

12.119: Concentration determination by isotope dilution

Most concentration determinations that are done by thermal ionization mass spectrometry use the technique of isotope dilution. The basic principle of isotope dilution is that a known amount of a spike (or tracer) of known isotopic composition and elemental concentration is added to a sample of unknown isotopic composition and unknown element concentration. From the measured isotopic composition of the spiked sample, the isotopic composition and elemental concentration of the unknown can be calculated. From the viewpoint of arithmetic, it is a simple mixing problem:

Atoms in sample + atoms in spike = atoms in mixture

The “atoms in spike” is known from previous measurements and the weight of the spike; the “atoms in mixture” is the quantity measured in the mass spectrometer, so that the unknown is “atoms in sample.” The only kicker in the works is that we measure ratios of atoms in the mass spectrometer, because they are easier to measure, and have fewer uncertainties than measurements of “absolute” numbers of atoms. Correspondingly, the arithmetic is complicated by having to deal with ratios.

In our laboratory, we use two different Pb spikes – a ^{205}Pb spike and a ^{208}Pb spike. Here are the data for the spikes:

	^{204}Pb	^{205}Pb	^{206}Pb	^{207}Pb	^{208}Pb
MIT 1M:	0.000475717	18.4094	0.009715	0.00703748	0.015377
Data in picomoles/gram of spike					
MIT 208:	3.7620e-6		0.00767233	5.5536e-5	155.093136
Data in picograms/milligram of spike					
Atomic weights:					
	203.97302	204.9737	205.97444	206.975872	207.976627

The data for samples run with the two spikes are (these are fractionation corrected, atomic ratios):

	$^{206}\text{Pb}/^{204}\text{Pb}$	$^{207}\text{Pb}/^{204}\text{Pb}$	$^{208}\text{Pb}/^{204}\text{Pb}$	$^{206}\text{Pb}/^{205}\text{Pb}$	sample wt. (g)	MIT-1M spike wt. (g)	
T 2545	18.702	15.644	38.464	45041.035	0.1420	0.0105	
	$^{206}\text{Pb}/^{204}\text{Pb}$	$^{207}\text{Pb}/^{204}\text{Pb}$	$^{208}\text{Pb}/^{204}\text{Pb}$	$^{208}\text{Pb}/^{206}\text{Pb}$	sample wt. (g)	MIT 208 spike wt. (g)	extracted wt. (g)
Ch4 EtOH IC	18.584	15.594	38.250		0.3138		12.3029
Ch4 EtOH ID				29.963841	0.0961 ¹	0.0219	

¹ Of the total extracted weight in the line above, this is the weight of the aliquot I spiked.

Your task is to calculate the concentration of Pb in the two samples.

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