Solutions: Percentage.

A. Introduction

This handout continues the discussion of solutions, introduced in the “Molarity” handout. It focuses on the concentration unit “weight percentage”, %(w/w). Some related units, such as %(w/v) and “ppm” are also introduced. As background, the handout develops the concept of percentage.

The core material is Sect B-D. The rest is optional; do individual sections as suits your interests or needs.

Please let me know if you want more problems for some sections, or if you have other needs about percentages.

In the problem sets, a * indicates a problem that is “more difficult” or which introduces some new idea. If you are scanning through the problems, pay particular attention to the ones with *.

B. Comparisons; ratios; the idea of percentage

This section develops the idea of percentage. There is no chemistry here. If you are comfortable working with ratios and percentages, you may want to skip some of this section.

Comparisons

Consider two metal bars. Bar A is 4.0 cm long, Bar B is 1.0 cm long. The following three statements all compare these two bars.

.

1. Bar A is longer than Bar B.

2. Bar A is 3 cm longer than Bar B.

3. Bar A is 4 times the length of Bar B.

All three statements are valid comparisons. However, they take different approaches to doing the comparison, and it is important to understand these differences. #1 is a qualitative comparison. #2 & #3 are quantitative, but they take different approaches to doing the quantitative comparison. #2 uses subtraction, whereas #3 uses division.

Now consider another pair of bars. Bar A′ is 103 cm long, Bar B′ is 100 cm long. The first two comparison statements above are still true. But statement #3 is quite different: In this case Bar A′ is 1.03 times longer than Bar B′.

So which type of comparison is "correct"? All are correct, but one may be more appropriate in a context. In particular, the division-type comparison of statement #3 is very commonly the one of interest; it takes into account the absolute sizes. Think about it this way… Is it "important" (or "significant") that one bar is 3 cm longer? Well, if we are talking about very short bars (1-4 cm), then it probably is very important. But if we are talking about long bars (100 cm), then 3 cm may be a very "small" difference.

The purpose of the preceding discussion is to emphasize the usefulness of "divisional" comparisons (such as statement #3). Both ratios and percentages build on the idea of divisional comparisons.

Problem

1. One evening I heard the final score for a baseball game: Oakland 5, Chicago 2. Which of the three types of comparison (above) is most relevant in this case?

Ratios

A ratio is one way to express a divisional comparison. Statement #3, above, is essentially a statement of a ratio. The statement is equivalent to saying that the ratio of (the lengths of) bars A & B is 4 to 1, or 4:1, or just 4.

Say we have 12 apples and 6 oranges. We say that the ratio of apples to oranges is 12 to 6, or 12:6, or 12/6. Of course, we can do the implied division, and report that the ratio of apples to oranges is 2 to 1. However we say it, the idea with the ratio is to say that there are twice as many apples as oranges. One way or another, we obtain a ratio by dividing one measurement by another.

Percentages

Percentages are very much like ratios, in that they involve a divisional comparison. However, percentages are expressed "per 100"; "per cent" means "per 100". To calculate a percentage, do the indicated division, then multiply by 100.

Example. Calculate the length of bar A′ (above) as a percentage of the length of bar B′.

The ratio of the lengths is

$$\frac{103\ \cancel{cm}}{100\ \cancel{cm}} = 1.03$$

To calculate the percentage, multiply the ratio by 100. That is, bar A′ is 103% of the length of bar B′.

We will see more examples of ratios and percentages as we proceed.

C. The units of "percent"

We have emphasized the use of units to guide you in setting up problems. So, what units go with percentages?

At first glance, it may seem that percentages don't have units. After all, a percentage is the ratio of two measurements, and the units should cancel. This may be so -- at least in some cases. Nevertheless, we can talk about the units for percentages in ways that are helpful -- helpful in using dimensional analysis to guide problem solving.

There are two general ways to look at the units of percentages. One is simple, and merely guides you about the "hundred" aspect of a percentage. The other is more complex, and considers the specific measurements.

The "hundred"

When you calculate one number as a percentage of another, you divide the two numbers, and then multiply by 100 to convert to percentage. Or do you divide by 100? There is a little trick to help you remember. The trick makes use of the basic approach of dimensional analysis, that you can always multiply by something that has the value of 1; such a multiplication can change the form of a number, but not its value. The relationship: 100% = 1. Thus, multiplying by 100%/1, with the % sign in the numerator, converts a number to percentage. Multiplying by the inverse, 1/100%, would get rid of the % sign.

Example B1. There are 50 people in a room. 10 of them are left handed (l-h). The percentage of l-h people is

$$\frac{10}{50} \times \frac{100\%}{1} = 20\%$$

(You can write the conversion factor as 100%/1 or simply 100%.)

Example B2. (This is the reverse of Example B1.)
There are 50 people in a room, with 20% of them l-h. The number of l-h people is given by

$$50 \times 20\% \times \frac{1}{100\%} = 10$$

The final two terms, 20% x 1/100% = 0.2. Perhaps you knew that you could do this problem simply by multiplying 50 x 0.2. Fine, if you knew that. If not, you now have a guide to dealing with the % sign.

Complex units for percentages

Sometimes it is logical to associate more specific units with a percentage. We should think of this as an informal use of units, done because it helps us work through a problem involving the percentage. The key to such informal use of units for percentages is to understand what the particular percentage expression really means. And, of course, always remember that the word "percentage" means "per hundred."

Example B3. This is a repeat of Example B2, but using "complex units."
You know that 20% of the people are left-handed; that means "20 l-h people per 100 total people".

$$50 \cancel{\text{ total people}} \times \frac{20 \text{ l-h people}}{100 \cancel{\text{ total people}}} = 10 \text{ l-h people}$$

In this problem the percentage of left-handed people is used as a conversion factor between total people and l-h people. Writing the conversion factor requires knowing that percentage means per hundred, and that in this case the percentage involves l-h people and total people. Once you have figured out the conversion factor, you can do the problem by ordinary dimensional analysis.

We have now done this problem three ways: twice under B2 (using no conversion factor at all, and using 100%/1), and once here using the complex conversion factor. We got the same answer each time. Good; all the methods are correct. If you are comfortable putting in and taking out % signs, ok. If not, you can use the general factor 100%/1 to guide you; using this reflects a general understanding of percentage. And if you aren't sure what to do, try thinking out what the percentage really means, and expressing that as a conversion factor. Then you can fall back on dimensional analysis to guide you in solving the problem. Writing out the conversion factor forces you to find out or figure out what the percentage means. (This is particularly likely to be helpful when the percentage deals with unfamiliar quantities.)

Problems

These problems all deal with the apples and oranges introduced in Sect B, under Ratios.

2. How would you express this ratio including units?
3. Calculate a ratio of apples and total fruit; include units.
* 4. Give the comparison as a percentage; include clear units.

D. Weight percentage, %(w/w)

A simple way to describe a solution is to give the mass (weight) of each ingredient. This can be expressed as the percentage of the total mass which is solute.

Example. A solution is made by weighing 10.0 g of NaCl and adding 40.0 g of water. This solution is 20% NaCl by weight (20% w/w).

Why? The total weight is 10.0 g solute + 40.0 g solvent = 50.0 g. The solute is 10 g of that…

$$\%\ \text{NaCl} = \frac{10.0\ \text{g NaCl}}{50.0\ \text{g total}} \times 100\% = 20\%\ (\text{“by weight”, or “w/w”})$$

In this set-up, the "g" cancels. (Yes, they are g of different things. But for now, we just want g. Weight percentage uses g/g.) Multiplying by 100% is the way to convert to percentage (Sect C).

Note: mass vs volume.

Since the density of water is very close to 1.00 g/mL at room temperature, we may well measure the water as 40.0 mL rather than 40.0 g. This is for convenience; it's often quicker to measure a liquid by volume than by weight. But, careful… we are talking about weight percentage here, and we need the weight of the solvent. To convert between weight and volume, we must use the density. For water, this is so easy (1.00 g/mL) that we often do it without formally writing it. If the solvent is something else, you will need to look up the density and do the appropriate calculations -- or just weigh the solvent.

More about mass vs volume in later sections.

Using weight percentage

A weight percentage in a problem means g solute/100 g solution. Recognizing this, you have a useful conversion factor. You are probably going to use the weight percentage number to do some calculation involving g of solute or g of solution -- or something that can be related to these (such as mol solute). Expanding the percentage number as you set up the problem guides you to using the percentage correctly. The key here, of course, is to know what the percentage means -- to recognize and distinguish the various kinds of percentage type units.

Example. How much of a 10% (w/w) solution do we need to get 25 g of solute? The problem asks us to convert amount (g) solute to amount (g) solution. The conversion factor is the weight percentage, 10 g solute/100 g solution.

$$25\ \cancel{\text{g solute}} \times \frac{100\ \text{g solution}}{10\ \cancel{\text{g solute}}} = 250\ \text{g solution}$$

In this case, we wrote the concentration, 10 g solute/100 g solution, upside down because that allowed "g solute" to cancel, and put the desired unit "g solution" in the numerator.

Problems

5. You make a solution by adding 75 g of sugar to 225 g of water. What is the concentration of this solution, in weight percentage, %(w/w)? (If you need the formula of the sugar, please ask.)
6. You make a solution by adding 200 g of a solute to 800 g of water. What is the concentration of this solution, in weight percentage, %(w/w)?
* 7. You have 100 g of a solution that is 30% cesium chloride (w/w). How much CsCl is in this sample?
* 8. You have a 10% (w/w) stock solution of NaCl. How much of this solution do you need in order to get 50 g of NaCl? (Careful with the units of the answer.)
* 9. How would you make a 15% (w/w) solution of sodium hydroxide? Describe the steps, and the amounts you would measure. (How much solution? You choose a convenient amount.)
10. You want to make 100 g of a 1.00% (w/w) solution of sodium carbonate. How much solute do you need?
* 11. You want to make 100 g of a 1.00% (w/w) solution of sodium carbonate. The available sodium carbonate is $Na_2CO_3 \cdot 7H_2O$. How much solute do you need?
* 12. Continuing… How much water would you add?
* 13. You dissolve 1.00 mg of a protein in 10.0 g of water. What is the protein concentration, in weight percent?
* 14. You dissolve 1.00 mg of a protein in 10.0 mL of water. What is the protein concentration, in weight percent?

E. Volume percentage, %(v/v)

In Sect D we discussed percentage "by weight" or "w/w". There are other ways to express percentage.

%(v/v) is percentage by volume: volume solute per volume solution.

Care is needed in making a v/v solution, since the volume of a mixture is (in general) not equal to the sum of the individual volumes. If you want 50% alcohol by volume, you take 50 mL alcohol, then add enough water to reach a total volume of 100 mL. Adding 50 mL of water won't work. Volumes are not additive. Nevertheless, working with v/v solutions, once they have been made, is perfectly straightforward; the unit v/v has a perfectly clear meaning.

Problems. These problems deal with a solution that is labeled "20%(v/v) glycerol".

15. Write a conversion factor that shows what this % means.
16. How much of this solution do you need if you want 100 mL of glycerol?
17. How would you make 3.0 L of this solution?

F. Weight/volume percentage, %(w/v)

%(w/v) is based on weight solute per volume of solution. A solution which is 1% (w/v) has 1 g of solute in a total solution volume of 100 mL. More generally, %(w/v) is grams solute per 100 mL solution. (Compare: % w/w is g solute per 100 g solution.)

When you do calculations with %(w/v), the units do not seem to cancel properly. Nevertheless, %(w/v) is operationally convenient and fairly common. (Why? Most solutes are solids, so weighing them is convenient. And the solutions themselves are liquids, so measuring their volume is convenient.) In effect, %(w/v) has a clear meaning by convention.

In all cases discussed here, the denominator of the percentage calculation refers to the amount of solution. That is, "percentage" is the percentage of the total that is solute. The various kinds of percentage differ in using mass and/or volume.

Be careful that you know what a particular percentage description means. Unfortunately, you are likely to find solutions (or requests for solutions) labeled %, without making clear what is meant. Sometimes it may be "obvious from context", but be cautious. In some cases, I think it is obvious only to the person who wrote it (and only at that moment). (You might want to review problem #4 including the discussion of the units in the answer section.)

Problems

Problems 18-20 deal with a solution that is labeled "20%(w/v) glucose".

18. Write a conversion factor that shows what this % means.
19. How much of this solution do you need if you want 100 g of glucose?
20. Compare these problems to the ones in Sect E.

21. A lab manual calls for using a 5% (w/v) solution of copper(II) sulfate, $CuSO_4$. How much solute would you need to make 250 mL of this solution?
* 22. Continuing… How much solute would you need if the only form of copper sulfate available is the pentahydrate?

Problems 23-24 deal with a detection system that is claimed to detect DNA at 0.1 ng/µL. (These problems are independent.)

* 23. What is this detection limit in percentage (w/v)?
24. What is the detection limit in molarity of nucleotides? (Molarity of DNA is a rather complicated idea. After all, different kinds of DNA have different molar masses. A useful idea in many cases is to talk about it in the sense of molarity of nucleotides, where an average nucleotide has a molar mass 330 g/mol.)

G. ppm, etc.

There are other concentration units that are logically similar to percentage. Recall that "percentage" is "parts per hundred." For more dilute solutions, "parts per thousand", "parts per million", "parts per billion" (etc.!) may be appropriate. As with percentage, these may be in terms of mass and/or volume. Parts per thousand may be indicated by a symbol that looks like a percent sign, but with a second "o" on the bottom (^{o}/oo). Parts per million is ppm, parts per billion is ppb.

To work with these concentration units, use appropriate units analogous to those discussed for percentage. For example, to convert to ppm, remember that 10^6 ppm = 1. Complex units follow the same logic introduced in Sect C for percentage.

Example

Given 12 ppm (w/w) of NaCl (in water), how would you write this in a problem? Well, ppm literally means parts per million, and it says w/w, so why not… 12 ppm (w/w) = 12 g NaCl per million g solution.

It doesn't matter that you don't have a million g of solution; you are merely expressing the given data in a convenient form. Individual terms in a dimensional analysis set-up do not have to be of any particular practical magnitude; they just have to be true.

Convince yourself that each of the following factors would be a valid way to write 12 ppm (w/w) aqueous NaCl in a problem. That is, the following factors are all equal…

$$12\text{ ppm (w/w)} = \frac{12\text{ g NaCl}}{10^{6}\text{ g solution}} = \frac{12 \times 10^{-6}\text{ g NaCl}}{1\text{ g solution}}$$

$$= \frac{12\text{ g NaCl}}{1\text{ Mg solution}} = \frac{12\ \mu\text{g NaCl}}{1\text{ g solution}}$$

Since all of the above factors are equal, and all reflect the same data, all are correct. Your choice among them may depend on one seeming more appropriate to a particular problem -- or may just be a matter of comfort. After all, if they are all equal, all are correct. You can do further conversions as needed once you have the set-up properly started. As usual with dimensional analysis, there is no advantage of spending time making clever choices of terms.

Problem

25. Write a similar set of conversion factors that you could use for a solution that contains Hg (mercury) at 25 ppb (w/w) (parts per billion).

There are more ppm problems in Sect K; these problems integrate material from several sections.

H. Converting from w/w to w/v

A %(w/w) concentration means $\dfrac{\text{g solute}}{\text{100 g solution}}$

A %(w/v) concentration means $\dfrac{\text{g solute}}{\text{100 mL solution}}$

The difference between these two types of concentration units is the denominator: weight of solution in one case, volume of solution in the other. Can you convert from one to the other? Well, you could if you knew the relationship between those two denominators… g solution and mL solution, i.e., the weight and volume of the solution. That relationship is simply the density of the solution.

⇒ Message: You can convert between w/w and w/v type units by using the density.

There is a second message: How do you know that you need the density? You know that by understanding what the two kinds of percentages mean. If you can write each concentration with expanded units, as shown above, you can then see what relationship you need to complete the problem. This illustrates another way that clear dimensional analysis can help you in a problem, by guiding you as to what information you need.

> (Solution densities for common solutes, as a function of concentration, are often available in handbooks, such as the CRC Handbook of Chemistry and Physics. Further, solution density is easy to measure.)

Example

You have a 10.00% (w/w) aqueous solution of sodium chloride, NaCl. What is this concentration in %(w/v)? The density of the solution is 1.071 g/mL.

$$\frac{\text{10.00 g NaCl}}{100\ \cancel{\text{g solution}}} \times \frac{1.071\ \cancel{\text{g solution}}}{\text{mL solution}} = \frac{\text{10.71 g NaCl}}{\text{100 mL solution}} =$$

10.71% (w/v)

Note that the density is written so that g solution cancels, leaving g NaCl/mL solution. (Also note that I left the 100 in the problem, since I knew that I wanted percentage. I could have expressed the result as 0.1071 g NaCl/mL solution, and then multiplied by 100% to get back to percentage.)

Problems. (I would prefer that you look up the data you need to do these problems in a handbook. If you do not have access to a handbook, please see me.)

26. Commercial "concentrated hydrochloric acid" is a 37% (w/w) solution of HCl in water. Express this as a w/v concentration.
27. You add 50.0 g of sucrose (table sugar) to 50.0 g of water. What is the concentration of this solution in %(w/w)?
28. Continuing… in %(w/v)?
* 29. You add 1.0 g of sodium nitrate, $NaNO_3$, to 99.0 g of water. What is the concentration of this solution in %(w/w)?
30. Continuing… in %(w/v)?

I. The approximation of dilute aqueous solutions

If the density of the solution is 1.0 g/mL, then doing the above conversion (Sect H) will show that the numeric values of %(w/w) and %(w/v) are equal. Of course, d=1.0 g/mL is the density of water. And it is also -- very nearly -- the density of dilute aqueous solutions. Thus, as a practical matter, you can often interchange w/w and w/v type units for dilute solutions. You saw an example of this in #30, above.

How dilute does a solution have to be for this to be useful? Well, that depends on the solute -- and on your required accuracy. The dilute solution approximation is almost certainly appropriate whenever you are dealing with small units such as ppm or ppb. It may even be appropriate for solutions with a few % solute. [A 10% solution of NaCl has d=1.07 g/mL (Example of Sect H). If you ignored this, and approximated the density by 1.0 g/mL, you would be making a 7% error.]

Example

A solution contains 45 ppm (w/w) of phenol. What is this in ppm (w/v)? in g/mL? [Assume that the solution has density = 1.0 g/mL (which it would if there were no major solutes).]

If the density is (or is assumed to be) 1, then ppm (w/w) = ppm (w/v). The solution is 45 g solute/10^6 g solution as given, or 45 g solute/10^6 mL solution.

To get g/mL, more formally from the given data…

$$\frac{45\ \text{g phenol}}{10^6\ \cancel{\text{g solution}}} \times \frac{1\ \cancel{\text{g solution}}}{1\ \text{mL solution}} = 4.5\text{x}10^{-5}\ \text{g/mL} = 45\ \mu\text{g/mL}$$

Remember, w/w and w/v units are distinct. To convert from one to the other, you need the density of the solution. But if the density is (very nearly) 1 g/mL, the numeric values of the concentration will be (very nearly) the same in w/w and w/v terms.

> [The very low concentration units, such as ppm or ppb, are rarely given in w/v. In fact, it's usually just assumed that these are w/w, even though it isn't stated. But for dilute aqueous solutions, it would be the same numeric value either way, so the ambiguity doesn't really matter. Although ppm (w/v) may not be of much interest, getting to g/mL or to molarity may be; logically, you need w/v units to get to molarity. Next section.]

J. Converting from w/w or w/v to moles or molarity

Molarity is moles solute/L solution. w/v concentration units have the form g solute/vol solution. Thus w/v concentration units can be easily converted to molarity, by converting the numerator from g to moles using the molar mass.

You may also need to adjust the denominator units. Both have volume units in the denominator, but one may well be mL and the other L. Hopefully, by now, you consider this a routine dimensional analysis step.

To calculate molarity from w/w units, one must "first" calculate the w/v concentration, using the density (Sect H or I, above), then convert to molarity. Of course, both of these steps can be combined into a single calculation.

Example

Calculate the molarity of 10% (w/w) NaCl. (This is the same solution discussed in the Example of Sect F.)

$$\frac{10.00\ \cancel{\text{g NaCl}}}{100\ \cancel{\text{g solution}}} \times \frac{1.071\ \cancel{\text{g solution}}}{\cancel{\text{mL}}\ \text{solution}} \times \frac{\text{mole NaCl}}{58.44\ \cancel{\text{g NaCl}}} \times \frac{1000\ \cancel{\text{mL}}}{\text{L}}$$

$$= 1.83\ \text{M}$$

K. More Problems

The problems here combine issues from several sections above.

31. A solution is labeled as 35 ppm of sulfate. What is this concentration, in μg/mL? (Assume d = 1.0 g/mL.)
32. A solution is labeled as 75 ppb of arsenic. What is this concentration, in μg/L? (Assume d = 1.0 g/mL.)
33. You have a solution labeled 0.063 mg/mL. What is this in ppm?
34. Calculate the molarity of a 25.0% (w/v) solution of cesium chloride, CsCl.

35. Calculate the molarity of a 15 ppm (w/w) solution of barium chloride, $BaCl_2$. (Try to use an appropriate prefix on M.)
36. A water sample contains 2.4 ppb of lead ions. Calculate [Pb^{2+}], in molarity.
37. You want 150 g of potassium nitrate, KNO_3. You have a 10.0% (w/w) stock solution, d = 1.063 g/mL. What volume of this solution do you need?
38. You have a solution which contains silver ions at 85 ppm (w/w). What volume of this solution would it take to get a mole of Ag?
39. A solution contains 50 ppm of sulfate (SO_4^{2-}). What is the concentration of sulfur (S), in ppm?
40. What is the molarity of a 0.89% (w/v) solution of sodium chloride, NaCl? (This solution is known as physiological saline. It has the same total salts concentration as blood.)

L. Answers

Sect B

1. #1, qualitative. The winner is the team with the most runs. It doesn't matter how much you win by.

Sect C

2. 2 apples/1 orange (or arithmetic equivalent)
3. 12 apples/18 total fruit
4. 67% of the fruit are apples. That is, there are 67 apples/100 total fruit. Or we might abbreviate this as 67% (apples/fruit) or 67%(a/f) -- just as a preview of things to come. You might also calculate the percentage as 200%(a/o). That seems odd in this context, but it is logical in principle. And the units should be clear to you. (If you just said 67%, that is not satisfactory.)

Sect D

5. 25% (w/w) (The formula and molar mass of the sugar are irrelevant.)
6. 20% (w/w) 7. 30 g
8. 500 g. (Mass. What would the volume be? Well, we would have to calculate that from the mass of the solution. See Sect I, J)
9. Weigh out 15 g of the solute (sodium hydroxide), and 85 g of the solvent. (What is the solvent? Hm, it doesn't say. Probably water; that is the common solvent and we often don't bother to say it. NaOH, an ionic compound and strong base, is quite soluble in water, so this is reasonable. But the calculation here would be the same, regardless of solvent.) Add the solute to the solvent. Any multiple of the amounts given here would be fine.
10. 1.00 g 11. 2.19 g (You want 1.00 g of Na_2CO_3. 2.19 g of $Na_2CO_3 \cdot 7H_2O$ <u>contains</u> 1.00 g of Na_2CO_3 <u>and</u> 1.19 g of water. If you want a rigorous approach, think moles. 1.00 g of Na_2CO_3 is some number of moles; you need that many moles of the hydrated salt.)

12. 97.81 g (You want 99 g of water, but you got 1.19 g of that along with the solute. This point may be negligible in some cases in practice, but it is logically precise.)
13. 0.01% (w/w) (Note that the mass of the solute is negligible in the denominator.)

14. Same as previous question. 10 mL of water = 10 g of water, since density of water = 1.00 g/mL. But it is important you notice that the data is given in volume, not mass. You can't calculate %(w/w) from volume without converting the volume to mass, by using the density. For water, this step is easy, but be sure you notice it.

Sect E

15. 20 mL glycerol/100 mL solution 16. 500 mL
17. 600 mL glycerol. Add water until final volume is 3.0 L.

Sect F

18. 20 g glucose/100 mL solution 19. 500 mL
20. One has a liquid solute, measured by volume. The other has a solid solute, measured by mass. But once the solutions are made, both are liquids. The conversion factors and subsequent calculations are very much in parallel.
21. 12.5 g 22. 19.6 g
23. 10^{-5} % 24. $3\text{x}10^{-7}$ M

Sect G

25.

$$25 \text{ ppb (w/w)} = \frac{25 \text{ g Hg}}{10^{9} \text{ g solution}} = \frac{25 \times 10^{-9} \text{ g Hg}}{1 \text{ g solution}}$$

$$= \frac{25 \text{ g Hg}}{1 \text{ Gg solution}} = \frac{25 \text{ ng Hg}}{1 \text{ g solution}}$$

Sect H

26. 44% (w/v) 27. 50.0% (w/w) 28. 61.5% (w/v)
29. 1.0% (w/w) 30. 1.0% (w/v)

Sect K

31. 35 µg/mL 32. 75 µg/L 33. 63 ppm
34. 1.48 M 35. $7.2\text{x}10^{-5}$ M = 72 µM (assume d = 1 g/mL)
36. $1.2\text{x}10^{-8}$ M = 12 nM 37. 1.41 L 38. $1.3\text{x}10^{3}$ L = 1.3 kL
39. 17 ppm (Think moles. This is another example of a substitution problem.)
40. 0.15 M (58.44) (Note that %w/v has the same general form as molarity.)