A.1 Basic Concepts and Definitions

a) Thermodynamic System

Def: large, many-body system (number of particles in the system typically $N \gtrsim 10^{23}$) with clear distinction from surroundings/environment

- no hard walls required, defined borders are sufficient
- classification:

  i) isolated / closed systems
  no heat transfer or particle exchange with environment
  MUST be classical

  ii) systems with heat contact only
  heat transfer between environment and system possible
  no particle exchange between environment and system (N fixed)

  iii) open systems
  system and environment can exchange heat and particles

- remark: boundary conditions strongly influence system behaviour

b) Thermodynamic or State Functions

Def: define some property of the system and have a definitive value at each state

- can be mechanical, electro-magnetic or "truly" thermodynamical
- examples (gas): p, V, T, N, S, U
- examples (magnet): H, m, $M(r)$, T, N, S, U
- classification:

  i) extensive state functions
  if quantity has the value A in a system with volume V, the quantity has the value αA in a system with the volume αV (IF both systems are in the same state, e.g., if we artificially split the system in two subsystems)
  examples: V, N, U, S

  ii) intensive state functions
  the quantity does not depend explicitly on the volume, i.e., the quantity stays the same if we split the system
  examples: p, T, $n = N/V$

c) Thermodynamic Limes

Def: we consider infinitely large systems with constant intensive variables, that is, $V \to \infty$ and $N \to \infty$, but $n = n/V = const.$

- all consideration in this course are done in the thermodynamic limes!

d) Thermodynamic State

Def: State of the system fully defined by a sufficiently large set of thermodynamic functions

- often only reduced sets of thermodynamic functions are quoted
- what is a "sufficiently large set" must be determined empirically

e) Equation of State

Def: connects a set of thermodynamic functions and reduces the number of state functions that fully define a state

- example (ideal gas): $pV = nk_BT$ (thermal)
- example (ideal gas): $U = \frac{3}{2}\,k_BT$ (caloric)

f) Thermodynamic Equilibrium

Def: special state of systems in which the state function do not change, that is for example, $U \neq U(t)$, $p \neq p(t)$, ...

- term is connected to the concept of equipartition and temperature (later more ...)
- all consideration in this course will concern systems in equilibrium

g) State Changes

Def: the way how the thermodynamic state changes

- classification

  i) real nonequilibrium state changes
  general case, but very hard to describe

  ii) quasi-static changes (very slow)
  system runs through a closely connected series of equilibrium states
  all machines and motors in Thermal Physics I are based on that principle