SOLAR ABUNDANCES OF THE ELEMENTS. O. Manuel, Nuclear Chemistry, University of Missouri, Rolla, MO 65401 USA (om@umr.edu).

Introduction: Isotopic abundances observed in meteorites and lunar samples support the 1917 elemental abundance estimate by Harkins [1] over popular, modern estimates [e.g., 2].

Background: In 1917, Harkins [1] determined the abundances of the elements. Noting that the Earth's crust and the Sun's gaseous envelope may not represent the overall compositions of these bodies, Harkins used chemical analyses on 443 ordinary meteorites to conclude that the seven most abundant elements are Fe, O, Ni, Si, Mg, S and Ca.

First, Cecilia Payne [3] and later Russell [4] used lines of different elements in the solar spectrum to show that hydrogen (H) is the most abundant element in the Sun's atmosphere. Payne regarded the high value derived for the abundance of H as "*spurious*" [See p. 186], and Russell regarded this as a puzzle that remained to be solved. Despite Harkins' earlier warning about using atmospheric abundances and Russell's comment that *"The calculated abundance of hydrogen in the sun's atmosphere is almost incredibly great"* [See p. 70], the scientific community began using line spectra of the solar photosphere to estimate the abundances of H, He and other light, volatile elements.

Isotopic Abundances: In 1969, the first Apollo mission returned with lunar samples and the Allende meteorite fell in Mexico. A comparison of the abundances of noble gas isotopes in lunar soil # 12001 with those in air and in a mineral separate of the Allende meteorite revealed a systematic enrichment of the lighter mass isotopes of each element implanted from the solar wind (SW). The abundances of SW-implanted He, Ne, Ar, Kr and Xe isotopes defined a smooth mass fractionation pattern [5], as expected if diffusion in the Sun selectively enriches lighter nuclides at the solar surface relative to heavier nuclides by a factor of $(m_H/m_L)^{4.56}$.

Elemental Abundances: Intra-solar diffusion also explains Russell's puzzle: H is the lightest and most abundant element in the Sun's atmosphere; the second lightest element, helium (He), is the second most abundant element there. When the abundances of all elements in the solar photosphere are corrected for the diffusive mass-fractionation observed across the isotopes of SW-implanted gases, the most abundant element in the unfractionated Sun is Fe [5]. Table 1 compares the first seven abundant elements in compilations by references [1, 2, 5].

Table 1. A Comparison of Estimates of the Seven Most Abundant Elements

Harkins [1]	Fe	O	Ni	Si	Mg	S	Ca
Anders and Grevesse [2]	H	He	O	C	Ne	N	Fe
Reference [5]	Fe	Ni	O	Si	S	Mg	Ca

The agreement between the compilations by Harkins [1] and ref. [5] is remarkable. One is from wet chemical analyses of common meteorites; the other from line spectra of the solar photosphere and isotopic analyses of SW-elements. Both indicate that the most abundant elements are those whose nuclei have low mass per nucleon. These are plentiful in planetary material closest to the sun, but they exist only as trace elements in the solar photosphere.

Conclusion: The empirical equation that fits the mass-fractionation pattern of isotopes in SW-implanted He, Ne, Ar, Kr and Xe also selects from the solar photosphere the same seven elements that Harkins [1] identified as most abundant in meteorites. The probability for the chance selection of any set of seven different elements from the 83 in the sun is $7!\ 76!\ /83! = 2 \times 10^{-10}$ if each element has equal chance for selection but less than 2×10^{-33} if the chance for selection depends on their atomic abundances in the photosphere. Fe is the Sun's most abundant element.

References: [1] Harkins W. D. (1917) *J. Am. Chem. Soc.*, ***39***, 856-879. [2] Anders E. and Grevesse N. (1989) *Geochim. Cosmochim. Acta*, ***53***, 197–214. [3] Payne C. H. (1925) *Stellar Atmospheres*, Harvard Observatory Monographs # 1, 177-189. [4] Russell H. N. (1929) *Ap. J.*, ***70***, 11-82. [5] Manuel O. K. and Hwaung G. (1983) *Meteoritics*, ***18***, 209-222.