

Boiling of Lukewarm Water at Low Pressure

Equipment:

suction flask with rubber stopper
vacuum hose
water aspirator

“Chemicals”:

lukewarm water (30...40°C)

Safety:

The usual precautions for working in a vacuum have to be observed: The suction flask should not show any damage (“stars”, cracks etc.) and one should always wear safety glasses. Protection against the risk of implosion can be provided by a plastic coating, e.g. with self-adhesive film.

Procedure:

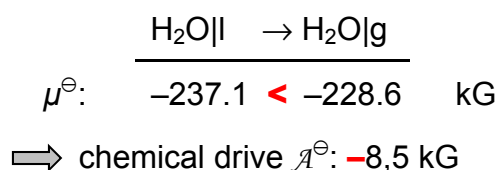
The suction flask is filled to one-third with lukewarm water and closed with the rubber stopper. Subsequently, it is evacuated with the water aspirator.

Observation:

The water boils in a vacuum at temperatures far below 100°C, even at room temperature if the pressure is low enough.

Explanation:

The boiling process can be described by the following conversion formula:

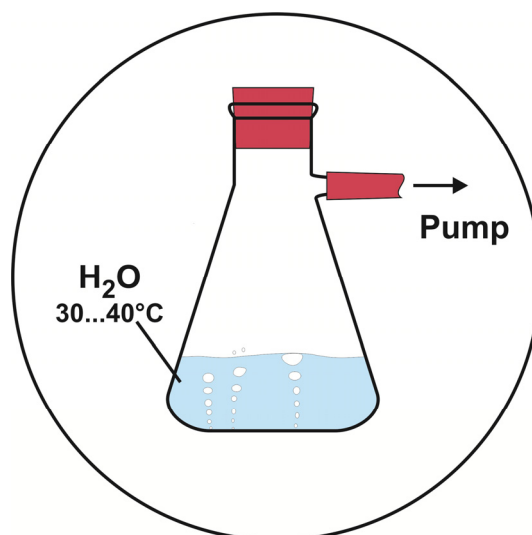


Liquid water has a smaller chemical potential than water vapor under standard conditions (298 K, 100 kPa), i.e. the chemical drive is negative and the process will not take place.

But the chemical potential of gases, and therefore also that of water vapor, is strongly pressure dependent as shown by a high pressure coefficient.

Necessary chemical potentials and pressure coefficients ($T^\ominus = 298 \text{ K}$, $p^\ominus = 100 \text{ kPa}$):

Substance	Chemical potential μ^\ominus [kG]	Pressure coefficient β [$\mu\text{G Pa}^{-1}$]
H ₂ O l	-237.1	18.1
H ₂ O g	-228.6	24.8×10^3



If the pressure is lowered enough by pumping the air above the water out of the closed container the chemical potential of water vapor will at some point fall below that of liquid water. The “cold” water begins to transform into water vapor, it boils.