

## Solution to FMS Homework 3, SS 2017

Checklist before you start this homework. (The boxes are clickable.)

☒ I have read the atomic structure related portion (p.18-26) of the chapter.

☒ I have worked on the Example Problems and Concept Check questions.

### Homework Problems:

1. Chemical analysis in materials science laboratories is frequently done by means of the scanning electron microscope. In this instrument, an electron beam generates characteristic x-rays that can be used to identify chemical elements. This instrument samples a roughly cylindrical volume at the surface of a solid material. Calculate the number of atoms sampled in a 1  $\mu\text{m}$ -diameter by 1  $\mu\text{m}$ -deep cylinder in the surface of solid copper.

Solution:

density of Cu:  $8.93 \text{ g/cm}^3$   
atomic mass of Cu:  $63.55 \text{ amu}$   
     $\Downarrow$  means

$$\frac{63.55 \text{ g Cu}}{\text{Avogadro's \# of Cu atoms}}$$

The volume sampled is

$$V_{\text{sample}} = \pi \left( \frac{1 \mu\text{m}}{2} \right)^2 \times 1 \mu\text{m} \\ = 0.785 \times 10^{-12} \text{ cm}^3$$

Thus, the number of atoms sampled is

$$N_{\text{sample}} = \frac{8.93 \text{ g}}{\text{cm}^3} \times 0.785 \times 10^{-12} \text{ cm}^3 \times \frac{6.02 \times 10^{23} \text{ atoms}}{63.55 \text{ g}} \\ = \underline{\underline{6.64 \times 10^{10} \text{ atoms}}}$$

2. One mole of solid MgO occupies a cube 22.37 mm on a side. Calculate the density of MgO (in g/cm<sup>3</sup>).

Solution

From textbook data sheet:

$$\begin{aligned} &\text{mass of 1 mole of MgO} \\ &= \text{atomic mass of Mg (in g)} \\ &\quad + \text{atomic mass of O (in g)} \\ &= 24.31 \text{ g} + 16.00 \text{ g} = 40.31 \text{ g} \end{aligned}$$

$$\begin{aligned} \text{density} &= \frac{\text{Mass}}{\text{Volume}} \\ &= \frac{40.31 \text{ g}}{(22.37 \text{ mm})^3 \times 10^{-3} \text{ cm}^3/\text{mm}^3} \\ &= \underline{\underline{3.60 \text{ g/cm}^3}} \end{aligned}$$

3. Calculate the dimensions of a cube containing 1 mole of solid magnesium.

Solution

From textbook data sheet:

$$\text{density of Mg} = 1.74 \text{ g/cm}^3$$

$$\text{atomic mass of Mg} = 24.31 \text{ amu}$$

$$\text{Volume of 1 mol} = \frac{24.31 \text{ g/mol}}{1.74 \text{ g/cm}^3}$$
$$= 13.97 \text{ cm}^3/\text{mol}$$

$$\text{edge of cube} = (13.97)^{1/3} \text{ cm}$$
$$= 2.408 \text{ cm} \times 10 \text{ mm/cm}$$
$$= \underline{\underline{24.08 \text{ mm}}}$$