Analysis: ‘Radon (Rn-222) in water’

This method for the determination of radon (Rn-222) in water solutions is a special case of the well known de-emanation method primarily developed for radiochemical Ra-226 analysis working without interference.

Basics

The Henry-Dalton distribution law describes the distribution of gases between the liquid and the gas phase. This law leads to a partition coefficient for radon called Ostwald’s partition coefficient a_{Rn} that depends on the liquid and the temperature. The low value for radon in water allows its determination by indirect measuring methods p.e. the de-emanation method using scintillation chambers to detect radon and its progenies.
Experiments have shown that a five- to tenfold liquid volume of inactive gas results in quantitative de-emanation success for water at nominal temperatures.

Methods

Depending on the user’s needs with respect to detection limit and measuring time exist three methods of determining the radon concentration in a water solution:

1. Usage of standard de-emanation tubes which may contain sample volumes of 25 ml and one sample bubbling under the verified assumption that radon gas is transported into scintillation chambers quantitatively.
2. Usage of greater flexible volume bottles containing up to 150 ml liquid with complete transfer of the gas phase to the scintillation chamber. In this case only one sample treatment will not lead to quantitative results. Two de-emanation procedures are necessary. From their results the radon concentration can be calculated without knowledge of the partition coefficient.
3. Instead of flexible sample bottles glassware can be used without complete transfer of the gas phase as described under point 2. Additional volume corrections are necessary.

Method description

Sampling

The user must think of the high volatility of radon gas. From this reason an open handling of the sample should be avoided. The best way is to evacuate a bottle and fill it with the sample under water. The rest pressure in the bottle to half or two-thirds fill it with sample is to be determined by experiments in laboratory. This air cushion is necessary to have a partitioning of radon in air and liquid. The filling without evacuated bottles also leads to good results. Bubbling during the bottle filling procedure must be avoided.

Method 1 - De-Emanation

An equipment like a complete emanation-stand should favourably be used for the de-emanation procedure. The method is the same as for Ra-226 analysis where from the standard de-emanation tube radon gas is quantitatively transferred to the scintillation chamber.

1. *Evacuation of apparatus*

   Attach a nitrogen flushed scintillation chamber as well as the sample tube to the apparatus. With the vacuum pump on open valves 3, 4, 6 (Valve 5 is for evacuation purposes during radium analysis). When the control instrument shows constant pressure close valve 3.

2. *De-Emanation*

   Slowly open valve 2 until pressure equalisation visualised by the instrument. Pressure value will reach about 100 mbar. Very carefully open valve 1 and let nitrogen bubble through the liquid. Useful is a needle valve for slow gas transport. Prevent the drying tube from contamination with foam. At pressure equalisation close all valves with valve 6 being the first.

3. *Volume determination*

   Measure the sample volume in the tube.

The chamber is counted with the analysis ‘Radon in liquid 1’ of the counter program. The calculation result is the concentration of radon in the analysed water solution.

Methods 2/3 - De-Emanation

The handling during this procedure is described for both: flexible and rigid sample bottles:

1. *Evacuation of apparatus*

   Attach a nitrogen flushed scintillation chamber as well as the sample bottle to the apparatus. With the vacuum pump on open valves 3, 4, 6. When the control instrument shows constant pressure valve 3.

2. *First De-Emanation*

   Slowly and carefully open valve 2. For flexible bottles: until liquid fills completely the bottle. It will be deformed by atmospheric pressure. *Pressure equalisation* between chamber and sample bottle *is not necessary*. Essential is the complete transport of the gas phase activity to the chamber. For glass bottles: Until pressure equalisation is reached. Close all valves. Fill the chamber with nitrogen to normal pressure.

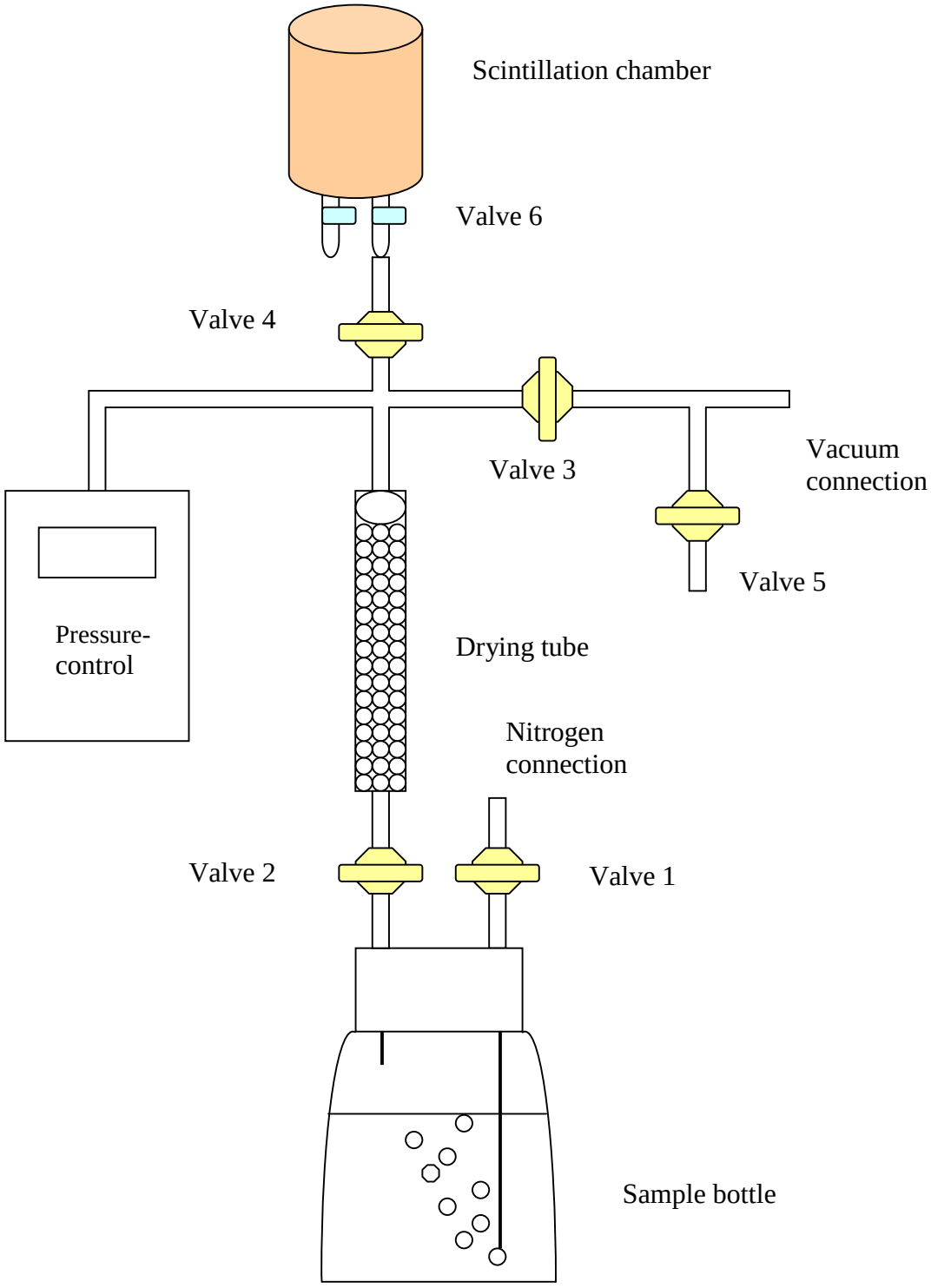
3. Second De-Emanation

Let nitrogen fill completely the bottle by opening valve 1. Close it after pressure equalisation. Wait to reach equilibrium between gas and liquid phase. After attaching a second evacuated chamber to the stand and opening of valves 4 and 6 repeat step *2*.

4. Volume determination

Measure the sample volume in the bottle.

Count the chambers with analysis ‘Radon in liquid 1’ (for the first chamber) resp. ‘Radon in liquid 2’ (the second one). After termination of the measurements both values can be combined by use of the ‘Radon in liquid’ menu item from the menu ‘Measurements’. The single values are only intermediate results.


Scintillation chamber
Valve 6
Valve 4
Valve 3
Vacuum
connection
Valve 5
Pressure-
control
Drying tube
Nitrogen
connection
Valve 2
Valve 1
Sample bottle