Chapter 1 Problem Solutions (Easy)

1.7 The desired number of atoms is the length of the line divided by the diameter of one atom, or
\[(1 \text{ cm}) = (10^{-2} \text{ m})(10^{-10} \text{ m}) = 10^8 \text{.} \] (See Table 1-1 for SI prefixes.)

1.10 (a) \((35.0 \text{ mi/h})(1609 \text{ m/mi})(1 \text{ h}=3600 \text{ s}) = 15.6 \text{ m/s} \).
(b) \((35.0 \text{ mi/h})(5280 \text{ ft/mi})(1 \text{ h}=3600 \text{ s}) = 51.3 \text{ ft/s} \).

1.12 The number of seconds in a year is approximately
\[(365.24 \text{ d})(86,400 \text{ s/d}) = 3.1557 \times 10^7 \text{ s} \] (see Appendix C), which differs from the mnemonic \(\pi \times 10^7 \text{ s} \) in the third decimal place. The percent difference, to two significant figures, is
\[100(3.1557 - 3.1416) = 0.45\% . \]

1.13 \(1 \text{ m}^3 = (10^2 \text{ cm})^3 = 10^6 \text{ cm}^3 \).

1.20 With reference to Appendix C,
\[
\left(550 \times 10^6 \text{ bbl/y}\right) \left(42 \frac{\text{gal}}{\text{bbl}}\right) \left(\frac{1 \text{ y}}{3.156 \times 10^7 \text{ s}}\right) = \left(7.32 \times 10^5 \frac{\text{gal}}{\text{s}}\right) \left(\frac{3.786 \text{ L}}{\text{gal}}\right) = 2.77 \times 10^6 \frac{\text{L}}{\text{s}}
\]

1.25 We can first solve for \(a = 2\pi r^2\) to find its dimensions (which are usually denoted by square brackets). Thus 
\([a] = [x] [T^2] = LT^{-2}\).

1.35 Substitute the given values into the equation for the temperature
\[
T = \left(\frac{S}{4\sigma}\right)^{1/4} = \left(\frac{1.4 \times 10^3 \text{ kg} \cdot \text{s}^{-3}}{4 \times 5.7 \times 10^{-8} \text{ kg} \cdot \text{s}^{-3} \cdot \text{K}^{-4}}\right)^{1/4} = 2.8 \times 10^5 \text{ K}
\]
The result is expressed in scientific notation with two significant figures.
1.27 The dimensions of the righthand sides of the three formulas are:
\[ g^2 = (L/T^2)^2 = 1/L^2, \quad L^2 = (T^2)^2 = L^2, \quad \sqrt[2]{Lg} = (L/T^2)^{1/2} = L/T. \]
Since [g] = L/T, only the third formula is dimensionally correct. (Note: [ . . . ] means the dimensions of " . . . ".)

1.33 (a) The area of each (identical) component is the total area of the chip divided by the number of components, or \((5 \text{ mm} \times 5 \text{ mm}) \times 10^6 = 2.5 \times 10^{-5} \text{ mm}^2\).

(b) The side of a square is the square root of its area, so the side of one component is \(\sqrt{2.5 \times 10^{-5} \text{ mm}^2} = 5.0 \times 10^{-3} \text{ mm} = 5.0 \mu \text{m}\).

1.40 (a) \(\sqrt[3]{3} = 1.732 \ldots = 1.73(1.73)^3 = 5.177 \ldots = 5.18\).

(b) \(\sqrt[3]{3} = 1.73205 \ldots \times 1.732(1.732)^3 = 5.1957 \ldots = 5.20\)

1.44 My reach is a little under 2 m; the distance from New York City to Los Angeles is about \(5 \times 10^7 \text{ km}\). Therefore, about \(5 \times 10^6 \text{ m} \times 2.5 \times 10^6 \text{ people my size would be needed to reach across the country.}\)

1.45 The electrical power consumed by the entire population of the United States, divided by the power converted by one square meter of solar cells, is the area required by this question: \((250 \times 10^6 \times 3 \text{ kW})/(20\% \times 0.3 \text{ kW/m}^2) = 1.25 \times 10^{10} \text{ m}^2 = 10^9 \text{ km}^2\). (We assume that 3 kW is a per capita average over 24 h periods of all types of weather.) The land area of the United States is approximately the area of a rectangle the size of the distance from New York to Los Angeles by the distance from New York to Miami, or \(5000 \text{ km} \times 2000 \text{ km} = 10^7 \text{ km}^2\). (See the figure for the preceding problem.) Then the fraction of area to be covered by solar cells would be only \(10^9 \text{ km}^2/10^7 \text{ km}^2 = 0.1\%,\) comparable to the fraction of land now covered by airports.
1.52 The volume of gum is its mass divided by its density, or $8 \text{ g} = \left(1 \text{ g/cm}^3\right) = 8 \text{ cm}^3$. The volume of the bubble (a thin spherical shell) is $4\pi R^2 d$, where $R$ is the radius and $d(\varnothing - R)$ is the thickness, and is equal to the volume of gum. Thus, $d = \left(8 \text{ cm}^3\right)/4\pi(5 \text{ cm})^2 = 0.26 \text{ mm}$.

1.55 (a) Human tissue is mostly water, so for a rough estimate we could consider the human body to contain about as many atoms as an equivalent amount of water. One mole of water ($\text{H}_2\text{O}$) is $18 \text{ g} = 0.018 \text{ kg}$ and contains Avogadro’s number of molecules, or about $3 \times 6 \times 10^{23}$ atoms. An average-sized human of 65 kg (Table 1-3) would contain about $(65 \text{ kg} \times 0.018 \text{ kg}) \times (3 \times 6 \times 10^{23}) = 6.5 \times 10^{27}$ atoms.

(b) With an average density of $1 \text{ kg/L}$ (same as water), the volume of an average-sized human is 65 L (volume = mass/density). The volume of an average-sized cell (a red blood cell, Table 1-1) is about $(8 \mu\text{m})^3 = 5 \times 10^{-13} \text{ L}$, so an average human body might contain approximately $65 \times 10^{-13} = 1.3 \times 10^{14}$ cells.