IRMM

Institute for Reference Materials and Measurements

CERTIFICATE
SPIKE ISOTOPIC REFERENCE MATERIAL IRMM-622

9.739 (18) · 10^{-6} mol (^{111}Cd) · kg^{-1} (solution)

The Spike Isotopic Reference Material is supplied with an isotope amount content of ^{111}Cd certified as above.

The amount of other cadmium isotopes present are related to the ^{111}Cd content through the following certified amount ratios**:**

$n(^{106}Cd)/n(^{111}Cd)$:	< 0.000 05
$n(^{108}Cd)/n(^{111}Cd)$:	< 0.000 05
$n(^{110}Cd)/n(^{111}Cd)$:	0.004 44 (42)
$n(^{112}Cd)/n(^{111}Cd)$:	0.021 74 (10)
$n(^{113}Cd)/n(^{111}Cd)$:	0.005 818 (56)
$n(^{114}Cd)/n(^{111}Cd)$:	0.010 875 (88)
$n(^{116}Cd)/n(^{111}Cd)$:	0.001 629 (44)

This corresponds to an isotopic composition with the following abundances **:**

	amount fraction (·100)		mass fraction (·100)
$n(^{106}Cd)/n(Cd)$	< 0.005	$m(^{106}Cd)/m(Cd)$	< 0.005
$n(^{108}Cd)/n(Cd)$	< 0.005	$m(^{108}Cd)/m(Cd)$	< 0.005
$n(^{110}Cd)/n(Cd)$	0.425 (40)	$m(^{110}Cd)/m(Cd)$	0.421 (40)
$n(^{111}Cd)/n(Cd)$	95.740 (42)	$m(^{111}Cd)/m(Cd)$	95.682 (42)
$n(^{112}Cd)/n(Cd)$	2.080 9 (94)	$m(^{112}Cd)/m(Cd)$	2.098 6 (94)
$n(^{113}Cd)/n(Cd)$	0.557 0 (54)	$m(^{113}Cd)/m(Cd)$	0.566 7 (54)
$n(^{114}Cd)/n(Cd)$	1.041 1 (84)	$m(^{114}Cd)/m(Cd)$	1.068 8 (86)
$n(^{116}Cd)/n(Cd)$	0.156 0 (42)	$m(^{116}Cd)/m(Cd)$	0.162 9 (44)

The molar mass of the cadmium in this sample is 110.970 87 (80) $g \cdot mol^{-1}$

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From the certified values, the following amount content and mass fractions are derived:

10.172	(18) · 10^{-6}	mol (Cd)·	kg^{-1} (solution)
1.080 1	(20) · 10^{-6}	kg (^{111}Cd)·	kg^{-1} (solution)
1.128 8	(20) · 10^{-6}	kg (Cd) ·	kg^{-1} (solution)

NOTES

1. All uncertainties indicated are expanded uncertainties $U = k \cdot u_c$ where u_c is the combined standard uncertainty estimated following the ISO/BIPM Guide to the Expression of Uncertainty in Measurement. They are given in parentheses and include a coverage factor $k = 2$. They apply to the last two digits of the value. The values certified are traceable to the SI.

2. The Spike Isotopic Reference Material IRMM-622 comes in a flame-sealed glass ampoule containing about 0.04 µmol cadmium in 4 mL of a chemically stable nitric acid solution. The molality is about ~1 m HNO_3 (i.e. ~1 mol HNO_3 per kg of solvent); the molarity is about ~1M HNO_3 (i.e. ~1 mol HNO_3 per Liter of solution).

3. The molar masses, used in the calculations, are[1]

^{106}Cd :	105.906 458 (12)	g·mol^{-1}
^{108}Cd :	107.904 183 (12)	g·mol^{-1}
^{110}Cd :	109.903 006 (6)	g·mol^{-1}
^{111}Cd :	110.904 182 (6)	g·mol^{-1}
^{112}Cd :	111.902 757 7 (60)	g·mol^{-1}
^{113}Cd :	112.904 401 4 (60)	g·mol^{-1}
^{114}Cd :	113,903 358 6 (60)	g·mol^{-1}
^{116}Cd :	115.904 756 (6)	g·mol^{-1}

4. The Avogadro constant used is in the calculations is 6.022 136 (12) 10^{23} mol^{-1}.

5. Full details of the certification procedure can be found in IRMM internal Report GE/R/SIM/37/1997.

6. Using this Spike Isotopic Reference Material, the cadmium content in an unknown sample can be determined by Isotope Dilution, through a measurement of the isotope amount ratio $R(B) = n(^{112}\text{Cd})/n(^{111}\text{Cd})$ in a blend. It should be computed with the aid of the following equation which enables an easy quantification of the uncertainty sources in the procedure:

[1] G. Audi and A.H. Wapstra, The 1993 atomic mass evaluation , Nucl Phys A565 (1993) 1-65.

$$c(Cd, X) = \frac{R(Y) - R(B)}{R(B) - R(X)} \cdot \frac{\sum R_i(X)}{\sum R_i(Y)} \cdot \frac{m(Y)}{m(X)} \cdot c(Cd, Y)$$

where:

$R(X)$	=	amount ratio $n(^{112}Cd)/n(^{111}Cd)$ in the unknown sample material X
$R(Y)$	=	amount ratio $n(^{112}Cd)/n(^{111}Cd)$ in the spike material Y
$\sum R_i(X)$	=	sum of all amount ratios in the unknown sample material X
$\sum R_i(Y)$	=	sum of all amount ratios in the spike material Y
$m(X)$	=	mass of the unknown sample used in the measurement
$m(Y)$	=	mass of the sample of spike solution used in the measurement
$c(Cd, X)$	=	amount content of Cd · kg^{-1} sample material
$c(Cd, Y)$	=	amount content of Cd · kg^{-1} spike solution.

Chemical preparation of the samples and the isotopic measurements were carried out by A Götz by means of Thermal Ionisation Mass Spectrometry. Supervision of the thermal ionisation mass spectrometry was done by A Lamberty.

Metrological weighings required in the preparation and certification were performed by F Hendrickx. The ampoulation of this Spike Isotopic Reference Material was accomplished by G Van Baelen, P Taylor and I Papadakis.

The overall co-ordination leading to the establishment, certification and issuance of this Spike Isotopic Reference Material was performed by A Verbruggen.

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