DILUTIONS

Basic Mathematics For Chemical Analysts

BASICS OF CHEMISTRY

RECAP

1. UNITS, NORMALITY & STANDARDISATION
2. PURITY
3. EXPERIMENT Std. OF HCL & KOH PURITY
4. pH METRY
5. KARL FISCHER
6. THIN LAYER CHROMATOGRAPHY
7. HIGH PERFORMANCE LIQUID CHROMATOGRAPHY
8. GAS CHROMATOGRAPHY

PRE-REQUISITES

- 01 FUNDAMENTALS
- 02 FRACTIONS & DECIMALS
- 03 RATIO, PROPORTIONS & PERCENTS
- 04 LIQUID MEASURES
- 05 CONCENTRA-TIONS
- 06 DILUTIONS THEORY
- 07 BUSINESS MATH
- 08 CONCLUSION

DILUTIONS

OBJECTIVES

1. Be Able To Define A Stock Solution.
2. Be Able To Calculate Dilution Concentrations.
3. Be Able To Determine Dilutions Of Liquids.
4. Be Able To Determine Dilutions Of Solids.
5. Be Able To Perform Alligation Calculations.

(a) An amount of solute is weighed out on an analytical balance and then

(b) A portion of the solvent is added to the volumetric flask.

STOCK SOLUTIONS/ SOLIDS

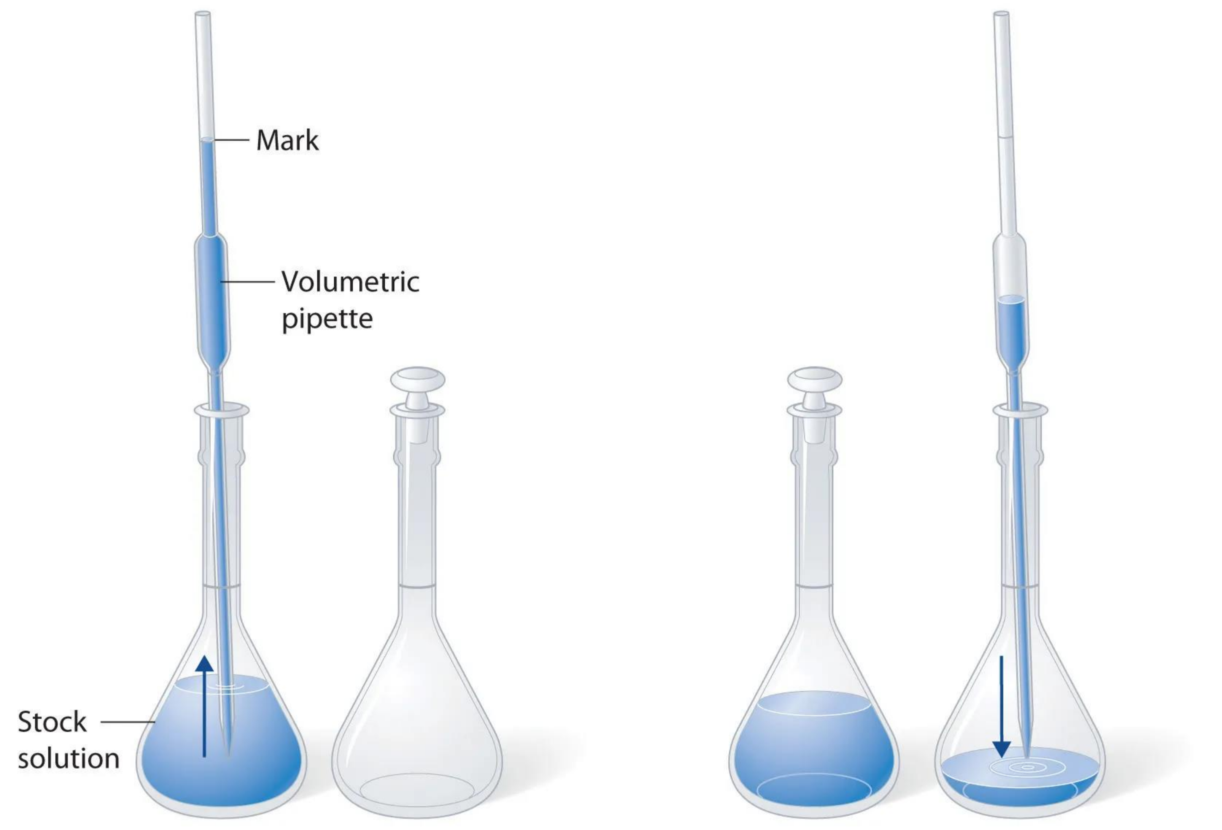
1. Stock Solutions Or Solids Are Generally Concentrated Solutions Or Solids That Are Used To Prepare Weaker Ones.
2. Stock Solutions Or Solid Concentrations Are Often Expressed As Ratio Strengths w/v Or w/w (1:400 w/v) But Can Also Be Expressed As A Percent Strength w/v Or w/w (50% w/v).
3. Dilution Of These Concentrated Solutions Or Solids Creates A Smaller Concentration In A Higher Volume That Will Allow For Easier, More Accurate Measurement Of A Desired Quantity.

(c) The mixture is swirled until *all* of the solute is dissolved.

(d) Additional solvent is added up to the mark on the volumetric flask.

STOCK SOLUTIONS/ SOLIDS

1. A Solution That Has A Concentration 50% (50 g/100 ml) And Has The Volume Doubled Now Has A Concentration Of 25% (25 g/100 ml).
2. The Amount Of Medication (Or Solute) In The Solution Did Not Change, Only The Volume Of The Liquid (Diluent). This Means That The Same Amount Of Solute Is Now In Twice As Much Diluent, Creating A Weaker Solution.
3. The Same Would Be True For A Solid Product (Ointment Or Creams). A Cream With A Percent Strength Of 18% (18 g/100 g) And A Weight Of 20 g That Is Combined With An Additional 20 g Of Cream Base Would Now Have A Percent Strength Of 9% (9 g/100 g).



(a) A volume (V_s) containing the desired moles of solute (M_s) is measured from a stock solution of known concentration.

(b) The measured volume of stock solution is transferred to a second volumetric flask.

STOCK SOLUTIONS/ SOLIDS

1. When Performing Calculations To Create A More Dilute Product, The Shortest Route Is Not Always The Best. It Is More Important To Be Accurate, So That May Mean More Steps In The Calculation.
2. Remembering Three Key Rules Can Help Simplify The Process.
   A. Ratio Strengths Should Be Converted To Percent Strengths For Easier Calculations.
   The Ratio Strength 1:500 = 0.2%.
   B. Proportions (20:5) Or Fractions (6/30) Should Be Simplified To Their Lowest Form. The Ratio 20:5 = 4:1 And The Fraction 6/30=1/5
   C. BODMAS Rule.

(c) The measured volume in the second flask is then diluted with solvent up to the volumetric mark $[(V_s)(M_s) = (V_d)(M_d)]$.

STOCK SOLUTIONS/ SOLIDS

EXAMPLE NO. 1

How many milliliters of 1:500 w/v solution is needed to make 3 L of a 1:2000 w/v solution?

Convert ratios to percents: $1{:}500 = \frac{1}{500} = \frac{x}{100\%}$ $\quad x = 0.2\%$

$$1{:}2000 = \frac{1}{2000} = \frac{x}{100\%} \qquad x = 0.05\%$$

$$\frac{0.2\%}{0.05\%} = \frac{3000 \text{ mL } (3 \text{ L})}{x}$$

$x = (3000 \text{ mL} \times 0.05\%) \div 0.2\% = 750 \text{ mL}$

$$Since, Q1\ \alpha\ \frac{1}{C1}\ \&\ Q2\ \alpha\ \frac{1}{C2},$$

$$\therefore \frac{Q1}{Q2} = \frac{\frac{1}{C1}}{\frac{1}{C2}} = \frac{C2}{C1} \quad \therefore Q1 \times C1 = Q2 \times C2,$$

Also,

$$N1V1 = N2V2$$

$$M1V1 = M2V2$$

750 mL of the concentrated solution is added to 2250 mL of the diluent to obtain 3 L total volume with a concentration of 1:2000.

STOCK SOLUTIONS/ SOLIDS

EXAMPLE No. 2

How many grams of zinc oxide 10% ointment is needed to make 2400 g of a 3% concentration ointment?

$$3\% = \frac{3\text{ g}}{100\text{ g}} = \frac{x}{2400\text{ g}}$$

$x = (3\text{ g} \times 2400\text{ g}) \div 100\text{ g} = 72\text{ g}$, 72 g of zinc in 2400 g of a 3% concentration

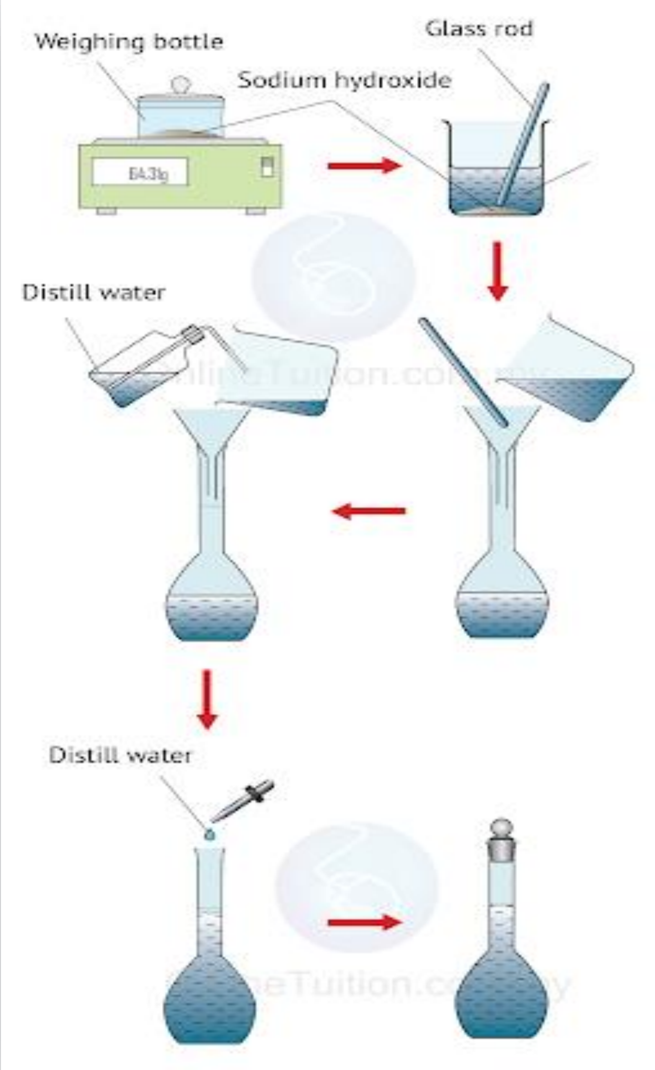
$$10\% = \frac{10\text{ g}}{100\text{ g}} \quad \text{so} \quad \frac{10\text{ g}}{100\text{ g}} = \frac{72\text{ g}}{x}$$

$x = (72\text{ g} \times 100\text{ g}) \div 10\text{ g} = 720\text{ g}$ of 10% zinc is needed

720 g of 10% zinc is added to 1680 g of ointment base for a total weight of 2400 g.

LIQUID DILUTIONS

1. Diluting Liquids Changes The Concentration Of That Liquid.
2. Since Three Of The Four Components Are Already Known, The Concentration Of The New Solution Can Be Determined By Using The Proportion Rule.
3. This Procedure Can Also Be Used To Determine How Much Product (Weaker Strength) Can Be Made From A Known Amount Of A Higher Concentration.



LIQUID DILUTIONS

EXAMPLE No. 3

What is the new concentration (% strength) of a dextrose 70% 500 mL solution diluted to 2000 mL?

$$70\% = \frac{70\text{ g}}{100\text{ mL}} = \frac{x}{500\text{ mL}}$$

$$x = (70\text{ g} \times 500\text{ mL}) \div 100\text{ mL} = 350\text{ g} \quad \text{total grams dextrose in 500 mL}$$

$$\frac{350\text{ g}}{2000\text{ mL}} = \frac{x}{100\text{ mL}}$$

$$x = (350\text{ g} \times 100\text{ mL}) \div 2000\text{ mL} = 17.5\text{ g} = 17.5\%$$

This problem can also be solved by using the following formula:

Q1 (quantity 1) × C1 (concentration 1) = Q2 (quantity 2) × C2 (concentration 2)

The quantity 1 (Q1) and concentration 1 (C1) represents what is being diluted or changed. The quantity 2 (Q2) and concentration 2 (C2) represents the end product—final dilution.

LIQUID DILUTIONS

EXAMPLE No. 4

What is the new concentration (% strength) of a dextrose 70% 500 mL solution diluted to 2000 mL?

$$Q1 \times C1 = Q2 \times C2$$

$$500 \text{ mL} \times 70\% = 2000 \text{ mL} \times x\%$$

$$3500 = 2000x$$

$$17.5\% = x$$

LIQUID DILUTIONS

EXAMPLE No. 5

How many milliliters of 3% gentamicin solution can be made from 60 mL of 10% gentamicin?

$$10\% = \frac{10\text{ g}}{100\text{ mL}} = \frac{x}{60\text{ mL}} = (10\text{ g} \times 60\text{ mL})/100\text{ mL}$$

$$= 6\text{ g gentamicin in 60 mL stock ointment}$$

$$3\% = \frac{3\text{ g}}{100\text{ mL}} = \frac{6\text{ g}}{x}$$

$$x = (6\text{ g} \times 100\text{ mL}) \div 3\text{ g} = 200\text{ mL}$$

Or, try the following formula:

$$Q1 \times C1 = Q2 \times C2$$

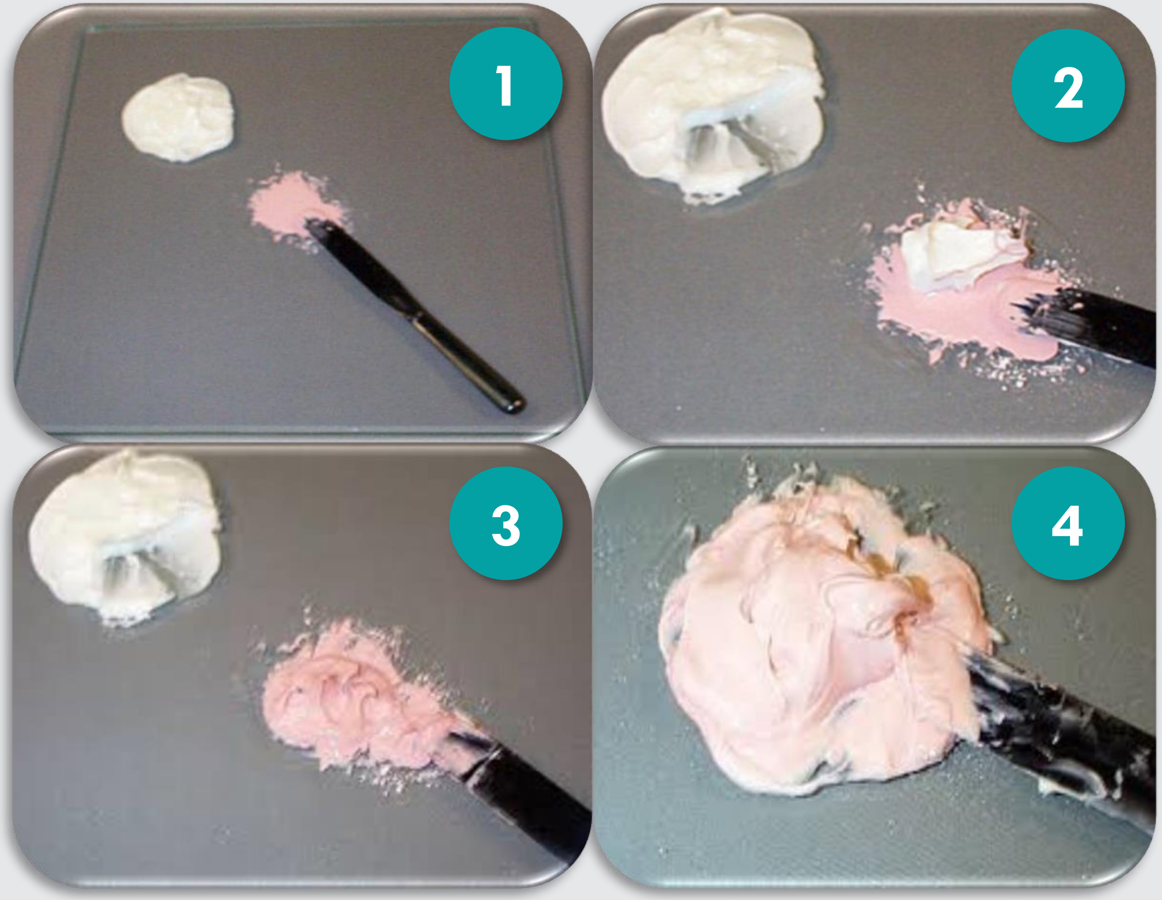
$$60\text{ mL} \times 10\% = x\text{ mL} \times 3\%$$

$$600 = 3x$$

$$x = 200\text{ mL}$$

SOLID DILUTIONS

1. The Dilution Of Solid Products (Creams And Ointments) Reduces Their Concentration Also.
2. They Can Be Represented As Ratio Strengths Or Percent Strengths Just Like Solutions.
3. They Are Diluted With An Ointment Or Cream Base With No Active Ingredient. The Calculations Are Done The Same Way As Solution Dilutions.
4. The Proportion Rule Or Quantity/ Concentration Formula Can Be Used.



SOLID DILUTIONS

EXAMPLE No. 6

How many grams of lidocaine 20% ointment and how many grams of an ointment base must be combined to obtain 2 lbs of a 2.5% lidocaine topical ointment?

(1 lb = 454 g)

$$2.5\% = \frac{2.5\text{ g}}{100\text{ g}} = \frac{x}{908\text{ g (2 lbs)}}$$

$x = (2.5\text{ g} \times 908\text{ g}) \div 100\text{ g} = 22.7\text{ g}$ lidocaine total in 2 lbs

$$20\% = \frac{20\text{ g}}{100\text{ g}} = \frac{22.7\text{ g}}{x}$$

$x = (22.7\text{ g} \times 100\text{ g}) \div 20\text{ g} = 113.5\text{ g}$

113.5 g of lidocaine 20%

794.5 g of ointment base

113.5 + 794.5 = 908 g = 2 lbs

Or, try the following formula:

$Q1 \times C1 = Q2 \times C2$

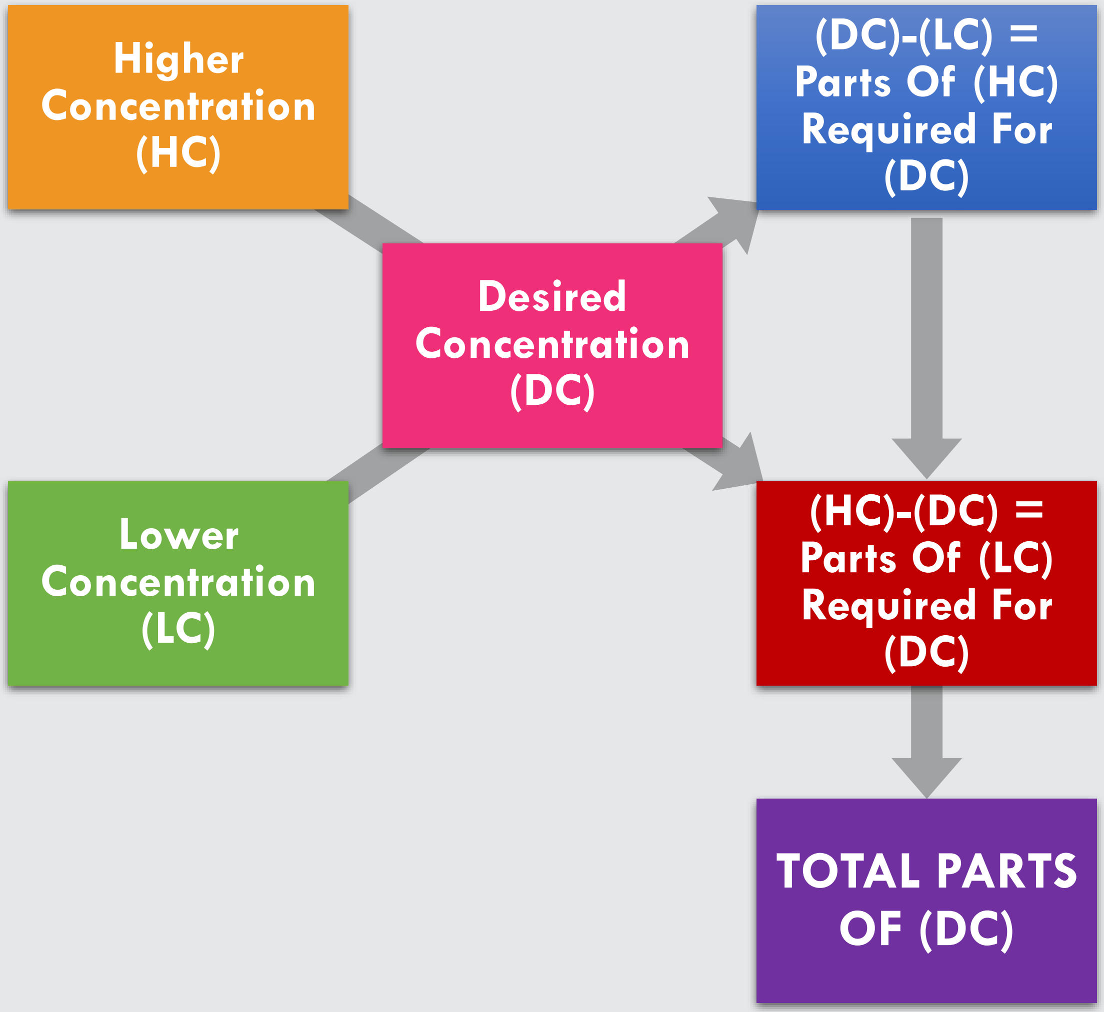
$x\text{ g} \times 20\% = 908\text{ g} \times 2.5\%$

$20x = 2270$

$x = 113.5\text{ g}$ lidocaine 20%

ALLIGATIONS

1. Alligations Is A Method Used To Calculate The Percent Strength When Combining Multiple Strengths Of The Same Ingredient.
2. It Can Also Be Used When The Volume Of Each Of Two Different Strengths Of The Same Ingredient Must Be Determined In Order To Make A New Strength.
3. This New Strength Must Be In-between The Two Strengths That Are Being Combined.



ALLIGATIONS

1. There Are Two Different Ways To Perform Alligation Calculation.
2. The First Method Uses The Total Volumes Of The Solutions And The Total Grams Of The Ingredient In The Solutions, And Then, Using The Proportion Rule, The New Percent Strength Is Determined.

$$\frac{A\text{ g} + B\text{ g} + C\text{ g}}{A\text{ volume} + B\text{ volume} + C\text{ volume}} = \frac{x\text{ g}}{100\text{ mL}}$$

$x = \%$ strength

ALLIGATIONS

EXAMPLE No. 7

Mix together 100 mL of 50% dextrose with 250 mL of 40% dextrose and 450 mL of 70% dextrose. What is the new percent strength?

$50\% = \frac{50\text{ g}}{100\text{ mL}}$ so 100 mL of 50% solution = 50 g

$40\% = \frac{40\text{ g}}{100\text{ mL}}$ so 250 mL of 40% solution = 100 g (40×2.5)

$70\% = \frac{70\text{ g}}{100\text{ mL}}$ so 450 mL of 70% solution = 315 g (70×4.5)

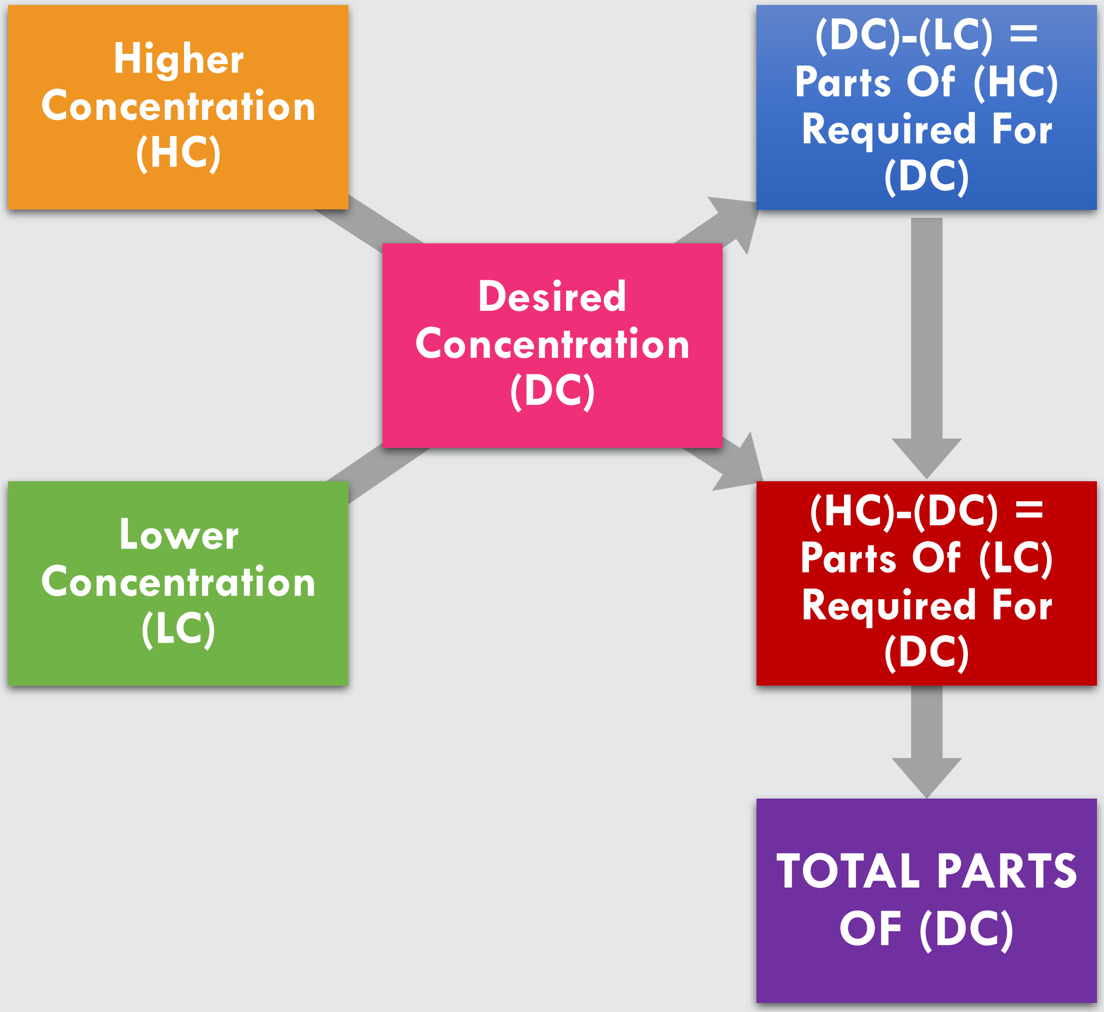
Totals = 800 mL volume 465 g ingredient

$$\frac{465\text{ g}}{800\text{ mL}} = \frac{x}{100\text{ mL}}$$

$x = (465\text{ g} \times 100\text{ mL}) \div 800\text{ mL} = 58.125\text{ g} = 58\%$

ALLIGATIONS

1. The Second Method Uses The Percent Strengths Converted Into Decimals And Then Multiplied By Their Respective Volumes.
2. This New Volume Then Is Divided By The Original Volume And The Answer Is Multiplied By 100 To Obtain A Percent Strength.



ALLIGATIONS

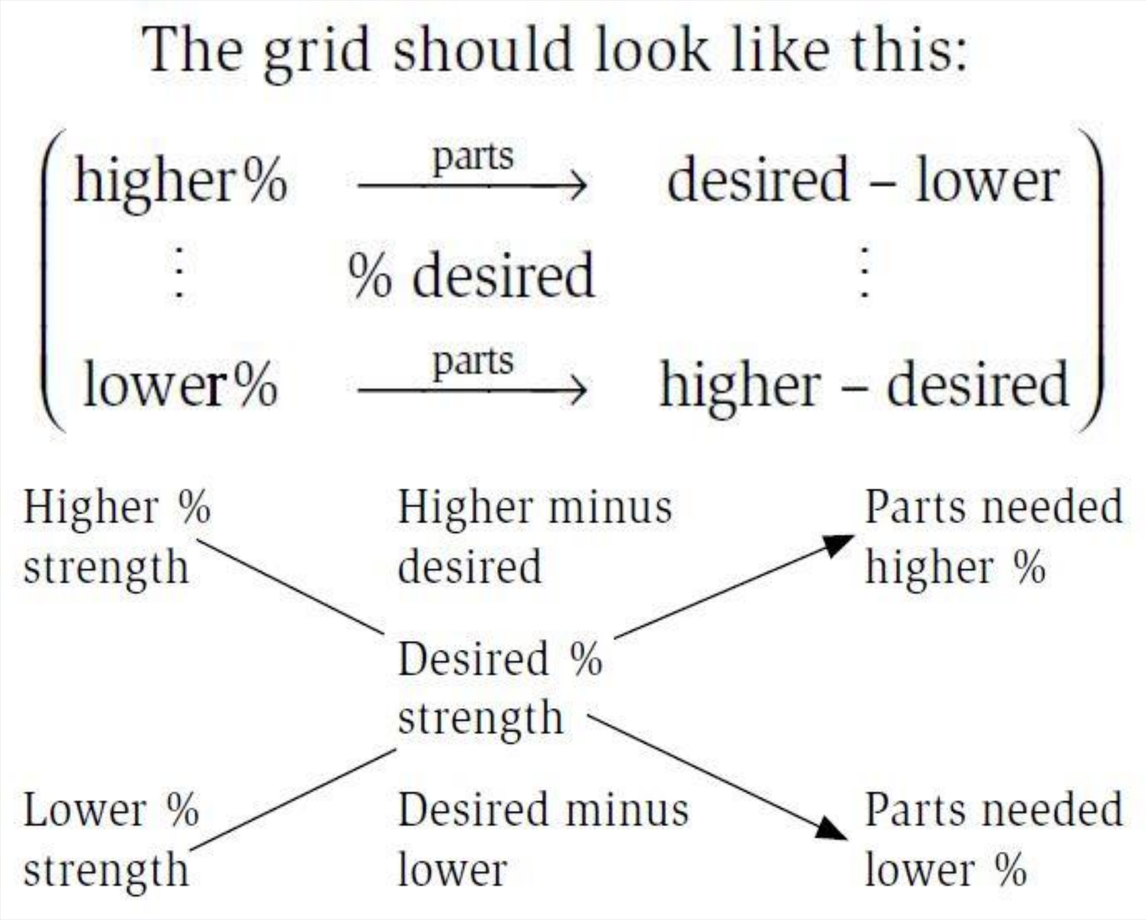
EXAMPLE No. 8

Mix together 100 mL of 50% dextrose with 250 mL of 40% dextrose and 450 mL of 70% dextrose. What is the new percent strength?

50% = 0.5 × 100 mL = 50 mL
40% = 0.4 × 250 mL = 100 mL
70% = 0.7 × 450 mL = 315 mL
Totals: 800 mL 465 mL
465 mL ÷ 800 mL = 0.58125 × 100 = 58.125% = 58%

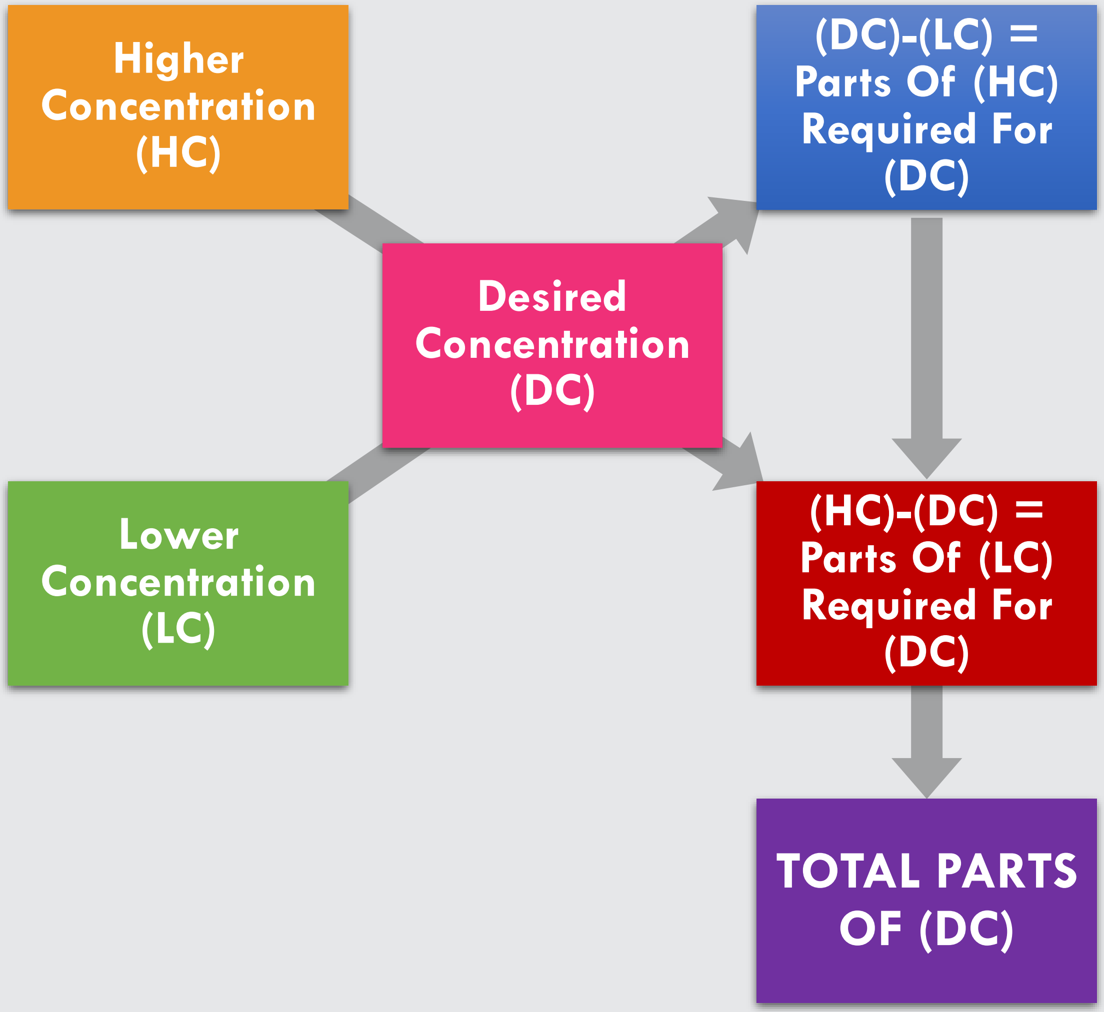
ALLIGATIONS

1. Both Methods Produce The Same Answer. As Mentioned Earlier, The Simplest Way Is Not Always The Best Way. Confidence In Calculations Is Important, So The Method Used (When More Than One Is Possible) Depends On The Person.
2. Alligations Alternate Is The Method Used To Determine The Volume Necessary For Each Ingredient Combined (i.e., Same Ingredient, Different Percent Strength) To Produce A New Percent Strength. This New Percent Strength Must Be In –Between The Two Being Combined..



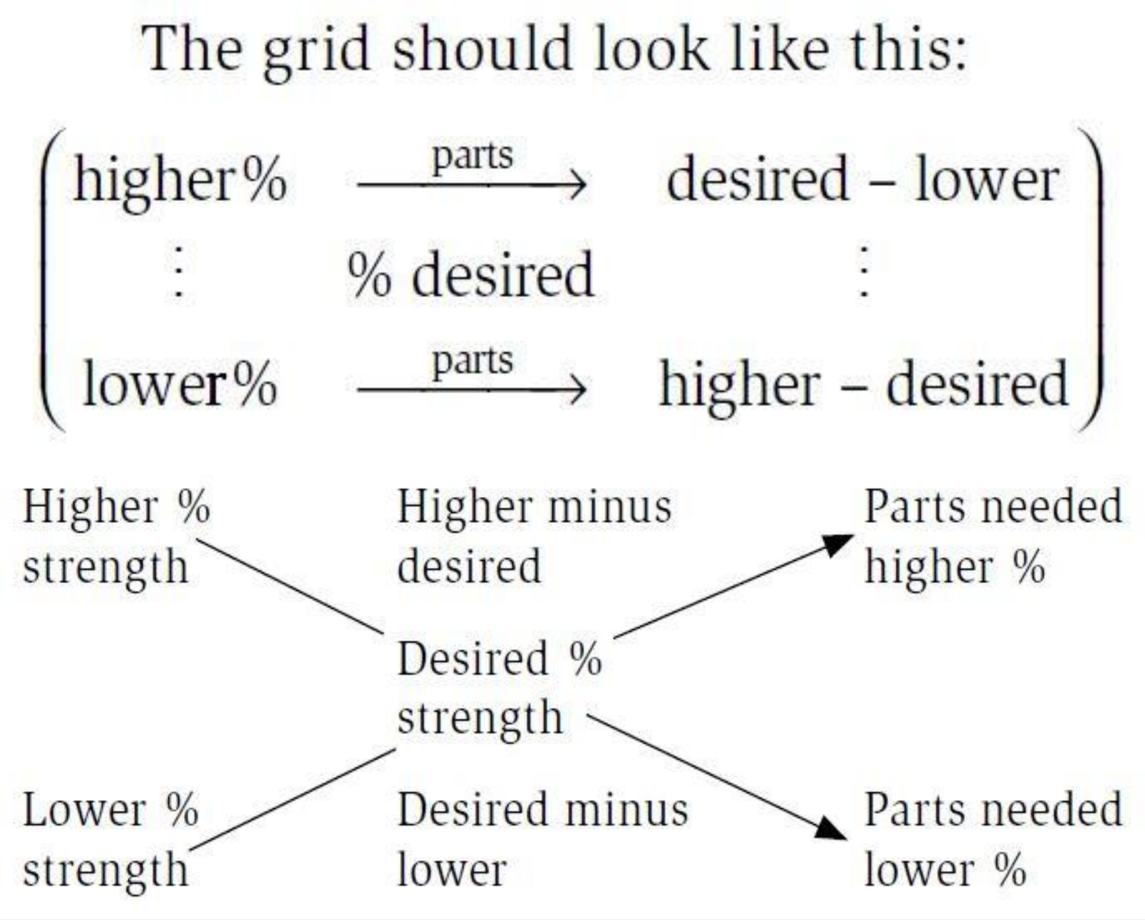
ALLIGATIONS

4. This Method Uses A Grid To Complete The Calculations. It Resembles A Tic-tac-toe Board And Provides A Great Visual For Calculating. The Answers Obtained Will Be The Ratio In Which The Ingredients Should Be Combined. The Ratio Should Always Be Simplified To It Smallest Form.
5. The Percent Strengths On Hand Go In The Left-hand Boxes Of The Grid, The Desired Percent Strength Goes In The Middle Box, And The "Parts" Needed Are In The Right-hand Boxes, Which Translate To The Ratio.



ALLIGATIONS

6. When The Desired Strength Is Subtracted From The Higher Strength, It Represents The Parts Needed Of The Lower Strength. The Lower Strength Is Subtracted From The Desired Strength (To Obtain A Positive Number), And It Represents The Parts Needed Of The Higher Strength.



ALLIGATIONS

EXAMPLE No. 9

A patient needs 70% dextrose and the pharmacy carries 95% and 30% strengths. What proportion is needed to make the 70% solution?

$$\begin{pmatrix} 95 & \rightarrow & 40 \\ & 70 & \\ 30 & \rightarrow & 25 \end{pmatrix} \text{ ratio} = 40{:}25\text{, which simplifies to } 8{:}5$$

(higher %) 95 – (desired %) 70 = 25, which represents the parts needed of lower %
(desired %) 70 – (lower %) 30 = 40, which represents the parts needed of higher %
The ratio of 40:25 can be simplified to 8:5. This means, for every eight parts of 95%, five parts of 30% will be used.

ALLIGATIONS

EXAMPLE No. 10

Mix 70% and 30% dextrose to obtain 1000 mL of a 40% concentration.

$$\begin{pmatrix} 70 & \rightarrow & 10 \\ & 40 & \\ 30 & \rightarrow & 30 \end{pmatrix} \text{ ratio} = 10{:}30\text{, which simplifies to } 1{:}3$$

1 part + 3 part = 4 parts total, 1000 mL/4 parts = 250 mL/part

1 part 70% = 250 mL × 1 = 250 mL

3 parts 30% = 250 mL × 3 = 750 mL

$$\overline{1000 \text{ mL}}$$

ALLIGATIONS

EXAMPLE No. 11

How much 85% aminosyn must be added to 150 mL of 60% aminosyn to make an 80% solution?

$$\begin{pmatrix} 85 & \rightarrow & 20 \\ & 80 & \\ 60 & \rightarrow & 5 \end{pmatrix} \text{ ratio} = 20{:}5, \text{ which simplifies to } 4{:}1$$

The one part represents the 60% aminosyns, which has a known volume of 150 mL. The four parts represent the 85% aminosyn, 150 mL (1 part) $\times 4 = 600$ mL. An 80% solution needs 150 mL of 60% and 600 mL of 85%.

ALLIGATIONS

EXAMPLE No. 12

Sodium chloride 23.4% and water are mixed to make 2 L of 0.9% sodium chloride.

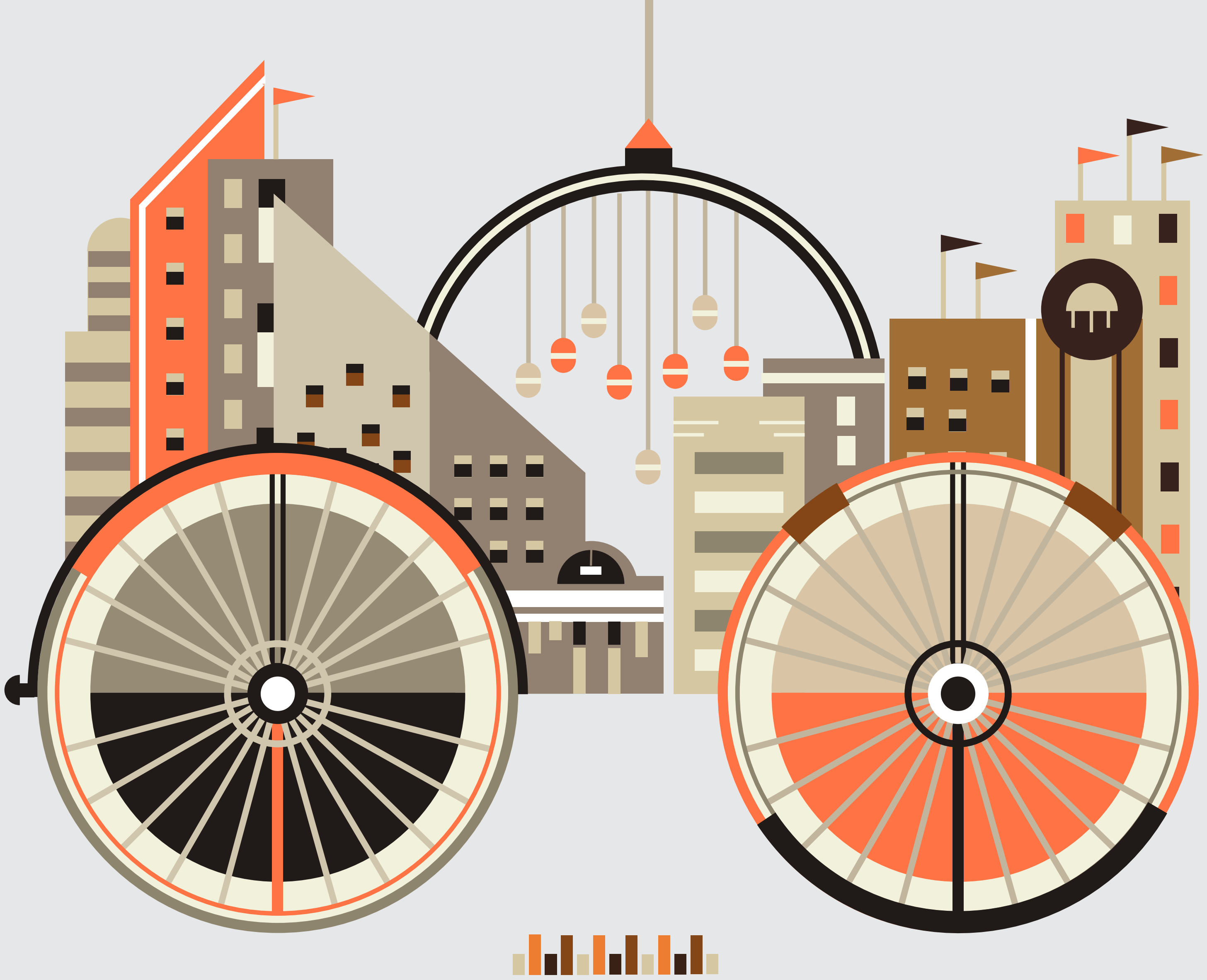
$$\begin{pmatrix} 234(23.4) & \rightarrow & 9 \\ & 9(0.9) & \\ 0 & \rightarrow & 225 \end{pmatrix}$$

Water = 0%
Ratio = 9:225, which simplifies to 1:25
Total parts = 1 + 25 = 26 and volume needed is 2000 mL (2 L)
2000 mL/26 = 76.9 mL per part (round to 77 mL)
1 part of 23.4% = 77 mL
25 parts of water (0%) = 76.9 × 25 = 1922.5 mL round to 1923 mL
1923 mL + 77 mL = 2000 mL

CONCLUSION

Systematic Dilution Methods Significantly Improve The Accuracy Of Solution Preparation Especially At Low Concentration For Highly Potent Chemicals.

During Chemical Analysis Of Trace Residue The Dilution Technique Are Absolutely Crucial.



THANK YOU VERY MUCH