



**CERTIFICATE  
SPIKE ISOTOPIC REFERENCE MATERIAL IRMM-644**

**$3.262\ 8(80) \cdot 10^{-4} \text{ mol } (^{32}\text{S}) \cdot \text{kg}^{-1} \text{ (solution)}$**

The Spike Isotopic Reference Material is supplied with an isotope amount content of  $^{32}\text{S}$  certified as above.

The amount content of other sulphur isotopes present are related to the  $^{32}\text{S}$  content through the following certified amount ratios:

$n(^{33}\text{S})/n(^{32}\text{S}) :$	<b>0.007 969 8(70)</b>
$n(^{34}\text{S})/n(^{32}\text{S}) :$	<b>0.045 162 2(82)</b>
$n(^{36}\text{S})/n(^{32}\text{S}) :$	<b>0.000 170 0(58)</b>

This corresponds to an isotopic composition with the following abundances :

amount fraction ( $\cdot 100$ )		mass fraction ( $\cdot 100$ )	
$n(^{32}\text{S})/n(\text{S})$	94.939 5(11)	$m(^{32}\text{S})/m(\text{S})$	94.661 9(12)
$n(^{33}\text{S})/n(\text{S})$	0.756 65(66)	$m(^{33}\text{S})/m(\text{S})$	0.778 02(68)
$n(^{34}\text{S})/n(\text{S})$	4.287 68(74)	$m(^{34}\text{S})/m(\text{S})$	4.542 01(78)
$n(^{36}\text{S})/n(\text{S})$	0.016 14(55)	$m(^{36}\text{S})/m(\text{S})$	0.018 10(62)

The molar mass of the sulphur in this sample is  $32.065\ 851(27) \text{ g} \cdot \text{mol}^{-1}$

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

$3.436\ 7(84) \cdot 10^{-4} \text{ mol (S)} \cdot \text{kg}^{-1} \text{ (solution)}$   
 $1.102\ 0(27) \cdot 10^{-5} \text{ kg (S)} \cdot \text{kg}^{-1} \text{ (solution)}$   
 $1.046\ 2(26) \cdot 10^{-5} \text{ kg } (^{32}\text{S}) \cdot \text{kg}^{-1} \text{ (solution)}$

## 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-644 comes in a flame-sealed glass ampoule containing about 2  $\mu\text{mol}$  sulphur in 5 mL of a nitric acid solution. The molarity is about 3.2 M  $\text{HNO}_3$ .
3. The atomic masses, used in the calculations, are<sup>1</sup>

$^{32}\text{S}$	: 31.97207073(15) $\text{g}\cdot\text{mol}^{-1}$
$^{33}\text{S}$	: 32.97145854(15) $\text{g}\cdot\text{mol}^{-1}$
$^{34}\text{S}$	: 33.96786687(14) $\text{g}\cdot\text{mol}^{-1}$
$^{36}\text{S}$	: 35.96708088(25) $\text{g}\cdot\text{mol}^{-1}$
4. IRMM-644 was obtained by dissolving  $\text{Ag}_2\text{S}$  in nitric acid and  $\text{Br}_2$  solution. The acid used was prepared in house by subboiling distillation of analytical grade nitric acid. Full details of the preparation procedure can be found in IRMM internal Report GE/IM/R/03/00.
5. The values of this Spike Isotopic Reference Material are traceable to the SI in the shortest possible way. Measurements calibrated against these Isotopic Reference Materials have therefore the potential of being traceable to the SI.

The chemical preparation of this Spike Isotopic Reference Material was performed by M Ostermann.

Metrological weighings required in the preparation and certification were performed by B Dyckmans–Van Hout. The ampoulation of this Spike Isotopic Reference Material was accomplished by M Ostermann, M Berglund and G Van Baelen.

M Berglund co-ordinated the work leading to the establishment, certification and issuance of this Isotopic Reference Material. A Verbruggen was responsible for the preparation and issuance of the certificate.



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IRMM Isotope Measurements

<sup>1</sup> G. Audi and A.H. Wapstra, The 1993 atomic mass evaluation, Nucl Phys A565 (1993) 1-65.