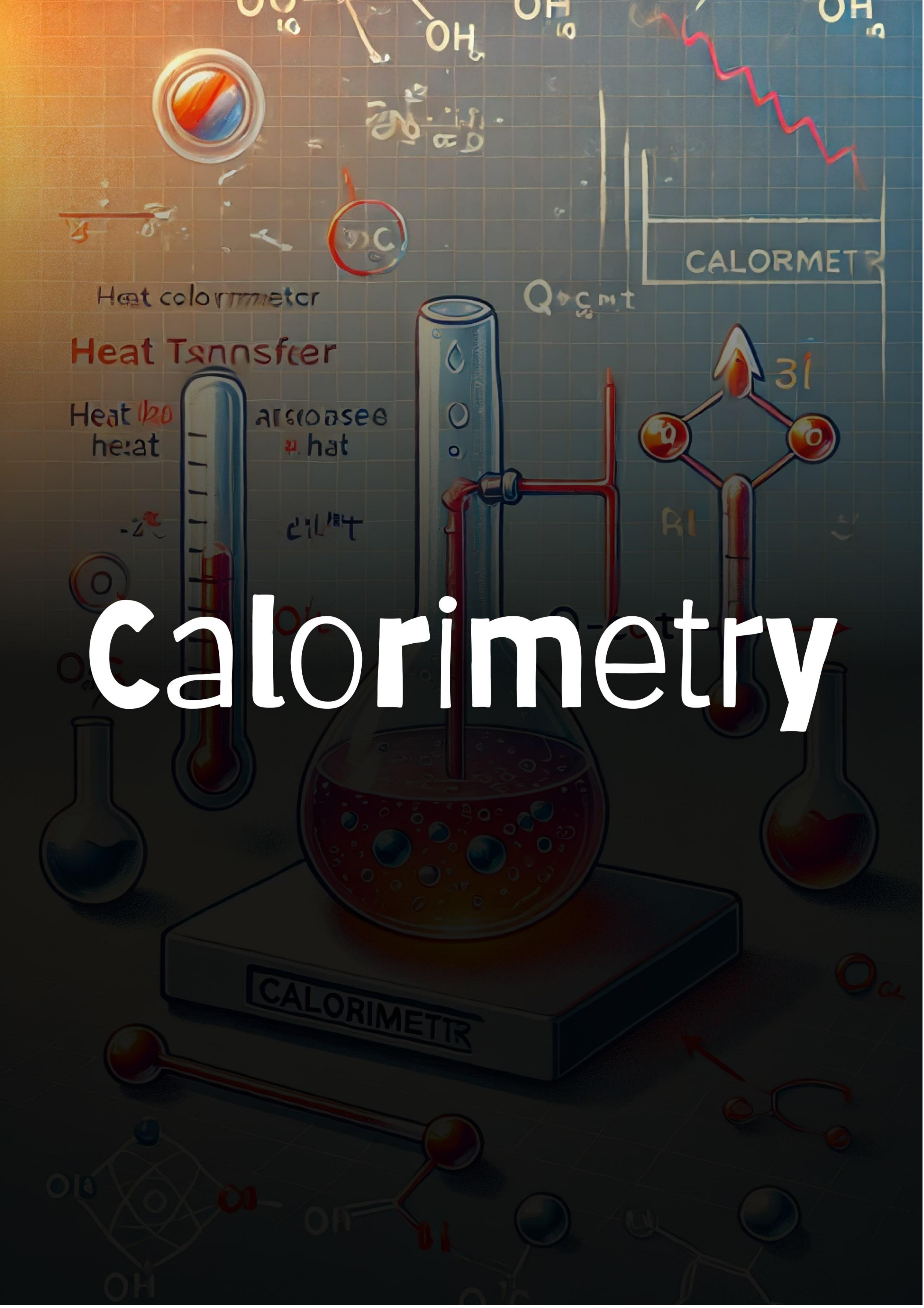


Calorimetry

Calorimetry

SPECIFIC HEAT

Amount of heat required to raise the temperature of mass unit of substance (Kg) by 1°c without change in phase is called (mass) specific heat.

Mathematically,

if $\Delta\theta$ is the heat required to raise the temperature of 'm' Kg of substance by temp ΔT, then specific heat is given by

$$C = \frac{\Delta\theta}{m\Delta T}$$

(by unitary method)

The more useful form of the above eqⁿ is

$$\Delta\theta = mc\Delta T$$

HEAT CAPACITY

The heat required to raise the temp. of the body by 1°c is called heat capacity of the body.

$$H = \frac{\Delta\theta}{\Delta T}$$

$$\therefore \; H = mc$$

SPECIFIC LATENT HEAT

The amount of heat required to change the phase of 1 mass unit (Kg) of substance (solid ⟷ liquid) or (liquid ⟷ vapour) without any change in temp. is called specific latent heat.

Mathematically,

If $\Delta\theta$ is heat required to change the phase of m Kg of substance, then

$$L = \frac{\Delta\theta}{m}$$

The more useful form of above eqⁿ is

$$\Delta\theta = mL$$

MIXING OF SUBSTANCES

Case 1: Without Phase Change

whenever liquids at different temperature are mixed then to find the temp. of resultant liquid, we use the fact that summation of heat gained by all liquids is 0. Here the heat lost to surroundings is ignored.

Mathematically,

$$\sum m_i C_i \Delta T_i = 0$$

(i is the i^{th} liquid or the vessel also if it absorbs heat)

Que.) An aluminium cup of mass 0.1 Kg has a temp. 20°C and now you pour 0.25 Kg coffee at 70°C. what is the final temp. after coffee is in the thermal equilibrium with the cup.

$C_{coffee} = 5000\ J/KgK$, $C_{Al} = 1000\ J/KgK$

$$0.1 \times 1000\,(T-20°) + 0.25 \times 5000 \times (T-70) = 0$$

$$0.1\,(T-20) = (70-T)\,1.25$$

$$T-20 = (70-T)\,12.5$$

$$T-20 = 875 - 12.5T$$

$$13.5T = 895$$

$$T = \frac{8950}{135} = \frac{1790}{27}$$

$$T = 66.3°C$$

Case 2: With change of Phrease

Here also, we use the fact that net heat gained by all the substances together is zero. However we also have to consider gain of latent heat during phase change.

Que.) we want to cool 0.25 Kg direct coke at 25°C by adding ice at −20°C. Find mass of ice required so that, finally all the ice is melted and we get drink at 0°C.

$C_{ice} = 2100\ J/KgK$, $C_{water} = 4200\ J/KgK$, $L = 3.34 \times 10^6\ J/Kg$

$$mL + mC_{ice}(0-T_i) + m_w(0-T_w) = 0$$

$3.34 \times 10^5 \times m + m \times 2100(20) + 0.25(-25)(4200) = 0$

How to Decide the final Outcome in phase Change problems

To comment on the final outcome upon mixing of various phases, we need to calculate the following four quantities :

1.) Q_{SO} :- The heat required to bring the solid from its initial position to solid at melting temperature.

2.) Q_{SC} :- The heat required to convert solid at melting temp. to liquid at melting temperature.

3.) Q_{LO} :- The heat released in converting the liquid from initial temperature to liquid at melting temperature.

4.) Q_{LS} :- The heat released in converting liquid at melting temp to solid at melting temperature.

4 Cases are Possible

1.) $Q_{SO} \geq Q_{LO} + Q_{LS}$
everything converts to solid.

2.) $Q_{LO} \geq Q_{SL} + Q_{SO}$
everything converts to liquid.

3.) $Q_{SO} + Q_{SL} \geq Q_{LO} > Q_{SO}$
Some solid melting and final temperature = melting temp.

4.) $Q_{LO} + Q_{LS} > Q_{SO} > Q_{LO}$
Some liquid solidfying & final temp. = melting temp.

Que.) A large lake has a layer of ice of thickness x_0, The atmospheric temp. is θ ($\theta < 0°C$). Find the thickness of ice as a function of time.

$$\frac{dQ}{dt} = \frac{(0-\theta)KA}{x}$$

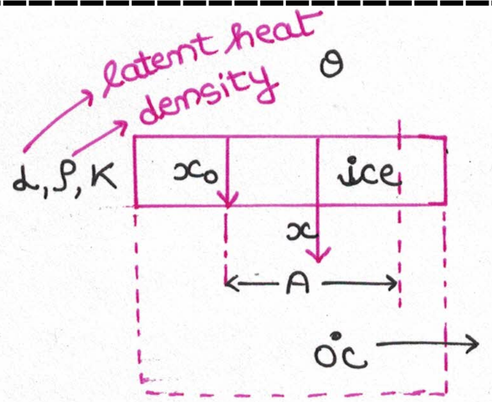
$$dQ = \frac{-KA\theta}{x} \cdot dt$$

$dQ = \rho A\, dx\, L$

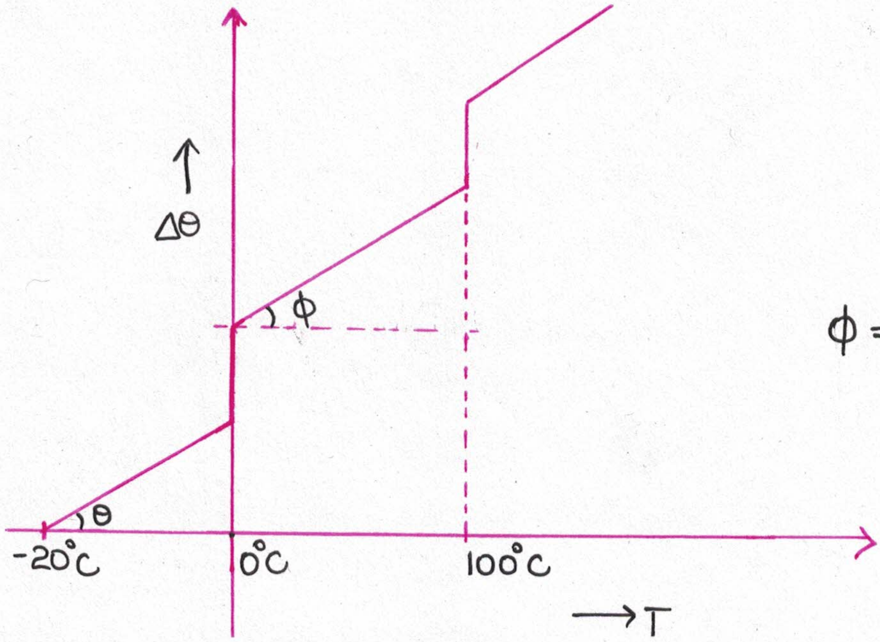
$\rho L A\, dx = -\frac{KA\theta}{x} \cdot dt$

$\frac{\rho L}{K\theta} \int_{x_0}^{x} x \cdot dx = -\int_0^t dt$

$x^2 - x_0^2 = -\frac{2K\theta t}{\rho L}$



HEATING GRAPH OF A TYPICAL SOLID



$\phi = \theta$