

Genie in the Bottle

Equipment:

Florence flask (made from Pyrex)
aluminum foil
graduated cylinder (50 mL or 100 mL)
long-stem funnel
tea bag
scissors
spatula
stopper (with a hole)



Chemicals:

hydrogen peroxide solution (30 % w/w)
manganese dioxide powder

Safety:

hydrogen peroxide solution (H_2O_2):



H302, H318

P102, P280, P305 + P351 + P338, P301 + P312, P501

manganese dioxide (MnO_2):



H272, H302 + H332

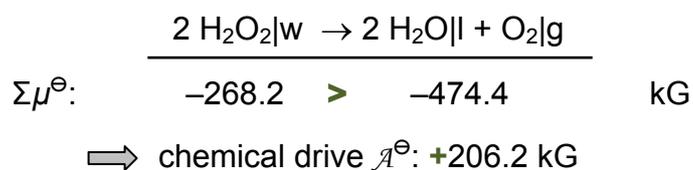
Concentrated hydrogen peroxide solution causes severe skin burns and eye damage. Therefore, it is necessary to wear a lab coat, safety goggles and protective gloves.

Procedure:

The Florence flask is wrapped in aluminum foil. Subsequently, 30 mL of hydrogen peroxide solution are poured into the flask with the help of the funnel so that no peroxide gets on the neck of the flask. A hole with a diameter of approx. 1 cm is cut in the upper part of the tea bag, the tea is carefully removed and in its place solid manganese dioxide is put into the bag. The string is fixed with the help of the stopper so that the “tea” bag dangles in the neck of the flask. (The stopper should have a hole in it just in case the reaction starts prematurely; in this way the gas evolved is allowed to escape.) When the stopper is removed the bag with the manganese dioxide will fall into the hydrogen peroxide solution. After a short while, a column of white fog, the “genie,” will rise from the flask.

Explication:

Hydrogen peroxide in aqueous solution exhibits a strong tendency to decompose into water and oxygen (disproportionation):



Necessary chemical potentials ($T = 298 \text{ K}$, $p = 100 \text{ kPa}$):

Substance	Chemical potential μ^\ominus [kJ]
$\text{H}_2\text{O}_2 w$	-134.1
$\text{H}_2\text{O} l$	-237.2
$\text{O}_2 g$	0

The chemical drive of the reaction is positive, i.e. the reaction should take place spontaneously. The decomposition rate at room temperature is, however, immeasurably small. But the rate can be appreciably increased by the addition of a catalyst.

Manganese dioxide is an example for a so-called *heterogeneous catalyst*, i.e. the phase of the catalyst is different from that of the reaction mixture. The surface of solid manganese dioxide provides a particularly favorable environment to catalyze the decomposition, though the mechanism is not understood very well. For increasing the surface area available for contact with the hydrogen peroxide solution a finely graded powder is used. The observed white fog (the “genie”) is caused by finely dispersed water droplets (formed by condensing water vapor) mixed with oxygen gas.

Disposal:

Hydrogen peroxide solutions can be disposed of down the drain with running water. Manganese dioxide can be reused after drying.