Selected Problems from Chapter 1

1) 1 shake = 10**-8 seconds. Find out how many nano seconds (ns) are there in 1 shake. (1 nano = 10**(-9))

a) 10 ns
b) 0.01 ns
c) 100 ns
d) 0.001 ns
e) 0.1 ns

$$1\,\text{shake} = 10^{-8}\text{s}$$

$$1\,\text{ns} = 10^{-9}\text{s} \rightarrow \left(\frac{1\,\text{ns}}{10^{-9}\text{s}}\right) = 1$$

$$1\,\text{shake} = 10^{-8}\text{s} \times 1 = 10^{-8}\text{s} \times \left(\frac{1\,\text{ns}}{10^{-9}\text{s}}\right) = \frac{10^{-8}}{10^{-9}}\text{ns} = 10^{9-8}\text{ns} = 10^{1}\,\text{ns} = 10\,\text{ns}$$

2) Express speed of sound, 330 m/s in miles/h .(1 mile = 1609 m)

a) 738 miles/h
b) 330 miles/h
c) 147 miles/h
d) 0.205 miles/h
e) 980 miles/h

$$330 \text{ m/s} = 330\,\frac{\cancel{\text{m}}}{\cancel{\text{s}}} \times \left(\frac{1\text{ mile}}{1609\,\cancel{\text{m}}}\right) \times \left(\frac{60\,\cancel{s}}{1\,\cancel{\text{min}}}\right) \times \left(\frac{60\,\cancel{\text{min}}}{1\text{ h}}\right) = 738\text{ miles/h}$$

3) A drop of oil (mass = 0.90 milligram and density = 918 kg/m**3) spreads out on a surface and forms a circular thin film of radius = 41.8 cm and thickness h. Find h in nano meter (nm). (1 nano = 10**(-9))

a) 1.8 nm
b) 0.00060 nm
c) 0.15 nm
d) 0.60 nm
e) 0.030 nm

$$M = 0.90\ mg = 0.90 \times 10^{-3} g \times \left(\frac{1kg}{10^3 g} \right) = 0.90 \times 10^{-6} kg$$

$$V = \frac{M}{\rho} = \frac{0.90 \times 10^{-6} kg}{918\ kg/m^3} = 9.8 \times 10^{-10} m^3$$

$$R = 41.8\ cm = 0.418\ m$$

$$V = \pi R^2 h$$

$$9.8 \times 10^{-10} m^3 = \pi \left(0.418\ m\right)^2 h$$

$$h = \frac{9.8 \times 10^{-10} m^3}{\pi \left(0.418\ m\right)^2} = 1.8 \times 10^{-9} m = 1.8\ nm$$

4) From the fact that the average density of the Earth is 5.50 *g/cm*^{3} and its mean radius is 6.37 $\times 10^6$ *m*, the mass of the Earth is:

A) 5.95 × 10^{24} *kg*
B) 3.98 × 10^{21} *kg*
C) 7.01 × 10^{17} *kg*
D) 2. 80 ×10^{18} *kg*
E) 5.50 × 10^{23} *kg*

$$M = \rho V$$

$$\rho = 5.50\ \mathrm{g/cm^3} \times \left(\frac{1\mathrm{kg}}{1000\ \mathrm{g}}\right) \times \left(\frac{100\ cm}{1\, m}\right)^3$$

$$= 5.50\ \mathrm{g/cm^3} \times \left(\frac{1\mathrm{kg}}{10^3\ \mathrm{g}}\right) \times \left(\frac{10^6\ cm^3}{1\, m^3}\right) = 5.50 \times 10^3 kg/m^3$$

$$V = \tfrac{4}{3}\pi R^3 = \tfrac{4}{3}\pi\left(6.37\times10^6 m\right)^3 = 1.08\times10^{21} m^3$$

$$M = \left(5.50\times10^3 kg/m^3\right)\times\left(1.08\times10^{21} m^3\right) = 5.94\times10^{24} kg$$

5) An aluminum cylinder of density 2.70 g/cm^3, a radius of 2.30 cm, and a height of 1.40 m has the mass of:

A) 6.28 kg
B) 45.1 kg
C) 13.8 kg
D) 8.50 kg
E) 25.0 kg

$$M = \rho V$$

$$\rho = 2.70\ \text{g/cm}^3 \times \left(\frac{1\,kg}{1000 g}\right) \times \left(\frac{100\ cm}{1\ m}\right)^3 = 2.70 \times 10^3 kg/m^3$$

$$R = 2.30\ cm = 0.0230\ m$$

$$V = \pi R^2 h = \pi \left(0.0230\ m\right)^2 \times 1.40\ m = 2.33 \times 10^{-3} m^3$$

$$M = 2.70 \times 10^3 kg/m^3 \times 2.33 \times 10^{-3} m^3 = 6.29\ kg$$

6) A nucleus of volume 3.4 x 10^3 fm^3 and mass of 1.0x 10^2 u has a density of:
(1 fm = 10^{-15} m, 1 u = 1.7 x 10^{-27} kg)

A) 5.0 × 10^{16} kg/m^3
B) 1.0 × 10^3 kg/m^3
C) 3.4 × 10^{14} kg/m^3
D) 12 × 10^3 kg/m^3
E) 3.6 × 10^{13} kg/m^3

$$\rho = m/V$$

$$m = 1.0 \times 10^2 \text{ u} = 1.0 \times 10^2 \times \left(1.7 \text{ x } 10^{-27} \text{ kg}\right) = 1.7 \times 10^{-25} kg$$

$$V = 3.4 \text{ x } 10^3 \text{ fm}^3 = 3.4 \text{ x } 10^3 \times \left(10^{-15} m\right)^3 = 3.4 \times 10^{-42} m^3$$

$$\rho = m/V = \frac{1.7 \times 10^{-25} kg}{3.4 \times 10^{-42} m^3} = 5.0 \times 10^{16} kg/m^3$$

7) The mass of 1.0 cm^3 of gold is 19.3 g. What is the mass of a solid cube of gold having a side of 0.70 cm?

A) 6.6×10^{-3} kg
B) 9.1×10^{-2} kg
C) 3.6×10^{-3} kg
D) 0.11 kg
E) 21 kg

$$\rho = 19.3\, g / cm^3$$

$$V = L^3 = \left(0.70\, cm\right)^3 = 0.343\, cm^3$$

$$m = \rho V = (19.3\, g / cm^3) \times \left(0.343\, cm^3\right) = 6.6\, g = 6.6 \times 10^{-3} kg$$

8) A cylindrical can, 6.00 inches high and 3.00 inches in diameter is filled with water. Density of water is 1.00 g/cm**3. What is the mass of water in the can in gram ? (1 inch = 2.54 cm).

A1 695 g
A2 277 g
A3 182 g
A4 107 g
A5 2780 g

$$m = \rho V$$

$$V = \pi R^2 h$$

$$h = 6.00\ in = 6.00 \times 2.54\ cm = 15.24\ cm$$

$$R = \frac{3.00\ in}{2} = 1.5\ in = 1.5 \times 2.54\ cm = 3.81\ cm$$

$$V = \pi R^2 h = \pi \left(3.81\ cm\right)^2 \times \left(15.24\ cm\right) = 695\ cm^3$$

$$m = \rho V = 1.00\ g / cm^3 \times 695\ cm^3 = 695\ g$$

9) Suppose $A = B^n / C^m$, where A has dimensions LT, B has dimensions L^2T^{-1}, and C has dimensions LT^2. Then the exponents n and m have the values:

A) $n = 1/5$; $m = -3/5$
B) $n = 2$; $m = 3$
C) $n = 4/5$; $m = -1/5$
D) $n = 1/5$; $m = 3/5$
E) $n = 1/2$; $m = 1/2$

2. The conversion factors 1 gry = 1/10 line, 1 line = 1/12 inch and 1 point = 1/72 inch imply that 1 gry = (1/10)(1/12)(72 points) = 0.60 point. Thus, 1 gry^2 = (0.60 point)^2 = 0.36 point^2, which means that 0.50 gry^2 = 0.18 point^2.

$$gry = \frac{1}{10}\, line;$$

$$line = \frac{1}{12}\, inch;$$

$$point = \frac{1}{72}\, inch.$$

$$\begin{aligned}
0.50\ gry^2 &= 0.50\ gry^2\, x \left(\frac{\frac{1}{10}\, line}{1\, gry} \right)^2 x \left(\frac{\frac{1}{12}\, inch}{1\, line} \right)^2 x \left(\frac{1\ point}{\frac{1}{72}\, inch} \right)^2 \\
&= 0.50\ gry^2\, x \left(\frac{line^2}{100\ gry^2} \right) x \left(\frac{inch^2}{144\ line^2} \right) x \left(\frac{5184\ point^2}{inch^2} \right) \\
&= 0.50 \times \frac{5184}{100 \times 144}\ point^2 \\
&= 0.18\ point^2
\end{aligned}$$

••7 Antarctica is roughly semicircular, with a radius of 2000 km (Fig. 1-5). The average thickness of its ice cover is 3000 m. How many cubic centimeters of ice does Antarctica contain? (Ignore the curvature of Earth.) SSM

Fig. 1-5 Problem 7.

7. The volume of ice is given by the product of the semicircular surface area and the thickness. The are of the semicircle is $A = \pi r^2/2$, where r is the radius. Therefore, the volume is

$$V = \frac{\pi}{2} r^2 z$$

where z is the ice thickness. Since there are 10^3 m in 1 km and 10^2 cm in 1 m, we have

$$r = (2000\,\text{km})\left(\frac{10^3\,\text{m}}{1\,\text{km}}\right)\left(\frac{10^2\,\text{cm}}{1\,\text{m}}\right) = 2000 \times 10^5\ \text{cm}.$$

In these units, the thickness becomes

$$z = 3000\,\text{m} = (3000\,\text{m})\left(\frac{10^2\,\text{cm}}{1\,\text{m}}\right) = 3000 \times 10^2\ \text{cm}$$

which yields,

$$V = \frac{\pi}{2}\left(2000 \times 10^5\ \text{cm}\right)^2 \left(3000 \times 10^2\,\text{cm}\right) = 1.9 \times 10^{22}\ \text{cm}^3.$$

•12 The fastest growing plant on record is a *Hesperoyucca whipplei* that grew 3.7 m in 14 days. What was its growth rate in micrometers per second?

12. A day is equivalent to 86400 seconds and a meter is equivalent to a million micrometers, so

$$\frac{(3.7\,\mathrm{m})(10^6\,\mu\mathrm{m/m})}{(14\,\mathrm{day})(86400\,\mathrm{s/day})} = 3.1\,\mu\mathrm{m/s}.$$

•14 Until 1883, every city and town in the United States kept its own local time. Today, travelers reset their watches only when the time change equals 1.0 h. How far, on the average, must you travel in degrees of longitude until your watch must be reset by 1.0 h? (*Hint:* Earth rotates 360° in about 24 h.)

14. Since a change of longitude equal to $360°$ corresponds to a 24 hour change, then one expects to change longitude by $360°/24 = 15°$ before resetting one's watch by 1.0 h.

•20 Gold, which has a mass of 19.32 g for each cubic centimeter of volume, 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?

20. To organize the calculation, we introduce the notion of density:

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

(a) We take the volume of the leaf to be its area A multiplied by its thickness z. With density $\rho = 19.32$ g/cm^3 and mass $m = 27.63$ g, the volume of the leaf is found to be

$$V = \frac{m}{\rho} = 1.430 \text{ cm}^3.$$

We convert the volume to SI units:

$$V = \left(1.430 \text{ cm}^3\right)\left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^3 = 1.430 \times 10^{-6} \text{ m}^3.$$

Since $V = Az$ with $z = 1 \times 10^{-6}$ m (metric prefixes can be found in Table 1–2), we obtain

$$A = \frac{1.430 \times 10^{-6} \text{ m}^3}{1 \times 10^{-6} \text{ m}} = 1.430 \text{ m}^2.$$

(b) The volume of a cylinder of length ℓ is $V = A\ell$ where the cross-section area is that of a circle: $A = \pi r^2$. Therefore, with $r = 2.500 \times 10^{-6}$ m and $V = 1.430 \times 10^{-6}$ m^3, we obtain

$$\ell = \frac{V}{\pi r^2} = 7.284 \times 10^4 \text{ m}.$$

•23 Iron has a mass of 7.87 g per cubic centimeter of volume, and the mass of an iron atom is 9.27×10^{-26} kg. If the atoms are spherical and tightly packed, (a) what is the volume of an iron atom and (b) what is the distance between the centers of adjacent atoms? SSM WWW

23. We introduce the notion of density, $\rho = m/V$, and convert to SI units: 1000 g = 1 kg, and 100 cm = 1 m.

(a) The density ρ of a sample of iron is therefore

$$\rho = \left(7.87 \text{ g/cm}^3\right)\left(\frac{1 \text{ kg}}{1000 \text{ g}}\right)\left(\frac{100 \text{ cm}}{1 \text{ m}}\right)^3$$

which yields ρ = 7870 kg/m^3. If we ignore the empty spaces between the close-packed spheres, then the density of an individual iron atom will be the same as the density of any iron sample. That is, if M is the mass and V is the volume of an atom, then

$$V = \frac{M}{\rho} = \frac{9.27 \times 10^{-26} \text{ kg}}{7.87 \times 10^3 \text{ kg/m}^3} = 1.18 \times 10^{-29} \text{ m}^3.$$

(b) We set $V = 4\pi R^3/3$, where R is the radius of an atom (Appendix E contains several geometry formulas). Solving for R, we find

$$R = \left(\frac{3V}{4\pi}\right)^{1/3} = \left(\frac{3\left(1.18 \times 10^{-29} \text{ m}^3\right)}{4\pi}\right)^{1/3} = 1.41 \times 10^{-10} \text{ m}.$$

The center-to-center distance between atoms is twice the radius, or 2.82×10^{-10} m.