# FIRST LAW OF THERMODYNAMICS

We have learnt that if a thermodynamic system has a conducting boundary (that is, it is not isolated from its surroundings) and its temperature T_1 is different from that of the surroundings T_2, there will be an exchange of energy driven by the temperature difference and this energy is called heat DQ. If $T_2 > T_1$ DQ enters our system, if $T_2 < T_1$, DQ leaves our system. For liquids and solids

$$DQ = mc\Delta T \quad \text{[change of temperature]}$$
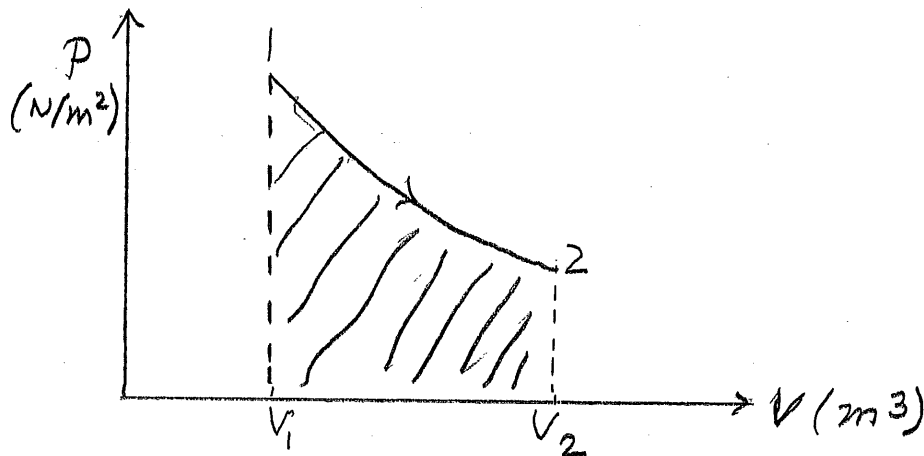$$DQ = mL \quad \text{[change of phase]}$$
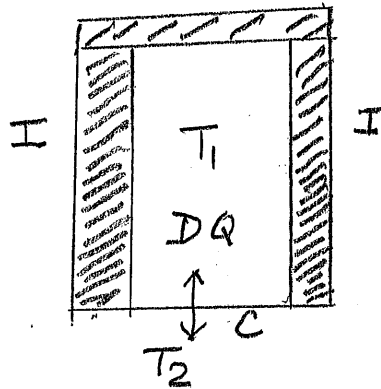
We have also learnt that we can use mechanical work to mimic the effects of heat. Indeed $4.18J$ will produce same effect as transferring one calorie of DQ. [Expt. On mechanical equivalent].
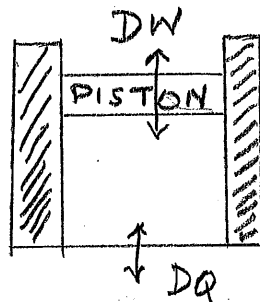
Next, consider a gas. If the piston moves by Δy work done is

$$\Delta W = F\Delta y = PA\Delta y = P\Delta V$$

For a finite change of volume

and the work done W_{1-2} is the area under the P vs. V curve.

Two facts stand out:
1. In the process 1-2 the work done depends on the path (thermodynamic)
2. Because work can be used to mimic DQ, the quantity of heat exchange also depends on the path

AND NOTE: DQ and DW both involve interaction of system with surrounding. [ΔT for former, moving piston for latter]

The beauty is that the algebraic sum of DQ and DW, that is,
$$\pm DQ \pm DW$$
Is <u>INDEPENDENT OF THE PATH!</u>

Recall that whenever we have a change of energy independent of the path we can define a potential so now we define a thermodynamic potential called the internal energy U
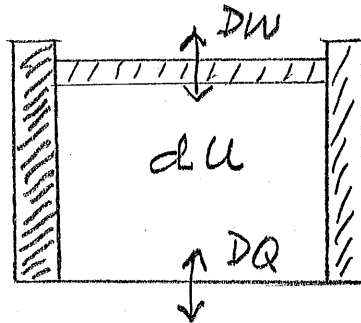
and this takes account of all the changes of energy in a thermodynamic process. The conservation law for energy then asserts that
$$\pm dU \pm DQ \pm DW \equiv 0$$
or equivalently
$$\boxed{dU = \pm DQ \pm DW}$$

Path Independent   Path Dependent

this is the formal statement of the first law of thermodynamics.

<u>N.B.</u> $d \to$ Path independent change
       $D \to$ Path dependent change
For solids/liquids DQ, DW go to change $dU = mc\Delta T$ or mL. For an ideal gas, U is a function of temperature only.

If gas is monatomic

$$U_{MA} = \frac{3}{2} N k_B T \qquad \text{(Proved in class)}$$

If gas is diatomic

$$U_{DA} = \frac{5}{2} N k_B T \qquad \text{(Good near 300K)}$$

$$k_B = 1.383 \times 10^{-23} \, J/K$$

T is temperature in $^\circ K$