

Concentration Expressions and Calculations

Chapter 21 – all except II.E. & Chapter 22 – Parts I.A and I.B

General Observations:

1. If you pay careful attention to the units in the given quantities and the units needed in the answer, you can do all of these problems with proportion equations, which we discussed in Chapter 9.
2. What's the difference between "amount" and "concentration"? p. 450, second column.
3. Table 21.2 on page 461 is a very important summary table and you can understand most of it based on what you learned in Ch. 9.
4. Molarity is the new concept for us here. After learning about molarity, you are ready to read Table 21.3 on page 461, where we discuss the first row and last row since those are the ones relevant to what we cover in this course.
5. p. 451, Table 21.1. What solvent is typically used (if we don't mention the solvent)? What does BTV mean in a biology lab? What does it mean that you actually do in the lab? Why?
6. After you learn about molarity and $C_1V_1 = C_2V_2$, then prepare a page of notes to use on the MATH test (not necessarily on the Biology test.) Your page should include the information from Table 21.2, with only a very brief additional amount of information about each, and a sentence or two about $C_1V_1 = C_2V_2$. I am asking you to prepare this so that you will focus on the essentials of how to identify the various types of problems and how to solve each.

Molarity:

1. What is the gram atomic weight of NaCl? Answer: Look on the periodic table and add the gram atomic weights of Na and of Cl: $22.99 + 35.45 = 58.44$
2. In this course, you won't need the periodic table. I'll give you the gram atomic weights of any substances for which you need that. (Coe tells me that, in the lab, you mainly just read the gram atomic weight from the label on the container.)
3. Read the definition of a 1 M (one molar) solution and describe how to make one liter of a 1 M solution of NaCl in water.
4. What is the significance of measuring the concentration as a molar solution as opposed to another kind of measure of concentration? What does Avogadro's number have to do with this?

5. Read through the examples in this section. Do you see that they are all proportion problems?
6. After you have solved them all as proportion problems, go back and look at p. 454, formula 1, to see an alternative way of solving a problem like this. Do the example problems on p 454-455.
7. Do page 455, problem 3. If you have trouble finding the gram atomic weight of this substance, just use the value 408.27 g.

Skip the last section of Ch. 21, on molality and normality.

For Chapter 21, review the summary on p. 461.

Discussion: How I “made sense” of all of this stuff.

1. Why are there all of these methods? Why not just one?
Short answer: What is convenient to measure? May differ in different situations.
2. Why don't we call these different things by different names instead of calling them all concentration? (That's the mathematician in me – if you call them the same thing, they should BE the same thing.)
Short answer: They're pretty close to the same thing for a lot of practical problems, like for many organic compounds.

Read on for a longer answer to this question.

3. Mathematically, it would seem to make sense to have the units of the numerator and denominator be the same, particularly if you're going to call it a percent. Notice that they DO say that must be true for ppm and ppb. Which one in the table 21.2 on p. 461 is that NOT true for? Why?
Short answer: Think of actually using these when you're going to dissolve salt in water – what is convenient to measure?

Read on for a longer discussion of the weight/volume method:

I was surprised to see 2% milk actually defined as grams/mL, because, as a math person, I always assumed that percents have the same units in the numerator and denominator, and this says it's grams of fat per mL of volume. I was talking to a friend of mine, who happened to be a physicist, who reminded me of some facts I already knew (and one or two more facts) that make this seem pretty reasonable.

Summary: For many organic compounds, mass (weight) in grams and volume in mL are almost the same number. We learned this fact back on page 125 when we discussed density, although we didn't focus on it in quite this way. When we discussed density (which is mass / volume, we saw that for the organic compounds they gave, the densities were not far from 1.) So,

mathematically, that means that the numerical measure for the mass in grams and the volume in mL of water, for instance, are about the same. So in the 2% milk, if we measured the mass of the milk in grams instead of the volume of the milk, it would be almost the same number as the volume in mL. So we can think of the 2% milk as being a ratio of grams / grams.

Now, let's go into more detail about why these densities are close to 1.

1 mL = 1 cc

These were almost equal before 1964. The liter was re-defined in 1964 to make these exactly be equal. Before that, they had two definitions of volume, from space and from length. They dropped the volume standard and agreed to only use the length³ standard for volume. So liter is not a really basic unit anymore. But, of course, it is still useful.

1 g is mass of 1 cc of pure water at water's maximum density, which is 4° Celsius. Grams were always defined in terms of the mass of water. Before 1964, this was in terms of mL at standard temperature and pressure. After 1964, they used at 4° Celsius instead of standard temperature and pressure.

Mass of 1 cc of water at standard temperature and pressure ("room temperature") is a little less than 1 g – like 0.997 at 25 Celsius, which is where we get the value for the density of water on p. 126, problem 1.

Many other organic substances are about the density of water (usually a little lighter.) That means that mass in grams is somewhat interchangeable with volume in cubic centimeters, or in mL.

Sidelight: For our purposes, we think of mass as just meaning weight. In a physics class, we'd discuss the differences between the concepts of mass and weight, but not here.

Ch. 22: The $C_1V_1 = C_2V_2$ equation and dilutions as fractions.

1. In Ch. 22, we learn that a typical way to dilute a solution is to use this formula:
 $C_1V_1 = C_2V_2$. Practice using this by working through the example problems.
2. Read p. 466, Box 1.
3. Read p. 467, part B. How an you use a proportion method to do this? How would you use the $C_1V_1 = C_2V_2$ equation?
4. What is the $C_1V_1 = C_2V_2$ method used for? (Preparing a dilute concentration from a stronger concentration.)
5. Read about Dilutions as fractions. These problems are easy to solve with proportions.