TOPIC 4: MAKING SOLUTIONS

SOLUTIONS 4.1: Making Solutions from Dry Chemicals

How do you make particular volumes of solutions of particular molarities, starting with a bottle of a compound?

EXAMPLE: Suppose you want 100 mL of a 5.00 M stock solution of CaCl₂.

Step one: Figure out how many grams would go in one liter:

5.00 M = 5.00 moles per liter

Convert moles to grams using the formula weight:

Formula Weight of CaCl₂ is 219.08 grams per mole.

\[
5.00\text{mol} \times \frac{219.08\text{g}}{\text{mol}} = 1095.4\text{g}
\]

Step two: Figure out what fraction of 1 liter you are making.

\[
\frac{100\text{mL}}{1000\text{mL}} = 0.1
\]

Step three: Use the same fraction of the 1095.4 g.

\[
0.1 \times 1095.4\text{ g} = 109.54\text{ g}
\]

So, to make 100 mL of a 5.00 M solution of CaCl₂, put 109.54 g into a container, then bring the solution up to 100 mL.

These steps can be simplified.
Written as one expression, the relationship looks like this:

\[ 5.00 \text{ mol} \times \frac{219.08 \text{ g}}{\text{mol}} \times \frac{10^{-1} \text{ L}}{\text{L}} \]

If you rewrite the L as the denominator of the first variable, and note that the second variable is molecular weight, this simplifies even further, providing a recipe for making solutions from dry chemicals.

**RECIPE SHORTCUT:**

\[ \text{Final Molarity} \times \text{Molecular weight} \times \text{Final volume [L]} = \text{Grams to add} \]

Don’t forget to bring the solution up to final volume.

**SOLUTIONS 4.2: Dealing with Hydrated Compounds**

Some chemicals come with water molecules attached. For example, you can buy sodium phosphate as NaH₂PO₄•H₂O (sodium phosphate monobasic). The practical consequence of this is that for every mole of sodium phosphate you add to your solution, you are also adding a mole of water.

You can also buy sodium phosphate with 12 waters attached: Na₃PO₄•12H₂O (sodium phosphate tribasic). For every mole of sodium phosphate you add, you are adding 12 moles of water.

One mole of water has a mass of 18.015 grams, and it has a volume of 18.015 mL. Twelve moles of water make up a volume of 216.18 mL. This can wreak havoc with your final concentrations.

The easy way to deal with this potential problem is to use the following method when working with hydrated compounds.
HYDRATED SHORTCUT 1

- Use a graduated cylinder as your mixing vessel.
- Fill the cylinder with about half the final volume of water.
- Add the desired molar amounts of your compounds.
- Bring the solution up to the final volume.

With this method, the volume of any water you added as part of the hydrated compound is automatically taken into account. When you bring the solution up to the final volume, you will be adding just the right volume.

The other way to deal with the problem is to calculate exactly what volume of water you will be adding when you add the hydrated compounds, and subtract that from the final volume of water to add.

- To calculate the added volume of water, first determine the number of moles of the compound times the number of molecules of H\(_2\)O in the compound. That is the number of moles of H\(_2\)O you will be adding.

- The number of moles you are adding, times 18.015, will tell you the number of mLs of water you are adding.

**EXAMPLE:** I wish to make up 500 mLs of a 200mM solution of MgCl\(_2\) using MgCl\(_2\)•6H\(_2\)O.

From the Recipe Shortcut, I know that I need the following:

\[
\text{Molarity} \times \text{Molecular weight} \times \text{Final volume [L]} = \text{Grams to add.}
\]

The Molecular weight (listed on the jar as F.W.) is 203.3, which is the molecular weight of MgCl\(_2\) (95.2) plus the molecular weight of 6H\(_2\)O (108.1).

Using the Recipe Shortcut,

\[
200 \times 10^{-3} \text{ mol/L} \times 203.3 \times 500 \times 10^{-3} \text{ L} = 20.33 \text{ grams to add}
\]

How much H\(_2\)O will that add?

\[
20.33 \text{ grams of MgCl}_2\cdot6\text{H}_2\text{O} \div \text{MW} = 0.1000 \text{ moles of compound being added}
\]
Each molecule of the compound has six molecules of H$_2$O; each mole of compound has six moles of H$_2$O.

0.1000 moles × 6 = 0.6000 moles of H$_2$O

0.6000 moles × 18.02 g/mol = 10.81 g

10.81 g × 1mL/g = 10.81 mL of water.

subtracting from the total,

500.0 mL − 10.81 mL = 489.2 mL of water

The recipe is:

489.2 mLs of H$_2$O plus 20.33g of MgCl$_2$•6H$_2$O

The abbreviated version of all the above calculations is as follows:

Molarity [M] × final volume [L] × number of H$_2$O’s per molecule × 18.015 mL/mol = mLs of water contributed by hydrated compound

We can express this relationship as the Hydrated Shortcut 2.

**HYDRATED SHORTCUT 2**

\[
M \left[ \frac{\text{mol}}{L} \right] \times \text{Vol}[L] \times \# \text{H}_2\text{O’s} \times 18.015 \frac{\text{mL}}{\text{mol}} = \text{mL H}_2\text{O from Compound}
\]

The easy way, however, is to add the compounds, then bring the solution up to the final volume.

**SOLUTIONS 4.3: Diluting Stocks to Particular Concentrations**

If you know what you want the concentration to be and you want to figure out how much of your stock to add, you can use the following equation:

\[
\frac{\text{What you want}}{\text{What you have}} \times \text{Final volume} = \text{Volume to add to mixture}
\]
You may recognize this as a version of $M_1V_1 = M_2V_2$

You use that formula to calculate everything but the water, then add enough water to bring the volume up to the desired volume.

Note: The units of what you want (the numerator) must be the same as the units of what you have, (the denominator).

**FOR EXAMPLE:**

I want 25 mL of the following solution: I have the following stock solutions:

- 0.50 M CaCl$_2$
- 1.0 M MgSO$_4$
- 5.0 M CaCl$_2$
- 2.5 M MgSO$_4$

**Step one:** Figure out how much of the CaCl$_2$ stock to add:

$$\frac{0.5M}{5.0M} \times 25\text{mL} = 2.5 \text{ mL of CaCl}_2 \text{ stock}$$

**Step two:** Figure out how much of the MgSO$_4$ stock to add:

$$\frac{1.0M}{2.5M} \times 25\text{mL} = 10 \text{ mL of MgSO}_4 \text{ stock}$$

**Step three:** Bring the solution up to 25 mL:

$$25\text{mL} - (2.5 \text{ mL} + 10 \text{ mL}) = 12.5 \text{ mL of water to add}$$

**Step four:** Check your result.

For CaCl$_2$:

$$2.5\text{mL of 5.0} \frac{\text{mol}}{10^3 \text{mL}} \text{ put into 25 mL total volume}$$
And, for MgSO\textsubscript{4}:

\[
\frac{10\text{mL} \times 2.5 \text{ mol}}{10^3 \text{mL}} = 1.0 \times 10^{-3} \text{ mol mL} \times \frac{10^3 \text{mL}}{\text{L}} = 1.0 \text{ M}
\]

Note: This is just a rearrangement of the dilution equation:

\[
\text{That is, } \frac{\text{volume to add} \times \text{have}}{\text{final volume}} = \text{want}, \text{ is a rearrangement of}
\]

\[
\frac{\text{want}}{\text{have}} \times \text{final volume} = \text{volume to add}
\]

---

**DILUTION SHORTCUT**

\[
\frac{\text{what you Want}}{\text{what you Have}} \times \text{Final Volume} = \text{Amount to add or, } \frac{\text{W}}{\text{H}} \times \text{FV} = \text{A}
\]

---

**SOLUTIONS 4.4: Calculating Concentrations from Recipes**

Use the following words-to-symbols translation hints when calculating concentrations and dilutions:

1. “...of...” means multiply.
2. “Put ... into...” means divide by.

In other words, “a of j” means \(a \times j\) and “put q into s” means \(q \div s\). Note also that whatever the actual order of the events, you should rephrase a “put... into ...” phrase so that you are putting the solid into the liquid.
The trick to figuring out dilutions is to say, in words, what you have done. Then translate the words into algebraic expressions using the above words-to-symbols translation hints.

**EXAMPLE:** What is the concentration (in mg/mL) of enzyme in a given test tube?

**Step one:** Describe what happened.

I bought a bottle of enzyme. There was 1 mg of enzyme in the bottle. I added 1 mL of solvent to the bottle. Then, I took 100 µL of that solution and added it to a test tube that had 9.9 mL of solvent in it.

**Step two:** Draw a picture.

**Step three:** Translate each sentence (the following assumes two significant digits).

Words: I bought a bottle of enzyme. There was 1.0 mg of enzyme in the bottle. I added 1.0 mL of solvent to the bottle.

Translation: I put 1.0 mg of enzyme into 1.0 mL (i.e., $1 \times 10^{-3}$ L) of solvent.

Expression:
\[
\frac{1.0 \text{ mg of enzyme}}{1.0 \text{ mL of solvent}} = \frac{1.0 \text{ mg}}{10^{-3} \text{ L}}.
\]

Words: Then, I took 100 \(\mu\text{L} \, (1 \times 10^{-4}\text{L})\) of that solution.

Translation: I took \(1.0 \times 10^{-4} \mu\text{L}\) of that solution.

Expression:

\[
1.0 \times 10^{-4} \text{L} \times \frac{1 \text{mg}}{10^{-3} \text{L}} = 1.0 \times 10^{-1} \text{mg of enzyme} = 1.0 \times 10^2 \mu\text{g enzyme}
\]

Words: ... and added it to a test tube that had 9.9 mL of solvent in it.

Translation: I put \(1.0 \times 10^2 \mu\text{g of enzyme into 1.0} \times 10^1 \text{ mL total volume.}

Expression:

\[
\text{converting} \quad \frac{1.0 \times 10^2 \mu\text{g enzyme}}{1.0 \times 10^4 \mu\text{L solution}} \quad \text{to} \quad \frac{\text{mg}}{\text{mL}}:
\]

\[
\frac{1.0 \times 10^2 \mu\text{g}}{1.0 \times 10^4 \mu\text{L}} \times \frac{10^3 \mu\text{L}}{\text{mL}} \times \frac{1 \text{mg}}{10^3 \mu\text{g}} = \frac{1.0 \times 10^2 \text{mg enzyme}}{1.0 \times 10^4 \text{mL solution}}
\]

which simplifies to:

\[
\frac{1.0 \times 10^2 \text{mg enzyme}}{1 \text{ mL solution}}
\]

**Step four:** Thus, the answer is \(1.0 \times 10^{-2} \text{mg/mL.}\)

From these steps we can write a shortcut that describes how to calculate concentrations from recipes.
RECIPE TO CONCENTRATION SHORTCUT

1. Draw a picture.
2. Describe the picture.
3. Translate each sentence. “Of” means multiply; “Put ... into” means divide by.
4. Calculate.

SOLUTIONS 4.5: Converting Mass Per Volume to Molarity

To convert from mass per volume to moles per liter (molarity), you need to know the relationship between the units. Use the trick for converting between units developed in Topic 1.

EXAMPLE: Convert mg/mL to M.

Set up a units-only equation.

$$\frac{\text{mg}}{\text{mL}} \times \frac{\text{mg}}{\text{L}} \times \frac{\text{mol}}{\text{g}} = \frac{\text{mol}}{\text{L}}$$

You know the relationship between mL and L: $10^3\text{mL} = 1\text{ L}$

Is there a relationship between mg and mol? Yes. Molecular weight $\frac{\text{g}}{\text{mol}}$.

Let’s say the last example concerned an enzyme of molecular weight, $8.98 \times 10^4 \frac{\text{g}}{\text{mol}}$; the conversion looks like this:

$$1.0 \times 10^{-2} \frac{\text{mg}}{\text{mL}} \times \frac{1\text{mol}}{8.98 \times 10^4 \text{g}} \times \frac{1\text{g}}{10^3 \text{mg}} \times \frac{10^3\text{mL}}{\text{L}} = 1.1 \times 10^{-7} \frac{\text{mol}}{\text{L}}$$

Thus, for this enzyme $1.0 \times 10^{-2} \text{mg/mL}$ is $1.1 \times 10^{-7}$ M.

The general equation looks like this:

$$\frac{\text{mg}}{\text{mL}} \times \frac{\text{mol}}{\text{g}} \times \frac{1\text{g}}{10^3 \text{mg}} \times \frac{10^3\text{mL}}{\text{L}} = \frac{\text{mol}}{\text{L}}$$
Now, look at the general equation above. The final two fractions on the LHS multiply to 1, so they have no effect on the magnitude of the number. Thus, as long as you have set up your equations with the correct units, the general equation can be simplified and written as a shortcut.

**MASS PER VOLUME TO MOLARITY SHORTCUT**

\[
\frac{\text{mg}}{\text{mL}} \div \text{MW} = M
\]

(Here M.W. stands for molecular weight.) In fact, as long as the prefix is the same on both the mass and the volume, you can use this trick, because you will always be multiplying by 1 when you do the conversion.

But, don’t forget: If the prefixes are not the same, you cannot use the above shortcut; you must start at the beginning.

**SOLUTIONS 4.6: Percents**

Percent means “out of 100”; it is not a unit. Percents are dimensionless numbers. 37% of \( x \) means 37 hundredths of \( x \) or \( 0.37 \times x \).

The amount of an ingredient in a solution is sometimes described as a percent of the total solution. A percent can be thought of as the amount of one quantity per another. If the same units appear in the numerator and denominator, percents mean what you’d expect:

\[
\frac{5\text{L}}{20\text{L}} = 25\%
\]

100% = 1g/1g

1% = 10 mL/L
Percent mass per volume is based on a convention and it works as follows:

**MASS PER VOLUME**

- 100% means 1 g/mL
- 10% means 100 mg/mL
- 1% means 10 mg/mL

This convention is based on the mass/volume of pure water: one mL of water has a mass of 1 gram, hence 1 g/mL = 100%.

**SOLUTIONS 4.7: Dilution Ratios**

Recipes for solutions sometimes contain directions for diluting a stock solution according to a certain ratio. To read these directions, you need to know the following: A dilution in the ratio 1:x means add 1 volume of concentrate to (x – 1) volumes of diluent to create a total volume equal to x. It makes sense: In the final solution, what you added will be 1/xth of the total.

- 1:100 means one part concentrate, 99 parts diluent
- 1:14 means one part concentrate, 13 parts diluent
- 1:2 means one part concentrate, 1 part diluent
- 1:1 means straight concentrate

*Note:* This is the original convention; however, it is not always followed. If you see 1:9, chances are the author means 1:10, and if you see 1:1, chances are the author means 1:2. You have to use your judgment in interpreting such ratios. Because of this confusion, it is always better to report concentrations rather than recipes.

**DILUTION DEFINITION**

1:x means 1 part concentrate in (x – 1) parts diluent
SOLUTIONS – TRY IT OUT

EXERCISE I

Note: as you work through this exercise, you will be practicing progressively more of the technique, so it is important to work through the entire exercise.

You are preparing to use an antibody against the protein E-cadherin to find out where it is located in a cell. You do not know what concentration will be just enough but not too much, so you are going to prepare five solutions of different concentrations. Five mL of the antibody already in solution arrives from the company. The antibody is at a concentration of 1 mg/mL. What is the concentration of the following solutions?

A. Solution A is 10.0 µL of antibody plus 90.0 µL of solvent buffer. What is the concentration in mg/mL of antibody in solution A?

1. Draw a picture.

2. Describe the picture.

   Put 10.0 µL of 1.00 mg/mL into 100 µL total.

3. Translate.

   \[
   \left(10.0 \, \mu\text{L} \times 1.00 \, \frac{\text{mg}}{\text{mL}}\right) \div 100 \, \mu\text{L}
   \]
Math for Life

4. Calculate mg/mL.
5. What information would you need to calculate the molarity of this solution?

B. Solution B is 10.0 µL of solution A plus 90.0 µL of solvent buffer. What is the concentration in mg/mL of antibody in solution B?

1. Draw a picture.
2. Describe the picture.

\[ \text{Put 10.0 µL of } 1.00 \times 10^{-1} \text{ mg/mL into 100 µL total.} \]

3. Translate.
4. Calculate mg/mL.

C. Solution C is 20.0 µL of solution B plus 80.0 µL of solvent buffer. What is the concentration in mg/mL of antibody in solution C?

1. Draw a picture.
2. Describe the picture.
3. Translate.
4. Calculate mg/mL.
D. Solution D is 50.0 µL of solution C plus 275 µL of solvent buffer. What is the concentration in mg/mL of antibody in solution D?

1. Draw a picture.

2. Describe the picture.

3. Translate.

4. Calculate mg/mL.

E. Solution E should be 100 µL of antibody solution at a concentration of $1.50 \times 10^{-3}$ mg/mL. How would you make solution E using solution B and solvent?

1. Draw a picture.

2. Describe the picture.

3. Calculate the amount of solution B to add.

4. Calculate the amount of solvent to add.

**EXERCISE II**

The following is a recipe for agar:

- 3.00g NaCl (F.W. 58.44 g/mol)
- 17.0g agar
- 2.50 g peptone
- 5.00 mg cholesterol (F.W. 386.7 g/mol)

Bring to a final volume of $1.00 \times 10^3$ mL

A. What is the concentration of NaCl (in mg/mL)?  

B. What is the concentration of NaCl (in mM)?

C. What is the molarity of cholesterol in this solution?
D. How much water would you add to 1.00 mL of this solution to make the molarity of cholesterol 6.45 µM?

EXERCISE III

The result of a Formosan Banded Krait *Bungarus multicinctus* bite is paralysis caused by a toxin known as α–bungarotoxin. α–bungarotoxin can be purchased in lots of 1.00 mg of crystalline venom. You wish to observe the effect of this toxin on cultured muscle cells at a concentration of $1.24 \times 10^{-5}$ M.

A. Create a 1.00 mM stock solution of toxin, then make further dilutions of the stock to make a test solution of the appropriate concentration. Assume this protein has a molecular weight of 6421. All of your numbers should have three significant digits.

1. Draw a picture.

2. Calculate how much solvent to add to make the stock solution.

3. Calculate the amounts of stock and solvent to mix to make $1.00 \times 10^1$ mL of $1.24 \times 10^{-5}$M solution; call this solution A.

   Amount of stock =

   Amount of solvent =

B. Solution A killed all your cultured cells, so you decide to dilute it. You add 3.00 mL of solvent to 1.00 mL of solution A. What is the molarity of this new dilution, solution B?

1. Draw a picture.

2. Describe the picture.

3. Translate.
4. Calculate molarity.

5. Convert to mg/mL.

6. Shortcut: You are diluting solution A 1:4; therefore, the final molarity of solution B will be 1/4 the molarity of the solution A. Recalculate the molarity this way.

7. How many mL of solution B do you have?

C. Using solution B, calculate how much solution and solvent to mix to make 25.0 mL of a solution C that is $6.20 \times 10^{-7}$ M.

1. What volume do you have and what volume do you want?

2. Calculate the volume of solution to add.

3. Calculate the volume of solvent to add.

4. Do you have enough of solution B to make this final dilution?

5. What is the maximum amount of $6.20 \times 10^{-7}$ M solution that you could make from the solution B you already have?

6. What is the maximum amount of $6.20 \times 10^{-7}$ M solution that you could make if you used the entire amount of venom that you purchased?

7. What reminder can be drawn from this exercise?
LINKS TO ANSWERS

EXERCISE I – The antibody solutions

A.
B.
C.
D.
E.

EXERCISE II

EXERCISE III – The Formosan Banded Krait toxin

A.
B.
C.
TRY IT OUT: SOLUTIONS

I.A. Solution A is 10.0 µL of antibody plus 90.0 µL of solvent buffer.

4. Calculate mg/mL.

\[ 1.00 \times 10^{-1} \, \text{mg/mL} \]

5. What information would you need to calculate the molarity of this solution?
TRY IT OUT: SOLUTIONS

I.B. Solution B is 10.0 µL of solution A plus 90.0 µL of solvent buffer.

3. Translate.

\[
\frac{(10.0 \mu\text{L})(1.00 \times 10^{-1} \frac{\text{mg}}{\text{mL}})}{100\mu\text{L}}
\]

4. Calculate mg/mL.

\[
1.00 \times 10^{-2} \frac{\text{mg}}{\text{mL}}
\]
TRY IT OUT: SOLUTIONS

I.C. Solution C is 20.0 µL of solution B plus 80.0 µL of solvent buffer.

1. Draw a picture

   ![Diagram: Solution C](image)

   20.0 µL of 1.00 × 10⁻² mg/mL
   100 µL

2. Describe the picture.

   *Put* 20.0 µL of 1.00 × 10⁻² mg/mL *into* 100 µL total.

3. Translate.

   \[
   \frac{(20.0 \mu L)(1.00 \times 10^{-3} \text{ mg/mL})}{100 \mu L} = \text{mg/mL}
   \]

4. Calculate mg/mL.

   \[
   2.00 \times 10^{-3} \text{ mg/mL}
   \]
TRY IT OUT: SOLUTIONS

I.D. Solution D: 50.0 µL of solution C plus 275 µL of solvent buffer?

1. Draw a picture.

2. Describe the picture.

   *Put 50.0 µL of $2.00 \times 10^{-3}$ mg/mL into 325 µL total*

3. Translate.

   \[
   \frac{(50.0\mu L)(2.00 \times 10^{-3} \frac{mg}{mL})}{3.25 \times 10^2 \mu L}
   \]

4. Calculate mg/mL.

   *3.08 \times 10^{-4} \frac{mg}{mL}.*
TRY IT OUT: SOLUTIONS

I.E. Solution E should be 100µL of antibody solution at a concentration of $1.50 \times 10^{-3}$ mg/mL. How would you make Solution E using Solution B and solvent?

1. Draw a picture.

I want $1.50 \times 10^{-3}$ mg/mL.
I have $1.00 \times 10^{-2}$ mg/mL.
I want a final volume (FV) of 100 µL.

2. Describe the picture.

3. Calculate the amount of solution B to add.

$$\frac{W}{H} \times \text{FV} = A \quad \frac{1.50 \times 10^{-3} \text{mg}}{1.00 \times 10^{-2} \text{mg/mL}} \times 100 \mu\text{L} = 1.50 \times 10^1 \mu\text{L}$$

4. Calculate the amount of solvent to add.

$$100 \mu\text{L} - 1.50 \times 10^1 \mu\text{L} = 85 \mu\text{L} \quad \text{(see the section on adding and subtracting with significant digits)}$$
TRY IT OUT: SOLUTIONS

II. The agar recipe

A. What is the concentration of NaCl in mg/mL?

\[
3.00 \text{g} \times \frac{10^3 \text{mg}}{\text{g}} \times \frac{1.00 \times 10^2 \text{mL}}{1.00 \times 10^3 \text{mL}} = 3.00 \frac{\text{mg}}{\text{mL}}.
\]

B. What is the concentration of NaCl in mM?

\[
3.00 \frac{\text{mg}}{\text{mL}} \times \frac{1\text{mol}}{58.44\text{g}} \times \frac{1\text{g}}{10^3 \text{mg}} \times \frac{10^3 \text{mL}}{1\text{L}} \times \frac{10^3 \text{mmol}}{1\text{mol}} = 5.13 \times 10^1 \text{mM}
\]

C. What is the molarity of cholesterol in this solution?

\[
5.00 \frac{\text{mg}}{\text{L}} \times \frac{1\text{mol}}{386.7\text{g}} \times \frac{1\text{g}}{10^3 \text{mg}} = 1.29 \times 10^{-3} \text{M}
\]

D. How much water would you add to 1.00 mL of this solution to make the molarity of cholesterol 6.45 µM?

\[
\left(\frac{\text{W}}{\text{H}} \times \text{FV} = \text{A}\right) \text{ then } \left(\frac{\text{A} \times \text{H}}{\text{W}} = \text{FV}\right) \text{ and } (\text{FV} - \text{A} = \text{water to add})
\]

\[
1.00 \text{mL} \times 1.29 \times 10^{-5} \text{M} = 2.00 \text{mL}; \ 2.00 \text{mL} - 1.00 \text{mL} = 1.00 \text{mL}
\]
III. The Formosan Banded Krait

A. 1. Draw a picture.

2. Calculate how much solvent to add to make the stock solution.

\[
\frac{1.00 \text{ mg}}{? \text{ L}} = 10^{-3} \text{ M} \quad \text{rearranges to} \quad \frac{1.00 \text{ mg}}{10^{-3} \text{ M}} = ? \text{ L}
\]

\[
\frac{1.00 \text{ mg}}{10^{-3} \text{ mol}} \times \frac{1 \text{ mol}}{6421 \text{ g}} \times \frac{1 \text{ g}}{10^3 \text{ mg}} = 1.56 \times 10^{-4} \text{ L}
\]

3. Calculate the amounts of stock and solvent to mix to make 1.00 × 10^1 mL of 1.24 × 10^{-5} M solution (Solution A).

\[
\frac{W}{H} \times \text{FV} = A \\
\frac{1.24 \times 10^{-5} \text{ M}}{1.00 \times 10^{-3} \text{ M}} \times 1.00 \times 10^1 \text{ mL} = 1.24 \times 10^{-1} \text{ mL}
\]

Amount of stock = 1.24 × 10^{-1} mL

Amount of solvent = 10.0 mL – 1.24 × 10^{-1} mL = 9.9 mL
TRY IT OUT: SOLUTIONS

III.B. Venom dilution (A → B)

B.

1. Draw a picture

2. Describe the picture.

*Put 1.00 mL of $1.24 \times 10^{-5}$ M into 4.00 mL total.*

3. Translate.

$$\frac{1.00\text{mL} \times 1.24 \times 10^{-5}\text{M}}{4.00\text{mL}}$$

4. Calculate molarity.

$3.10 \times 10^{-6}\text{M}$

5. Convert to mg/mL.

$$3.10 \times 10^{-6}\text{mol} \frac{\text{mol}}{\text{L}} \times \frac{10^{-3}\text{L}}{\text{mL}} \times \frac{6421\text{g}}{\text{mol}} \times \frac{10^{3}\text{mg}}{\text{g}} = 1.99 \times 10^{-2}\text{mg} \frac{\text{mg}}{\text{mL}}.$$
6. Shortcut: You are diluting solution A 1:4; therefore, the molarity of solution B will be 1/4 the molarity of solution A. Recalculate the molarity this way.

\[
\frac{1.24 \times 10^{-5} \text{M}}{4} = 3.10 \times 10^{-6} \text{M}
\]

7. How many mL of solution B do you have?

1.00 mL + 3.00 mL = 4.00 mL
TRY IT OUT: SOLUTIONS

III.C. Using solution B, calculate how much solution and solvent to mix to make 25.0 mL of a solution C that is $6.20 \times 10^{-7}$ M.

C.

1. What do you have and what do you want?

   I want $6.20 \times 10^{-7}$ M.
   I have $3.10 \times 10^{-6}$ M.
   I want a final volume of 25.0 mL.

2. Calculate the volume of solution to add.

   \[
   \frac{6.20 \times 10^{-7} \text{M}}{3.10 \times 10^{-6} \text{M}} \times 25.0 \text{mL} = 5.00 \text{mL}
   \]

3. Calculate the volume of solvent to add.

   \[25.0 \text{ mL} - 5.00 \text{ mL} = 20.0 \text{ mL}\]

4. Do you have enough of solution B to make this final dilution?

   No.

5. What is the maximum amount of $6.20 \times 10^{-7}$ M solution that you could make from the solution B you already have?

   \[
   \frac{A \times H}{W} = FV \quad \text{or, alternatively:} \quad \frac{4.00 \text{mL} \times 3.10 \times 10^{-6} \text{M}}{6.20 \times 10^{-7} \text{M}} = 20.0 \text{mL}
   \]

6. What is the maximum amount of $6.20 \times 10^{-7}$ M solution that you could make if you used the entire amount of venom that you purchased?
7. What reminder can you draw from this exercise?

Do all the calculations before you begin to mix reagents.

\[
\frac{1 \text{mg}}{6.20 \times 10^{-7} \text{mol L}^{-1}} \times \frac{10^{-3} \text{g}}{\text{mg}} \times \frac{1 \text{mol}}{6421 \text{g}} = 2.51 \times 10^2 \text{mL}
\]