Evaluating Secondary Physical Constants

Symbol	Name	Value
c	Speed of light	2.9979×10^{10} cm/sec
h	Planck's constant	6.6262×10^{-27} erg sec
m	Electron mass	9.1095×10^{-28} gms
e	Electron charge	4.80325×10^{-10} esu
G	Gravitation constant	6.6732×10^{-8} dyn cm^{2} gm^{-2}
M	Proton mass	1.6726×10^{-24} gms

Also use $\pi = 3.1415926$

Although there are only a dozen fundamental physical constants of Nature, they can be combined to define many additional basic constants in physics, chemistry and astronomy.

In this exercise, you will evaluate a few of these 'secondary' constants to three significant figure accuracy using a calculator and the defined values in the table.

Problem 1 - Bremstrahlung Radiation Constant: $$\frac{32\pi^2 e^6}{3(2\pi)^{1/2} m^3 c}$$

Problem 2 - Photoionization Constant: $$\frac{32\pi^2 e^6 (2\pi^2 e^4 m)}{3^{3/2} h^3}$$

Problem 3 - Stark Line Limit: $$\frac{16\pi^4 m^2 e^4}{h^4 M^5}$$

Problem 4 - Thompson Scattering Cross-section: $$\frac{8\pi}{3}\left(\frac{e^2}{mc^2}\right)^2$$

Problem 5 - Gravitational Radiation Constant: $$\frac{32}{5}\frac{G^5}{c^{10}}$$

Problem 6 - Thomas-Fermi Constant: $$\frac{324}{175}\left(\frac{4}{9\pi}\right)^{2/3}$$

Problem 7 - Black Hole Entropy Constant: $$\frac{c^3}{2hG}$$

Answer Key

Method 1: Key-in to a calculator all the constants with their values as given to all indicated significant figures, write down final calculator answer, and round to three significant figures.

Method 2: Round all physical constants to 4 significant figures, key-in these values on the calculator, then round final calculator answer to 3 significant figures.

Note: When you work with numbers in scientific notation, Ex 1.23×10^5, the leading number '1.23' has 3 significant figures, but 1.23000 has 6 significant figures if the '000' are actually measured to be '000', otherwise they are just non-significant placeholders.

Also, you cannot have a final answer in a calculation that has more significant figures than the smallest significant figure number in the set. For example, 6.25*5.1 which a calculator would render as 31.875 is 'only good' to 2 significant figures (determined from the number 5.1) so the correct, rounded, answer is 32.

Problem	Method 1	Method 2
1	2.28×10^{16}	2.27×10^{16}
2	2.46×10^{-39}	2.46×10^{-39}
3	2.73×10^{135}	2.73×10^{135}
4	6.65×10^{-25}	6.64×10^{-25}
5	1.44×10^{-140}	1.44×10^{-140}
6	5.03×10^{-1}	5.03×10^{-1}
7	3.05×10^{64}	3.05×10^{64}

Note Problem 1 and 4 give slightly different results.

Problem 1: Method 1 answer 3.8784/1.7042 = 2.27578 or 2.28
Method 2 answer 3.8782/1.7052 = 2.2743 = 2.27

Problem 4: Method 1 answer 1.3378/2.0108 = 0.6653 = 0.665
Method 2 answer 1.3376/2.0140 = 0.6642 = 0.664