PARAMETERIZED HYDROSTATIC AND EXPLOSIVE BURNING OF HYDROGEN, HELIUM, AND CARBON B. S. Meyer, Department of Physics and Astronomy, Clemson University, Clemson, SC 29634-1911.

The peculiar isotopic abundances in some meteoritic grains allow us to identify these grains as presolar [e.g. 1-3]. Comparison of the isotopic abundance patterns to predictions of abundances in stellar environments may also allow us to infer the site or sites of condensation of these grains. Such research provides a direct link between the sciences of meteoritics and astronomy.

Because of the small size and the low abundances of trace elements in presolar grains, most studies of the origination sites of presolar grains concentrate on the dominant isotopic constituents. These are typically isotopes of carbon, oxygen, aluminum, and silicon. Many detailed calculations of the yields of these isotopes from various astrophysical environments exist [e.g. 4-7]. There are fewer detailed calculations of the yields of the trace elements (especially elements heavier than zinc) from stellar environments in the astrophysical literature. Nevertheless, the trace elements may also provide important clues about the stellar environment in which the grains formed, so more calculations of the yields of these elements may be valuable.

With this motivation in mind, I calculated the isotopic yields from parameterized hydrostatic hydrogen, helium, and carbon burning and explosive helium and carbon burning. The network code I used employs up-to-date reaction rates for nuclei from hydrogen to bismuth [8-11]. The tables of output from each run give the mass fraction and overproduction factor of each stable or long-lived isotope from hydrogen to bismuth, thus providing information on all the trace elements. Note that the overproduction factor for a given isotope is the ratio of the mass fraction of that isotope in the nucleosynthetic environment to its mass fraction in the solar system. The tables are available electronically upon request (send e-mail to brad@cosmo.phys.clemson.edu).

Table 1 shows the hydrostatic runs. I calculated hydrogen burning at a constant temperature of $T_9 = 0.04$ (where $T_9 = T/10^9$ K so $T_9 = 0.04$ indicates a temperature of 4×10^7 K) and a density of 10 g/cm^3 (run 1). The initial abundances were a solar composition [12]. I stopped the burning once the hydrogen mass fraction dropped below 10^{-5} after 2.7×10^6 years. I then used the ashes of hydrogen burning as seeds for helium burning. I ran helium burning at conditions indicated in Table 1 until the ^{4}He mass fraction had dropped below 10^{-5} (run 2). I used the ashes of helium burning as seeds for each of the three calculations of carbon burning (runs 3-5). Each of these calculations proceeded until the mass fraction of ^{12}C had dropped to 10^{-5}.

Table 2 shows the explosive runs. In each of these runs one should imagine the material was shocked to a peak temperature T_{9p} and density ρ_p. The material then expanded as $\rho(t) = \rho_p \exp(-t/\tau)$, with $\tau = 446/\sqrt{\rho_p}$ seconds, that is, the hydrodynamical time scale. In these cases, the expansion is assumed to be adiabatic so that $\rho \propto T^3$. The calculations ran until the temperature dropped below 10^7 K, at which point nuclear reactions ceased. These parameterizations model fairly well the response of a stellar atmosphere to shock passage during a supernova. The initial abundances for explosive helium burning (runs 6-9) are the ashes of hydrostatic hydrogen burning (run 1 of Table 1) while the initial abundances for explosive carbon burning (runs 10-12) are the ashes of hydrostatic helium burning (run 2 of Table 1).

While the models run are simply parameterized calculations and not made within a detailed stellar model, the conditions chosen are similar to those that found in real stars. The output tables provide yields for isotopes beyond zinc. In this way they can provide more information for those seeking to confront meteoritical data with astrophysical predictions.

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Table 1.

Hydrostatic

Run	Burning	T_9	$\rho(g/cm^3)$	t (yr)
1	H	0.04	10	2.57×10^6
2	He	0.2	10^3	1.36×10^6
3	C	0.8	10^5	6.00×10^6
4	C	1.0	10^5	1.10×10^4
5	C	1.2	10^5	89.0

Table 2.

Explosive

Run	Burning	T_{9p}	$\rho_p(g/cm^3)$
6	He	0.5	10^4
7	He	1.0	10^4
8	He	1.5	10^4
9	He	2.0	10^4
10	C	1.8	10^5
11	C	2.0	10^5
12	C	2.2	10^5