20 E GO The record for the largest glass bottle was set in 1992 by a team in Millville, New Jersey—they blew a bottle with a volume of 193 U.S. fluid gallons. (a) How much short of 1.0 million cubic centimeters is that? (b) If the bottle were filled with water at the leisurely rate of 1.8 g/min, how long would the filling take? Water has a density of 1000 kg/m^3.

$V = 193$ gallon $\longrightarrow$? cm^3

Appendix D : 1 U.S. fluid gallon = 231 in^3

$1\ in^3 = 16{,}39\ cm^3$

a) $V = 193$ gallon $= 193 \times 231\ in^3 = 193 \times 231 \times 16{,}39 \simeq 7{,}31 \times 10^5\ cm^3$

(231 in^3) (16,39 cm^3)

1 million cubic cm $= 10^6\ cm^3 \Rightarrow 10^6 - 7{,}31 \times 10^5 = 2{,}69 \times 10^5\ cm^3$

b) $R = 1{,}8$ g/min $\rho = 10^3\ kg/m^3 = 10^3 \dfrac{10^3 g}{(10^2 cm)^3} = 10^3 \times \dfrac{10^3}{10^6} \dfrac{g}{cm^3} = 1\ g/cm^3$

$V_{water} = 7{,}31 \times 10^5\ cm^3 \Rightarrow M = \rho V = 1 \times 7{,}31 \times 10^5 = 7{,}31 \times 10^5\ g$

min	g
1	1,8
t	$7{,}31 \times 10^5$

$\Rightarrow t = \dfrac{7{,}31 \times 10^5}{1{,}8} \simeq 4{,}06 \times 10^5$ min

$t = 4{,}06 \times 10^5 \div 60 = 6766{,}7\ h \div 24 = 281{,}94$ day

$t = 281{,}94 \div 30 \simeq 9{,}4$ month

21 E Earth has a mass of 5.98 × 10^{24} kg. The average mass of the atoms that make up Earth is 40 u. How many atoms are there in Earth?

$M_E = 5{,}98 \times 10^{24}$ kg

$m = 40u$ $\rightsquigarrow$ unified atomic mass unit

Example : $H_2O \rightarrow m_H = 1u$, $m_O = 16u$ $\Rightarrow m_{H_2O} = 2 \times 1 + 16 = 18 \Rightarrow \bar{m} = \dfrac{18}{3} = 6$

$M_E = N \cdot m$ → N: number of atoms

Appendix D : $1u = 1{,}661 \times 10^{-27}$ kg

u	kg
1	$1{,}661 \times 10^{-27}$
x	$5{,}98 \times 10^{24}$

$\Rightarrow x = \dfrac{5{,}98 \times 10^{24}}{1{,}661 \times 10^{-27}} \simeq 3{,}6 \times 10^{51}\ u$

$3{,}6 \times 10^{51} = N \times 40$

$\Rightarrow N = \dfrac{3{,}6 \times 10^{51}}{40} \simeq 0{,}9 \times 10^{50} = 9 \times 10^{49}$ atom

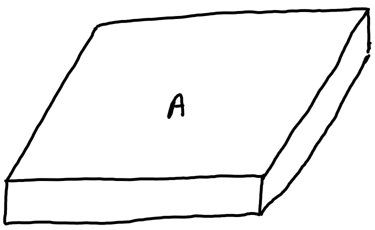
22 E Gold, which has a density of 19.32 g/cm^3, is the most ductile metal and can be pressed into a thin leaf or drawn out into a long fiber. (a) If a sample of gold, with a mass of 27.63 g, is pressed into a leaf of 1.000 μm thickness, what is the area of the leaf? (b) If, instead, the gold is drawn out into a cylindrical fiber of radius 2.500 μm, what is the length of the fiber?

$\rho = 19{,}32\ g/cm^3$

$M = 27{,}63\ g$

$1\ \mu m = 10^{-6}\ m = 10^{-6} \times 10^{2} = 10^{-4}\ cm$ ($m = 10^2\ cm$)

a)



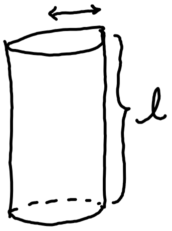
$\rho = \frac{M}{V} \Rightarrow V = \frac{\rho}{M}$

$V = \frac{19{,}32}{27{,}63} \simeq 1{,}430\ cm^3$

$V = A \cdot d \Rightarrow A = \frac{V}{d} = \frac{1{,}430}{1{,}000 \times 10^{-4}} \simeq 1{,}430 \times 10^{4}\ cm^2$

b)

$r = 2{,}500\ \mu m = 2{,}500 \times 10^{-4}\ cm$



$V' = \pi r^2 l \Rightarrow l = \frac{V'}{\pi r^2} = \frac{1{,}430}{3{,}14\,(2{,}500 \times 10^{-4})^2}$

$\Rightarrow l \simeq 0{,}07286 \times 10^{8}\ cm = 7{,}286 \times 10^{6}\ cm$

23 E SSM (a) Assuming that water has a density of exactly 1 g/cm^3, find the mass of one cubic meter of water in kilograms. (b) Suppose that it takes 10.0 h to drain a container of 5700 m^3 of water. What is the "mass flow rate," in kilograms per second, of water from the container?

a) $\rho = 1\ g/cm^3$, $V = 1\ m^3$

$\rho = \frac{M}{V} \Rightarrow M = \rho V \rightarrow M = 1 \times 10^3 \times 1 = 1 \times 10^3 = 1000\ kg$

$\rho = 1 \times \frac{10^{-3}\ kg}{(10^{-2}\ m)^3} = 1 \times \frac{10^{-3}}{10^{-6}} \frac{kg}{m^3} = 1 \times 10^3 = 1000\ kg/m^3$

b) $t = 10.0\ h$

$V = 5700\ m^3$

$R = \frac{M}{t}\ \frac{kg}{s} = ?$

$M = \rho V = 1 \times 10^3 \times 5700 = 57 \times 10^5 = 5{,}70 \times 10^6\ kg$ ✓

$t = 10.0\ h = 10.0 \times 3600 = 36 \times 10^3\ s$ ✓

$\Rightarrow R = \frac{M}{t} = \frac{5{,}70 \times 10^6}{36 \times 10^3} \simeq 1{,}58 \times 10^2 = 158\ kg/s$

24 M GO Grains of fine California beach sand are approximately spheres with an average radius of 50 μm and are made of silicon dioxide, which has a density of 2600 kg/m^3. What mass of sand grains would have a total surface area (the total area of all the individual spheres) equal to the surface area of a cube 1.00 m on an edge?

$r = 50\ \mu m = 50 \times 10^{-6}\ m \longrightarrow V = \frac{4}{3}\pi r^3$

$\rho = 2600\ kg/m^3$

$\rho = \frac{m}{V} \longrightarrow m = \rho V = \rho \times \frac{4}{3}\pi r^3 = \underbrace{2600}_{26\times10^{2}} \times \frac{4}{3} \times 3{,}14 \times \underbrace{(5\times10^{-5})^3}_{125\times10^{-15}}$

$m = \underbrace{26 \times \frac{4}{3} \times 3{,}14 \times 125}_{\simeq 13606{,}7 = 1{,}36\times10^{4}} \times 10^{-13} \Longrightarrow m = 1{,}36\times10^{-9}\ kg$

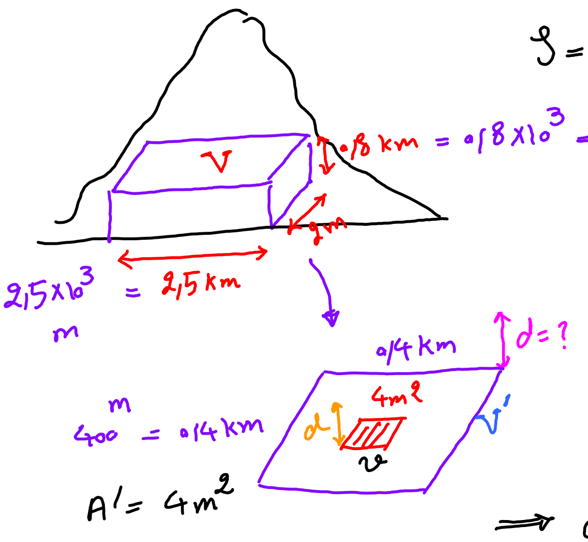
$\left.\begin{matrix} A_{cubic} = 6a^2 \\ a = 1{,}00\ m \end{matrix}\right\} \Rightarrow A_{cubic} = 6{,}00\ m^2$

$A_{sphere} = 4\pi r^2 = 4 \times 3{,}14 \times \underbrace{(5\times10^{-5})^2}_{25\times10^{-10}} = 4\times3{,}14\times25\times10^{-10} = 3{,}14\times10^{-8}\ m^2$

number of sands : $N = \frac{6{,}00}{3{,}14\times10^{-8}} \simeq 1{,}91\times10^{8}$

$M_{total} = N \cdot m = 1{,}91\times10^{8} \times 1{,}36\times10^{-9} \simeq 0{,}26\ kg$

25 M FCP During heavy rain, a section of a mountainside measuring 2.5 km horizontally, 0.80 km up along the slope, and 2.0 m deep slips into a valley in a mud slide. Assume that the mud ends up uniformly distributed over a surface area of the valley measuring 0.40 km × 0.40 km and that mud has a density of 1900 kg/m^3. What is the mass of the mud sitting above a 4.0 m^2 area of the valley floor?



$\rho = 1900\ kg/m^3$

$V = V'$

$V = 8\times10^{2} \times 2{,}5\times10^{3} \times 2 = 4\times10^{6}\ m^3$

$A = 400 \times 400 = 16\times10^{4}\ m^2$

$V' = A \cdot d \Rightarrow d = \frac{V'}{A}$

$\Rightarrow d = \frac{4\times10^{6}}{16\times10^{4}} = 0{,}25\times10^{2} = 25\ m$

$v = A' \cdot d = 4 \times 25 = 100\ m^3$

$\rho = \frac{m}{v} \rightarrow m = \rho v = 1900 \times 100 = 19\times10^{4} = 1{,}9\times10^{5}\ kg$