFER.



THAWING PROCESS



THAWING TAKES LONGER THAN FREEZING

$$\phi \equiv Q$$

$$\phi_{parallel} = Q_{parallel} > \phi_{series} = Q_{series}$$

system that water, polysaccharide and air

$$K_{er} = \frac{1}{\frac{\varepsilon_w}{K_w} + \frac{\varepsilon_{polys}}{K_{polys.}} + \frac{\varepsilon_{air}}{K_{air}}}$$

when porosity is high,

$\frac{\varepsilon_{air}}{K_{air}}$ is very large !

and K_{ser} is very small

SLICE 16, EMT MODEL FOR TWO COMPONENT, ONE COMPONENT IS THE DISPERSED PHASE (INDICATED BY "d", AND THE OTHER COMPONENT IS THE CONTINUOUS PHASE (INDICATED BY "c")

IN ICE CREAM WHAT IS THE DISPERSED PHASE AND WHAT IS THE CONTINUOUS PHASE?

ICE IS THE DISPERSED PHASE

PROTEIN + FAT + SUGAR + ETC ≡ CONTINUOUS PHASE