2.3: Calculation of Heat

Heat (Q) is a property that gets transferred between substances. Similarly to work, the amount of heat that flows through a boundary can be measured, but its mathematical treatment is complicated because *heat is a path function*. As you probably recall from general chemistry, the ability of a substance to absorb heat is given by a coefficient called the heat capacity, which is measured in SI in $\frac{\text{J}}{\text{mol K}}$. However, since heat is a path function, these coefficients are not unique, and we have different ones depending on how the heat transfer happens.

Processes at constant volume (isochoric)

The heat capacity at constant volume measures the ability of a substance to absorb heat at constant volume. Recasting from general chemistry:

The molar heat capacity at constant volume is the amount of heat required to increase the temperature of 1 mol of a substance by 1 K at constant volume.

This simple definition can be written in mathematical terms as:

$$C_V = \frac{đQ_V}{ndT} \Rightarrow đQ_V = nC_V dT. \tag{2.3.1}$$

Given a known value of C_V, the amount of heat that gets transfered can be easily calculated by measuring the changes in temperature, after integration of Equation \ref{2.3.1:

$$đQ_V = nC_V dT \rightarrow \int đQ_V = n\int_{T_i}^{T_F} C_V dT \rightarrow Q_V = nC_V \int_{T_i}^{T_F} dT, \tag{2.3.2}$$

which, assuming C_V independent of temperature, simply becomes:

$$Q_V \cong nC_V \Delta T. \tag{2.3.3}$$

Processes at constant pressure (isobaric)

Similarly to the previous case, the heat capacity at constant pressure measures the ability of a substance to absorb heat at constant pressure. Recasting again from general chemistry:

The molar heat capacity at constant pressure is the amount of heat required to increase the temperature of 1 mol of a substance by 1 K at constant pressure.

And once again, this mathematical treatment follows:

$$C_P = \frac{đQ_P}{ndT} \Rightarrow đQ_P = nC_P dT \rightarrow \int đQ_P = n\int_{T_i}^{T_F} C_P dT, \tag{2.3.4}$$

which result in the simple formula:

$$Q_P \cong nC_P \Delta T. \tag{2.3.5}$$