Thermodynamics

Premises: conservation of mechanical energy (work-energy theorem)

$$mgh = \frac{1}{2} m\upsilon^2$$

$$W = \frac{1}{2} m\upsilon_2{}^2 - \frac{1}{2} m\upsilon_1{}^2 = \Delta E_{\text{kin.}}$$

Where does the energy disappear in the case of inelastic collision (or acting friction force)?

„Warms up the body” (increases the temperature)

„Becomes heat”

$$W = \Delta E_{\text{internal}}$$

One of the fundamental physical quantities is the internal energy (E_{internal})

Its origin: thermal motion of atomic particles, and the interactions among them.

Thermal interaction

New macroscopic interaction (besides the mechanical one), heat is added to the body

$$Q = \Delta E_{\text{internal}}$$

Two new quantities: heat (Q) and temperature (T)

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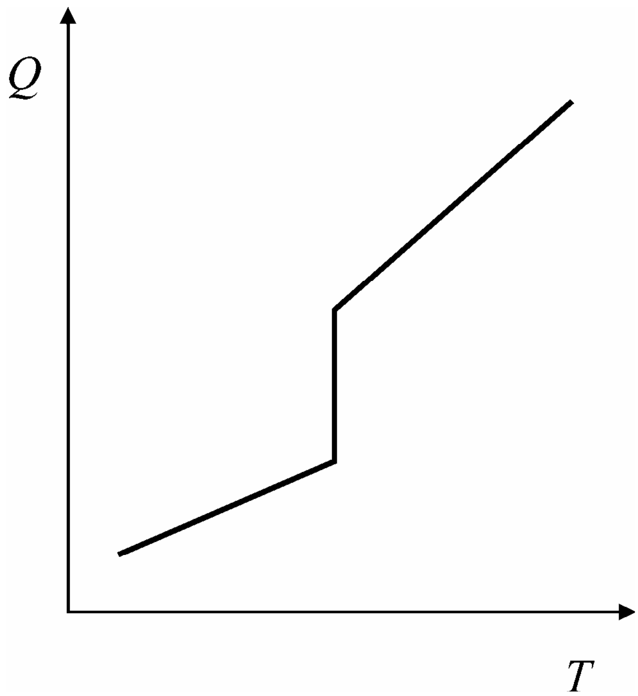
What could happen because of the added heat?

The body heats up, means increases its temperature,
dilates, means increases its volume (see exceptions)

How can we characterize these processes?



Heat capacity (of a body):

$$C = \frac{\Delta Q}{\Delta T}$$

Specific heat capacity (of a medium):

$$c = \frac{\Delta Q}{m \Delta T}$$

Molar heat capacity (of a medium):

$$C_v = \frac{\Delta Q}{v \Delta T}$$

Latent heat of fusion or vaporization $Q = L\, m$

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Thermal expansion (free), small changes

expansion coefficients

Solids (linear): $$\alpha = \frac{\Delta l}{l \Delta T}$$

Liquids (volumetric): $$\beta = \frac{\Delta V}{V \Delta T}$$

Gases: they are compressible ($\kappa \approx 10^4$ GPa^{-1})

$$pV = NkT, \qquad \text{or} \qquad pV = \nu RT$$

$$kN_A = R$$
$$N/N_A = \nu$$

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Ideal gas (model)

- large number ($N \approx N_A$, Avogadro number $\sim 10^{23}$) of spherical particles with identical mass moving randomly,
- may collide elastically with each other and the walls of the container,
- all other interactions (e.g. attraction, repulsion) and
- the total volume of particles are negligible

Gas mixtures

partial pressure

Interpretation of temperature and pressure (based on the model)

$$\frac{1}{2}m\overline{\upsilon_x^2} = \frac{1}{2}kT$$

equipartition of energy

At each collision with the wall of the container the change of momentum is $\Delta m\upsilon = 2m\upsilon_x$,

these changes (according to the Newton's II. law) result short (Δt) impulses:

$$\Delta m\upsilon = F\Delta \mathrm{t}$$

Taking into consideration the huge number of collisions (N is close to N_A), an average force will act to the wall. The quotient of this force and the area of the wall, gives the pressure.

$$p = \frac{F}{A}$$

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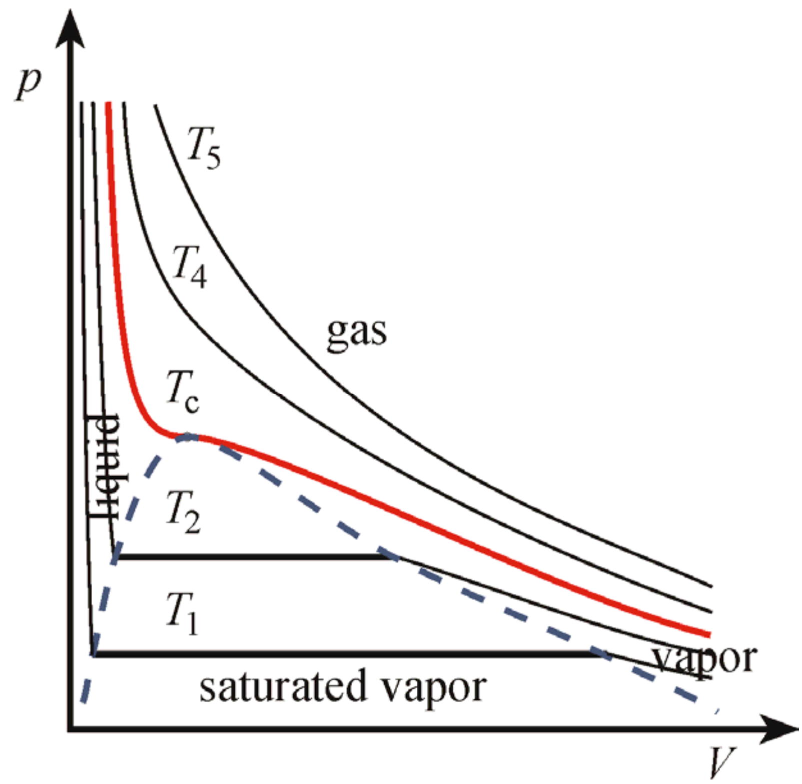
Real gas

vapor, saturated vapor,

saturated vapor pressure

In the new model we have to take into consideration

- the interactions, and
- the volume of particles



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Thermodynamic system (and environment):
„many" (~10^{23}) particles interacted with each other (macroscopic)

Major types:

Type	Matter-	Energy-
	exchange	
Isolated	–	–
Closed	–	+
Open	+	+

Characteristic quantities:

extensive: (e.g. V, q, N, E)
— proportional to the system size
— additivity: e.g. $V_1 + V_2 = V_{total}$
— (can flow)

intensive: (e.g. p, φ, μ, T)
— independent of the size of the system
— equalize
— (drive the flow)

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