Campers who have reconstituted dried food and care-givers who have mixed powdered baby formula with water to prepare a bottle have applied the technique of reconstitution of dry products. Some medications are supplied in the form of powders or crystals to which a liquid must be added for reconstitution shortly before use.

The medications are supplied in dry form because the product can be stored for a long time in dry form but becomes unstable and deteriorates in solution within a relatively short time. Such solutions are said to have a “short shelf life.” The equipment used to reconstitute medications must be calibrated for the medicines being dispensed. The capacity of syringes, medicine droppers, and “medication teaspoons” is precise, while that of household equipment varies greatly from spoon to spoon and cup to cup.
**ESSENTIAL Vocabulary**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluent</td>
<td>Fluid that makes a mixture less concentrated or viscous. The fluid dilutes the mixture. It is also used to convert a dry form of a substance to a liquid form. For example, water is used to liquefy a dry form of baby formula. When reconstituting medications, read the directions to find out which diluent needs to be used. Water or normal saline (NS) solution is often used to dilute medicines and to liquefy dry, powdered forms of medicines.</td>
</tr>
<tr>
<td>Dilution</td>
<td>Extent to which the concentration of a mixture is reduced.</td>
</tr>
<tr>
<td>Dilution Ratio</td>
<td>Special ratio indicating the number of parts of an active ingredient to the number of parts of inactive ingredients in a solution. For example, a 1:4 dilution ratio means that, out of 5 total parts, 1 part is active and 4 parts are inactive. Adding 4 parts water to 1 part powdered milk would provide a dilution ratio of 1:4.</td>
</tr>
<tr>
<td>Displacement</td>
<td>Process that increases the volume of a fluid when a liquid is added to another liquid or a solid, such as a powder.</td>
</tr>
<tr>
<td>Reconstitution</td>
<td>Process of combining the dry form of a mixture with a fluid to achieve a usable state. Process of diluting a liquid concentrate to achieve a usable state.</td>
</tr>
<tr>
<td>Solution Concentration (Strength)</td>
<td>Amount of drug in a quantity of solution expressed as a ratio (e.g., 100 mg/100 mL or 1:1) or as a fraction or a percentage (e.g., $\frac{1}{2}$ strength, or 50% solution).</td>
</tr>
<tr>
<td>Suspension</td>
<td>Liquid in which fine particles are dispersed throughout a fluid, where they are supported by the buoyancy of shaking or stirring. If a suspension is left standing, the solid particles settle. Antibiotics are often supplied as oral suspensions.</td>
</tr>
<tr>
<td>SW</td>
<td>Sterile water.</td>
</tr>
<tr>
<td>Bacteriostatic SW</td>
<td>Sterile water with an antimicrobial agent, such as benzyl alcohol.</td>
</tr>
<tr>
<td>Unit</td>
<td>Standardized laboratory measure of the therapeutic strength, as opposed to the weight or volume, of a drug. Often used as a standard of measure for medications that are derived from plants and animals and that have components with variable strengths. Substances, such as hormones and penicillin, that are partially derived from animal and plant sources are easily broken down to an unstable state of diminished effectiveness. The term units is also used to describe metric units of measurement.</td>
</tr>
<tr>
<td>Unstable</td>
<td>Easily broken down to a state of diminished effectiveness. Breakdown can occur rapidly with reconstituted solutions. Foods, solutions, and certain medications that are unstable, such as reconstituted medications, have a short shelf life. They must be discarded if they are not used in a timely fashion.</td>
</tr>
</tbody>
</table>

**RAPID PRACTICE 7-1 Vocabulary Review**

Estimated completion time: 5 minutes  Answers on page 000

Directions: Circle the correct definition for the following.

1. The amount of drug in a quantity of solution expressed as a ratio is called
   1. An emulsion  
   2. The concentration  
   3. A suspension  
   4. A diluent

2. The solution used to reconstitute powders and crystals from a dry form of medicine to a liquid form is called
   1. An emulsion  
   2. An elixir  
   3. A suspension  
   4. A diluent
3 Solutions that deteriorate rapidly in liquid form are considered to have a short
shelf life and are described as:

1. Crystals
2. Unstable
3. Bacteriostatic
4. Diluents

4 The process of combining a liquid with a solid form of medication so that the
medication can be used is called

1. Reconstitution
2. Dilution
3. Calibration
4. Concentration

5 Accurate measurement of liquid medications requires which type of equipment?

1. Household teaspoons and tablespoons
2. Metric equipment with calibrations
3. Household droppers and cups
4. A syringe and needle

Reconstituted Medications

Some medicines are very unstable in liquid form. Therefore, they are supplied
in a dry form to which an inactive diluent is added just before use. The information
about the specific type and amount of diluent to be added to achieve specific con-
centrations is provided on the label. The nurse selects the amount of diluent that
will provide the concentration closest to the dose ordered.

Interpreting Orders and Reading Labels
for Reconstituted Medications

Examine the following order: Augmentin suspension 125 mg tid PO × 5 days.
The order includes the form, oral suspension, but does not mention that the drug re-
quires reconstitution or describe how to prepare it. The nurse must read the med-
ication label and insert to determine how to prepare the medication.

Reading Labels Directions on the label state the precise amount and type of liquid
diluent to add in order to achieve specific dilutions or concentrations of the drug per
milliliter. The directions always state conditions and time limits for storage after re-
constitution to liquid form. Some products must be discarded immediately, while oth-
ers may be refrigerated for several hours so that they can be used for additional doses.

There is a lot of information on the label, but most of it is self-explanatory once
you have read one or two types of labels. Examine the directions on the following
label for an oral suspension to be reconstituted:
The route is oral. This is important to note because there are injectable antibiotics and other drugs with similar names made specifically for intramuscular or intravenous routes.

The type of diluent is water. Most oral suspension diluents use tap water unless otherwise specified. Pediatric patients and immunocompromised patients may need SW.

The total amount of diluent to be added is 90 mL, added in two parts: 60 mL for the first mix and 30 mL for the second. If you have ever made pan gravy, the same principle applies: you do not add all the water at once because it is harder to get the lumps out.

After reconstitution, the drug concentration will be 125 mg/5 mL water. The total amount of medication will be 100 mL, although only 90 mL of water was added. This discrepancy is due to displacement of liquid by the powder. Both ingredients occupy space. Discard after 10 days.

Marking the Label for Reconstituted Injectables

The label is marked only under the following conditions:

1. The drug label states that the medication may be used more than once after reconstitution.
2. The patient is eligible to receive another dose before the drug must be discarded.

The label for reconstituted injectables is the same as for oral reconstituted medications. It must contain the patient’s name, the date and time of preparation, the diluent type and amount added, the concentration per milliliter after dilution, and the nurse’s initials or name, according to agency policy. Discard date and time are added according to agency policy.

Note the following example:

RECONSTITUTED AUGMENTIN SUSP BOTTLE
Patient: John B. Doe
01/05/06 1800: 140mL SW added; 200 mg/5mL, jm, RN
Discard date and time*:

*Check institutional policies for specific agency requirements, especially discard date requirements. Some agencies require that the nurse add the discard date and time for the prepared reconstituted drug to the label. Other agencies prefer that the expiration or discard date and time be redetermined from the reconstitution date and label directions by each nurse administering the medication.

Expired Reconstituted Drugs

Single-dose preparations cannot be stored. They must be discarded if they are not used by the expiration date and time. Only multidose preparations may be stored according to label directions and hospital policy.
RAPID PRACTICE 7-2  Interpreting Labels for Reconstituted Medications

Estimated completion time: 25 minutes  Answers on page 000

Directions: Read the labels for the medications to be reconstituted, and fill in the spaces with the required information for preparation and storage. Use brief phrases.

1. Form and route of medication: ______________________________________
2. Type of diluent to be used: _________________________________________
3. Amount of diluent to add to bottle: ________________________________
4. Mixing directions: ________________________________________________
5. Unit dose concentration after reconstitution: _______________________
6. Unit dose or multidose container: ________________________________
7. Total volume in container after reconstitution: ______________________
8. Number of unit doses in container after reconstitution: _______________
9. Storage location in dry form: ______________________________________
10. Storage location after reconstituted: ______________________________
11. Expiration, or discard, time after reconstitution: ____________________

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4. Mixing directions: ____________________________________________
5. Unit dose concentration after reconstitution: ____________________
6. Usual adult dose: ____________________________________________
7. Usual child dose: ____________________________________________
8. Unit dose or multidose container: ______________________________
9. Expiration, or discard time, after reconstitution: ________________

If a slash (/) is used on a drug label or in a drug order, be careful to avoid reading it as the number 1.

Compare and contrast the contents and directions in the label in problem 1 with those in the label in problem 2. It is easy to see why the labels must be scrutinized. The information on both labels is easy to follow but very different in content.

1. Form and route of medication: _________________________________
2. Type and amount of diluent to be used: ________________________
3. Total volume in container after reconstitution: _________________
4. Unit dose concentration after reconstitution: __________________
5. Storage directions: _________________________________________
6. Mixing directions after reconstitution: _________________________
7. Discard directions: _________________________________________

Note that the labels in problems 2 and 3 are for the same medication but contain different unit dose concentrations per 5 mL (1 medication teaspoon). Remember to use special calibrated medication teaspoons and/or droppers if those implements are needed. Use a syringe without a needle for measurement if the implements are not provided.
This label is included to illustrate medications that need to be reconstituted for routes other than oral and that offer multiple options for dilution. If the label permits several choices of dilution in order to obtain different unit dose strengths, the nurse must take special care to focus on the appropriate dilution. Several choices of dilution are more likely to be found with reconstituted parenteral drugs.

1. What are the amounts of diluent recommended for the 1 gram reconstituted intramuscular preparation and for the 1 gram intravenous preparation?

2. What will be the concentration of the 1 gram reconstituted intramuscular preparation and the 1 gram intravenous preparation?

If you require reading glasses, keep them handy for reading the reconstitution directions.

1. Trade name: ________________________________
2. Generic name: ______________________________
3. Form and route: ______________________________
4. Unit dose concentration after reconstitution: ______________________________
5. Lot number: ________________________________
6. Expiration date (in dry form): ______________________________

Many antibiotics come in both oral and injectable forms as noted on the labels.
Rapid Practice 7-3: Reconstituting, Calculating, and Measuring Doses

Estimated completion time: 30 minutes  Answers on page 000

Directions: Read the order and the label, estimate the dose, calculate the dose using a DA equation, and evaluate the answer.

1. Ordered: cefaclor for oral susp 0.3 g PO bid for a patient with sinusitis.

1. Amount and type of diluent to be added: ______________________________

2. Estimate: more than or less than unit dose after reconstitution? (Circle one.)

3. How many milliliters will you prepare? _________________________________

DA verification:

4. Evaluation: ________________________________________________________

5. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
Ordered: Augmentin oral susp 0.25 g q8h PO for a patient with otitis media.

1. Amount and type of diluent to be added: ______________________________

2. Estimate: more than or less than unit dose after reconstitution? (Circle one.)

3. How many milliliters will you prepare? ________________________________

DA verification:

4. Evaluation: ________________________________________________________

5. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
Ordered: amoxicillin oral susp 0.2 g PO q8h for a patient with an infection.

1. Amount and type of diluent to be added: ______________________________

2. Estimate: more than or less than unit dose after reconstitution? (Circle one.)

3. How many milliliters will you prepare? _________________________________

DA verification:

4. Evaluation: ________________________________________________________

5. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.

[Image of medicine cup and syringe]
Ordered: fluconazole oral susp 0.03 g PO daily for a patient with oral candidiasis.

1. Amount and type of diluent to be added: ______________________________

2. Estimate: more than or less than unit dose after reconstitution? (Circle one.)

3. How many milliliters will you prepare? _________________________________

DA verification:

4. Evaluation: ________________________________________________________

5. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
Ordered: penicillin V potassium for oral sol 75 mg PO tid for a patient with an infection.

1. Amount and type of diluent to be added: ______________________________
2. Estimate: more than or less than unit dose after reconstitution? (Circle one.)
3. How many milliliters will you prepare? _________________________________

DA verification:
4. Evaluation: ________________________________________________________
5. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.

Reconstituted Parenteral Drugs

- Parenteral medications must be sterile and have a much shorter shelf life than do drugs administered by other routes.

Diluents

Whereas tap water may be used for oral reconstituted medications, sterile diluents must be used for parenteral medications.
Sterile water *for injection* and sterile NS solution are the most commonly used diluents. Occasionally, custom diluents or dextrose solutions are required. Some labels permit either SW or NS. Other labels are specifically limited to one choice of diluent because of incompatibility. Incompatibility can result in crystallization and/or clumping of the drug in solution and can cause a problem in the tissue or circulation of the patient.

➤ Distinguish SW *for injection* from bacteriostatic water *for injection* on diluent directions. The latter contains a preservative. One cannot be substituted for the other. The label must be read and followed exactly. Some references use the abbreviation SW for *sterile water for injection* and NS for *sterile normal saline solution for injection*. Bacteriostatic water is spelled out in the dilution directions on the label.

**Selecting the Appropriate Unit Dose Concentration based on Dilution Directions When More Than One Dilution Is Offered**

If a 1:100 concentration of sugar water was needed for your hummingbird feeder and you had on hand a 1:30 solution, a 1:50 solution, and a 1:100 solution, you would select the more dilute 1:100 concentration for the feeder. Giving the more concentrated solutions would overdose the hummingbirds with sugar. Similarly, with medications the nurse prepares the strength that provides the dose needed and the most convenient volume for the route ordered.

In selecting the appropriate amount of diluent, the nurse considers the relevant factors in the following sequence when reading the label:

- Route ordered
- Dose ordered and amount needed
- Drug concentrations and volumes available that are close in amount to the ordered dose for that route

Based on the ordered amount, the nurse examines the label to make critical decisions. For example, consider an order of Drug X 200 mg IM. The label dilution directions state, for IM injection,

Add 1.8 mL SW for injection to obtain 200 mg/mL.
Add 3.6 mL SW for injection to obtain 100 mg/mL.
Add 5.2 mL SW for injection to obtain 75 mg/mL.

and for IV injection,

Add 8.4 mL SW for injection to obtain 50 mg/mL.

According to the label, three concentrations are safe to inject into the muscle. The nurse chooses a concentration based on the order. In this example, one intramuscular option allows the patient to receive the smaller injected volume of 200 mg/mL.

1 Which is the more concentrated solution after reconstitution according to the reconstitution directions cited above for Drug X?

2 Can I use SW, NS, and bacteriostatic water interchangeably to dilute medicines? (Refer to Essential Vocabulary.)
Reconstitution directions for Drug X for IM administration:

<table>
<thead>
<tr>
<th>Diluent SW</th>
<th>Total Volume</th>
<th>Solution Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mL</td>
<td>1.4 mL</td>
<td>480 mg/ mL</td>
</tr>
<tr>
<td>2 mL</td>
<td>3 mL</td>
<td>250 mg/ mL</td>
</tr>
<tr>
<td>4 mL</td>
<td>5.8 mL</td>
<td>100 mg/ mL</td>
</tr>
</tbody>
</table>

For IV administration:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>12 mL</td>
<td>15.8 mL</td>
<td>50 mg/ mL</td>
</tr>
</tbody>
</table>

- The more diluent added, the weaker the concentration of the solution.

- Keep in mind that the average-sized adult should receive no more than 3 mL in one intramuscular site and that the nurse should select a dilution that permits at least 0.5 mL of intramuscular injection.

Select the dilution from the list above that is closest to the unit dose you need and that meets the foregoing criteria. Calculate doses to the nearest tenth of a milliliter. Examine the routes first. Then compare the order to the concentrations to find a reasonable low-volume dose. Verify the answer with a DA equation where requested.

1. Ordered: Drug X 50 mg IM.
   1. How much diluent will you add? 5.8 mL
   2. What will be the unit dose concentration? 100 mg/ mL
   3. How many milliliters will you give? 0.5 mL

2. Ordered: Drug X 0.1g IM.
   1. How much diluent will you add? ______________________________
   2. What will be the unit dose concentration? ______________________________
   3. How many milliliters will you give? ______________________________

3. Ordered: Drug X 0.25 g IM.
   1. How much diluent will you add? ______________________________
   2. What will be the unit dose concentration? ______________________________
   3. How many milliliters will you give? ______________________________

4. Ordered: Drug X 0.3 g IM.
   1. How much diluent will you add? ______________________________
   2. What will be the unit dose concentration? ______________________________
   3. How many milliliters will you give? ______________________________
   DA equation:
   4. Evaluation: ______________________________________________________

5. Ordered: Drug X 0.5 g IV.
   1. How much diluent will you add? ______________________________
   2. What will be the unit dose concentration? ______________________________
   3. How many milliliters will you give? ______________________________
   DA equation:
   4. Evaluation: ______________________________________________________

1. If you were to receive 150 mg of an intramuscular injection and the directions for reconstitution of the medicine specified (a) add 20 mL to obtain 50 mg/ mL or (b) add 10 mL to obtain 100 mg/ mL, which concentration would you select for reconstitution?

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Reconstituted Drug Prefilled Containers

Some parenteral medications for reconstitution are supplied with diluents that are in prefilled syringe cartridges, ampules, or vials. Others are attached to the vial (Figure 7-1) and can be mixed by depressing the stopper without opening the vials. There is less chance for contamination of the contents when the ingredients are not exposed to air.

Reconstituting Injectable Medications Using Two Vials

Some reconstituted parenteral drugs are supplied in two vials: one with the dry drug and one with the diluent. Using sterile technique, both vials are cleaned with an alcohol swab. The amount in milliliters of diluent for the desired concentrate is withdrawn with a syringe and placed in the dry drug vial. The mixture is rotated until it is thoroughly mixed. This technique requires some clinical practice with the actual equipment. It is not complicated.

RAPID PRACTICE 7-5  Interpreting Directions and Calculating Reconstituted Injectables

Estimated completion time: 30 minutes  Answers on page 000

Directions: Examine the worked-out problem 1. Read the labels to answer the questions for problems 2-5.

1. Ordered: ceftazidime 0.5g IM, an antibiotic, for a patient with an infection.
1. What kind of diluent is specified? SW for injection
2. How much diluent will you add? 3 mL
3. What will the total volume in milliliters be after the diluent is added? 3.6 mL
4. Unit dose concentration after dilution: 280 mg/mL
5. Is the dose ordered (after you move decimal places) more or less than the unit dose after dilution? 0.5 g = 500 mg, which is more than 280 mg
6. Estimated dose in milliliters: A little less than 2 mL
7. Actual dose in milliliters calculated with a DA equation to the nearest measurable dose on a 3-mL syringe:

\[
\frac{? \text{ mL}}{280 \text{ mg}} \times \frac{500 \text{ mg}}{14} = \frac{25}{14}
\]

1.78 rounded to 1.8 mL for the 3-mL syringe
8. Evaluation: Estimate supports answer. Equation is balanced. If satisfactory, draw a vertical line through the calibrated line of the exact dose on the syringe.

9. How will you mark label? Patient: John Doe, 2/01/06 1800, 3 mL sterile H2O added, 280 mg/mL, jm reece, RN
10. Storage and/or discard directions: Stable 18 hours at room temperature or 7 days if refrigerated (5°C)
2 Ordered: oxacillin 200 mg IM, an antibiotic, for a patient with an infection.

1. What kind of diluent or diluents are specified? _________________________
2. How much diluent will you add? ______________________________________
3. Unit dose concentration after dilution: ________________________________
4. Estimated dose: Is the dose ordered (after you move decimal places) more or less than the unit dose after dilution? (Circle one.)
5. Actual dose in milliliters calculated with a DA equation to the nearest measurable dose on the syringe below:

DA equation:
6. Evaluation: ________________________________________________________
   If satisfactory, draw a vertical line through the calibrated line of the exact dose on the syringe.

3 Ordered: Ancef 0.4 g IM, an antibiotic, for a patient with an infection

1. What kind of diluent or diluents are specified? _________________________
2. How much diluent will you add? ______________________________________
3. Unit dose concentration after dilution: ________________________________
4. Estimated dose: Is the dose ordered (after you move decimal places) more or less than the unit dose after dilution? (Circle one.)
5. Actual dose in milliliters calculated with a DA equation to nearest measurable dose on the syringe below:

DA equation:
6. Evaluation: ________________________________________________________
   If satisfactory, draw a vertical line through the calibrated line of the exact dose on the syringe.
Ordered: cephapirin 0.5 g IM, an antibiotic, for a patient with an infection.

1. What kind of diluent or diluents are specified? _________________________
2. How much diluent will you add? ______________________________________
3. Unit dose concentration after dilution: ________________________________
4. Estimated dose: Is the dose ordered (after you move decimal places) more or less than the unit dose after dilution? (Circle one.)
5. Estimated dose in milliliters? _________________________________________
6. Actual dose in milliliters calculated with a DA equation to the nearest measurable dose on the syringe below:

DA equation:
7. Evaluation: ________________________________________________________
   If satisfactory, draw a vertical line through the calibrated line of the exact dose on syringe.

Ordered: Geopen 0.8 g IM, an antibiotic, for a patient with an infection

1. Total number of grams and milligrams in vial? __________________________
2. Using the 9.5 mL of diluent for the 5-g vial, what will the unit dose be? ______
3. Estimated dose: Is the dose ordered (after you move decimal places) more or less than the unit dose after dilution? (Circle one.)
4. Actual dose in milliliters to nearest measurable dose on the syringe below:
DA equation:

5. Evaluation: ________________________________________________________
If satisfactory, draw a vertical line through the calibrated line of the exact
dose on syringe.

6. Storage and/or discard directions: _________________________________

### Clinical Relevance
Many of the medications for reconstitution are antibiotics. They may be supplied in several forms
and a variety of concentrations for oral, topical, intramuscular, or intravenous routes. Some have
similar-sounding generic and trade names. Take care when comparing the order to the label.

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Trade Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>cefaclor</td>
<td>Ceclor</td>
</tr>
<tr>
<td>cefprozil</td>
<td>Cefzil</td>
</tr>
<tr>
<td>cefuroxime</td>
<td>Ceftin</td>
</tr>
<tr>
<td>cephalexin</td>
<td>Keflex</td>
</tr>
<tr>
<td>cephazolin</td>
<td>Kefzol</td>
</tr>
<tr>
<td>ciprofloxacin</td>
<td>Cipro</td>
</tr>
<tr>
<td></td>
<td>Cipro XR</td>
</tr>
<tr>
<td>gatifloxacin</td>
<td>Tequin</td>
</tr>
<tr>
<td>gemifloxacin</td>
<td>Factive</td>
</tr>
<tr>
<td>sulfamethoxazole</td>
<td>Bactrim DS</td>
</tr>
<tr>
<td>+ trimethoprim</td>
<td>Septra DS</td>
</tr>
</tbody>
</table>

### Communication
“Good morning, Mr. Smith. How are
you today? Any changes since yester-
day?” (Wait for an answer and re-
spond.). “I have an antibiotic, Cefzil
500 mg for your infection. Have you
had problems with antibiotics?”

### Clinical Relevance
Some patients are allergic to certain antibiotics and need a reminder. Assess lung sounds for
wheezes and the skin for rashes, and ask the patient if there have been any bowel changes
(e.g., diarrhea). These are the most common symptoms of allergic reactions. A skin rash may
precede more serious symptoms.

### Liquid Concentrates: Diluting Liquids

The pharmacy usually dilutes medication solutions to the ordered strength. Occa-
sionally, the nurse will need to dilute a medication, nutritional beverage supple-
ment, or irrigation solution based on a dilution ratio or percent concentration. Dilu-
tion is done to protect the patient from side effects of an overly strong concentration.

➤ Always look for dilution instructions when you see the word concentrate on a
medication label. Failure to do so could result in serious injury to the patient.

Liquids administered through feeding tubes full strength may cause gastroin-
testinal distress. Solutions for irrigation treatments may need to be diluted to avoid
tissue injury.
Orders may be written in one of three ways to indicate the strength or concentration of a solution:

<table>
<thead>
<tr>
<th>Order</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>Percent means “per 100.” For example, 50% strength denotes a solution that contains 50% active ingredient (the drug) plus 50% inactive ingredient (the diluent).</td>
</tr>
<tr>
<td>Fraction</td>
<td>For example, $\frac{1}{2}$ or “half strength” indicates that 1 part out of a total of 2 parts is the active ingredient and the other part is the inactive ingredient. The denominator of the fraction denotes the total number of parts.</td>
</tr>
<tr>
<td>Ratio</td>
<td>For example, 1:1 denotes 2 total parts: 1 part active ingredient added to 1 part inactive ingredient. The left number is the active ingredient, or the drug. The right number is the inactive ingredient, or the diluent.</td>
</tr>
</tbody>
</table>

Drug concentrations are expressed as ratios.

**Inactive Ingredients Used for Dilutions**

Water or NS is often the inactive ingredient used for dilution. Check the order and label for the diluent. Sterile water may be indicated for wound irrigations, pediatric formulas, or immunocompromised patients. Normal saline solution is supplied as a sterile solution. Read the label and check agency protocols. Order the supplies from the pharmacy or central supply, according to agency guidelines.

Percent or fractional strengths are written more frequently for dilution than are ratios.

- The two sides of a ratio need to be added to obtain the total number of parts.
- The nurse must be able to interpret any of the three ways the order may be written.

The order may read as follows:

- “Ensure $\frac{1}{2}$ strength, for 3 days PO,”
- “Irrigate abdominal wound with 20% hydrogen peroxide (H₂O₂) and NS bid,” or
- “Baby formula 60 mL 1:3 sol q2h. If tolerated, increase to 1:2 sol tomorrow.”

**Converting Dilution Ratios to Fractions and Percentages**

- To convert a ratio to a fraction, add the total number of parts to create a denominator. Place the number of active-ingredient parts in the numerator.
- To convert a fraction to a percentage, multiply the fraction by 100 and add a percent sign.
- To convert a percentage to a fraction, divide the percentage by 100, remove the percent sign, and reduce the fraction.

---

**EXAMPLES**

1. Ordered: 120 mL q2h Ensure 50%. Preparation: 60 mL Ensure; 60 mL water to make a 1:1 ratio $\frac{1}{2}$ strength, or 50% solution. $1:1 = 1$ part active ingredient per, to, or plus 1 part inactive ingredient (ratio of Ensure to water). Total parts $= 2 = \frac{1}{2}$ strength $= 50%$ solution $(\frac{1}{2} \times 100)$.

2. Ordered: Irrigation with peroxide solution: 1:4. 1:4 = 1 part active ingredient (peroxide) per, to, or plus 4 parts inactive ingredient (water). Total parts $= \frac{5}{5}$, or 20% solution. Use 1 part active ingredient, and add 4 parts diluent.

- Note that the dilution ratio 1:4 does not convert to the fraction $\frac{1}{4}$.
- Think of the dilution ratio 1:4 as 1 part added to 4 parts (1 + 4 = 5 total parts).
- Read the fraction as 1 part out of 5 total parts, or $\frac{1}{5}$.
- Read 20% strength as 20 parts per 100 parts, or $\frac{1}{5}$.

Recall from Chapter 1, Essential Math Review, that the denominator of a fraction indicates the number of total parts and that percent means “per 100.” Read $\frac{1}{5}$-strength concentration as 20%.
Most dilution orders can be solved with mental arithmetic or simple arithmetic. The nurse needs to know the concentration and the total amount to be given in order to calculate the amount of active ingredients per the amount of inactive ingredients in milliliters.

Simple DA-style equations are solved using fraction forms. Change the percentage in the order to a fraction.

When in doubt about dilutions, consult the agency pharmacist.

**Rapid Practice 7-6 Interpreting Dilution Orders**

Estimated Completion Time: 25 minutes  Answers on page 000

Directions: Fill in the dilution tables from left to right with the correct equivalent terms and solution amounts, as shown in first row of table that follows.

<table>
<thead>
<tr>
<th>Fractional Strength</th>
<th>Ratio of Active to Inactive Ingredients</th>
<th>Percent</th>
<th>Order</th>
<th>Amount of Active Ingredient</th>
<th>Amount of Diluent (Inactive Ingredient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>1:3</td>
<td>25%</td>
<td>100 mL 1 h</td>
<td>25 mL</td>
<td>75 mL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60%</td>
<td>60 mL tid</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75%</td>
<td>1000 mL q8h</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20%</td>
<td>240 mL four times daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10%</td>
<td>50 mL once a day</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What is the difference between a dilution ratio and a fraction? How will I remember? Which one is easier (one less step) to convert to a percentage: the ratio or the fractional strength?

**Multiple-Choice Review**

Estimated completion time: 20-30 minutes  Answers on page 000

Directions: Circle the correct answer for the following.

1. Which of the following statements defines displacement?
   1. Liquid oral medications are prepared using clean technique and nonsterile equipment.
2. The diluent for oral liquid medications is usually water.
3. The volume after reconstitution exceeds the amount of liquid diluent added.
4. Oral liquid medications are usually prepared to the nearest tenth of a milliliter for adults.

2 Which of the following statements can lead to medication calculation errors?
1. Suspensions must be combined with a precise amount of diluent and thoroughly mixed.
2. Elixirs are solutions that contain alcohol.
3. Extracts are solutions that are concentrated.
4. It is acceptable to use household teaspoons and tablespoons to measure liquids.

3 Plastic medication cups have the following milliliter calibrations:
1. Multiples of 5
2. Multiples of 10
3. Multiples of 15
4. Multiples of 30

4 If a liquid medication order calls for 13 mL, how will the nurse prepare it?
1. Pour at eye level to just below the 15 mL line
2. Pour to 10 mL at eye level and add 3 mL with a needleless syringe.
3. Pour to 15 mL, remove 2 mL, and return the 2 mL to the medication bottle.
4. Draw 20 mL in a 20-mL syringe and discard 7 mL.

5 If a liquid medication order calls for 7.5 mL, how will the nurse prepare it?
1. Pour at eye level to 5 mL and add 2.5 mL with a needleless syringe.
2. Pour to 10 mL, remove 2.5 mL, and return the 2 mL to the medication bottle.
3. Withdraw 7.5 mL in a 10-mL syringe and place it in the medication cup.
4. Give 1.5 medication teaspoonsful.

6 One of the most important ways to eliminate errors in the dose calculations is to
1. Estimate the answer.
2. Pour oral medications to the nearest tenth of a milliliter.
3. Move decimal places to obtain equivalent measurements.
4. Compare generic and trade names on the label with the order.

7 Which conversion is most commonly used in medication problems?
1. 1000 mg = 1 mg
2. 1000 mg = 1 g
3. 1,000,000 mcg = 1 g
4. 1000 mL = 1 L

8 The usual adult dose for oral liquid medications is measured to the
1. Nearest tenth of a milliliter
2. Nearest hundredth of a milliliter
3. Nearest 0.5 mL
4. Nearest whole milliliter

9 What is the advantage of converting metric units by moving decimal places?
1. It reinforces multiples, base units, and powers of 10.
2. It simplifies the math and often permits mental calculation of the dose.
3. It eliminates the need to compare answers with estimates.
4. It eliminates the need to analyze the equation setup.

10 An order calls for hydrogen peroxide 20% irrigation of 150 mL with NS diluent. The nurse prepares 150 mL of total irrigation. How many milliliters of hydrogen peroxide will be prepared?
1. 15
2. 30
3. 100
4. 120
Estimated completion time: 1 hour  Answers on page 000

Directions: Examine the labels, change the units to equivalents by moving decimal places, estimate the answer, calculate the dose to the nearest tenth of a milliliter, and evaluate your answer. Then shade in the dose on the medicine cup and draw a vertical line through the calibrated line of each syringe for the dose to be given.

1. Ordered: amoxicillin clavulanate potassium oral susp 0.3 g q8h.

This drug is a combination drug.

1. Estimated dose: ___________________________

2. Calculated dose with equation to the nearest tenth of a milliliter:

DA equation:

3. Evaluation: _______________________________________________________

4. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
2 Order: amoxicillin 0.2 g PO q8h.

1. Estimated dose: __________________________
2. Calculated dose with equation to nearest tenth of a milliliter:

   DA equation:

3. Evaluation: _______________________________________________________
4. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
Ordered: Erythromycin ethylsuccinate susp 0.25 g PO q8h.

1. Estimated dose: ___________________________
2. Calculated dose with equation to nearest tenth of a milliliter:

   DA equation:

3. Evaluation: _______________________________________________________
4. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
Ordered: cefaclor 0.2 g mg PO q8h.

1. Estimated dose: ___________________________
2. Calculated dose with equation to nearest tenth of a milliliter:
   
   DA equation:
3. Evaluation: _______________________________________________________
4. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.
5 Ordered: clarithromycin oral susp 0.15 g. Note the form of this oral solid drug before reconstitution.

1. Estimated dose: __________________________
2. Calculated dose with equation to nearest tenth of a milliliter:
   DA equation: __________________________
3. Evaluation: _______________________________________________________
4. Shade in the dose on the medicine cup and draw a vertical line through the calibrated line of the syringe as applicable.

6 Ordered: Ensure food supplement 200 mL 25% strength q 8h for 3 days.
   1. What will be the ratio of Ensure to the water diluent? ______________________
   2. How would the 25% concentration be expressed as a fraction? ____________
   3. How many milliliters of Ensure will be used for the dose? __________________
   4. How many milliliters of water will be added? __________________________

7 Ordered: Baby formula \( \frac{1}{3} \) strength, 30 mL/hr to be diluted with SW.
   1. What is the equivalent percent concentration to the nearest whole number? ______
   2. What is the equivalent ratio of active to inactive ingredients? ____________
   3. How much formula will the nurse pour? ______________________________
   4. How much diluent will the nurse add? ________________________________
8 The baby in problem 7 tolerated the \( \frac{1}{3} \) strength formula without vomiting or diarrhea. The prescriber changed the order 48 hours later to, “Increase formula to 1:1 concentration.”

1. What is the equivalent percent concentration of this order? ______________
2. What is the equivalent fractional concentration of this order? ______________
3. How much formula will the nurse place in the bottle? ______________
4. How much SW will the nurse add? ______________

9 An NS solution has a concentration of sodium chloride (NaCl) 0.9%. NaCl is supplied in grams. The diluent is SW.

1. Is the concentration more or less than a 1% solution? ______________
2. How many grams of solute (NaCl is the concentrate) are contained in 100 mL of NS? ______________
3. How many grams of solute are contained in 1000 mL (1L) of NS? ______

10 A wound irrigation order calls for 50 mL \( \frac{1}{2} \) strength NS irrigations tid. The nurse needs to prepare the irrigation from full-strength NS by adding SW.

1. What will be the ratio of NS solution to SW? ______________
2. How much NS solution will the nurse pour? ______________
3. How much SW will the nurse add? ______________

**Suggested References**

Mosby’s medical dictionary of medicine, nursing and health professions, ed. 7, St. Louis, 2006, Mosby

www.emea.eu.int/html/vet/presub/q11.htm

www.niaid.nih.gov/publications/allergies.htm

www.rxmed.com

www.vh.org/navigation/vh/topics/adult_provider_pharmacy_services.html

Additional information can be found on the CD

Chapter 8 provides a variety of practice problems for subcutaneous and intramuscular dose calculations.
Feature art to be supplied by publisher.
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