



## Chemistry or Biology... Dimensional considerations to distinguish these 2 sciences - Correction

### Radius of an atom

- Weigh the mass of the copper sample using a scale:  $m_{\text{sample}} = 25.0 \text{ g} = 2.50 \times 10^{-2} \text{ kg}$
- Measure the volume of the copper sample by displacement of water, using a graduated cylinder:  $V_{\text{sample}} = 2.8 \text{ mL} = 2.8 \times 10^{-6} \text{ m}^3$
- By comparing the mass of a copper atom with that of the sample, deduce the number of copper atoms in the sample:  $N_{\text{Cu}} = \frac{m_{\text{sample}}}{m_{\text{Cu}}} = \frac{2.50 \times 10^{-2}}{1.1 \times 10^{-25}} = 2.3 \times 10^{23} \text{ atoms}$ .
- Derive an estimate of the volume of a copper atom, then its radius:

$$V_{\text{Cu}} = \frac{V_{\text{sample}}}{N_{\text{Cu}}} = \frac{2.8 \times 10^{-6}}{2.3 \times 10^{23}} = 1.2 \times 10^{-29} \text{ m}^3$$

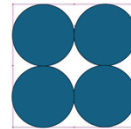
$$\Rightarrow R_{\text{Cu}} = \sqrt[3]{\frac{3}{4\pi} V_{\text{Cu}}} = \sqrt[3]{\frac{3}{4\pi} \times 1.2 \times 10^{-29}} = 1.4 \times 10^{-10} \text{ m} = 0.14 \text{ nm}$$

Note: The accepted value of the radius of the copper atom is  $R_{\text{Cu,th}} = 128 \text{ pm} = 1.28 \times 10^{-10} \text{ m}$ . The experimental estimation can be considered as acceptable.

We can also calculate the relative difference between the 2 values:

$$\frac{\Delta R}{R} = \frac{|R_{\text{Cu,th}} - R_{\text{Cu}}|}{R_{\text{Cu,th}}} = \frac{|1.28 \times 10^{-10} - 1.4 \times 10^{-10}|}{1.28 \times 10^{-10}} = 0.094 = 9.4 \%$$

One explanation for the discrepancy between the measured value and the theoretical value is that, since the atoms are spherical in shape, they do not occupy the entire volume of the cylinder, which is also empty.



### Radius of a cell



The red blood cell is considered to be a sphere. We can measure its diameter and deduce its radius:

$$\phi_{\text{rbc}} = 0.7 \text{ UA} = 0.7 \times 10 = 7 \text{ }\mu\text{m} \Rightarrow R_{\text{rbc}} = \frac{\phi_{\text{rbc}}}{2} = \frac{0.7}{2} = 0.3 \text{ }\mu\text{m} = 3 \times 10^{-7} \text{ m}$$

### Conclusion

One number is considered negligible in front of another when there is a factor of  $10^2$  between the 2.

The radius of an atom being  $1000 = 10^3$  times smaller than the radius of a cell, these 2 objects are not at the same scale.

We therefore can differentiate a chemist and a biologist by the scale of the object they are working with.



### And what about molecules?

$$1 \text{ tsp} = 4.93 \text{ mL} = 4.93 \times 10^{-3} \text{ L.}$$

$$1 \text{ m}^3 = 10^3 \text{ L} \Rightarrow 1 \text{ L} = 10^{-3} \text{ m}^3 \Rightarrow 1 \text{ tsp} = 4.93 \times 10^{-6} \text{ m}^3$$

The volume of olein in the spoon is therefore  $V_{ol} = 4.93 \times 10^{-6} \text{ m}^3$

$$1 \text{ ft} = 30.48 \text{ cm} = 0.3048 \text{ m} \Rightarrow 1 \text{ ft}^2 = 1 \text{ ft} \times 1 \text{ ft} = 0.3048 \times 0.3048 = 9.290 \times 10^{-2} \text{ m}^2$$

$$\Rightarrow 1 \text{ ac} = 43560 \text{ ft}^2 = 43560 \times 9.290 \times 10^{-2} = 4047 \text{ m}^2$$

$$\Rightarrow \frac{1}{2} \text{ ac} = \frac{4047}{2} = 2023 \text{ m}^2. \text{ The surface covered by olein is } S_{ol} = 2023 \text{ m}^2$$

The thickness of the olein layer, assumed to be monomolecular (1 single molecule), is therefore :

$$h_{ol} = \frac{V_{ol}}{S_{ol}} = \frac{4,93 \cdot 10^{-6}}{2023} = 2.38 \times 10^{-9} \text{ m} = 2,38 \text{ nm}$$

The length of an olein molecule is  $l_{ol} = 2,38 \text{ nm} = 2.38 \times 10^{-9} \text{ m}$

$$l_{ol} \approx 10 R_{at} \approx \frac{1}{100} R_{cell}$$

If an atom is smaller than a molecule, it is not negligible in relation to it. On the other hand, a molecule can be considered negligible in relation to a cell.

**Chemists study atoms and molecules, the elementary structures of matter, while biologists study cells, the elementary structures of living matter.**

**While a molecule can be considered as an assembly of atoms, a cell is much more than just an assembly of molecules.**

*Note: These distinctions are, of course, permeable. A biologist can study the behavior of molecules in relation to cells. This is biochemistry.*