

23. We introduce the notion of density (which the students have probably seen in other courses):

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

and convert to SI units:  $1000 \text{ g} = 1 \text{ kg}$ , and  $100 \text{ cm} = 1 \text{ m}$ .

(a) The density  $\rho$  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  $\rho = 7870 \text{ kg/m}^3$ . 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

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

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