

**SPECIFIC GRAVITY AND DENSITY**

**Density** is the mass per unit volume. In System International units, it is expressed as kilograms per cubic meter. The older style, and one still used by many mineralogists and geologists, is to express density as grams per cubic centimeter.

Density may be calculated from mineral data as follows;

$$D = \frac{Z \times M}{N \times V}$$

where  $Z = \#$  of formula units per unit cell

$M$  = molecular weight of the substance in question - these can be calculated using the table of atomic weights in the textbook

$N$  = Avogadro's number  $6.02338 \times 10^{23}$

$V$  = volume of the unit cell, converted to appropriate units

$V$  is often given in Angstroms ( $\text{\AA}$ ) or nm. One  $\text{\AA} = 10^{-10}$  meters, while  $1 \text{ nm} = 10^{-9}$  meters. To convert  $\text{\AA}^3$  to  $\text{cm}^3$ , it is necessary to multiply by  $(10^{-8})^3$ , or  $10^{-24}$ . To convert  $\text{nm}^3$  to  $\text{cm}^3$ , it is necessary to multiply by  $(10^{-7})^3$ , or  $10^{-21}$ .

**Unit cells** are an expression of the three-dimensional lattices used to describe mineral structures. This topic will be developed more later in the course. Units cells have three dimensions ( $a$ ,  $b$ , and  $c$ ) which may or may not be orthogonal. For the purposes of this exercise, all units cells will be orthogonal. For non-orthogonal cells, trigonometric corrections must be used to correct for the non-orthogonal axis or axes.

**Specific gravity** is a relative weight, mineral to an equal volume of water. It may be calculated using the formula;

$$G = \frac{W_A}{(W_A - W_W)}$$

where  $W_A$  is the weight in air

$W_W$  is the weight in water

Note: Since specific gravity is a ratio, it is dimension less.

**Problems:** Show all work! Clearly label your answer, including units, if any.

1. The mineral nantokite, CuCl, has a cubic unit cell whose dimension is 0.5407 nm. Cubic means that all three unit cell dimensions are identical.  $Z = 4$ . What is the calculated value of the density? Express your answer in grams per cubic centimeter, then convert the answer to kilograms per cubic meter.(6 points)

$$D = \frac{Z \cdot M}{N \cdot V} \qquad M = 63.546 + 35.453 = 98.999 \frac{g}{mol}$$

$$V = a^3 = (0.5407nm)^3 = (0.5407 \cdot 10^{-7} cm)^3 = 1.581 \cdot 10^{-22} \frac{cm^3}{mol}$$

$$D = \frac{4(98.999)}{(6.0234 \cdot 10^{23})(1.581 \cdot 10^{-22})} = \frac{395.996}{95.230} = 4.158 \frac{g}{cm^3}$$

1 gram/cubic centimeter = 1 000 kilogram/cubic meter, so:

$$4.158 \frac{g}{cm^3} = 4.158 \times 10^3 \frac{kg}{m^3}$$

2. The mineral Salesite,  $[\text{Cu}(\text{IO}_3)_2(\text{OH})]$ , is orthorhombic, with unit cell dimensions:

$$a = 4.78 \text{ \AA}, b = 10.77 \text{ \AA}, c = 6.70 \text{ \AA} \quad Z = 4$$

What is the calculated value of the density, expressed in a) grams per cubic centimeter and b) kilograms per cubic meter? (6 points)

$$M = (63.546 + 126.9045 + 3(15.9994) + 15.9994 + 1.0079) = 255.46 \frac{\text{g}}{\text{mol}}$$

$$V = a \cdot b \cdot c = (4.78 \cdot 10^{-8})(10.77 \cdot 10^{-8})(6.70 \cdot 10^{-8}) = 344.9 \cdot 10^{-24} \frac{\text{cm}^3}{\text{mol}}$$

$$D = \frac{4(255.46)}{(6.023 \cdot 10^{23})(344.9 \cdot 10^{-24})} = \frac{1021.8}{207.73} = 4.92 \frac{\text{g}}{\text{cm}^3}$$

$$4.92 \frac{\text{g}}{\text{cm}^3} = 4.92 \times 10^3 \frac{\text{kg}}{\text{m}^3}$$

3. The mineral samuelsonite,  $(\text{Ca,Ba})\text{Ca}_8(\text{Fe,Mn})_4\text{Al}_2(\text{PO}_4)_{10}(\text{OH})_2$ , has a density of  $3.35 \text{ g/cm}^3$ . Express this density in  $\text{kg/m}^3$ . (2 points)

$$3.35 \frac{\text{g}}{\text{cm}^3} = 3.35 \times 10^3 \frac{\text{kg}}{\text{m}^3}$$

4. A sample of monazite,  $(\text{Ce, La, Th}) \text{PO}_4$ , has a weight in air of 11.21 grams. The same sample has a weight in water of 8.99 grams. What is  $G$ ? (3 points)

$$G = \frac{W_A}{W_A - W_w} = \frac{11.21}{11.21 - 8.99} = \frac{11.21}{2.22} = 5.05$$

5. A sample of erythrite,  $\text{Co}_3(\text{AsO}_4)_2 \cdot 2 \text{H}_2\text{O}$ , is weighed in air. The weight is 9.67 grams. The weight of the same sample in water is 6.51 grams. What is  $G$ ? (3 points)

$$G = \frac{9.67}{9.67 - 6.51} = \frac{9.67}{3.16} = 3.06$$