

Introduction to Quadrupole Mass Spectrometry

Introduction

The quadrupole mass spectrometer (QMS) is an instrument for measuring the relative amounts of different gases in a mixture. The gas could be atmospheric air, could be evolved from a chemical process, might be trapped inside a small mineral sample, or even be dissolved in a liquid such as sea water. When the gas is that which remains inside a vacuum chamber following removal of most of the air, the quadrupole mass spectrometer is commonly known as a Residual Gas Analyser, or RGA, and that is really the only distinction between them.

This simple introduction aims to provide a basic overview of the main concepts. Quadrupole mass spectrometry has been studied, developed and applied over many years however and there are numerous detailed treatments for the interested reader. A good place to start is the classic text on the subject “Quadrupole Mass Spectrometry and its Applications” by Peter H. Dawson.

How Does It Work?

The QMS works by ionising the gas mixture and then separating the formed ions according to their different masses (more accurately the mass-to-charge ratio). Once separated, the ions are detected and displayed in software by plotting the relative intensity of the different masses. The QMS has three main elements;

1. The Ion Source

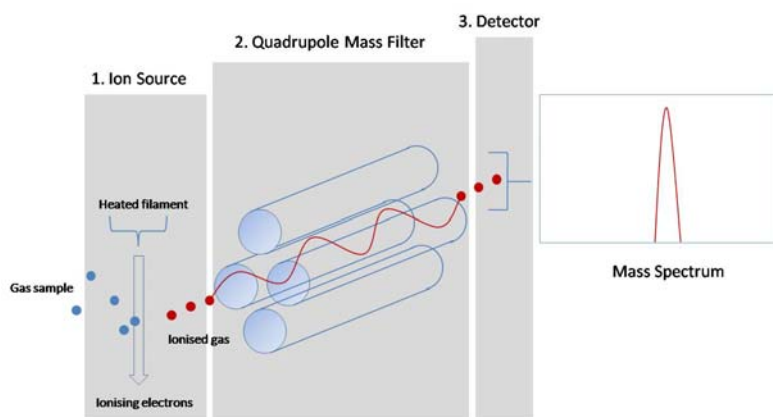
Molecules from the gas sample are ionised by energetic electrons from a heated filament.

2. The Quadrupole Mass Filter

A mixture of a.c. and d.c. voltages applied to opposite pairs of cylindrical metal rods allow ions of a chosen mass to pass from the ion source to the detector. All others are rejected. Varying these voltages allows different masses to pass in turn and a scanned spectrum is produced.

3. The Detector

Chosen ions are detected and generate a measured current that is used to construct the mass spectrum.



Schematic of the QMS



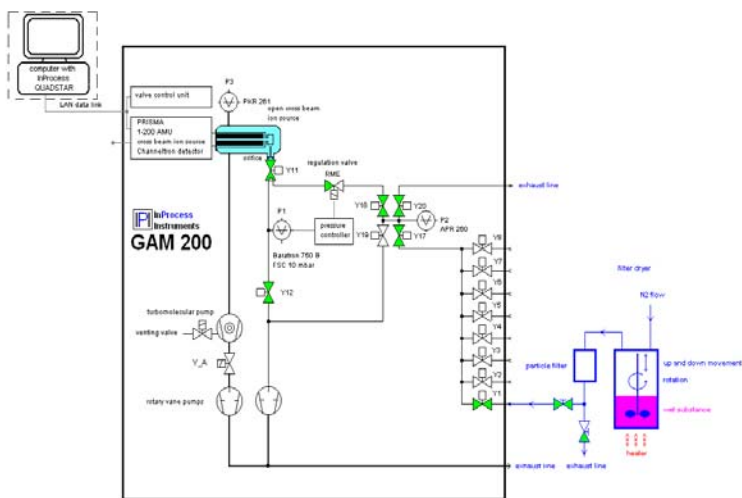
MKS Spectra 'Microvision-IP' QMS

If the gas was made up of just one component, say oxygen, then we might measure just one intensity, or peak, corresponding to 100% and appearing on our measurement scale at mass 32 (the molecular weight of oxygen). In practice the spectrum of even single component gases usually requires some interpretation due to the existence of naturally occurring isotopes and the fragmentation processes that happen in the ion source. Luckily, these are very well known and modern mass spectrometers can handle these artefacts with ease allowing accurate and repeatable measurement from 100% to sub-ppm levels.

Application Specific Configurations

The QMS can only be operate when it is in a low pressure vacuum chamber because at higher pressures the gas molecules and ions to be analysed would be scattered by collisions with other molecules. For vacuum related measurements the QMS simply bolts directly onto the host chamber and no further pressure reduction is required. For many other applications needing analysis of atmospheric pressure gases however, the QMS is configured and supplied with its own vacuum chamber, complete with vacuum pumps and appropriate gas inlet.

The example below shows the process interface, gas introduction and pressure reduction inlet of the InProcess Instruments GAM200 Pharma QMS, an on-line gas analyser specifically configured to analyse pharmaceutical drying processes.



Schematic of QMS Inlet/Sampling System for Pharma Drying Application InProcess Instruments GAM200 Pharma QMS

Summary

Quadrupole mass spectrometers are analytical tools which, with appropriate configuration, are routinely used in a wide range of laboratory and on-line applications spanning more than 12 decades of pressure.



[InProcess Instruments](#) manufacture the most comprehensive range of quadrupole mass spectrometers for on-line industrial process gas analysis applications ranging from UF₆ isotope measurement to analysis of bulb & lamp fill gases. [MKS Spectra](#) manufacture the most comprehensive range of industry leading RGA's, analytical quadrupole mass spectrometers and vacuum process monitors.