Plan Your Strategy
Write the formula for percent (v/v) concentration.
Rearrange the formula to solve for the volume of solute.
Substitute the data into the expression to calculate the volume of methanol solute, V.

Act on Your Strategy
Formula for percent (v/v) concentration:
$$\text{percent (v/v)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

Rearranged equation to solve for the volume of solute:
$$\text{percent (v/v)} \times \text{volume of solution} = \text{volume of solute} \times 100\%$$
$$\text{volume of solute} = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$

Substitution to calculate the volume of methanol:
$$v = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$
$$= \frac{40\% \times 4.0 \text{ L}}{100\%}$$
$$= 1.6 \text{ L}$$

The volume of methanol in the windshield washer fluid is 1.6 L.

Check Your Solution
The volume of methanol is less than half the volume of solution, which is approximately 40% of the total volume. The calculated answer seems reasonable and correctly shows two significant digits.

24. **Practice Problem (page 376)**
    A concentrated solution of engine coolant contains 75% (v/v) ethylene glycol in water. The label tells consumers to use a 1:1 mixture of the concentrate with water in their cars. Determine the approximate volume of pure ethylene glycol in an automotive cooling system that contains 6.0 L of the diluted solution.

    What Is Required?
    You need to determine the volume of ethylene glycol (solute) in the cooling system of an engine.

What Is Given?
You know the volume of the solution: 6.0 L
You know the percent (v/v) concentration of stock solution: 75%
You know the stock solution will be diluted 1:1 with water.

Plan Your Strategy
Determine the percent (v/v) concentration of ethylene glycol in the engine's cooling system.
Write the formula for percent (v/v) concentration.
Rearrange the formula for percent (v/v) to solve for the volume of solute.
Substitute the data into the expression to calculate the volume of ethylene glycol, V.

Act on Your Strategy
Since the stock solution of ethylene glycol is diluted 1:1, each volume of ethylene glycol in the cooling system is diluted in an equal volume of water. The percent (v/v) concentration of the coolant solution in the engine therefore is $\dfrac{1}{2}$ the concentration of the stock solution:

$$\frac{1\text{ volume ethylene glycol}}{1\text{ volume ethylene glycol } + 1\text{ volume of }H_2O} \times 75\% = \frac{1\text{ volume}}{2\text{ volumes}} \times 75\%$$

$$= 37.5\%$$

Formula for percent (v/v) concentration:
$$\text{percent (v/v)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

Rearranged equation to solve for the volume of solute:
$$\text{percent (v/v)} \times \text{volume of solution} = \text{volume of solute} \times 100\%$$

$$\text{volume of solute} = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$

Substitution to calculate the volume of ethylene glycol:
$$v = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$

$$= \frac{37.5\% \times 6.0\text{ L}}{100\%}$$

$$= 2.25\text{ L}$$

$$= 2.2\text{ L}$$

The volume of ethylene glycol in the engine is 2.2 L.

Check Your Solution
Rounding the data and estimating the percent (v/v) concentration:
$$\frac{2\ \text{L}}{6\ \text{L}} \times 100\% = 33\%$$
This estimate approximates the given concentration. The calculated answer correctly shows two significant digits.

25. Practice Problem (page 376)
Describe how to prepare a 5.00% (v/v) solution with 50.0 mL of pure ethylene glycol.

What Is Required?
You need to determine the volume of an ethylene glycol solution and outline how to prepare this solution.

What Is Given?
You know the percent (v/v) concentration of the solution: 5.00% (v/v)
You know the volume of ethylene glycol solute: 50.0 mL

Plan Your Strategy
Write the formula for percent (v/v) concentration.
Rearrange the expression for the percent (v/v) concentration to solve for the volume of solution.
Substitute the data into the expression to calculate the volume.
Subtract the volume of solute from the volume of the solution to determine the volume of solvent (water) required.

Act on Your Strategy
Formula for percent (v/v) concentration:
$$\text{percent (v/v)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

Rearranged formula to solve for the volume of solution:
$$\text{percent (v/v)} \times \text{volume of solution} = \text{volume of solute} \times 100\%$$
$$\text{volume of solution} = \frac{\text{volume of solute} \times 100\%}{\text{percent (v/v)}}$$

Rearranged formula to solve for the volume of solute:
percent (v/v) × volume of solution = volume of solute × 100%

$$\text{volume of solute} = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$

Substitution to calculate the volume of ethanol, v:

$$v = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$

$$= \frac{5.0\% \times 30 \text{ L}}{100\%}$$

$$= 1.5 \text{ L}$$

The volume of ethanol in the gasoline is 1.5 L.

Check Your Solution
Using the calculated volume of ethanol and the volume of solution, estimate the percent (v/v):

$$\frac{1.5 \text{ L}}{30 \text{ L}} \times 100\% = 5\% \text{ (v/v)}$$

The calculated answer is reasonable and correctly shows two significant digits.

27. Practice Problem (page 376)
A vending machine mixes a liquid flavour concentrate with water in a ratio of 1:10 to make coffee. Determine the percent (v/v) concentration of the flavour concentrate in the drink.

What Is Required?
You need to determine the percent (v/v) concentration of a liquid flavour concentrate.

What Is Given?
You know the volume ratio of concentrate to water (solvent): 1:10

Plan Your Strategy
Assume that 1.0 L of concentrate (solute) and 10.0 L of water (solvent) are used to make the solution.
Add the volume of the solute and the volume of the solvent to determine the volume of the solution.
Write the formula for percent (v/v) concentration.
Substitute the data into the expression to calculate the concentration.

Act on Your Strategy

volume of solution = volume of solute + volume of solvent

$$= 1.0 \text{ L} + 10.0 \text{ L}$$
$$= 11.0 \text{ L}$$

$$\text{percent (v/v)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

$$= \frac{1.0 \cancel{L}}{11.0 \cancel{L}} \times 100\%$$

$$= 9.09 \%$$
$$= 9.1 \%$$

The concentration of the flavour concentrate is 9.1% (v/v).

Check Your Solution
Using the answer and the given volume of solution, 9% of 11 L is about 1 L of solute. The calculated answer is reasonable and correctly shows two significant digits.

28. Practice Problem (page 376)
Your teacher has 4.0 L of a 15% (v/v) solution of sulfuric acid in water. What will be the volume of the solution if it is diluted to 10% (v/v)?

What Is Required?
You need to determine the volume of a diluted solution.

What Is Given?
You know the volume and percent (v/v) concentration of a concentrated sulfuric acid solution:
$V = 4.0$ L
concentration = 15% (v/v)
You know the percent (v/v) concentration of the dilute sulfuric acid solution:
10% (v/v)

Plan Your Strategy
Write the formula for percent (v/v) concentration.
Rearrange the expression to solve for the volume of solute.
Substitute the data for the concentrated solution to calculate the volume of sulfuric acid solute.
The volume of sulfuric acid (solute) is the same in each solution.
Rearrange the expression to solve for the volume of the dilute solution.

Substitution to calculate the volume of solute in Solution B:

$$\text{volume of solute} = \frac{25\% \times 14.0 \text{ L}}{100\%}$$

$$= 3.5 \text{ L}$$

Calculation of total volume of solute and total volume of solution:

$$\text{total volume of solute} = 4.5 \text{ L} + 3.5 \text{ L}$$

$$= 8.0 \text{ L}$$

$$\text{total volume of solution} = 6.0 \text{ L} + 14.0 \text{ L}$$

$$= 20.0 \text{ L}$$

Substitution to calculate the final concentration:

$$\text{percent (v/v)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

$$= \frac{8.0 \text{ L}}{20.0 \text{ L}} \times 100\%$$

$$= 40\%$$

The final concentration (v/v) after mixing the two solutions is 40%.

Check Your Solution
Solution A contributes a little more than half of the total volume of solute, but solution B contributes more than twice as much to the total volume of the solution. The answer seems reasonable, with the final concentration being between the two given concentrations and closer to the concentration of solution B.

30. **Practice Problem (page 376)**
You need 125 mL of white vinegar, which has a concentration of 5.0% (v/v) of acetic acid. You are out of white vinegar. However, you do have pickling vinegar with a concentration of 8.5% (v/v) of acetic acid. How much pickling vinegar should you dilute to substitute for the white vinegar?

What Is Required?
You need to determine the volume of pickling vinegar that has the same amount of acetic acid as a given amount of white vinegar.

What Is Given?
You know the volume and concentration of the white vinegar solution:
$V = 125$ mL
concentration = 5.0% (v/v)
You know the concentration of pickling vinegar: 8.5% (v/v)

Plan Your Strategy
Write the formula for percent (v/v) concentration.
Rearrange the formula to solve for the volume of solute.
Substitute the data to calculate the volume of solute in white vinegar.
The volume of acetic acid in white vinegar is equal to the volume of acetic acid in pickling vinegar.
Rearrange the expression for percent (v/v) concentration to calculate the volume of solution of pickling vinegar.

Act on Your Strategy
Formula for percent (v/v) concentration:
$$\text{percent (v/v)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$$

Rearranged formula to solve for the volume of solute:
$$\text{percent (v/v)} \times \text{volume of solution} = \text{volume of solute} \times 100\%$$
$$\text{volume of solute} = \frac{\text{percent (v/v)} \times \text{volume of solution}}{100\%}$$

Substitution to calculate the volume of solute in white vinegar:
$$\text{volume of solute} = \frac{5\cancel{\%} \times 125 \text{ mL}}{100\cancel{\%}}$$
$$= 6.25 \text{ mL}$$

The volume of the solute is 6.25 mL. Therefore, the volume of acetic acid in pickling vinegar is 6.25 mL.

Rearranged formula to solve for volume of solution:
$$\text{percent (v/v)} \times \text{volume of solution} = \text{volume of solute} \times 100\%$$
$$\text{volume of solution} = \frac{\text{volume of solute} \times 100\%}{\text{percent (v/v)}}$$

Substitution to calculate the volume of solute in white vinegar:

$$\text{volume of solution} = \frac{6.25 \text{ mL} \times 100\%}{8.5\%}$$
$$= 73.529 \text{ mL}$$
$$= 74 \text{ mL}$$

The volume of pickling vinegar needed is 74 mL.

Check Your Solution
A smaller volume of pickling vinegar should be required since the pickling vinegar has a higher percent (v/v) concentration of acetic acid. The volume of pickling vinegar may be estimated:

$$125 \text{ mL} \times \frac{5.0}{8.5} = 71 \text{ mL}$$

The calculated answer seems reasonable and correctly shows two significant digits.

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31. Practice Problem (page 378)
A sample of lake water has a mass of 310 g and contains 2.24 mg of dissolved oxygen. Calculate the oxygen concentration in parts per million.

What Is Required?
You need to calculate the concentration of dissolved oxygen in parts per million.

What Is Given?
You know the mass of dissolved oxygen (solute): 2.24 mg
You know the mass of water (solution): 310 g

Plan Your Strategy
Convert the mass of dissolved oxygen from milligrams to grams so that you can cancel the units:1 mg $= 1 \times 10^{-3}$ g
Write the formula for ppm.
Substitute the data into the expression to calculate the concentration of dissolved oxygen.