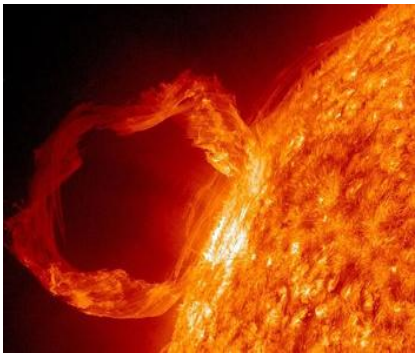

In addition to mass and volume, density is the next most important feature of matter that we can easily determine. Density is just the mass of an object divided by its volume. With the exception of the air that we breathe, most things around us have about the same density. In space, and among all the diverse objects and systems we find there, densities can vary enormously.

Although density is usually measured in terms of kg per cubic meter, in astronomy we prefer to use the number of particles per cubic meter. The mass of a hydrogen atom is 1.6×10^{-27} kg, so we can easily convert densities given in kg/m^3 into hydrogen atoms/meter^3.

Problem 1 – Complete the table below by calculating the density of each indicated astronomical system in equivalent hydrogen atoms/meter^3.

Name	Volume	Mass	Density (H/m^3)
Atmosphere of Earth	4.2×10^{18} m^3	5.1×10^{18} kg	
Red Supergiant Betelgeuse	2.3×10^{33} m^3	4.0×10^{31} kg	
Surface of the Sun	6.0×10^{28} m^3	1.2×10^{25} kg	
Atmosphere of Moon	1.9×10^{15} m^3	1.0×10^{4} kg	
Solar Corona	9.0×10^{26} m^3	8.9×10^{13} kg	
Interstellar Dark Cloud	5.0×10^{47} m^3	9.5×10^{31} kg	
Orion Nebula	6.2×10^{51} m^3	1.5×10^{33} kg	
Solar Wind inside Earth Orbit	1.4×10^{34} m^3	4.5×10^{14} kg	
Milky Way Galaxy	1.6×10^{60} m^3	2.0×10^{39} kg	
Van Allen Radiation Belts	1.3×10^{23} m^3	1.1×10^{-2} kg	

Problem 1 – Complete the table below by calculating the density of each indicated astronomical system in equivalent hydrogen atoms/meter^3.

Answer: See below.

Example: Solar Corona
D = M/V
= $8.9 \times 10^{13} / 9.0 \times 10^{26}$
= 9.9×10^{-14} kg/m^3

Then N = $9.9 \times 10^{-14} / 1.6 \times 10^{-27}$
= 6.2×10^{13} hydrogen atoms/m^3

Name	Volume	Mass	Density (H/m^3)
Atmosphere of Earth	4.2×10^{18} m^3	5.1×10^{18} kg	**7.5×10^{26}**
Red Supergiant Betelgeuse	2.3×10^{33} m^3	4.0×10^{31} kg	**1.1×10^{25}**
Surface of the Sun	6.0×10^{28} m^3	1.2×10^{25} kg	**1.3×10^{23}**
Atmosphere of Moon	1.9×10^{15} m^3	1.0×10^{4} kg	**3.3×10^{15}**
Solar Corona	9.0×10^{26} m^3	8.9×10^{13} kg	**6.2×10^{13}**
Interstellar Dark Cloud	5.0×10^{47} m^3	9.5×10^{31} kg	**1.2×10^{11}**
Orion Nebula	6.2×10^{51} m^3	1.5×10^{33} kg	**1.5×10^{8}**
Solar Wind inside Earth Orbit	1.4×10^{34} m^3	4.5×10^{14} kg	**2.0×10^{7}**
Milky Way Galaxy	1.6×10^{60} m^3	2.0×10^{39} kg	**8.1×10^{4}**
Van Allen Radiation Belts	1.3×10^{23} m^3	1.1×10^{-2} kg	**53**