Metrology

Following systems of measurement are used in pharmacy

1. **Household system & Avoirdupois system**
2. **Apothecary system**
3. **metric system**

1. Household system & Avoirdupois system

The household system of measurement includes teaspoons, table spoons, pints, quarts and gallons for measuring liquid. The household system and the avoirdupois system are synonymous for measuring weight, and include ounces and Pounds. In both systems, Pound are found is 16 Ounces.

2. Apothecary system

- Apothecary System is an outdated system of measurement.
- Apothecary system 1 pound is equal to 12 ounces.
- Equivalent unit of measure between the apothecary system & the avoirdupois is the **Grain** for measuring the weight.
- One grain is equal to 64.8 milligrams (mg) (Sometime expressed as 65 mg)

3. Metric system of Measurement

- **Metric system** is legal standard for measurement in Pharmacy (Also in Pharmacopoeia-IP).
- In metric system, the basic unit of measurement is meter (m), for measuring length or distance; Liter (L), for measuring liquid volume; and gram (g), for measuring weight.

Prefixes used in metric system

Prefix	Symbol	Meaning	Conversion
Kilo	K	One thousand times	Base unit $\times 10^{3}$
Hecto	H	One hundred times	Base unit $\times 10^{2}$
Deci	D	One tenth	Base unit $\times 10^{-1}$
Centi	C	One hundredth	Base unit $\times 10^{-2}$
Milli	M	One thousandth	Base unit $\times 10^{-3}$
Micro	Mc or µ	One millionth	Base unit $\times 10^{-6}$

Common Equivalents used in Pharmacy Practice

Common Equivalents used in Pharmacy Practice	
1 mL=16.23 minim	1 mg= 1000 mcg (mcg=microgram)
1 pt=473 mL (pt=pint)	1g= 1000 mg (mg-milligram)
1g=15.432 gr	1 kg= 1000 g
1 gr=64.8 mg (gr= grain)	1 in= 2.54 cm (in=inches)
1 oz= 28.35 g (oz=Ounce)	1m= 39.37 in
1 kg=2.2 lb (lb=Pound)	1 cm= 0.394 in

FOR VOLUME MEASUREMENTS		
System	Unit/Symbol	Equivalent
Apothecary	Minim	0.06 mL
	Fluidram	5 mL=60 minim
	Fluidounce	6 Fluidram =30 mL
	Pint	16 Fluidounce = 480 mL
	Quart	2 pint=32 Fluidounce =960 mL
	Gallon	4 Quart= 8 pint=3840 mL
Household	Teaspoon (tsp)	5 mL
	Tablespoon (tbsp)	3 tsp=15 mL
	Fluid ounce (fl oz)	2 tbsp=30 mL
	Cup (c)	8 fl oz =240 mL
	Pint (pt)	2c=480 mL
	Quart (qt)	2pt=4c=960 mL
	Gallon (gal)	4 qt=16c=3840 mL
FOR WEIGHT MEASUREMENT		
Avoirdupois	Grain (gr)	65 mg
	Ounce (oz)	473.5 gr=30 g
	Pound (lb)	16 oz= 7000 gr= 454 g
Apothecary	Grain (gr)	65 mg
	Scruple	20 gr= 1.3 g
	Dram	3.9 g
	Ounce	30 g
	Pound	373.2 g
Household	Ounce (oz)	30 g
	pound	16 oz= 454 g

Table: Systems of measurement & Equivalents used in Pharmacy

IU (International Units)

- Drugs amounts are expressed in IU.
- For Example, Amount of Insulin & Vitamin D is measured in IU.
- IU per milligram varies with each drug.

Milliequivalents

- **The Milliequivalents** expresses electrolyte concentration. A **Milliequivalents** is the number of positively charged ions per liter of salt solution & indicates the composition of IV fluids.

Temperature

- Every 5 degree change in the Celsius scale is equivalent to a 9 degree change in the Fahrenheit scale.
- At one temperature, the value on the celcius and Fahrenheit scales are equal, that is - 40 ºF = - 40 ºC.
- To convert from Fahrenheit to Celsius.

$$^{o}F = (1.8 \times {}^{o}C) + 32^{o}$$

Concentration

- Concentration indicates the amount of active ingredient per volume or weight of substances.

Expression of Concentration

1) % w/v (% weight-in-volume)
2) % v/v (%volume-in-volume)
3) % w/w (% weight-in-weight)

Expression of Concentration	Description	Example
% w/v (% weight-in-volume)	• For conc Expression as **Solids in Liquids.** • **% weight-in-volume**= number of grams of a solid substance per 100 mL of Liquid vehicle.	5% dextrose solution-5 % w/v solution of Dextrose in water contains 5 g dextrose in per 100 mL of total vehicle.
% v/v (% volume-in-volume)	• For conc Expression as **Liquids in Liquids.** • **% volume-in-volume**= number of millilitres of a liquid per 100 mL of Liquid vehicle.	70 % Isopropyl alcohol- contains 70 mL of isopropyl alcohol in every 100 mL of total solution. Note- 70 mL isopropyl alcohol and added water (≈30 mL)to make 100 mL volume.
% w/w (% weight-in-weight)	• To expresses the **Mixture of solids** • **% w/w (% weight-in-weight)** =number of grams of a solid substance in 100 gms of a solid vehicle	10 % w/w Hydrocortisone cream- contains 10g of Hydrochloride per 100 g cream

Percentage

Percentage refer to parts per a total of 100 parts.

Dilution

- It is the process of decreasing the concentration of a liquid. Pharmaceutical products are diluted by adding a diluent to the original preparation.
- Upon dilution, the amount of drug in the final product will remain constant but drug concentration will decrease.

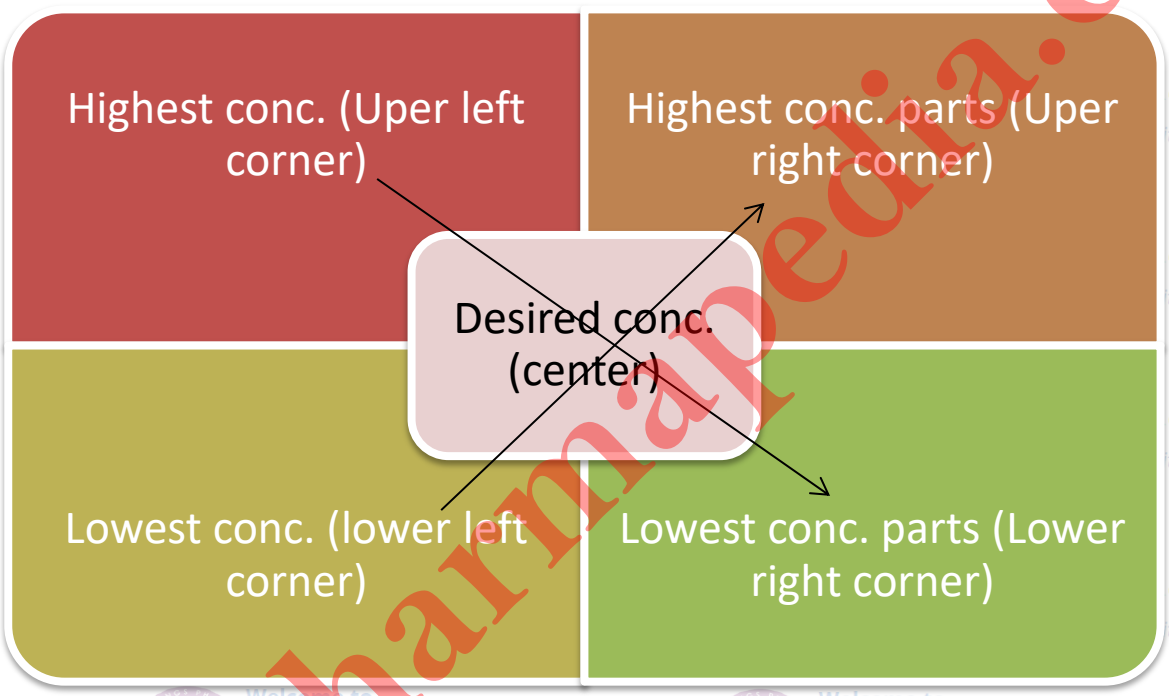
$$Q1 \times C1 = Q2 \times C2$$

Q1= Quantity of first solution

C1= Conc of the first solution
Q2= Quantity of second solution
C2= Conc of the second solution

Alligation method for compounded products

- In Alligation method, two different strength solutions containing the same active ingredient can be combined to achieve the desired strength.
- This method may be used for both weight or volume.
- Alligation method is used to calculate the amount of high-strength product and a low-strength product that must be added together to make an intermediate-strength product.



Procedure

1. In the upper left corner, place the given highest concentration as a whole number. In the lower left corner, write the given lowest concentration. In the center of the box, write the desired concentration.

2. Write the difference between the upper left corner and the centre corner in the lower right corner (subtracting the smaller number from the larger number). Next, write the difference between the lower left corner number and the centre number in the upper right corner. The numbers on the right corners represent the required part of each solution to make a new solution.

3. Add the numbers in the right sides to determine the total part needed for the new solution

Example1: How to prepare a 500 mL of 30% v/v alcohol from a 70 % v/v alcohol solution and 20 % v/v alcohol solution?

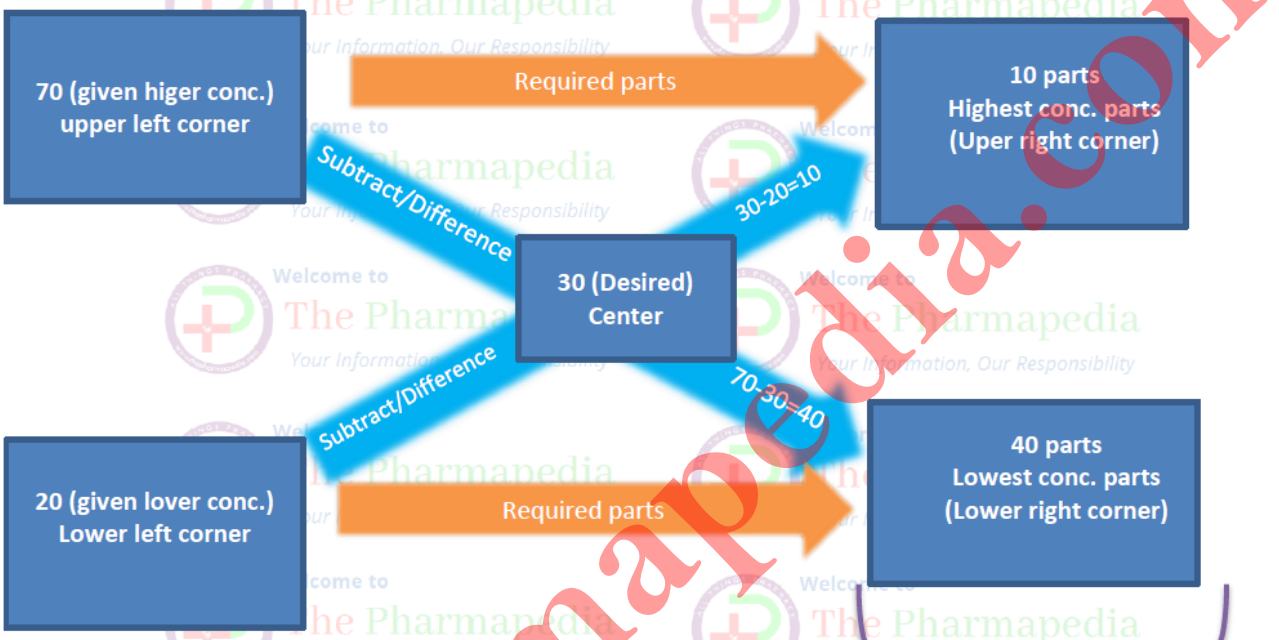
Solution:

Desired= 30% v/v alcohol

Given= 70 % v/v alcohol solution and 20 % v/v alcohol solution

Step 1: Write the given/known strength quantities and desired strength

Step 2: Subtract (Diagonal) & write the difference in the corner as mentioned in procedure



For total 50 parts or 50 mL of 30% v/v alcohol, we need to mix 10 parts of 70% v/v alcohol and 40 parts of 20% v/v alcohol;

But we need to prepare total 500 mL of 30% v/v alcohol so

-For 50 mL we need 70% v/v alcohol= 10 parts/mL

-So for 1 mL we need 70% v/v alcohol $=\frac{10}{50}$

-So for 500 mL we need 70% v/v alcohol= $\frac{10}{50}\times500$=100 mL of 70% v/v alcohol

Like this

-For 50 mL we need 20% v/v alcohol= 40 parts/mL

-So for 1 mL we need 20% v/v alcohol $=\frac{40}{50}$

-So for 500 mL we need 20% v/v alcohol= $\frac{40}{50}\times500$=400 mL of 70% v/v

So finally we have to mix 100 part of 100 mL of 70% v/v alcohol & 400 part or 400 mL of 20 %v/v alcohol to get **500 mL** of 30 % v/v alcohol

Right side total parts

10 parts + 40 parts =50 parts or 50 mL

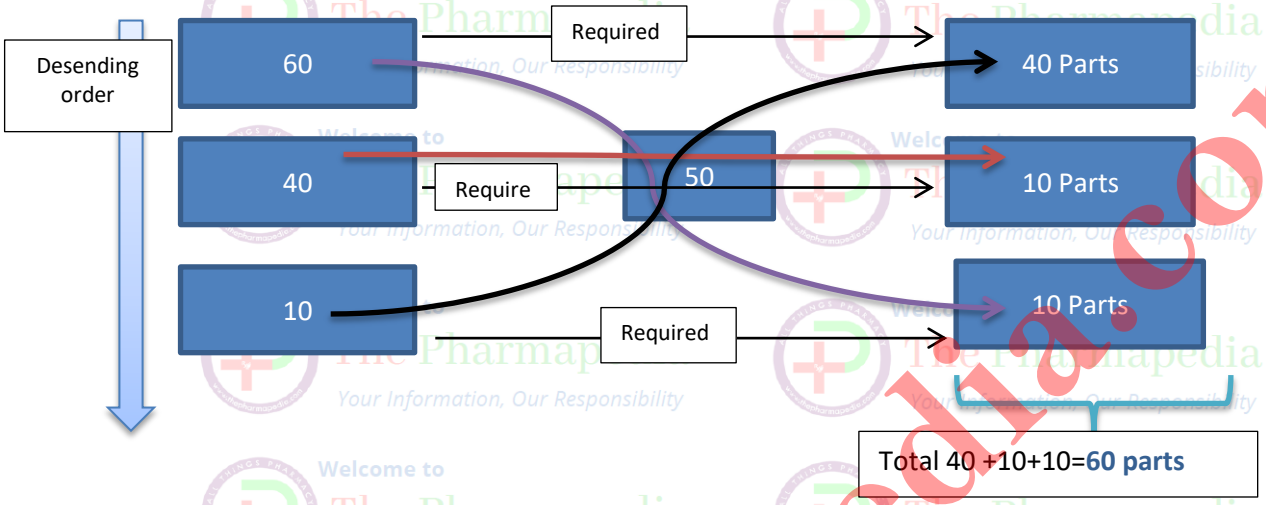
Example2: How to prepare a 1000 mL of 50% v/v alcohol from a 60 % v/v , 40 % v/v & 10% v/v alcohol solution ?

Solution:

Desired= 50% v/v alcohol

Given= 60 % v/v , 40 % v/v & 10 % v/v alcohol solution.

Follow as above steps.



For total **60 parts** or 60 mL , we need to mix 40 parts of **60% v/v** alcohol ,10 parts of **40% v/v** alcohol & 10 parts of 10 %v/v alcohol; (40+10+10=60)

But we need to prepare total 1000 mL of 50% v/v alcohol so

-For 60 mL we need **60% v/v** alcohol= 40 parts/mL

-So for 500 mL we need **60% v/v** alcohol= $\frac{40}{60}$×1000=**666.66 mL** of 60% v/v alcohol

Like this

-For 60 mL we need 4**0% v/v** alcohol= 10 parts/mL

-So for 1000 mL we need **20% v/v** alcohol= $\frac{10}{60}$×1000=**166.66 mL** of 40% v/v

Again like this

-For 60 mL we need 1**0% v/v** alcohol= 10 parts/mL

-So for 1000 mL we need **10% v/v** alcohol= $\frac{10}{60}$×1000=**166.66 mL** of 10% v/v

So finally we have to mix 666.66 part or **666.66 mL** of **60% v/v** alcohol , 166.66 parts or 166.66 mL of 40 % v/v alcohol & 166.66 part or **166.66 mL** of **10 %v/v** alcohol to get 1000 **mL** of 50 % v/v alcohol (666.66+166.66+166.66=999.99≈1000mL)

Specific Gravity

- Specific gravity is the ratio of the weight of a substance to the weight of an equal volume of water at same temperature. Or
- It has no unit.
- Specific gravity is a ratio of the density of a substance to the density of water.

$$\text{Specific gravity}=\frac{weight\ of\ substance}{number\ of\ milliliters\ of\ a\ substance}$$

- If Specific gravity > 1 =indicates solution or substance is thick & viscous / heavier than water.
- If Specific gravity < 1 =indicates solution or substance is volatile chemicals & prone to evaporation/ lighter than water.

Isotonicity

- For a solution to be termed isotonic (equal tone) it must have the same osmotic pressure as a specific body fluid.
- Example:
  - 0.9% w/v Normal saline (sodium chloride) solution
  - 5.0% w/v Dextrose solution
  - 2.0% w/v Boric acid solution
- Any solution is considered to be isotonic if it has a freezing point of –0.52◦C.
- If a solution is placed in contact with a membrane that is permeable to molecules of the solvent, but not to molecules of the solute, the movement of solvent through the membrane is called osmosis.
- Movement of solvent molecules across semi-permeable membrane is known as osmosis.

Importance of Isotonisity

- If a **hypotonic solution** (with lower osmotic pressure than that of a bodily fluid) is administered intravenously water will pass into the red blood cells, causing them to **swell** and possibly **burst (haemolysis)**.
- If a **hypertonic solution** (with higher osmotic pressure than that of a bodily fluid) is administered intravenously then water is drawn from the cells in an attempt to dilute the solution, causing them to **shrink (crenation)**.

Measurement of Tonicity

1. Based on Freezing point depression/ Cryoscopic Method
2. Based on Sodium Chloride equivalent value
3. Based on molecular weight
4. White-Vincent method
5. Hemolytic method

1. Based on Freezing point depression

All solutions, which freeze at -0.52°C, will be isotonic with body fluid/blood plasma.

Freezing points are usually expressed in terms of 1% solutions.

A hypotonic solution can be made isotonic by adding an adjusting substance, usually sodium chloride.

The exact amount of substance to be added is to be calculated by following the formula:-

$$W = \frac{0.52 - a}{b}$$

W=Weight of the added substance (g/100ml);
a=Freezing point depression of the unadjusted hypotonic solution;

b=Freezing point depression

Example

The freezing point depression of a 1% w/v solution of morphine sulfate is 0.08◦C and that of 1% w/v sodium chloride solution is 0.576. How many grams each of morphine sulfate and sodium chloride are required to prepare 50 ml of a 1% w/v morphine sulfate solution isotonic with blood plasma?

Note:

- Confusing '**freezing point**' and '**freezing point depression**' is common source of error in isotonicity.
- A solution with **freezing point depression 0.5◦C** has **freezing point –0.5◦C** as 'depression' indicates a decrease in value.
- All units must be in same manners for calculation.

Solution:-
The freezing point of (a 1% w/v solution of) morphine sulfate is –0.08˚C (means 1 % w/v morphine will reduce 0.08˚C in freezing point, but we require to reduce 0.52 ˚C for Isotonicity. The required freezing point is 0.52◦C, therefore the freezing point need to be lowered by: 0.52◦C - 0.08◦C (produced by morphine sulfate)= 0.44˚C; we can say that we will require to 0.44˚C depress the freezing point using NaCl substance. A 1% w/v sodium chloride solution produces a freezing point depression of 0.576˚C, therefore the weight of sodium chloride required to produce a depression of 0.44◦C is calculated by following equation

$$W = \frac{0.52 - a}{b}$$

W=Weight of the added substance (**g/100ml**);
a=Freezing point depression of the unadjusted hypotonic solution;
b=Freezing point depression of a 1% w/v solution of the adjusting substance

$$W = \frac{0.52 - a}{b}$$
$$= \frac{0.52 - 0.08}{0.576}$$
$$= 0.7638\text{g}/100\text{ml}$$

0.7638 g NaCl is required for 100 ml, but as per the question, we have to prepare 50 mL so

1. Morphine sulfate required for 50 ml, 1% w/v solution(i.e 1 g in to 100 ml) of morphine sulfate so for 50 ml solution, we require morphine=(1g/100ml) x50 ml=0.5 g.
2. Like this, 1 % w/v NaCl required for 50 mL solution=(0.7638 g/100 mL)x 50 mL= 0.3819g

Example

A pharmacist receives a prescription for 10 ml of isotonic 0.5% w/v chloramphenicol eye drops, what weight of sodium chloride is required to make the solution isotonic with tears? Given data:- A 1% w/v solution of chloramphenicol has a freezing point depression of 0.06◦C &1% w/v sodium chloride produces a freezing point depression of 0.576◦C./ 0.9% w/V NaCl produces a freezing point depression of 0.52°C.

Solutions:

1% w/v solution of chloramphenicol has a freezing point depression of 0.06◦C. Therefore a 0.5% w/v solution has a freezing point depression of 0.06◦C×0.5 = 0.03◦C. The required freezing point is −0.52◦C, therefore the freezing point must be lowered by: 0.52◦C−0.03◦C = 0.49◦C. 1% w/v sodium chloride produces a freezing point depression of 0.576◦C, therefore the weight of sodium chloride required to produce a depression of 0.49◦C is:

$$W = \frac{0.52 - a}{b}$$
$$= \frac{0.52 - 0.03}{0.576}$$
$$= 0.8507\text{g}/100\text{ml}$$

As the prescription requests 10 ml of eye drops we require {(0.8507/100)}x 10 = 0.08507g = 85.07mg of sodium chloride.

2. Based on Sodium Chloride equivalent value

Sodium chloride equivalent (E) of a drug is the amount of sodium chloride that is equivalent to 1 gm of the drug. The percent of sodium chloride required for adjusting the isotonicity can be calculated using the following equation.

PSA = 0.9 – (PSM × E of medicament)

PSM = Percent strength of medicament

PSA = Percent of sodium chloride for adjustment of isotonicity

Above equation is used to calculate the amount of adjusting substance (sodium chloride) required for making the solution isotonic. It is valid for 100 ml solution.

Example - Calculate the gram of sodium chloride needed to make 30 ml of a 2% isotonic physostigmine salicilate solution using sodium chloride method.

Solution:

E value of physostigmine salicilate = 0.16

PSM =2.0 %

Volume of preparation required = 30 ml For equation

PSA = 0.9 – (PSM × E of medicament)

= 0.9 – (2.0 × 0.16)

= 0.9 - 0.32 = 0.58 %

The above strength is valid for 100 ml since is expressed in percent. It should be prepared from 30 ml of solution.

For 100 ml of solution, sodium chloride required =0.58

For 30 ml of solution, sodium chloride required

30 × 0.58/100 = 17.4/100 =0.174 g of sodium chloride