Chapter 1 Solutions

***1.1** With V = (base area) · (height)

$$V = \pi r^2 \cdot h$$

and $\rho = \dfrac{m}{V}$, we have

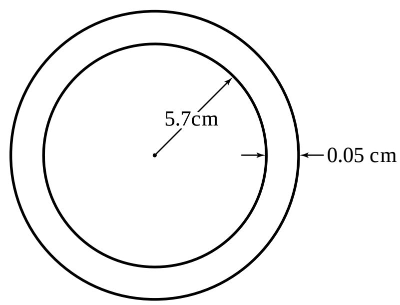
$$\rho = \frac{m}{\pi r^2 h} = \frac{1\ \text{kg}}{\pi (19.5\ \text{mm})^2\ 39.0\ \text{mm}}\left(\frac{10^9\ \text{mm}^3}{1\ \text{m}^3}\right)$$

$$\rho = \boxed{2.15 \times 10^4\ \ \text{kg/m}^3}$$

1.2 $\rho = \dfrac{M}{V} = \dfrac{M}{\frac{4}{3}\pi R^3}$

$$\rho = \frac{3(5.64 \times 10^{26}\ \text{kg})}{4\pi (6.00 \times 10^7\ \text{m})^3} = \boxed{623\ \text{kg/m}^3}$$

1.3 $V_{Cu} = V_0 - V_i = \dfrac{4}{3}\ \pi (r_o^3 - r_i^3)$



$$V_{Cu} = \frac{4}{3}\ \pi\left[(5.75\ \text{cm})^3 - (5.70\ \text{cm})^3\right] = 20.6\ \text{cm}^3$$

$$\rho = \frac{m}{V}$$

$$m = \rho V = (8.92\ \text{g/cm}^3)(20.6\ \text{cm}^3) = \boxed{184\ \text{g}}$$

1.4 $V = V_o - V_i = \dfrac{4}{3}\ \pi\ (r_2^3 - r_1^3)$

$$\rho = \frac{m}{V},\ \text{ so }\ m = \rho V = \rho\left(\frac{4}{3}\pi\right)(r_2^3 - r_1^3) = \boxed{\frac{4\pi\rho\ (r_2^3 - r_1^3)}{3}}$$

***1.5** (a) The number of moles is $n = m / M$, and the density is $\rho = m / V$. Noting that we have 1 mole,

$$V_{1\ \text{mol}} = \frac{m_{\text{Fe}}}{\rho_{\text{Fe}}} = \frac{n_{\text{Fe}} M_{\text{Fe}}}{\rho_{\text{Fe}}} = \frac{(1\ \text{mol})(55.8\ \text{g/mol})}{7.86\ \text{g/cm}^3} = \boxed{7.10\ \text{cm}^3}$$

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(b) In 1 mole of iron are N_A atoms:

$$V_{1\text{ atom}} = \frac{V_{1\text{ mol}}}{N_A} = \frac{7.10\text{ cm}^3}{6.02\times10^{23}\text{ atoms/mol}} = 1.18\times10^{-23}\text{ cm}^3$$

$$= \boxed{1.18\times10^{-29}\text{ m}^3}$$

(c) $d_{\text{atom}} = \sqrt[3]{1.18\times10^{-29}\text{ m}^3} = 2.28\times10^{-10}\text{ m} = \boxed{0.228\text{ nm}}$

(d) $V_{1\text{ mol U}} = \dfrac{(1\text{ mol})(238\text{ g/mol})}{18.7\text{ g/cm}^3} = \boxed{12.7\text{ cm}^3}$

$$V_{1\text{ atom U}} = \frac{V_{1\text{ mol U}}}{N_A} = \frac{12.7\text{ cm}^3}{6.02\times10^{23}\text{ atoms/mol}} = 2.11\times10^{-23}\text{ cm}^3$$

$$= \boxed{2.11\times10^{-29}\text{ m}^3}$$

$$d_{\text{atom U}} = \sqrt[3]{V_{1\text{ atom U}}} = \sqrt[3]{2.11\times10^{-29}\text{ m}^3} = 2.77\times10^{-10}\text{ m} = \boxed{0.277\text{ nm}}$$

***1.6** $r_2 = r_1\sqrt[3]{5} = (4.50\text{ cm})(1.71) = \boxed{7.69\text{ cm}}$

1.7 Use m = molar mass / N_A and 1 u = 1.66×10^{-24} g

(a) For He, $m = \dfrac{4.00\text{ g/mol}}{6.02\times10^{23}\text{ mol}^{-1}} = \boxed{6.64\times10^{-24}\text{ g} = 4.00\text{ u}}$

(b) For Fe, $m = \dfrac{55.9\text{ g/mol}}{6.02\times10^{23}\text{ mol}^{-1}} = \boxed{9.29\times10^{-23}\text{ g} = 55.9\text{ u}}$

(c) For Pb, $m = \dfrac{207\text{ g/mol}}{6.02\times10^{23}\text{ mol}^{-1}} = \boxed{3.44\times10^{-22}\text{ g} = 207\text{ u}}$

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Goal Solution

Calculate the mass of an atom of (a) helium, (b) iron, and (c) lead. Give your answers in atomic mass units and in grams. The molar masses are 4.00, 55.9, and 207 g / mol, respectively, for the atoms given.

Gather information: The mass of an atom of any element is essentially the mass of the protons and neutrons that make up its nucleus since the mass of the electrons is negligible (less than a 0.05% contribution). Since most atoms have about the same number of neutrons as protons, the atomic mass is approximately double the atomic number (the number of protons). We should also expect that the mass of a single atom is a very small fraction of a gram ($\sim 10^{-23}$ g) since one mole (6.02×10^{23}) of atoms has a mass on the order of several grams.

Organize: An atomic mass unit is defined as 1 / 12 of the mass of a carbon-12 atom (which has a molar mass of 12.0 g / mol), so the mass of any atom in atomic mass units is simply the numerical value of the molar mass. The mass in grams can be found by multiplying the molar mass by the mass of one atomic mass unit (u):

$$1 \text{ u} = 1.66 \times 10^{-24} \text{ g}.$$

Analyze: For He, $m = 4.00 \text{ u} = (4.00 \text{ u})(1.66 \times 10^{-24} \text{ g/u}) = 6.64 \times 10^{-24} \text{ g}$

For Fe, $m = 55.9 \text{ u} = (55.9 \text{ u})(1.66 \times 10^{-24} \text{ g/u}) = 9.28 \times 10^{-23} \text{ g}$

For Pb, $m = 207 \text{ u} = (207 \text{ u})(1.66 \times 10^{-24} \text{ g/u}) = 3.44 \times 10^{-22} \text{ g}$

Learn: As expected, the mass of the atoms is larger for bigger atomic numbers. If we did not know the conversion factor for atomic mass units, we could use the mass of a proton as a close approximation: $1\text{u} \approx m_p = 1.67 \times 10^{-24}$ g.

***1.8** $$\Delta n = \frac{\Delta m}{M} = \frac{3.80 \text{ g} - 3.35 \text{ g}}{197 \text{ g/mol}} = 0.00228 \text{ mol}$$

$$\Delta N = (\Delta n) N_A = (0.00228 \text{ mol})(6.02 \times 10^{23} \text{ atoms/mol}) = 1.38 \times 10^{21} \text{ atoms}$$

$$\Delta t = (50.0 \text{ yr})(365 \text{ d/yr})(24.0 \text{ hr/d})(3600 \text{ s/hr}) = 1.58 \times 10^{9} \text{ s}$$

$$\frac{\Delta N}{\Delta t} = \frac{1.38 \times 10^{21} \text{ atoms}}{1.58 \times 10^{9} \text{ s}} = \boxed{8.72 \times 10^{11} \text{ atoms/s}}$$

1.9 (a) $$m = \rho L^3 = (7.86 \text{ g/cm}^3)(5.00 \times 10^{-6} \text{ cm})^3 = \boxed{9.83 \times 10^{-16} \text{ g}}$$

(b) $$N = m\left(\frac{N_A}{\text{Molar mass}}\right) = \frac{(9.83 \times 10^{-16} \text{ g})(6.02 \times 10^{23} \text{ atoms/mol})}{55.9 \text{ g/mol}}$$

$$= \boxed{1.06 \times 10^{7} \text{ atoms}}$$

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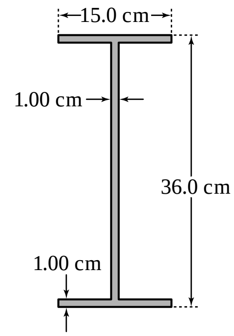
1.10 (a) The cross-sectional area is



$$A = 2(0.150\text{ m})(0.010\text{ m}) + (0.340\text{ m})(0.010\text{ m})$$

$$= 6.40 \times 10^{-3}\text{ m}^2$$

The volume of the beam is

$$V = AL = (6.40 \times 10^{-3}\text{ m}^2)(1.50\text{ m}) = 9.60 \times 10^{-3}\text{ m}^3$$

Thus, its mass is $m = \rho V = (7.56 \times 10^3\text{ kg/m}^3)(9.60 \times 10^{-3}\text{ m}^3)$ $= \boxed{72.6\text{ kg}}$

(b) Presuming that most of the atoms are of iron, we estimate the molar mass as $M = 55.9\text{ g/mol} = 55.9 \times 10^{-3}\text{ kg/mol}$. The number of moles is then

$$n = \frac{m}{M} = \frac{72.6\text{ kg}}{55.9 \times 10^{-3}\text{ kg/mol}} = 1.30 \times 10^3\text{ mol}$$

The number of atoms is

$$N = nN_A = (1.30 \times 10^3\text{ mol})(6.02 \times 10^{23}\text{ atoms/mol}) = \boxed{7.82 \times 10^{26}\text{ atoms}}$$

***1.11** (a) $n = \dfrac{m}{M} = \dfrac{1.20 \times 10^3\text{ g}}{18.0\text{ g/mol}} = 66.7\text{ mol}$, and

$$N_{pail} = nN_A = (66.7\text{ mol})(6.02 \times 10^{23}\text{ molecules/mol})$$

$$= \boxed{4.01 \times 10^{25}\text{ molecules}}$$

(b) Suppose that enough time has elapsed for thorough mixing of the hydrosphere.

$$N_{both} = N_{pail}\left(\frac{m_{pail}}{M_{total}}\right) = (4.01 \times 10^{25}\text{ molecules})\left(\frac{1.20\text{ kg}}{1.32 \times 10^{21}\text{ kg}}\right),\text{ or}$$

$$N_{both} = \boxed{3.65 \times 10^4\text{ molecules}}$$

1.12 r, a, b, c and s all have units of L.

$$\left[\sqrt{\frac{(s-a)(s-b)(s-c)}{s}}\right] = \sqrt{\frac{L \times L \times L}{L}} = \sqrt{L^2} = \boxed{L}$$

Thus, the equation is dimensionally consistent.

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1.13 The term s has dimensions of L, a has dimensions of LT^{-2}, and t has dimensions of T. Therefore, the equation, $s = ka^m t^n$ has dimensions of

$$L = (LT^{-2})^m (T)^n \quad \text{or} \quad L^1 T^0 = L^m T^{n-2m}$$

The powers of L and T must be the same on each side of the equation. Therefore,

$$L^1 = L^m \text{ and } \boxed{m = 1}$$

Likewise, equating terms in T, we see that $n - 2m$ must equal 0. Thus,

$$\boxed{n = 2m = 2}$$

The value of k, a dimensionless constant, $\boxed{\text{cannot be obtained by dimensional analysis}}$.

1.14 $$\left[2\pi\sqrt{\frac{l}{g}}\right] = \sqrt{\frac{L}{L/T^2}} = \sqrt{T^2} = \boxed{T}$$

1.15 (a) $\boxed{\text{This is incorrect}}$ since the units of $[ax]$ are m^2/s^2, while the units of $[v]$ are m / s.

(b) $\boxed{\text{This is correct}}$ since the units of $[y]$ are m, and $\cos(kx)$ is dimensionless if $[k]$ is in m^{-1}.

1.16 Inserting the proper units for everything except G,

$$\left[\frac{\text{kg m}}{\text{s}^2}\right] = \frac{G[\text{kg}]^2}{[\text{m}]^2}$$

Multiply both sides by $[\text{m}]^2$ and divide by $[\text{kg}]^2$; the units of G are

$$\boxed{\frac{\text{m}^3}{\text{kg} \cdot \text{s}^2}}$$

1.17 One month is 1 mo = (30 day)(24 hr / day)(3600 s / hr) = 2.592×10^6 s

Applying units to the equation,

$$V = (1.50 \text{ Mft}^3/\text{mo})t + (0.00800 \text{ Mft}^3/\text{mo}^2)t^2$$

Since 1 $\text{Mft}^3 = 10^6 \text{ ft}^3$,

$$V = (1.50 \times 10^6 \text{ ft}^3/\text{mo})t + (0.00800 \times 10^6 \text{ ft}^3/\text{mo}^2)t^2$$

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Converting months to seconds,

$$V = \frac{1.50 \times 10^6 \text{ ft}^3/\text{mo}}{2.592 \times 10^6 \text{ s/mo}}\, t + \frac{0.00800 \times 10^6 \text{ ft}^3/\text{mo}^2}{(2.592 \times 10^6 \text{ s/mo})^2}\, t^2$$

Thus, $\boxed{V[\text{ft}^3] = (0.579 \text{ ft}^3/\text{s})t + (1.19 \times 10^{-9} \text{ ft}^3/\text{s}^2)t^2}$

***1.18** Apply the following conversion factors:

1 in = 2.54 cm, 1 d = 86400 s, 100 cm = 1 m, and 10^9 nm = 1 m

$$\left(\frac{1}{32} \text{ in/day}\right)\frac{(2.54 \text{ cm/in})(10^{-2} \text{ m/cm})(10^9 \text{ nm/m})}{86400 \text{ s/day}} = \boxed{9.19 \text{ nm/s}}$$

This means the proteins are assembled at a rate of many layers of atoms each second!

1.19 Area A = (100 ft)(150 ft) = 1.50×10^4 ft^2, so

$$A = (1.50 \times 10^4 \text{ ft}^2)(9.29 \times 10^{-2} \text{ m}^2/\text{ft}^2) = \boxed{1.39 \times 10^3 \text{ m}^2}$$

<u>Goal Solution</u>

A rectangular building lot is 100 ft by 150 ft. Determine the area of this lot in m^2.

G: We must calculate the area and convert units. Since a meter is about 3 feet, we should expect the area to be about A ≈ (30 m)(50 m) = 1 500 m^2.

O: Area = Length × Width. Use the conversion: 1 m = 3.281 ft.

A: $A = L \times W = (100 \text{ ft})\left(\frac{1 \text{ m}}{3.281 \text{ ft}}\right)(150 \text{ ft})\left(\frac{1 \text{ m}}{3.281 \text{ ft}}\right) = 1\,390 \text{ m}^2$

L: Our calculated result agrees reasonably well with our initial estimate and has the proper units of m^2. Unit conversion is a common technique that is applied to many problems.

1.20 (a) $V = (40.0 \text{ m})(20.0 \text{ m})(12.0 \text{ m}) = 9.60 \times 10^3 \text{ m}^3$

$$V = 9.60 \times 10^3 \text{ m}^3 (3.28 \text{ ft}/1 \text{ m})^3 = \boxed{3.39 \times 10^5 \text{ ft}^3}$$

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(b) The mass of the air is

$$m = \rho_{\text{air}} V = (1.20\ \text{kg/m}^3)(9.60 \times 10^3\ \text{m}^3) = 1.15 \times 10^4\ \text{kg}$$

The student must look up weight in the index to find

$$F_g = mg = (1.15 \times 10^4\ \text{kg})(9.80\ \text{m/s}^2) = 1.13 \times 10^5\ \text{N}$$

Converting to pounds,

$$F_g = (1.13 \times 10^5\ \text{N})(1\ \text{lb}/4.45\ \text{N}) = \boxed{2.54 \times 10^4\ \text{lb}}$$

***1.21** (a) Seven minutes is 420 seconds, so the rate is

$$r = \frac{30.0\ \text{gal}}{420\ \text{s}} = \boxed{7.14 \times 10^{-2}\ \text{gal/s}}$$

(b) Converting gallons first to liters, then to m^3,

$$r = \left(7.14 \times 10^{-2}\ \frac{\text{gal}}{\text{s}}\right)\left(\frac{3.786\ \text{L}}{1\ \text{gal}}\right)\left(\frac{10^{-3}\ \text{m}^3}{1\ \text{L}}\right)$$

$$r = \boxed{2.70 \times 10^{-4}\ \text{m}^3/\text{s}}$$

(c) At that rate, to fill a 1-m^3 tank would take

$$t = \left(\frac{1\ \text{m}^3}{2.70 \times 10^{-4}\ \text{m}^3/\text{s}}\right)\left(\frac{1\ \text{hr}}{3600\ \text{s}}\right) = \boxed{1.03\ \text{hr}}$$

1.22 $$v = \left(5.00\ \frac{\text{furlongs}}{\text{fortnight}}\right)\left(\frac{220\ \text{yd}}{1\ \text{furlong}}\right)\left(\frac{0.9144\ \text{m}}{1\ \text{yd}}\right)\left(\frac{1\ \text{fortnight}}{14\ \text{days}}\right)\left(\frac{1\ \text{day}}{24\ \text{hrs}}\right)\left(\frac{1\ \text{hr}}{3600\ \text{s}}\right)$$

$$= \boxed{8.32 \times 10^{-4}\ \text{m/s}}$$

This speed is almost 1 mm/s; so we might guess the creature was a snail, or perhaps a sloth.

1.23 It is often useful to remember that the 1600-m race at track and field events is approximately 1 mile in length. To be precise, there are 1609 meters in a mile. Thus, 1 acre is equal in area to

$$(1\ \text{acre})\left(\frac{1\ \text{mi}^2}{640\ \text{acres}}\right)\left(\frac{1609\ \text{m}}{\text{mi}}\right)^2 = \boxed{4.05 \times 10^3\ \text{m}^2}$$

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1.24 Volume of cube = L^3 = 1 quart (Where L = length of one side of the cube.) Thus,

$$L^3 = (1\text{ quart})\left(\frac{1\text{ gallon}}{4\text{ quarts}}\right)\left(\frac{3.786\text{ liters}}{1\text{ gallon}}\right)\left(\frac{1000\text{ cm}^3}{1\text{ liter}}\right) = 946\text{ cm}^3,\text{ and}$$

$$L = \boxed{9.82\text{ cm}}$$

1.25 The mass and volume, in SI units, are

$$m = (23.94\text{ g})\left(\frac{1\text{ kg}}{1000\text{ g}}\right) = 0.02394\text{ kg}$$

$$V = (2.10\text{ cm}^3)(10^{-2}\text{ m/cm})^3 = 2.10 \times 10^{-6}\text{ m}^3$$

Thus, the density is

$$\rho = \frac{m}{V} = \frac{0.02394\text{ kg}}{2.10 \times 10^{-6}\text{ m}^3} = \boxed{1.14 \times 10^4\text{ kg/m}^3}$$

Goal Solution

A solid piece of lead has a mass of 23.94 g and a volume of 2.10 cm^3. From these data, calculate the density of lead in SI units (kg/m^3).

G: From Table 1.5, the density of lead is $1.13 \times 10^4\text{ kg/m}^3$, so we should expect our calculated value to be close to this number. This density value tells us that lead is about 11 times denser than water, which agrees with our experience that lead sinks.

O: Density is defined as mass per volume, in $\rho = \frac{m}{V}$. We must convert to SI units in the calculation.

A: $\rho = \frac{23.94\text{ g}}{2.10\text{ cm}^3}\left(\frac{1\text{ kg}}{1000\text{ g}}\right)\left(\frac{100\text{ cm}}{1\text{ m}}\right)^3 = 1.14 \times 10^4\text{ kg/m}^3$

L: At one step in the calculation, we note that *one million* cubic centimeters make one cubic meter. Our result is indeed close to the expected value. Since the last reported significant digit is not certain, the difference in the two values is probably due to measurement uncertainty and should not be a concern. One important common-sense check on density values is that objects which sink in water must have a density greater than 1 g/cm^3, and objects that float must be less dense than water.

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1.26 (a) We take information from Table 1.1:

$$1\text{ LY} = (9.46\times10^{15}\text{ m})\left(\frac{1\text{ AU}}{1.50\times10^{11}\text{ m}}\right) = \boxed{6.31\times10^{4}\text{ AU}}$$

(b) The distance to the Andromeda galaxy is

$$2\times10^{22}\text{ m} = (2\times10^{22}\text{ m})\left(\frac{1\text{ AU}}{1.50\times10^{11}\text{ m}}\right) = \boxed{1.33\times10^{11}\text{ AU}}$$

1.27 $N_{\text{atoms}} = \dfrac{m_{\text{Sun}}}{m_{\text{atom}}} = \dfrac{1.99\times10^{30}\text{ kg}}{1.67\times10^{-27}\text{ kg}} = \boxed{1.19\times10^{57}\text{ atoms}}$

1.28 1 mi = 1609 m = 1.609 km; thus, to go from mph to km/h, multiply by 1.609.

(a) $1\text{ mi/h} = \boxed{1.609\text{ km/h}}$

(b) $55\text{ mi/h} = \boxed{88.5\text{ km/h}}$

(c) $65\text{ mi/h} = 104.6\text{ km/h}$. Thus, $\Delta v = \boxed{16.1\text{ km/h}}$

1.29 (a) $\left(\dfrac{6\times10^{12}\text{ \$}}{1000\text{ \$/s}}\right)\left(\dfrac{1\text{ hr}}{3600\text{ s}}\right)\left(\dfrac{1\text{ day}}{24\text{ hr}}\right)\left(\dfrac{1\text{ yr}}{365\text{ days}}\right) = \boxed{190\text{ years}}$

(b) The circumference of the Earth at the equator is $2\pi(6378\times10^{3}\text{ m}) = 4.01\times10^{7}\text{ m}$. The length of one dollar bill is 0.155 m so that the length of 6 trillion bills is $9.30\times10^{11}\text{ m}$. Thus, the 6 trillion dollars would encircle the Earth

$$\frac{9.30\times10^{11}\text{ m}}{4.01\times10^{7}\text{ m}} = \boxed{2.32\times10^{4}\text{ times}}$$

Goal Solution

At the time of this book's printing, the U.S. national debt is about \$6 trillion. (a) If payments were made at the rate of \$1 000 per second, how many years would it take to pay off a \$6-trillion debt, assuming no interest were charged? (b) A dollar bill is about 15.5 cm long. If six trillion dollar bills were laid end to end around the Earth's equator, how many times would they encircle the Earth? Take the radius of the Earth at the equator to be 6 378 km. (*Note:* Before doing any of these calculations, try to guess at the answers. You may be very surprised.)

(a)

G: \$6 trillion is certainly a large amount of money, so even at a rate of \$1000/second, we might guess that it will take a lifetime (~ 100 years) to pay off the debt.

O: Time to repay the debt will be calculated by dividing the total debt by the rate at which it is repaid.

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A: $T = \frac{\$6 \text{ trillion}}{\$1000/\text{s}} = \frac{\$6 \times 10^{12}}{(\$1000/\text{s})(3.16 \times 10^{7} \text{ s/yr})} = 190 \text{ yr}$

L: OK, so our estimate was a bit low. $6 trillion really is a lot of money!

(b)
G: We might guess that 6 trillion bills would encircle the Earth at least a few hundred times, maybe more since our first estimate was low.

O: The number of bills can be found from the total length of the bills placed end to end divided by the circumference of the Earth.

A: $N = \frac{L}{C} = \frac{(6 \times 10^{12})(15.5 \text{ cm})(1 \text{ m}/100 \text{ cm})}{2\pi\, 6.37 \times 10^{6} \text{ m}} = 2.32 \times 10^{4} \text{ times}$

L: OK, so again our estimate was low. Knowing that the bills could encircle the earth more than 20 000 times, it might be reasonable to think that 6 trillion bills could cover the entire surface of the earth, but the calculated result is a surprisingly small fraction of the earth's surface area!

1.30 (a) $(3600 \text{ s/hr})(24 \text{ hr/day})(365.25 \text{ days/yr}) = \boxed{3.16 \times 10^{7} \text{ s/yr}}$

(b) $V_{mm} = \frac{4}{3}\pi r^{3} = \frac{4}{3}\pi(5.00 \times 10^{-7} \text{ m})^{3} = 5.24 \times 10^{-19} \text{ m}^{3}$

$$\frac{V_{\text{cube}}}{V_{mm}} = \frac{1 \text{ m}^{3}}{5.24 \times 10^{-19} \text{ m}^{3}} = 1.91 \times 10^{18} \text{ micrometeorites}$$

This would take $\frac{1.91 \times 10^{18} \text{ micrometeorites}}{3.16 \times 10^{7} \text{ micrometeorites/yr}} = \boxed{6.05 \times 10^{10} \text{ yr}}$

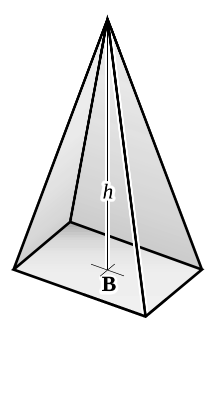
1.31 $V = At$, so $t = \frac{V}{A} = \frac{3.78 \times 10^{-3} \text{ m}^{3}}{25.0 \text{ m}^{2}} = \boxed{1.51 \times 10^{-4} \text{ m (or } 151\ \mu\text{m)}}$

1.32 $V = \frac{1}{3}Bh = \frac{[(13.0 \text{ acres})(43560 \text{ ft}^{2}/\text{acre})]}{3}(481 \text{ ft})$

$= 9.08 \times 10^{7} \text{ ft}^{3}$, or

$V = (9.08 \times 10^{7} \text{ ft}^{3})\left(\frac{2.83 \times 10^{-2} \text{ m}^{3}}{1 \text{ ft}^{3}}\right)$

$= \boxed{2.57 \times 10^{6} \text{ m}^{3}}$



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1.33 $F_g = (2.50 \text{ tons/block})(2.00 \times 10^6 \text{ blocks})(2000 \text{ lb/ton}) = \boxed{1.00 \times 10^{10} \text{ lbs}}$

1.34 The area covered by water is

$$A_w = 0.700\, A_{\text{Earth}} = (0.700)(4\pi R_{\text{Earth}}^2) = (0.700)(4\pi)(6.37 \times 10^6 \text{ m})^2 = 3.57 \times 10^{14} \text{ m}^2$$

The average depth of the water is

$$d = (2.30 \text{ miles})(1609 \text{ m/l mile}) = 3.70 \times 10^3 \text{ m}$$

The volume of the water is

$$V = A_w d = (3.57 \times 10^{14} \text{ m}^2)(3.70 \times 10^3 \text{ m}) = 1.32 \times 10^{18} \text{ m}^3$$

and the mass is $m = \rho V = (1000 \text{ kg/m}^3)(1.32 \times 10^{18} \text{ m}^3) = \boxed{1.32 \times 10^{21} \text{ kg}}$

***1.35** SI units of volume are in m^3:

$$V = (25.0 \text{ acre-ft})\left(\frac{43560 \text{ ft}^2}{1 \text{ acre}}\right)\left(\frac{0.3048 \text{ m}}{1 \text{ ft}}\right)^3 = \boxed{3.08 \times 10^4 \text{ m}^3}$$

***1.36** (a) $d_{\text{nucleus, scale}} = d_{\text{nucleus, real}}\left(\frac{d_{atom,\ scale}}{d_{\text{atom, real}}}\right)$

$$= (2.40 \times 10^{-15} \text{ m})\left(\frac{300 \text{ ft}}{1.06 \times 10^{-10} \text{ m}}\right)$$

$$= 6.79 \times 10^{-3} \text{ ft, or}$$

$$d_{\text{nucleus, scale}} = (6.79 \times 10^{-3} \text{ ft})(304.8 \text{ mm/1 ft}) = \boxed{2.07 \text{ mm}}$$

(b) $\frac{V_{\text{atom}}}{V_{\text{nucleus}}} = \frac{4\pi r_{\text{atom}}^3/3}{4\pi r_{\text{nucleus}}^3/3} = \left(\frac{r_{\text{atom}}}{r_{\text{nucleus}}}\right)^3 = \left(\frac{d_{\text{atom}}}{d_{\text{nucleus}}}\right)^3$

$$= \left(\frac{1.06 \times 10^{-10} \text{ m}}{2.40 \times 10^{-15} \text{ m}}\right)^3 = \boxed{8.62 \times 10^{13} \text{ times as large}}$$

1.37 The scale factor used in the "dinner plate" model is

$$S = \frac{0.25 \text{ m}}{1.0 \times 10^5 \text{ lightyears}} = 2.5 \times 10^{-6} \text{ m/lightyears}$$

The distance to Andromeda in the scale model will be

$$D_{\text{scale}} = D_{\text{actual}} S = (2.0 \times 10^6 \text{ lightyears})(2.5 \times 10^{-6} \text{ m/lightyears}) = \boxed{5.0 \text{ m}}$$

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1.38 (a) $$\frac{A_{\text{Earth}}}{A_{\text{Moon}}} = \frac{4\pi r_{\text{Earth}}^2}{4\pi r_{\text{Moon}}^2} = \left(\frac{r_{\text{Earth}}}{r_{\text{Moon}}}\right)^2 = \left(\frac{(6.37\times 10^6\text{ m})(100\text{ cm/m})}{1.74\times 10^8\text{ cm}}\right)^2 = \boxed{13.4}$$

(b) $$\frac{V_{\text{Earth}}}{V_{\text{Moon}}} = \frac{4\pi r_{\text{Earth}}^3/3}{4\pi r_{\text{Moon}}^3/3} = \left(\frac{r_{\text{Earth}}}{r_{\text{Moon}}}\right)^3 = \left(\frac{(6.37\times 10^6\text{ m})(100\text{ cm/m})}{1.74\times 10^8\text{ cm}}\right)^3 = \boxed{49.1}$$

1.39 To balance, $m_{\text{Fe}} = m_{\text{Al}}$ or $\rho_{\text{Fe}}V_{\text{Fe}} = \rho_{\text{Al}}V_{\text{Al}}$

$$\rho_{\text{Fe}}\left(\frac{4}{3}\right)\pi r_{\text{Fe}}^3 = \rho_{\text{Al}}\left(\frac{4}{3}\right)\pi r_{\text{Al}}^3$$

$$r_{\text{Al}} = r_{\text{Fe}}\left(\frac{\rho_{\text{Fe}}}{\rho_{\text{Al}}}\right)^{1/3}$$

$$r_{\text{Al}} = (2.00\text{ cm})\left(\frac{7.86}{2.70}\right)^{1/3} = \boxed{2.86\text{ cm}}$$

1.40 The mass of each sphere is

$$m_{\text{A1}} = \rho_{\text{Al}}V_{\text{Al}} = \frac{4\pi\rho_{\text{Al}}r_{\text{Al}}^3}{3} \quad \text{and} \quad m_{\text{Fe}} = \rho_{\text{Fe}}V_{\text{Fe}} = \frac{4\pi\rho_{\text{Fe}}r_{\text{Fe}}^3}{3}$$

Setting these masses equal,

$$\frac{4\pi\rho_{\text{Fe}}r_{\text{Fe}}^3}{3} = \frac{4\pi\rho_{\text{Fe}}r_{\text{Fe}}^3}{3} \quad \text{and} \quad \boxed{r_{\text{Al}} = r_{\text{Fe}}\sqrt[3]{\rho_{\text{Fe}}/\rho_{\text{Al}}}}$$

1.41 The volume of the room is $4\times 4\times 3 = 48\text{ m}^3$, while

the volume of one ball is $\frac{4\pi}{3}\left(\frac{0.038\text{ m}}{2}\right)^3 = 2.87\times 10^{-5}\text{ m}^3$.

Therefore, one can fit about $\frac{48}{2.87\times 10^{-5}} \sim \boxed{10^6}$ ping-pong balls in the room.

As an aside, the actual number is smaller than this because there will be a lot of space in the room that cannot be covered by balls. In fact, even in the best arrangement, the so-called "best packing fraction" is $\frac{\pi\sqrt{2}}{6} = 0.74$ so that at least 26% of the space will be empty. Therefore, the above estimate reduces to $1.67\times 10^6\times 0.740 \sim 10^6$.

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Goal Solution

Estimate the number of Ping-Pong balls that would fit into an average-size room (without being crushed). In your solution state the quantities you measure or estimate and the values you take for them.

G: Since the volume of a typical room is much larger than a Ping-Pong ball, we should expect that a very large number of balls (maybe a million) could fit in a room.

O: Since we are only asked to find an estimate, we do not need to be too concerned about how the balls are arranged. Therefore, to find the number of balls we can simply divide the volume of an average-size room by the volume of an individual Ping-Pong ball.

A: A typical room (like a living room) might have dimensions 15 ft × 20 ft × 8 ft. Using the approximate conversion 1 ft = 30 cm, we find

$$V_{\text{room}} \approx 15 \text{ ft} \times 20 \text{ ft} \times 8 \text{ ft} = 2400 \text{ ft}^3 \left(\frac{30 \text{ cm}}{1 \text{ ft}}\right)^3 = 7 \times 10^7 \text{ cm}^3$$

A Ping-Pong ball has a diameter of about 3 cm, so we can estimate its volume as a cube:

$$V_{\text{ball}} \approx (3 \times 3 \times 3) \text{ cm}^3 = 30 \text{ cm}^3$$

The number of Ping-Pong balls that can fill the room is

$$N \approx \frac{V_{\text{room}}}{V_{\text{ball}}} = \frac{7 \times 10^7 \text{ cm}^3}{30 \text{ cm}^3} = 2 \times 10^6 \text{ balls} \sim 10^6 \text{ balls}$$

L: So a typical room can hold about a million Ping-Pong balls. This problem gives us a sense of how big a million really is.

***1.42** It might be reasonable to guess that, on average, McDonalds sells a $3 \text{ cm} \times 8 \text{ cm} \times 10 \text{ cm} = 240 \text{ cm}^3$ medium-sized box of fries, and that it is packed 3/4 full with fries that have a cross section of $1/2 \text{ cm} \times 1/2 \text{ cm}$. Thus, the typical box of fries would contain fries that stretched a total of

$$L = \left(\frac{3}{4}\right)\left(\frac{V}{A}\right) = \left(\frac{3}{4}\right)\left(\frac{240 \text{ cm}^3}{(0.5 \text{ cm})^2}\right) = 720 \text{ cm} = 7.2 \text{ m}$$

250 million boxes would stretch a total distance of $(250 \times 10^6 \text{ box})(7.2 \text{ m/box}) = 1.8 \times 10^9 \text{ m}$. But we require an order of magnitude, so our answer is $\boxed{10^9 \text{ m} = 1 \text{ million kilometers}}$.

***1.43** A reasonable guess for the diameter of a tire might be 2.5 ft, with a circumference of about 8 ft. Thus, the tire would make $(50\,000 \text{ mi})(5280 \text{ ft/mi})(1 \text{ rev/8 ft}) = 3 \times 10^7 \text{ rev} \sim \boxed{10^7 \text{ rev}}$

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1.44 A typical raindrop is spherical and might have a radius of about 0.1 inch. Its volume is then approximately 4×10^{-3} in^3. Since 1 acre = 43,560 ft^2, the volume of water required to cover it to a depth of 1 inch is

$$(1 \text{ acre})(1 \text{ inch}) = (1 \text{ acre} \cdot \text{in})\left(\frac{43{,}560 \text{ ft}^2}{1 \text{ acre}}\right)\left(\frac{144 \text{ in}^2}{1 \text{ ft}^2}\right) \approx 6.3 \times 10^6 \text{ in}^3.$$

The number of raindrops required is

$$n = \frac{\text{volume of water required}}{\text{volume of a single drop}} \approx \frac{6.3 \times 10^6 \text{ in}^3}{4 \times 10^{-3} \text{ in}^3} = 1.6 \times 10^9 \sim \boxed{10^9}$$

***1.45** In order to reasonably carry on photosynthesis, we might expect a blade of grass to require at least $1/16$ in^2 = 43×10^{-5} ft^2. Since 1 acre = 43,560 ft^2, the number of blades of grass to be expected on a quarter-acre plot of land is about

$$n = \frac{\text{total area}}{\text{area per blade}} = \frac{(0.25 \text{ acre})(43{,}560 \text{ ft}^2/\text{acre})}{43 \times 10^{-5} \text{ ft}^2/\text{blade}}$$

$$= 2.5 \times 10^7 \text{ blades} \sim \boxed{10^7 \text{ blades}}$$

1.46 Since you have only 16 hours (57,600 s) available per day, you can count only \$57,600 per day. Thus, the time required to count \$1 billion dollars is

$$t = \frac{10^9 \text{ dollars}}{5.76 \times 10^4 \text{ dollars/day}}\left(\frac{1 \text{ year}}{365 \text{ days}}\right) = 47.6 \text{ years}$$

Since you are at least 18 years old, you would be beyond age 65 before you finished counting the money. It would provide a nice retirement, but a very boring life until then.

$\boxed{\text{We would not advise it.}}$

1.47 Assume the tub measure 1.3 m by 0.5 m by 0.3 m. One-half of its volume is then

$$V = (0.5)(1.3 \text{ m})(0.5 \text{ m})(0.3 \text{ m}) = 0.10 \text{ m}^3$$

The mass of this volume of water is

$$m_{\text{water}} = \rho_{\text{water}} V = (1000 \text{ kg/m}^3)(0.10 \text{ m}^3) = 100 \text{ kg} \quad \boxed{\sim 10^2 \text{ kg}}$$

Pennies are now mostly zinc, but consider copper pennies filling 50% of the volume of the tub. The mass of copper required is

$$m_{\text{copper}} = \rho_{\text{copper}} V = (8930 \text{ kg/m}^3)(0.10 \text{ m}^3) = 893 \text{ kg} \quad \boxed{\sim 10^3 \text{ kg}}$$

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***1.48** The typical person probably drinks 2 to 3 soft drinks daily. Perhaps half of these were in aluminum cans. Thus, we will estimate 1 aluminum can disposal per person per day. In the U.S. there are ~250 million people, and 365 days in a year, so $(250 \times 10^6 \text{ cans/day})(365 \text{ days/year}) \approx 10^{10}$ cans are thrown away or recycled each year. Guessing that each can weighs around 1/10 of an ounce, we estimate this represents

$$(10^{10} \text{ cans})(0.1 \text{ oz/can})(1 \text{ lb}/16 \text{ oz})(1 \text{ ton}/2000 \text{ lb}) \approx 3.1 \times 10^5 \text{ tons/year.}$$

$$\boxed{\sim 10^5 \text{ tons}}$$

1.49 Assume: Total population = 10^7; one out of every 100 people has a piano; one tuner can serve about 1,000 pianos (about 4 per day for 250 weekdays, assuming each piano is tuned once per year). Therefore,

$$\#\text{ tuners} \sim \left(\frac{1 \text{ tuner}}{1000 \text{ pianos}}\right)\left(\frac{1 \text{ piano}}{100 \text{ people}}\right)(10^7 \text{ people}) = \boxed{100}$$

1.50 (a) $\boxed{2}$ (b) $\boxed{4}$ (c) $\boxed{3}$ (d) $\boxed{2}$

1.51 (a) $\pi r^2 = \pi(10.5 \text{ m} \pm 0.2 \text{ m})^2$

$$= \pi\left[(10.5 \text{ m})^2 \pm 2(10.5 \text{ m})(0.2 \text{ m}) + (0.2 \text{ m})^2\right]$$

$$= \boxed{346 \text{ m}^2 \pm 13 \text{ m}^2}$$

(b) $2\pi r = 2\pi(10.5 \text{ m} \pm 0.2 \text{ m}) = \boxed{66.0 \text{ m} \pm 1.3 \text{ m}}$

1.52 (a)
```
 756.??
  37.2?
   0.83
+  2.5?
```
$796.\not{5}\not{3} = \boxed{797}$

(b) $0.0032 \text{ (2 s.f.)} \times 356.3 \text{ (4 s.f.)} = 1.14016 = \text{(2 s.f.)} \quad \boxed{1.1}$

(c) $5.620 \text{ (4 s.f.)} \times \pi \text{ (> 4 s.f.)} = 17.656 = \text{(4 s.f.)} \quad \boxed{17.66}$

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1.53 $r = (6.50 \pm 0.20)\text{ cm} = (6.50 \pm 0.20) \times 10^{-2}\text{ m}$

$m = (1.85 \pm 0.02)\text{ kg}$

$\rho = \dfrac{m}{\left(\frac{4}{3}\right)\pi r^3}$ also,

$\dfrac{\delta\rho}{\rho} = \dfrac{\delta m}{m} + \dfrac{3\delta r}{r}$

In other words, the percentages of uncertainty are cumulative.

Therefore, $\dfrac{\delta\rho}{\rho} = \dfrac{0.02}{1.85} + \dfrac{3(0.20)}{6.50} = 0.103$

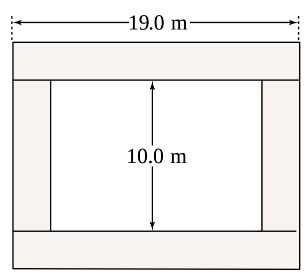
$$\rho = \frac{1.85}{\left(\frac{4}{3}\right)\pi\,(6.5 \times 10^{-2}\text{ m})^3} = \boxed{1.61 \times 10^3\text{ kg/m}^3}$$

and $\rho \pm \delta\rho = \boxed{(1.61 \pm 0.17) \times 10^3\text{ kg/m}^3}$

1.54 (a) $\boxed{3}$ (b) $\boxed{4}$ (c) $\boxed{3}$ (d) $\boxed{2}$

1.55 The distance around is 38.44 m + 19.5 m + 38.44 m + 19.5 m = 115.88 m, but this answer must be rounded to 115.9 m because the distance 19.5 m carries information to only one place past the decimal. $\boxed{115.9\text{ m}}$

1.56 $V = 2V_1 + 2V_2 = 2(V_1 + V_2)$



$V_1 = (17.0\text{ m} + 1.0\text{ m} + 1.0\text{ m})(1.0\text{ m})(0.09\text{ m}) = 1.70\text{ m}^3$

$V_2 = (10.0\text{ m})(1.0\text{ m})(0.090\text{ m}) = 0.900\text{ m}^3$

$V = 2(1.70\text{ m}^3) + 2(0.900\text{ m}^3) = \boxed{5.2\text{ m}^3}$

$$\left.\begin{aligned} \frac{\delta l_1}{l_1} &= \frac{0.12\text{ m}}{19.0\text{ m}} = 0.0063 \\ \frac{\delta w_1}{w_1} &= \frac{0.01\text{ m}}{1.0\text{ m}} = 0.010 \\ \frac{\delta t_1}{t_1} &= \frac{0.1\text{ cm}}{9.0\text{ cm}} = 0.011 \end{aligned}\right\} \frac{\delta V}{V} = 0.006 + 0.010 + 0.011 = 0.027 = \boxed{2.7\%}$$

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***1.57** It is desired to find the distance x such that $\frac{x}{100\text{ m}} = \frac{1000\text{ m}}{x}$ (i.e., such that x is the same multiple of 100 m as the multiple that 1000 m is of x) . Thus, it is seen that $x^2 = (100\text{ m})(1000\text{ m}) = 1.00 \times 10^5\text{ m}^2$, and therefore $x = \sqrt{1.00 \times 10^5\text{ m}^2} = \boxed{316\text{ m}}$.

1.58 The volume of oil equals $V = \frac{9.00 \times 10^{-7}\text{ kg}}{918\text{ kg/m}^3} = 9.80 \times 10^{-10}\text{ m}^3$. If the diameter of a molecule is d, then that same volume must equal $d(\pi r^2)$ = (thickness of slick)(area of oil slick) where $r = 0.418$ m. Thus,

$$d = \frac{9.80 \times 10^{-10}\text{ m}^3}{\pi(0.418\text{ m})^2} = \boxed{1.79 \times 10^{-9}\text{ m}}$$

1.59 $A_{\text{total}} = (N)(A_{\text{drop}}) = \left(\frac{V_{\text{total}}}{V_{\text{drop}}}\right)(A_{\text{drop}}) = \left(\frac{V_{\text{total}}}{4\pi r^3/3}\right)(4\pi r^2)$

$$= \left(\frac{3V_{\text{total}}}{r}\right) = 3\left(\frac{30.0 \times 10^{-6}\text{ m}^3}{2.00 \times 10^{-5}\text{ m}}\right) = \boxed{4.50\text{ m}^2}$$

1.60

α' (deg)	α (rad)	$\tan(\alpha)$	$\sin(\alpha)$	difference
15.0	0.262	0.268	0.259	3.47%
20.0	0.349	0.364	0.342	6.43%
25.0	0.436	0.466	0.423	10.2%
24.0	0.419	0.445	0.407	9.34%
24.4	0.426	0.454	0.413	9.81%
24.5	0.428	0.456	0.415	9.87%
24.6	0.429	0.458	0.416	9.98%
24.7	0.431	0.460	0.418	10.1%

$\boxed{24.6°}$

1.61 $2\pi r = 15.0\text{ m}$ $\quad r = 2.39\text{ m}$

$$\frac{h}{r} = \tan 55.0°$$

$$h = (2.39\text{ m})\tan(55.0°) = \boxed{3.41\text{ m}}$$

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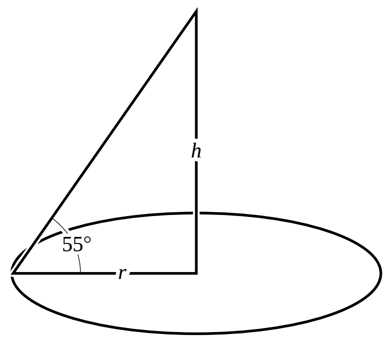

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***1.62** (a) $[V] = L^3$, $[A] = L^2$, $[h] = L$

$[V] = [A][h]$

$L^3 = L^3 L = L^3$. Thus, the equation is dimensionally correct.

(b) $V_{\text{cylinder}} = \pi R^2 h = (\pi R^2)h = Ah$, where $\boxed{A = \pi R^2}$

$V_{\text{rectangular object}} = \ell wh = (\ell w)h = Ah$, where $\boxed{A = \ell w}$

1.63 The actual number of seconds in a year is

$$(86{,}400\ \text{s/day})(365.25\ \text{day/yr}) = 31{,}557{,}600\ \text{s/yr}$$

The percentage error in the approximation is thus

$$\frac{\left|(\pi \times 10^7\ \text{s/yr}) - (31{,}557{,}600\ \text{s/yr})\right|}{31{,}557{,}600\ \text{s/yr}} \times 100\% = \boxed{0.449\%}$$

***1.64** From the figure, we may see that the spacing between diagonal planes is half the distance between diagonally adjacent atoms on a flat plane. This diagonal distance may be obtained from the Pythagorean theorem, $L_{\text{diag}} = \sqrt{L^2 + L^2}$. Thus, since the atoms are separated by a distance

$L = 0.200$ nm, the diagonal planes are separated $\frac{1}{2}\sqrt{L^2 + L^2} = \boxed{0.141\ \text{nm}}$

***1.65** (a) The speed of flow may be found from

$$v = \frac{(\text{Vol rate of flow})}{(\text{Area: } \pi D^2/4)} = \frac{16.5\ \text{cm}^3/\text{s}}{\pi(6.30\ \text{cm})^2/4} = \boxed{0.529\ \text{cm/s}}$$

(b) Likewise, at a 1.35 cm diameter,

$$v = \frac{16.5\ \text{cm}^3/\text{s}}{\pi(1.35\ \text{cm})^2/4} = \boxed{11.5\ \text{cm/s}}$$

***1.66** $$t = \frac{V}{A} = \frac{V}{\pi D^2/4} = \frac{4(12.0\ \text{cm}^3)}{\pi(23.0\ \text{cm})^2} = 0.0289\ \text{cm}\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)\left(\frac{10^6\ \mu\text{m}}{1\ \text{m}}\right) = \boxed{289\ \mu\text{m}}$$

1.67 $$V_{20\ \text{mpg}} = \frac{(10^8\ \text{cars})(10^4\ \text{mi/yr})}{20\ \text{mi/gal}} = 5.0 \times 10^{10}\ \text{gal/yr}$$

$$V_{25\ \text{mpg}} = \frac{(10^8\ \text{cars})(10^4\ \text{mi/yr})}{25\ \text{mi/gal}} = 4.0 \times 10^{10}\ \text{gal/yr}$$

Fuel saved $= V_{25\ \text{mpg}} - V_{20\ \text{mpg}} = \boxed{1.0 \times 10^{10}\ \text{gal/yr}}$

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1.68 (a) 1 cubic meter of water has a mass

$$m = \rho V = (1.00 \times 10^{-3}\ \text{kg/cm}^3)(1.00\ \text{m}^3)(10^2\ \text{cm/m})^3 = \boxed{1000\ \text{kg}}$$

(b) As a rough calculation, we treat each item as if it were 100% water.

cell: $m = \rho V = \rho$ **Error!** πR^3) = ρ **Error!** $\pi\ D^3$)

$$= (1000\ \text{kg/m}^3)\left(\frac{1}{6}\pi\right)(1.0 \times 10^{-6}\ \text{m})^3 = \boxed{5.2 \times 10^{-16}\ \text{kg}}$$

kidney:

$m = \rho V = \rho$ **Error!** $\pi\ R^3$) = $(1.00 \times 10^{-3}\ \text{kg/cm}^3)$**Error!** ^{3} = **Error!**

fly: $m = \rho\left(\frac{\pi}{4}D^2 h\right)$

$$= (1 \times 10^{-3}\ \text{kg/cm}^3)\left(\frac{\pi}{4}\right)(2.0\ \text{mm})^2(4.0\ \text{mm})(10^{-1}\ \text{cm/mm})^3$$

$$= \boxed{1.3 \times 10^{-5}\ \text{kg}}$$

1.69 The volume of the galaxy is

$$\pi r^2 t = \pi(10^{21}\ \text{m})^2\ 10^{19}\ \text{m} \sim 10^{61}\ \text{m}^3$$

If the distance between stars is 4×10^{16} m, then there is one star in a volume on the order of $(4 \times 10^{16}\ \text{m})^3 \sim 10^{50}\ \text{m}^3$.

The number of stars is about $\dfrac{10^{61}\ \text{m}^3}{10^{50}\ \text{m}^3/\text{star}} \sim \boxed{10^{11}\ \text{stars}}$

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1.70 The density of each material is $\rho = \frac{m}{V} = \frac{m}{\pi r^2 h} = \frac{4m}{\pi D^2 h}$

Al: $\rho = \frac{4(51.5\text{ g})}{\pi (2.52\text{ cm})^2 (3.75\text{ cm})} = \boxed{2.75\ \frac{\text{g}}{\text{cm}^3}}$ The tabulated value $\left(2.70\ \frac{\text{g}}{\text{cm}^3}\right)$ is $\boxed{2\%}$ smaller.

Cu: $\rho = \frac{4(56.3\text{ g})}{\pi (1.23\text{ cm})^2 (5.06\text{ cm})} = \boxed{9.36\ \frac{\text{g}}{\text{cm}^3}}$ The tabulated value $\left(8.92\ \frac{\text{g}}{\text{cm}^3}\right)$ is $\boxed{5\%}$ smaller.

Brass: $\rho = \frac{4(94.4\text{ g})}{\pi (1.54\text{ cm})^2 (5.69\text{ cm})} = \boxed{8.91\ \frac{\text{g}}{\text{cm}^3}}$

Sn: $\rho = \frac{4(69.1\text{ g})}{\pi (1.75\text{ cm})^2 (3.74\text{ cm})} = \boxed{7.68\ \frac{\text{g}}{\text{cm}^3}}$

Fe: $\rho = \frac{4(216.1\text{ g})}{\pi (1.89\text{ cm})^2 (9.77\text{ cm})} = \boxed{7.88\ \frac{\text{g}}{\text{cm}^3}}$ The tabulated value $\left(7.86\ \frac{\text{g}}{\text{cm}^3}\right)$ is $\boxed{0.3\%}$ smaller.

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