3.1 Spontaneous processes

Energy conservation and minimization is not the only criterion for stability or the direction of processes, i.e. the first law does not provide information about the direction of processes, e.g. a ball on a heated table will not start bouncing. For many processes our experience tells us clearly about the direction of motion, although the underlying processes are invariant to the change of time direction (like Newton's law):
"The second law establishes an arrow of time: the increase of entropy distinguishes the future from the past" (Kondepudi). According to Kelvin: "No cyclic process is possible in which the sole result is the absorption of heat from a reservoir and its complete conversion into work" (heat transferred from hot source is also used to heat a cold sink, hence it cannot be transformed completely into work).
The key idea: dispersal of energy determines spontaneity, i.e. spontaneous processes occur for changes of state leading to a dispersal of the total energy of the isolated system.
All above statements can be summarized in the second law:
The entropy of an isolated system increases in the course of a spontaneous change, $\Delta S_{tot} > 0$.

- Generally the entropy change of system and surrounding (= entropy of the universe) is meant. Considering split systems, it is possible to decrease the entropy in one subsystem, however, it must be compensated by the increase of entropy in the other subsystem.
- In the case of an isolated system, there are no subsystems, thus the entropy can only increase.
- Reversible processes are non-spontaneous. In this case we have for the isolated system $\Delta S = 0$.