

Math Diversion Problem 943

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December 2, 2025

Even the youths shall faint and be weary, and the young men
shall utterly fall: But they that wait upon the Lord shall
renew their strength; they shall mount up with wings
as eagles; they shall run, and not be weary;
and they shall walk, and not faint.
— Isaiah 40:30–31
[Just a personal word
of encouragement
in dark times.]

Source: [https://www.algebra.com/algebra/homework/word/mixtures/
Advanced-mixture-problems.lesson](https://www.algebra.com/algebra/homework/word/mixtures/Advanced-mixture-problems.lesson)
Title: A Mixed-Rate Problem
Presenter: Patrick

1 Problem

Problem 1 from the webpage: A chemist has three different acid solutions.¹ The first acid solution contains 15% acid, the second contains 30% acid, and the third contains 75% acid. He wants to use all three solutions to obtain a mixture of 216 liter containing 25% acid, using 2 times as much of the 75% solution as the 30% solution. How many liters of each solution should be used?

2 Solution

Let's make a diagram to help out.

¹When an author of an algebra problem says that there are 'three different acid solutions' to be added together, I interpret it to mean that there are three different concentrations of the same acid (chemically speaking) to be combined. One must be on the alert when solving a percentage problem a math teacher made up that involves 'chemistry'. Most of the time they work just fine. But, occasionally, they don't make sense from the get go.

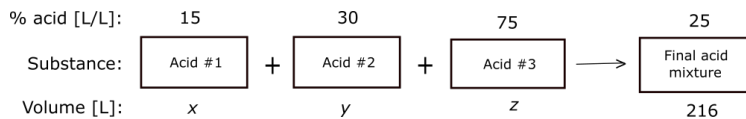


Figure C1. My preference is to treat this problem as a ‘three-variable’ problem, and not employ accelerated substitution by using the given constitutive relations between the variables in the diagram as volume descriptions.

As it stands, we have three unknowns, so we’d better find three equations to solve for them. From the requirement that the third volume be twice as much as the second, we have the constitutive equation² given by

$$z = 2y. \tag{1}$$

Now we investigate the two conservation equations. First, for volume:

$$x + y + z = 216, \tag{2}$$

and, second, for the conservation of ‘pure’ acid:

$$(0.15)x + (0.30)y + (0.75)z = (0.25)(216). \tag{3}$$

The solution for this system is

$$x = 168 \text{ gal}, \quad y = 16 \text{ gal}, \quad z = 32 \text{ gal}. \tag{4}$$

²A *constitutive relation* is a relation/constraint existing on one or more unknowns (variables) that is (usually) arbitrary constructed and exists independent of the conservation equations.