LEARNING OBJECTIVES
After completing this chapter, the student will be able to:

1. Explain why some parenteral medications are available in powder form
2. List two sources where a technician could find how much diluent is needed for reconstituting a parenteral drug
3. Calculate powder volume
4. Calculate the concentration of drug for reconstituted medications
5. Calculate the volume of reconstituted medications needed to deliver a specific dose of medication

Some parenteral products have limited stability when in solution, such as antibiotics. These drugs are supplied by manufacturers in powder form. When a powdered drug is to be administered to a patient or added to an infusion bag, it is reconstituted with a recommended diluent, usually sterile water for injection. The antibiotic manufacturer’s package insert includes other examples of recommended diluents.

The package insert, and sometimes the vial label, tell how much diluent to add for reconstitution. The label on the vial also indicates the amount of powdered drug contained in the vial.

The volume or space that the powdered drug occupies after it is reconstituted is called powder volume and is expressed in milliliters. For some drugs, the powder volume is so small that it is negligible. Other drugs have a substantial powder volume, which is always taken into consideration when reconstituting. For example, penicillin has substantial powder volume.

If the entire amount of powdered drug after reconstitution is to be used, then powder volume is not critical. However, if a partial dose is to be used, then powder volume is critical and must be calculated so that the final volume and the concentration are accurate.

<table>
<thead>
<tr>
<th>Vial Size</th>
<th>Diluent Added</th>
<th>Final Volume</th>
<th>Powder Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 125 mg</td>
<td>1 ml</td>
<td>1 ml</td>
<td>None (1 ml − 1 ml)</td>
</tr>
<tr>
<td>2. 250 mg</td>
<td>0.9 ml</td>
<td>1 ml</td>
<td>0.1 ml (1 ml − 0.9 ml)</td>
</tr>
<tr>
<td>3. 500 mg</td>
<td>1.8 ml</td>
<td>2 ml</td>
<td>0.2 ml (2 ml − 1.8 ml)</td>
</tr>
<tr>
<td>4. 1 g</td>
<td>3.4 ml</td>
<td>4 ml</td>
<td>0.6 ml (4 ml − 3.4 ml)</td>
</tr>
<tr>
<td>5. 2 g</td>
<td>6.8 ml</td>
<td>8 ml</td>
<td>1.2 ml (8 ml − 6.8 ml)</td>
</tr>
</tbody>
</table>

KEY TERMS

Powdered drug preparations: drugs that have limited stability in solution and are reconstituted at the time of use from a powder form

Powder volume: the space occupied by the powder in a powdered drug preparation

Reconstitution: adding a specified amount of diluent to a powdered drug preparation before administration
EXAMPLE
The powder volume equals final volume minus the diluent added.

Increasing volumes of diluent are added to increasing vial sizes to ensure that sufficient diluent is added for dissolution. Concentrations are expressed as weight per one milliliter—for example, mg/ml, units/ml, g/ml.

EXAMPLE
What is the concentration of drug in mg/ml for each of the strengths of drug in the chart on the previous page?

Calculate the concentration by dividing the weight of the drug in the vial by the final volume, and then reducing to milligrams in one milliliter.

1. \[
\frac{125 \text{ mg}}{1 \text{ ml}} \rightarrow 125 \text{ mg/ml}
\]

2. \[
\frac{250 \text{ mg}}{1 \text{ ml}} \rightarrow 250 \text{ mg/ml}
\]

3. \[
\frac{500 \text{ mg}}{2 \text{ ml}} \rightarrow \frac{500 \text{ mg/2 ml}}{2} \rightarrow \frac{250 \text{ mg/ml}}{2}
\]

4. \[
1 \text{ g} = 1,000 \text{ mg} \rightarrow \frac{1,000 \text{ mg}}{4 \text{ ml}} \rightarrow \frac{1,000 \text{ mg/4 ml}}{4} \rightarrow 250 \text{ mg/ml}
\]

5. \[
2 \text{ g} = 2,000 \text{ mg} \rightarrow \frac{2,000 \text{ mg}}{8 \text{ ml}} \rightarrow \frac{2,000 \text{ mg/8 ml}}{8} \rightarrow 250 \text{ mg/ml}
\]

EXAMPLE
You add 18 ml of sterile water for injection to a vial containing 500 mg of a drug that has a powder volume of 2 ml. What is the concentration of the drug in the solution?

First, find the final volume obtained after reconstitution.

\[
\begin{align*}
\text{Volume of diluent} & = 18 \text{ ml} \\
\text{Powder volume} & = 2 \text{ ml} \\
\text{Final volume} & = 20 \text{ ml}
\end{align*}
\]

The amount of drug in the vial = 500 mg

Calculate the concentration = \[
\frac{\text{amount of drug in vial}}{\text{Final volume}}\]

and reduce to mg/ml

\[
\begin{align*}
\frac{500 \text{ mg}}{20 \text{ ml}} \rightarrow \frac{500 \text{ mg/20 ml}}{20} \rightarrow 25 \text{ mg/ml} & \quad \text{answer}
\end{align*}
\]
EXAMPLE
If 17 ml of sterile water for injection is added to 2 g of drug and the concentration obtained is 100 mg/ml, what is the powder volume of the drug?

Set up a ratio and proportion to calculate the ml of final solution. Remember all units of measurement must be the same. 2 g = 2,000 mg

\[
\frac{100 \text{ mg}}{1 \text{ ml}} = \frac{2,000 \text{ mg}}{X} \rightarrow \frac{X \times 400 \text{ mg}}{400 \text{ mg}} = \frac{1 \text{ ml} \times 2,000 \text{ mg}}{100 \text{ mg}} \rightarrow X = 20 \text{ ml}
\]

The final volume = 20 ml (calculated)
Diluent added = 17 ml (given)
Powder volume = Final volume - diluent added
= 20 ml - 17 ml = 3 ml answer

EXAMPLE
A physician orders a 750 mg dose of a medication in an IVPB. The drug is available as 15 g powder for reconstitution. The instructions state to add 26 ml of sterile water for injection to the powder to get a concentration of 500 mg/ml.

1. What is the powder volume of the drug?

There are 15 g available. Convert this to milligrams by multiplying by 1,000.

\[
15 \times 1,000 \rightarrow 15,000 \text{ mg}
\]

Set up a ratio and proportion to find the number of milliliters to give 500 mg/ml.

\[
\frac{500 \text{ mg}}{1 \text{ ml}} = \frac{15,000 \text{ mg}}{X} \rightarrow X \times 500 \text{ mg} = 1 \text{ ml} \times 15,000 \text{ mg}
\]

Divide both sides by 500 mg, and cancel out the mg.

\[
X \times \frac{500 \text{ mg}}{500 \text{ mg}} = \frac{1 \text{ ml} \times 15,000 \text{ mg}}{500 \text{ mg}} \rightarrow X = 30 \text{ ml}
\]

The instructions state to add 26 ml. The difference is the powder volume:

\[
30 \text{ ml} - 26 \text{ ml} = 4 \text{ ml answer}
\]

2. How many milliliters of the reconstituted solution are needed to fill the order?

Set up a ratio and proportion using 500 mg/ml as the concentration:

\[
\frac{500 \text{ mg}}{1 \text{ ml}} = \frac{750 \text{ mg}}{X} \rightarrow X \times 500 \text{ mg} = 1 \text{ ml} \times 750 \text{ mg}
\]

Divide both sides by 500 mg, and cancel out the mg.

\[
X \times \frac{500 \text{ mg}}{500 \text{ mg}} = \frac{1 \text{ ml} \times 750 \text{ mg}}{500 \text{ mg}} \rightarrow X = 1.5 \text{ ml answer}
\]
Examples of medications in powder form that require reconstitution before use

Examples of 5% dextrose injection in minibags

* Medications such as antibiotics are added to minibags which are then “piggybacked” onto a patient’s established IV.
1. If 95 ml of sterile water for injection is added to a 10 g bulk powdered drug pharmacy container, the concentration obtained is 100 mg/ml. What is the powder volume of the drug?

2. Using another 10 g vial of the drug in question 1, you want a concentration of 200 mg/ml. How many ml of sterile water for injection should be added? (Use the powder volume calculated in question 1.)

3. The package directions for streptomycin instruct you to add 4.2 ml of sterile water for injection to 1 g of dry powder to give a concentration of 200 mg/ml. What is the powder volume of the streptomycin?

4. You have a vial of penicillin G potassium containing 20 million units. The directions are to add 32 ml of sterile water for injection to reconstitute to a concentration of 500,000 units/ml. What is the powder volume of the penicillin?

5. The directions for a vial containing 500 mg of powdered Rocephin state that the addition of 1.8 ml of sterile water for injection will yield a solution containing 250 mg/ml. What is the powder volume of the drug?

6. If you add 8 ml of sterile water for injection to a vial of 5 MU penicillin that has a powder volume of 2 ml, what is the concentration of the drug in solution?
7. You add 10 ml of sterile water for injection to 1 g of a drug that has a powder volume of 0.8 ml. What is the concentration of the drug in mg/ml in the final solution?

8. If you add 27 ml of diluent to a vial containing 2.5 g of drug that has a powder volume of 3 ml, what will be the concentration of the drug after reconstitution?

9. To prepare 3 g of Unasyn, the package insert states to add 6.4 ml of diluent. The concentration obtained is 375 mg/ml. What is the powder volume of the Unasyn?

10. The directions for reconstitution for a 2 g vial of Cloroxan state to add 10 ml of sterile water for injection to obtain a concentration of 180 mg/ml. What is the final volume obtained after reconstitution?

11. 10 ml of sterile water for injection is added to a 1 g vial of Mefoxin, giving a 10.5 ml final volume. What is the concentration of the reconstituted powdered Mefoxin?

12. A 6 g pharmacy bulk package of Fortaz is reconstituted with 26 ml of sterile water for injection. What will be the final concentration of the drug if the powder volume of the Fortaz is 4 ml?

13. You add 23 ml of sterile water for injection to a 3 g vial of antibiotic that has a powder volume of 3 ml. What is the concentration, in mg/ml, of the reconstituted drug?
14. A 20 g vial of a powdered drug requires the addition of 36 ml of sterile water for injection to give a concentration of 500 mg/ml. What is the powder volume of the drug?

15. Using another 20 g vial of the drug in question 14, you need a concentration of 400 mg/ml. How many ml of sterile water for injection do you need to add to the vial?

16. After adding 20 ml of sterile water for injection to a 4 g vial of powdered drug, the concentration is 325 mg/2 ml. What is the powder volume of the drug?

17. A 1.5 g vial of antibiotic has a powder volume of 1.4 ml. You need a concentration of 125 mg/ml. How many ml of sterile water for injection will you need to add to obtain this concentration?

18. Calculate the concentration, in mg/ml, after reconstitution with 19 ml of sterile water for injection, of a 2.75 g vial, if the drug has a powder volume of 2.2 ml.

19. A technician adds 64 ml of sterile water for injection to a pharmacy bulk bottle of 30 g of antibiotic powder. The antibiotic has a powder volume of 6 ml. Calculate the concentration, in mg/ml, obtained after reconstitution.

20. If you need a concentration of 250 mg/ml and you have on hand a 5 g vial of antibiotic with a powder volume of 1.6 ml, how many ml of sterile water for injection should you add?
21. A 2 g vial of a drug has a powder volume of 1.5 ml.
   a. How many ml of sterile water for injection will you add to obtain
      a concentration of 125 mg/ml?
   b. A patient dose is 325 mg. How many ml of the reconstituted solution will you use?

22. An 8 g vial of a powdered drug requires the addition of 9.8 ml of sterile water
    for injection to obtain a concentration of 800 mg/ml.
   a. What is the powder volume of the drug?
   b. If 2.6 ml of the reconstituted solution is added to a 500 ml bag of D5W,
      what dose (in g) will the patient receive?

23. A 40 g vial of an antibiotic has a powder volume of 5.2 ml. If 94.8 ml of sterile
    water for injection are added to the vial, what is the concentration (mg/ml) of the
    reconstituted solution?

24. A patient is ordered a 130 mg dose of a drug in 50 ml of D5W. A vial contains
    1 g of the powdered drug. The drug has a powder volume of 0.4 ml.
   a. How many ml of sterile water for injection are needed to obtain a
      concentration of 250 mg/ml?
   b. How many ml will be needed to fill the patient order?

25. A 2 g vial of a powdered drug is reconstituted with 100 ml of sterile water for
    injection. The drug has a powder volume of 2.3 ml. What is the concentration of
    the reconstituted solution?
26. 10 million units of a powdered antibiotic are contained in a vial. A concentration of 500,000 units per ml is obtained when sterile water for injection is added. The drug has a powder volume of 3.2 ml. How many ml of sterile water for injection should be added to the vial?

27. Using another vial of the antibiotic used in question 26, if 36.8 ml of sterile water for injection is added to the vial what is the concentration of the reconstituted solution?

28. A 1 g vial of Nafcillin is reconstituted with 3.4 ml of sterile water for injection. A concentration of 250 mg/ml Nafcillin is obtained.
   a. What is the powder volume of the Nafcillin?

   b. If a patient requires a 200 mg dose in 250 ml of D5W, how many ml of the reconstituted solution are needed?

29. A powdered drug is available in vials containing 35 mg of the drug. The reconstitution instructions indicate to add 6.2 ml of sterile water for injection to obtain a concentration of 5 mg/ml.
   a. What is the powder volume of the drug?

   b. How many ml of the reconstituted drug are needed for a 2.5 mg dose in 50 ml NS?

30. 1 ml of sterile water for injection is added to a 1.5 mg vial of a powdered drug with a powder volume of 0.2 ml. What is the concentration in mg/ml of the solution obtained?
31. A vial contains two different drugs. Medication A: 3.5 mg and medication B: 35 mg. The two drugs together have a powder volume of 0.5 ml. What is the concentration of each medication if 3 ml of sterile water for injection is added to the vial?

32. What is the powder volume of 40 g of a drug if after adding 89.6 ml of sterile water for injection the concentration obtained is 400 mg/ml?

33. A physician has ordered a loading dose of 600 mg in 50 ml of normal saline. The powder volume of the drug ordered is 0.9 ml.
   a. How many ml of sterile water for injection must be added to the 5 g vial of drug to obtain a concentration of 250 mg/ml?
   b. How many ml of the reconstituted solution are needed for the patient’s dose?

34. A 9 g vial of powdered medication is reconstituted with sterile water for injection to a concentration of 300 mg/ml. How many ml of SWFI should be added if the powder volume of the drug is 1.3 ml?

35. What is the concentration in g/ml of 35 g of a drug with a powder volume of 4 ml if 31 ml of sterile water for injection are added to the vial?
36. A patient requires 250 mcg of a medication in 50 ml of D5W. A 4 mg vial of the medication has a powder volume of 0.1 ml. 3.9 ml of sterile water for injection is added to the vial.
   a. What is the final concentration of the reconstituted solution?
   b. How many ml does the patient need?

37. A 1.5 g vial of Unasyn contains two drugs: 1 g ampicillin and 0.5 g of sulbactam. The powder volume of the Unasyn is 0.8 ml. The label instructions indicate that 3.2 ml of SWFI should be used to reconstitute the drug. What is the concentration of each of the drugs?

38. A drug concentration of 250 mg/ml is needed. The powdered drug is available in a 10 g vial with a powder volume of 2.4 ml. How many ml of sterile water for injection should be added to the vial to obtain the needed concentration?

39. A physician orders for a patient 8 MU of a drug in 100 ml of 0.9% sodium chloride solution. The drug is available as a 20 MU powder for reconstitution with sterile water for injection. The instructions are to add 32 ml of SWFI to obtain a concentration of 500,000 units/ml.
   a. What is the powder volume of the drug?
   b. How many ml of the reconstituted solution will the patient need?

40. If 7.2 ml of SWFI are added to 16 g of powdered medication with a powder volume of 0.8 ml, what is the final concentration in g/ml of the reconstituted solution?
41. A powdered drug is available in 50 mg vials. The label states to add 3.8 ml of water for injection to get a concentration of 12.5 mg/ml.
   a. What is the powder volume of the drug?

   b. The physician orders 18.75 mg. How many ml are needed for this dose?

42. If 0.9 ml of sterile water for injection is added to a vial containing 0.2 mg of medication with a powder volume of 0.1 ml, what is the final concentration in mcg/ml?

43. 3 ml of an antibiotic is added to a 50 ml IVPB. Then 5 g of the medication (powder volume = 0.7 ml) is reconstituted with 9.3 ml of sterile water for injection. How many g of the medication was added to the IVPB?

44. If 20 million units of penicillin have a powder volume of 8 ml, what is the final concentration for the following quantities of sterile water for injection used for reconstitution?

   a. 32 ml

   b. 42 ml

   c. 72 ml

   d. 92 ml