A.2 Thermodynamic Laws

0^{th} Law of Thermodynamics

i) a state function temperature, T, exists.

ii) two bodies in thermal contact and each in equilibrium are also in equilibrium with each other (they have the same T)

- definition of T here still unclear (later more)

1^{st} Law of Thermodynamics

i) a state function internal energy, U, exists.

ii) a perpetuum mobile of the first kind does not exist

iii) energy is conserved (in a very general sense)

$$\Delta U = Q + W = \text{heat} + \text{work} \qquad \text{or} \qquad dU = \delta Q + \delta W$$

- includes all types of energy: pdV (mechanic), EdP (electric), Hdm (magnetic)
- law connects thermodynamic with other fields of physics

2^{nd} Law of Thermodynamics

i) a state function entropy, S, exists.

ii) a perpetuum mobile of the second kind does not exist
heat flows spontaneously from hot to cold systems

iii) the entropy in a close systems is increasing or constant

$$T\,dS \;\geq\; \delta Q \qquad \Leftrightarrow \qquad \oint dS \geq 0$$

"=" sign for reversible / quasi-static changes

- in open systems (earth), entropy export is possible !!!

Fundamental Law of Thermodynamics

i) combines first and second law:

$$T\,dS \geq \delta Q = dU - \delta W$$

- basic relation for all technical applications

3^{rd} Law of Thermodynamics (Nernst)

i) the entropy at $T = 0$ is a unique function (does not depend on other state functions); at $T = 0$, we set $S = 0$ per definition

ii) states with $T = 0$ cannot be reached in experiments (exp. record is $T \approx 10^{-10}\,\text{K}$)

- consequences: see lecture notes / problems / books