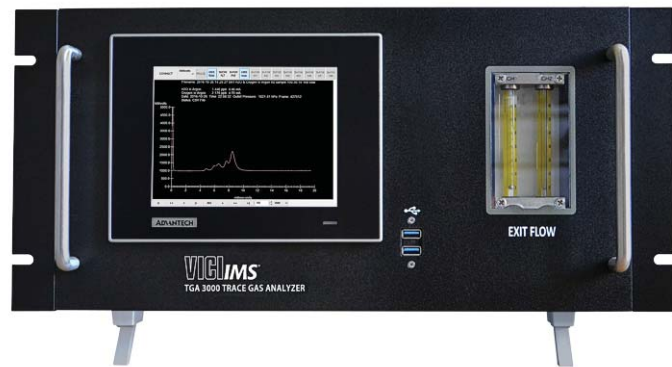


TRACE GAS ANALYZERS

TGA MODEL 3000

- Real-time results, in situ or online
- Sample flow less than 200 ml/min
- No vacuum pump, no moving parts
- Operating range of 0-30 ppb undiluted or 0-1000 ppb diluted
- Onboard PC operation/concentration display
- Variety of available outputs: RS-232, ethernet, 4-20mA, log file



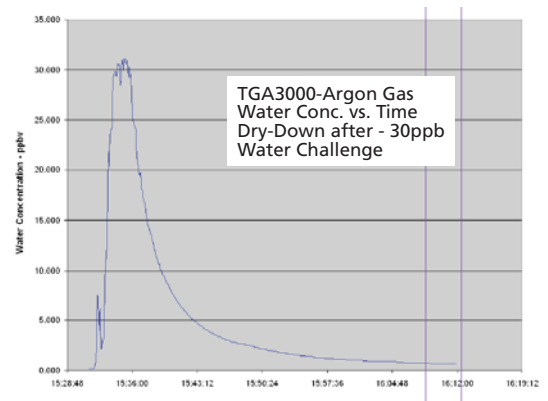
For many years, the Ion Mobility Spectrometer (IMS) has been successfully used to detect gas phase trace contaminants in a variety of applications. In general terms, the IMS is an electronic, gas phase, atmospheric pressure, trace chemical analyzer providing sub-ppb detection limits with chemical discrimination based upon ion mobility.

IMS has been shown to be an effective technique for the detection of many important trace contaminants in five major UHP bulk gases. Detection limits less than 0.1 ppb have been demonstrated.

TRACE MOISTURE AND OXYGEN

IN HIGH PURITY GASES

UHP bulk gas	O ₂ detection limit	H ₂ O detection limit
Argon	200 parts per trillion	200 parts per trillion
Helium	200 parts per trillion	200 parts per trillion
Nitrogen	200 parts per trillion	200 parts per trillion
Hydrogen	200 parts per trillion	200 parts per trillion
Carbon dioxide	500 parts per trillion	500 parts per trillion
Oxygen	n/a	200 parts per trillion



TRACE AMMONIA OR SULFUR DIOXIDE

IN HIGH PURITY GASES

UHP bulk gas	NH ₃ detection limit	SO ₂ detection limit
Carbon dioxide	500 parts per trillion	500 parts per trillion
Purified CDA	200 parts per trillion	200 parts per trillion

THEORY OF OPERATION

ION MOBILITY SPECTROMETRY

From elementary chemical kinetic theory applied to the ion molecule reactions that occur in the IMS, the change in concentration of the reactant ion, R, over time depends only on the concentrations of the interacting species (R and the sample chemical S) and the reaction rate constant. This is described mathematically by the following differential equation:

$$d[R]/dt = -k[R][S],$$

where the bracketed letters represent the concentrations of the reactants. The minus sign indicates that [R] is decreasing; R is the reactant ion being used up in the reaction. An advantage in calculating the rates of ion-molecule reactions in the atmospheric pressure IMS is that the concentrations of the various reactants will be greatly different from each other. The concentration of any ion in the IMS will be at least 3 to 4 orders of magnitude less than neutral sample molecules even when they are present at low ppb concentrations, so that even the complete consumption of the reactant ion R⁺ will affect

the concentration of S by a trivial amount. Thus, during the reaction, [S] can be considered a constant. If at t = 0, [R⁺] = [R_o⁺], then the following equation is easily derived after rearrangement and integration of the above differential equation:

$$\ln([R^+]/[R_{o^+}]) = -k[S]t,$$

where ln is the natural logarithm, [R_o⁺] is the intensity of the reactant ion before the introduction of S, [R⁺] is the intensity of the reactant ion after the introduction of S, k is the rate constant for the reaction of R⁺ with the sample chemical S, and t is the time of reaction, usually the drift time of R⁺ in the reaction region.

Once the peak intensities and rate constants of the relevant ions are known, the above equation can be simply rearranged to calculate the concentrations of the chemicals producing the IMS peaks, without further need for calibration.