Dilution: to make a solution less concentrated by adding more solvent

~ the number of molecules, or moles, of solute that is present remains the same before and after dilution ~

$$C_1V_1 = C_2V_2$$

- C_1: initial concentration (mol/L)
- V_1: initial volume (L)
- C_2: final concentration (mol/L)
- V_2: final volume (L)

Example problems

(i) ~ calculating initial volume ~

For an experiment, you must make 2.0 L of 0.10 mol/L sulfuric acid. The acid is usually sold as an 18 mol/L concentrated solution. How much of the concentrated solution should be used to make a new solution?

1- write the given information

$C_1 = 18\ mol/L$
$V_1 = ?$
$C_2 = 0.10\ mol/L$
$V_2 = 2.0\ L$

2- use formula $C_1V_1 = C_2V_2$

$C_1V_1 = C_2V_2 \qquad V_1 = \frac{C_2V_2}{C_1} \qquad V_1 = \frac{(0.10\ mol/L)(2.0\ L)}{18\ mol/L} = 0.01\ L$

(ii) ~ calculating final concentration ~

A solution is prepared by adding 600 mL of distilled water to 100 mL of 0.15 mol/L ammonium nitrate. Calculate the molar concentration of the diluted solution.

1- write the given information and convert to appropriate units

$C_1 = 0.15\ mol/L$
$V_1 = 100\ mL \times \frac{L}{1000\ mL} = 0.1\ L$
$C_2 = ?$
$V_2 = 600\ mL + 100\ mL = 700\ mL \times \frac{L}{1000\ mL} = 0.7\ L$

2- use formula $C_1V_1 = C_2V_2$

$C_1V_1 = C_2V_2 \qquad C_2 = \frac{C_1V_1}{V_2} = \frac{(0.15\ mol/L)(0.1\ L)}{0.7\ L} = 0.021\ mol/L$

(iii) ~ calculating required volume for dilution ~

How much water would I need to add to 500 mL of a 2.4 M KCl solution to make a 1.0 M solution?

1- write the given information and convert to appropriate units

$C_1 = 2.4\ g/mol\ KCl$
$V_1 = 500\ mL \times \frac{L}{1000\ mL} = 0.5\ L$
$C_2 = 1.0\ g/mol$
$V_2 = ?$

2- use formula $C_1V_1 = C_2V_2$

$C_1V_1 = C_2V_2 \qquad V_2 = \frac{C_1V_1}{C_2} = \frac{(2.4\ mol/L)(0.5\ L)}{1.0\ mol/L} = 1.2\ L$

3- find difference between V_1 and V_2

amount added $= V_2 - V_1 = 1.2\ L - 0.5\ L = 0.7\ L$

Creating Standard Solutions

Standard solution: solution containing precisely known concentration of a substance

uses : determine unknown concentrations of other substances via titration
as tested concentrations in scientific investigations

Preparing molar standard solutions ($mol\ L^{-1}$) using solid solute:

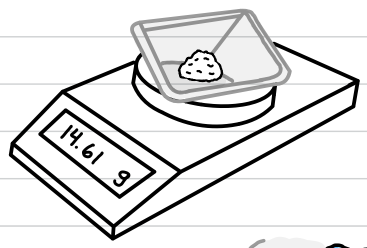


fig. 1

Part A: Calculate amount of solute needed

1 - Determine desired concentration and volume — ex: 500 mL of 0.5 M NaCl

2 - Calculate mass of solute needed using $n = cV$ — ex: $n = (0.5\ mol\ L^{-1})(0.5\ L)$
$= 0.25\ mol \times \frac{58.44\ g}{mol}$
$= 14.61\ g$ of NaCl needed

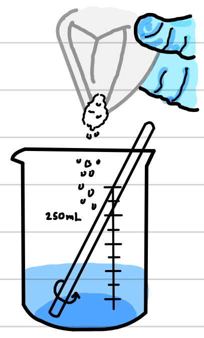


fig. 2

Part B: preparing solution

1 - weigh 14.61 g of NaCl on a weighing boat using electronic scale (±0.01 g) - fig. 1

2 - add ~ 100 mL of distilled water to a 250 mL beaker

3 - transfer 14.61 g of NaCl to beaker and stir with rod until dissolved. - fig. 2
Add more water if necessary

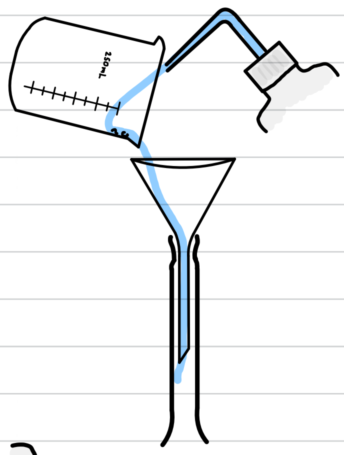


fig. 3

4 - transfer solution into 500 mL volumetric flask (±0.5 mL) using a funnel. Ensure all of solute is transferred by rinsing beaker with squirt bottle of water - fig. 3

5 - Add distilled water to flask until ~1cm below mark on neck. - fig. 4

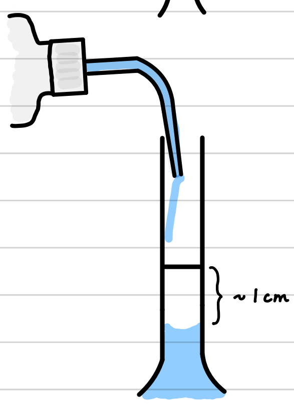


fig. 4

6 - Insert stopper and while holding it down with thumb, shake and invert flask multiple times

7 - While looking at mark at eye level, carefully add water using squirt bottle until bottom of miniscus reaches mark - fig. 5

Preparing molar standard solutions ($mol\ L^{-1}$) by dilution:

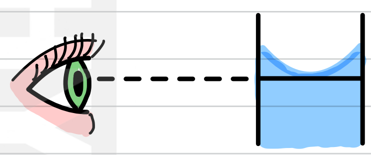


fig. 5

Part A: Calculate amount of solute needed

1 - Determine desired concentration and volume — ex: 100 mL of 0.1 M NaCl

2 - Determine concentration of initial standard solution — ex: 0.5M NaCl (aq)

3 - Calculate volume of solvent needed for dilution — ex: $V_1 = \frac{C_2 V_2}{C_1} = \frac{(0.1\ M)(0.1\ L)}{(0.5\ M)} = 0.02\ L \times \frac{1000\ mL}{L} = 20\ mL$ of 0.5M NaCl needed

Part B: preparing solution

1 - measure 20 mL of 0.5M NaCl solution using 50 mL graduated cylinder (±0.5 mL)

2 - transfer solution into 100 mL volumetric flask (±0.1 mL) using a funnel - fig. 6

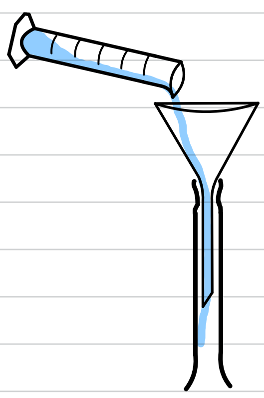


fig. 6

3 - Add distilled water to flask until ~1cm below mark on neck. - fig. 4

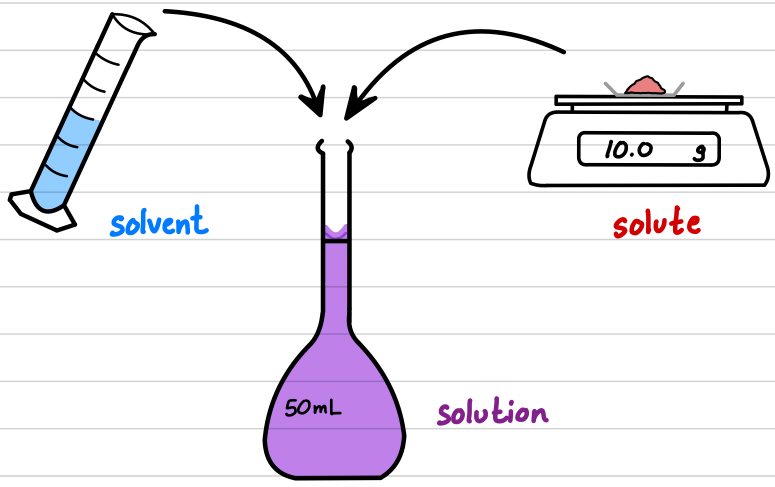
4 - Insert stopper and while holding it down with thumb, shake and invert flask multiple times

5 - While looking at mark at eye level, carefully add water using squirt bottle until bottom of miniscus reaches mark - fig. 5

Preparing % mass/volume solutions (% m/v):

↳ these solutions are made using solid solute dissolved in liquid solvents

$$\% \, m/v = \frac{\text{mass of solute (g)}}{\text{volume of solution (mL)}} \times 100$$



ex: You want to prepare 50 mL of 20 % sucrose solution
How much solute and solvent do you need?

$$\text{solute (g)} = \frac{\text{solution (mL)} \times \%}{100}$$

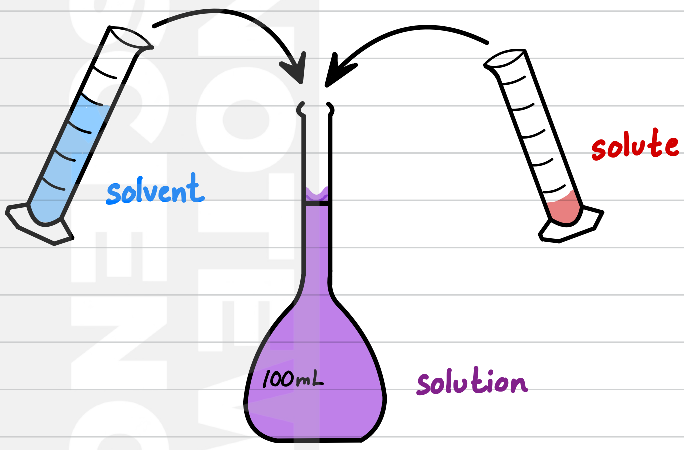
$$= \frac{(50\text{ mL})(20\%)}{100}$$

$= 10\text{ g}$ of sucrose dissolved into 50 mL of water

Preparing % volume/volume solutions (% v/v):

↳ these solutions are made using liquid solute dissolved in liquid solvents

$$\% \, v/v = \frac{\text{volume of solute (mL)}}{(\text{volume of solute (mL)} + \text{volume of solvent (mL)})} \times 100$$



ex: You want to prepare 100 mL of 5% HCl solution
How much solute and solvent do you need?

$$\text{solute (mL)} = \frac{\text{solution (mL)} \times \%}{100}$$

$$= \frac{(100\text{ mL})(5\%)}{100}$$

$= 5\text{ mL}$ of HCl

$\text{solvent (mL)} = \text{solution (mL)} - \text{solute (mL)}$

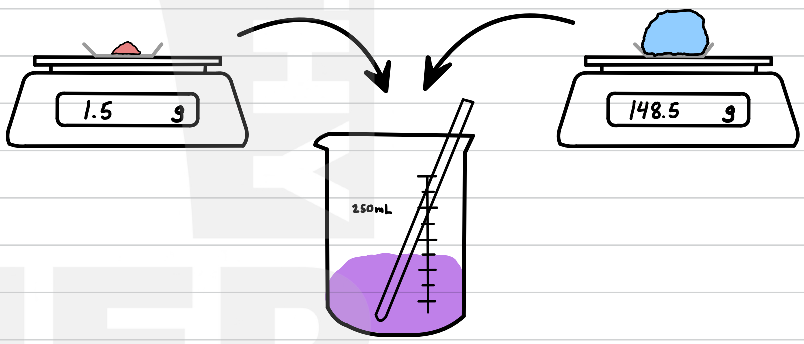
$= 100\text{ mL} - 5\text{ mL}$

$= 95\text{ mL}$ of water

Preparing % mass/mass mixtures (% m/m):

↳ these mixtures are often made using different solids

$$\% \, m/m = \frac{\text{mass of solute (g)}}{(\text{mass of solute (g)} + \text{mass of 'solvent' (g)})} \times 100$$



ex: You want to prepare 150g of 1% NaCl in sand mixture
How much NaCl and sand do you need?

$$NaCl\text{ (g)} = \frac{\text{solution (g)} \times \%}{100}$$

$$= \frac{(150\text{ g})(1\%)}{100}$$

$= 1.5\text{ g}$ NaCl

$\text{sand (g)} = \text{solution (mL)} - \text{solute (mL)}$

$= 150\text{ g} - 1.5\text{ g}$

$= 148.5\text{ g}$ of sand

*note: water has a density of 1 gmL^{-1} ∴ 1g water = 1mL of water