Calorimetry

Expansion

Expansion of Solid

Linear expansion

Linear expansivity $\alpha(\mathrm{K}^{-1})$

$$\alpha = \frac{l_2 - l_1}{(\theta_2-\theta_1)l_1} \quad \Rightarrow \quad l_2 = l_1[1+\alpha(\theta_2-\theta_1)]$$

Area expansion

Area expansivity $\beta(\mathrm{K}^{-1})$ $\quad , \beta = 2\alpha$

$$\beta = \frac{A_2 - A_1}{(\theta_2-\theta_1)A_1} \quad \Rightarrow \quad A_2 = A_1[1+\beta(\theta_2-\theta_1)]$$

Volume expansion

Volume expansivity $\gamma(\mathrm{K}^{-1})$ $\quad , \gamma = 3\alpha$

$$\gamma = \frac{V_2 - V_1}{(\theta_2-\theta_1)V_1} \quad \Rightarrow \quad V_2 = V_1[1+\gamma(\theta_2-\theta_1)]$$

Expansion of liquid

Volume expansitivity of liquid γ_ℓ,
volume expansivity of container γ_c,
apparent expansitivity γ_a

$$\gamma_\ell = \frac{V_1 - V_0}{V_0\Delta\theta} \quad \Rightarrow \quad V_1 = V_0(1+\gamma_\ell\Delta\theta)$$

$$3\alpha_c = \gamma_c = \frac{V_1' - V_0}{V_0\Delta\theta} \quad \Rightarrow \quad V_1' = V_0(1+\gamma_c\Delta\theta)$$

$$\gamma_a = \frac{V_1 - V_1'}{V_0\Delta\theta} \quad \Rightarrow \quad \gamma_\ell = \gamma_a + \gamma_c$$

Latent Heat

Specific latent heat of fusion

Heat required to convert unit mass of substance at its melting point into liquid of the same temperature.

$$L_f = \frac{Q}{m} \quad (Jkg^{-1})$$

Specific latent heat of vaporisation

Heat required to convert unit mass of substance at its boiling point into vapour of the same temperature.

$$L_v = \frac{Q}{m} \quad (Jkg^{-1})$$

Measuring specific latent heat of fusion of ice

Heat lost = Heat gained
Heat given by calorimeter & water = Heat used in melting ice + heat used to warm melted ice

$$m_1c_w(\theta_1-\theta_2) + C(\theta_1-\theta_2) = mL_f + mc_w(\theta_2 - 0)$$

Measuring specific latent heat of vaporisation of water

Heat given by steam + Heat given by condensed water cooling = Heat gained by calorimeter and water

$$mL_v + mc_w(100-\theta_2) = (m_1c_w + C)(\theta_2-\theta_1)$$

Heat Capacity

Heat Capacity

Quantity of heat required to raise temperature of a substance by 1 degree

$$C = \frac{Q}{\Delta T} \quad (\mathrm{JK}^{-1})$$

Specific Heat Capacity

Quantity of heat required to raise temperature of unit mass of substance by 1 degree

$$c = \frac{Q}{m\Delta T} \quad (\mathrm{Jkg}^{-1}\mathrm{K}^{-1})$$

Molar Heat Capacity

Quantity of heat required to raise temperature of 1 mol of gas at constant pressure (C_p) or constant volume (C_v)

$$C_v = \frac{Q}{n\Delta T}\ (\mathrm{Jmol}^{-1}\mathrm{K}^{-1}) \quad , \quad C_p = \frac{Q}{n\Delta T}\ (\mathrm{Jmol}^{-1}\mathrm{K}^{-1})$$

Measuring Specific Heat Capacity

Method of mixture

Heat lost from solid = Heat gained by water and calorimeter

$$mc(\theta_3-\theta_2) = m_wc_w(\theta_2-\theta_1) + m_cc_c(\theta_2-\theta_1)$$

Electrical heating method

Energy supplied = Heat gained

$$VIt = (mc_\ell + C)\Delta\theta$$

Continuous flow methof (Callendar & Barnes' method)

Require two sets of reading with same temperature diffrence to compute heat loss

Heat generated = Heat gained by liquid + heat loss

$$\begin{cases} V_1I_1t = m_1c(\theta_2-\theta_1) + ht \\ V_2I_2t = m_2c(\theta_2-\theta_1) + ht \end{cases}$$