
X-Ray Data Booklet

Section 1.7 ATOMIC SCATTERING FACTORS

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The optical properties of materials in the photon energy range above about 30 eV can be described by the atomic scattering factors. The index of refraction of a material is related to the scattering factors of the individual atoms by

$$n = 1 - \delta - i\beta = 1 - \frac{r_e}{2\pi} \lambda^2 \sum_i n_i f_i(0) \quad , \quad (1)$$

where r_e is the classical electron radius, λ is the wavelength, and n_i is the number of atoms of type i per unit volume. The parameters δ and β are called the refractive index decrement and the absorption index, respectively. The complex atomic scattering factor for the forward scattering direction is

$$f(0) = f_1 + if_2 \quad . \quad (2)$$

The imaginary part is derived from the atomic photoabsorption cross section:

$$f_2 = \frac{\sigma_a}{2r_e\lambda} \quad . \quad (3)$$

The real part of the atomic scattering factor is related to the imaginary part by the Kramers-Kronig dispersion relation:

$$f_1 = Z^* + \frac{1}{\pi r_e hc} \int_0^\infty \frac{\epsilon^2 \sigma_a(\epsilon)}{E^2 - \epsilon^2} d\epsilon \quad . \quad (4)$$

In the high-photon-energy limit, f_1 approaches Z^* , which differs from the atomic number Z by a small relativistic correction:

$$Z^* \approx Z - (Z/82.5)^{2.37} \quad . \quad (5)$$

On the following pages, Fig. 1-6 presents the scattering factors for 15 elements in their natural forms. Complete tables are given in B. L. Henke, E. M. Gullikson, and J. C. Davis, "X-Ray Interactions: Photoabsorption, Scattering, Transmission, and Reflection at $E = 50\text{--}30,000$ eV, $Z = 1\text{--}92$," *At. Data Nucl. Data Tables* **54**, 181 (1993).

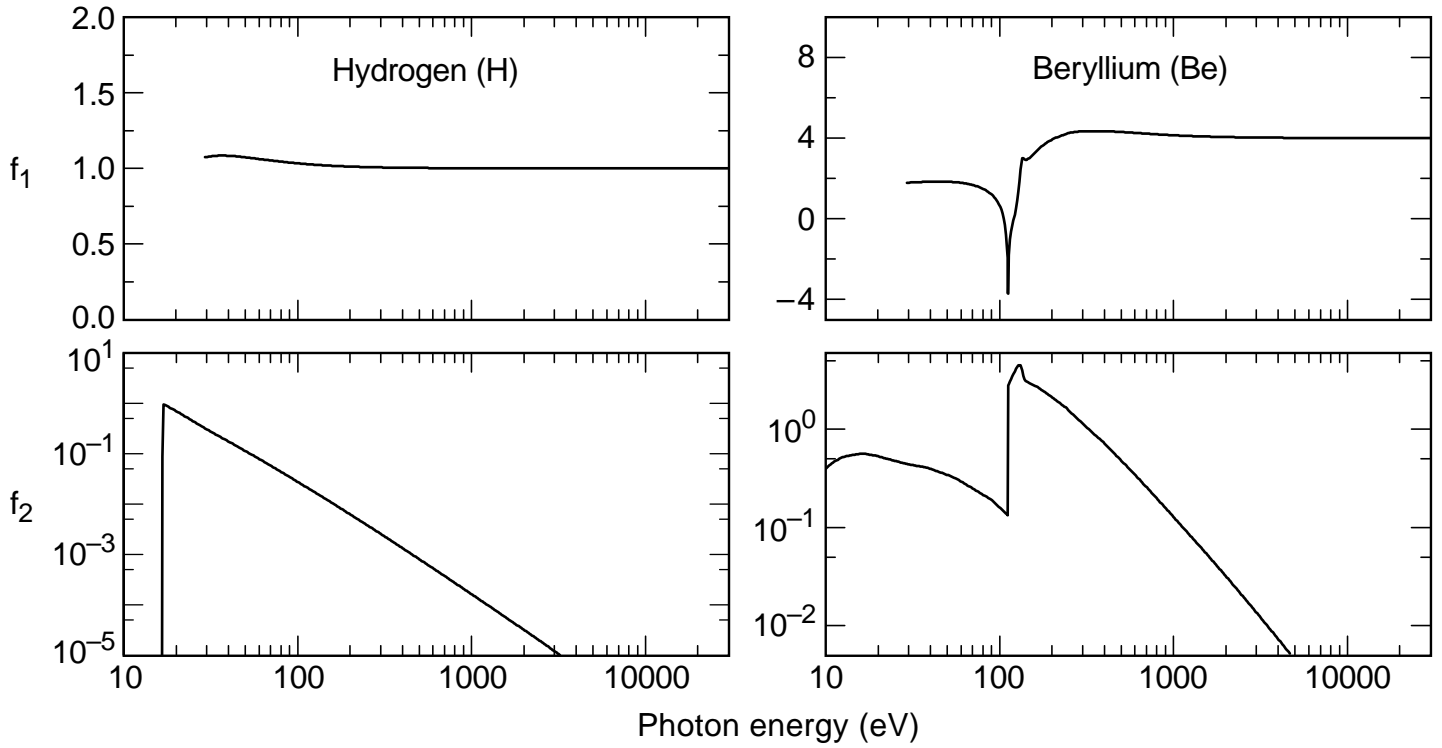


Fig. 1-6. Plots of scattering factors for several elements in their natural forms.

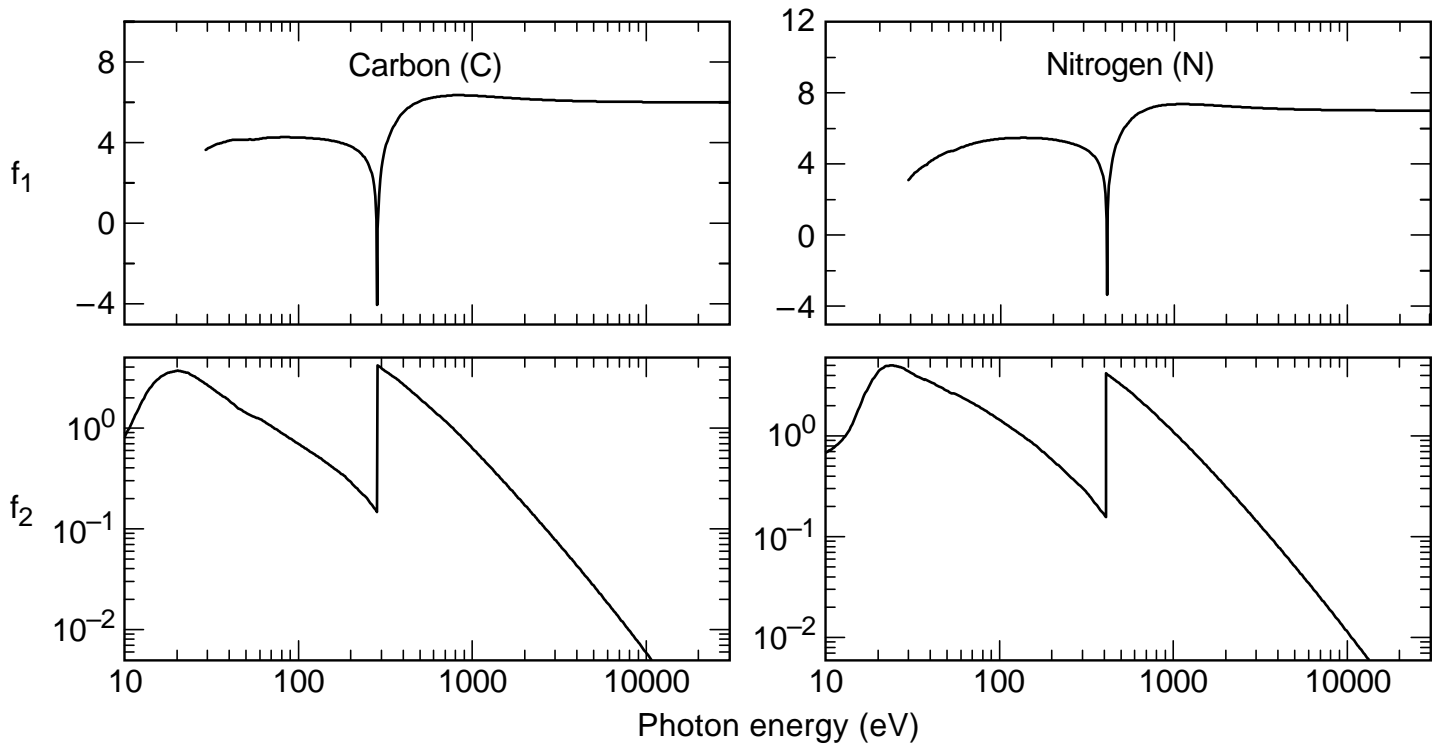


Fig. 1-6. Carbon and Nitrogen scattering factors.

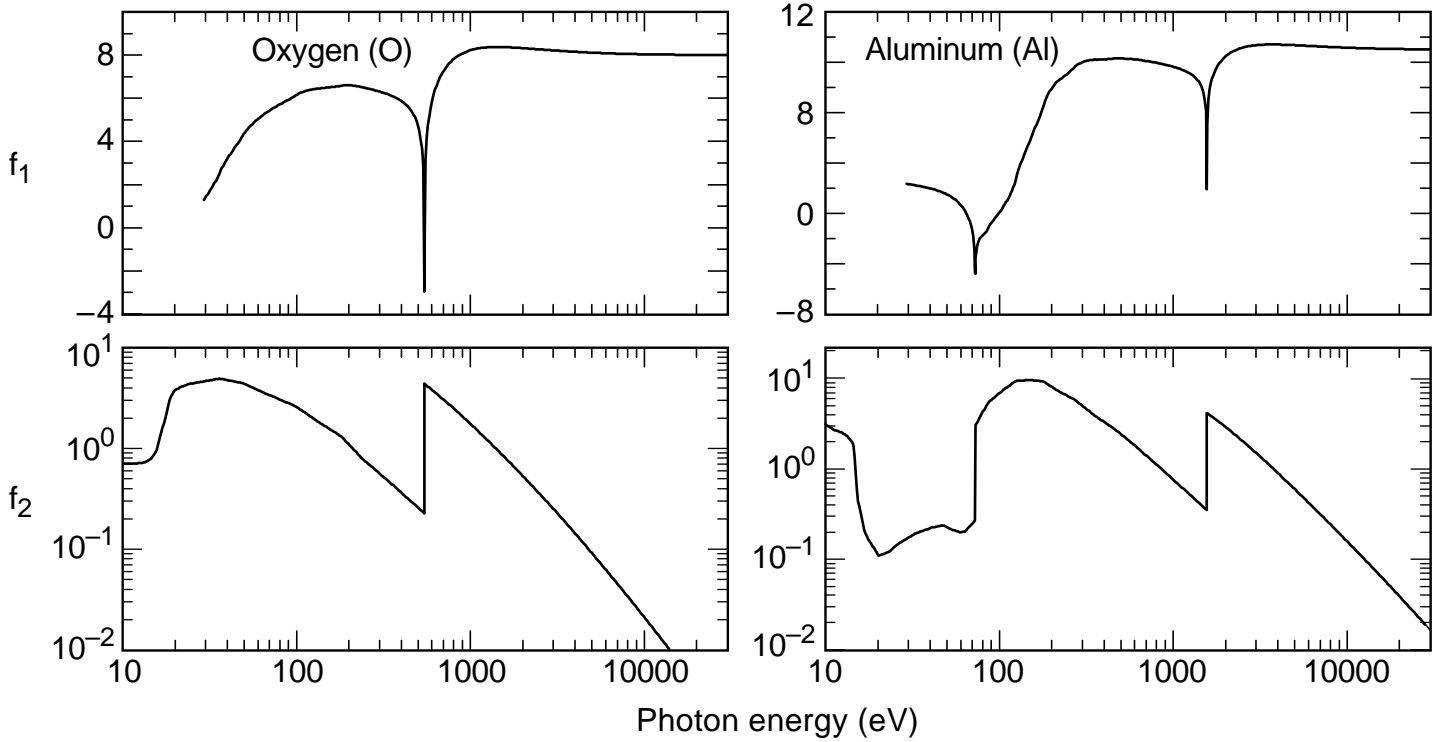


Fig. 1-6. Oxygen and Aluminium scattering factors.

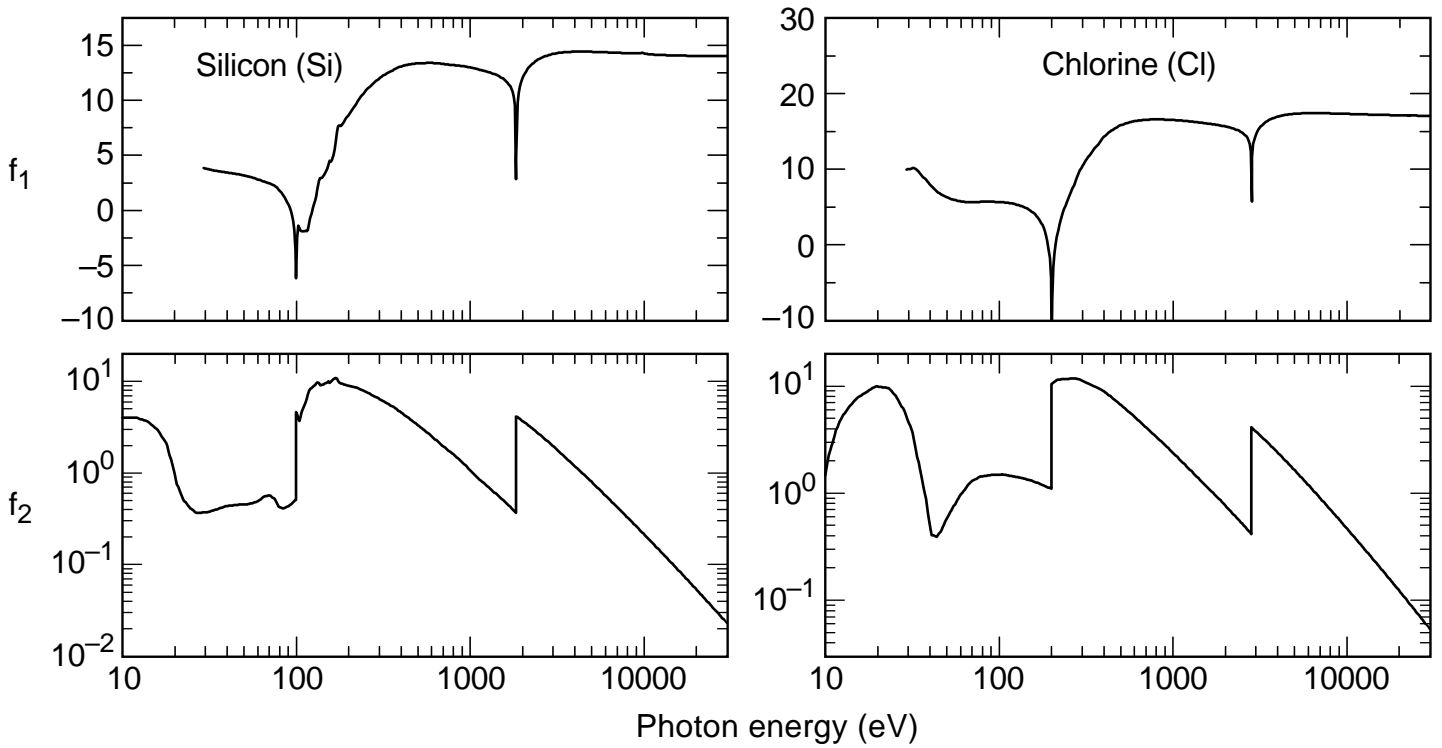


Fig. 1-6. Silicon and Chlorine scattering factors.

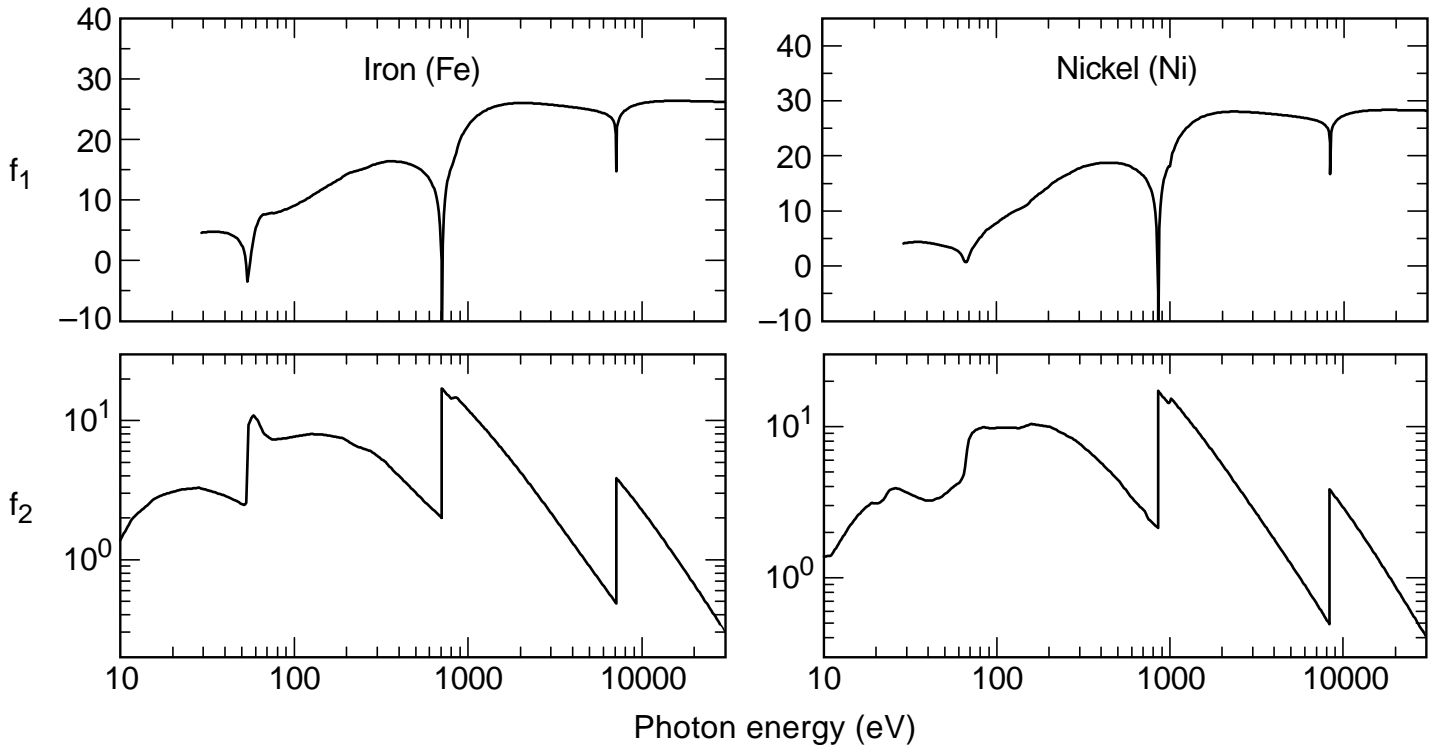


Fig. 1-6. Fe and Ni Scattering factors.

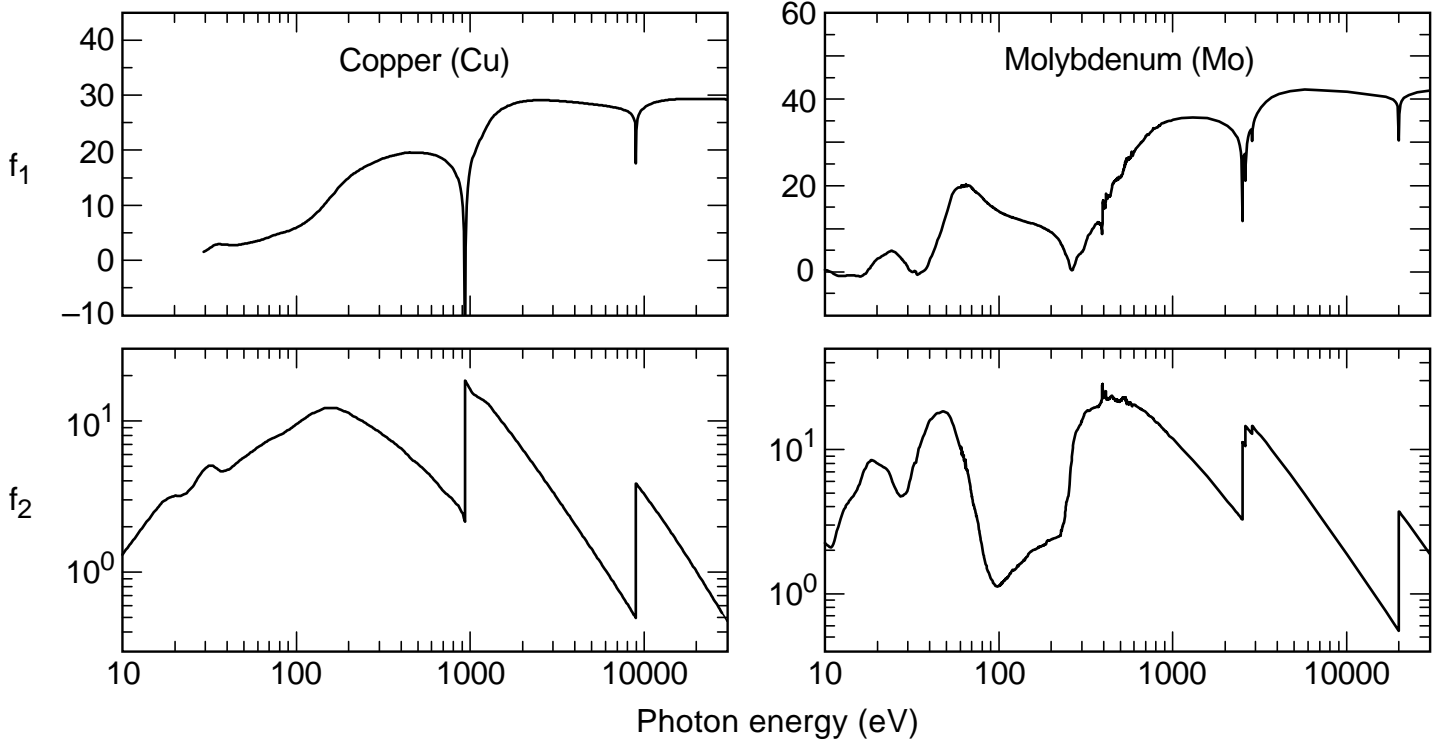


Fig. 1-6. Copper and Molybdenum scattering factors.

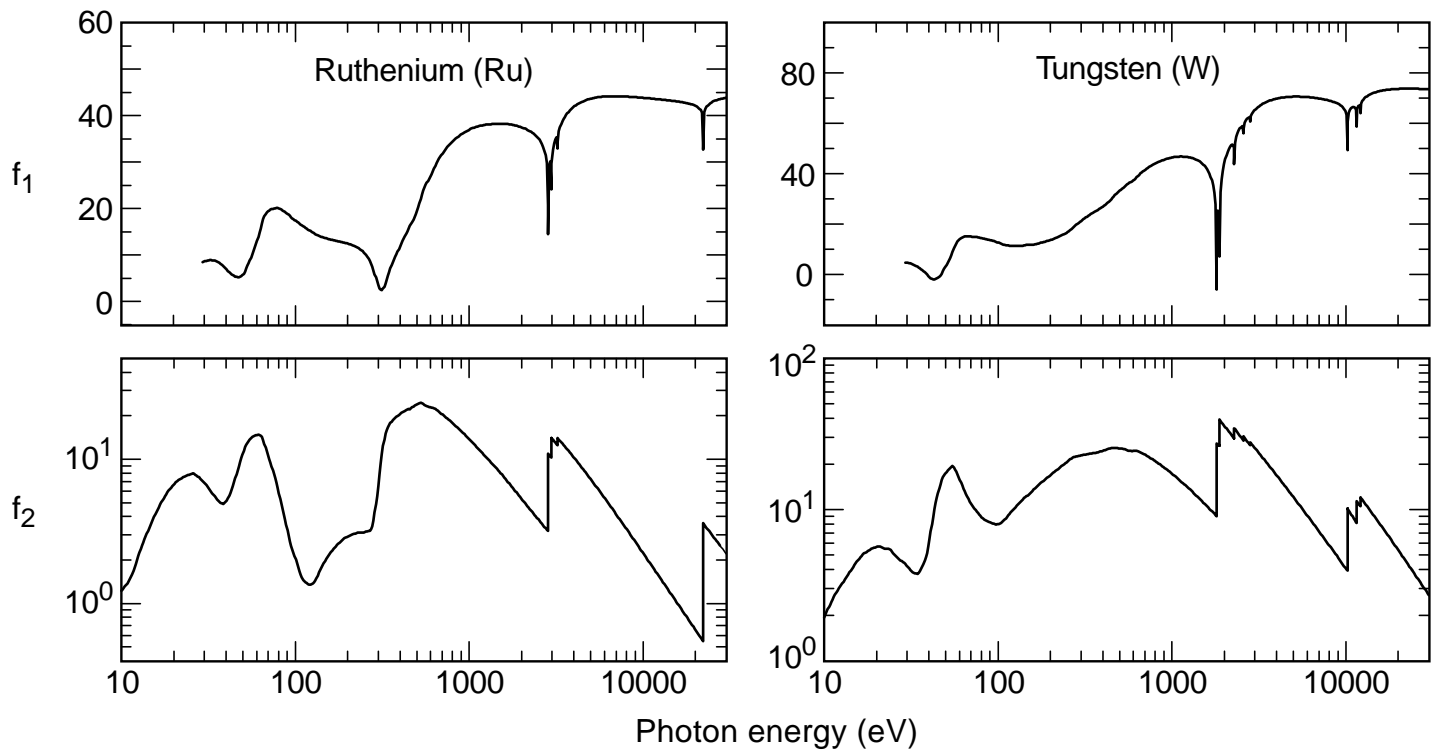


Fig. 1-6. Ruthenium and Tungsten scattering factors.

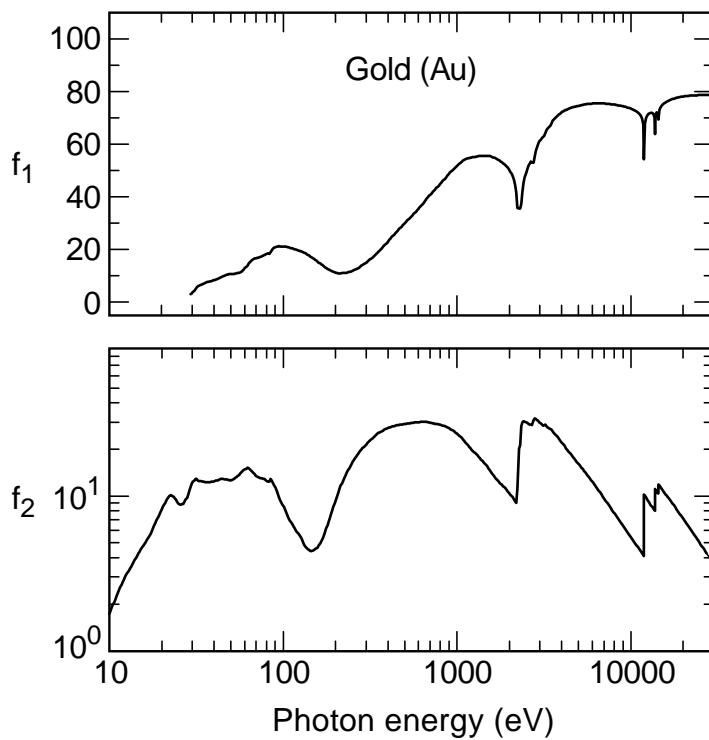


Fig. 1-6. Gold scattering factors.