Pharmaceutical Calculations

Weights & Measures:

- There are two systems of weights and measures:
  - **The Imperial System**
  - **The Metric System**

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The Imperial System:

- It is an **old system** of weights and measures.

Measurements of weights in imperial system

- **Weight is a measure of the gravitational force acting on a body and is directly proportional to its mass.**
- The imperial systems are of two types:

  (a) Avoirdupois system

  (b) Apothecaries system

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(a) Avoirdupois system

- In this system **pound (lb)** is taken as the standard of weight (mass).

1 pound avoir (lb) = 16 oz avoir **oz is pronounced as *ounce*.**
1 pound avoir (lb) = 7000 grains (gr)

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(b) Apothecary or Troy system

- In this system **grain (gr)** is taken as the standard of weight (mass).

1 pound apoth (lb)	= 12 ounces ( )	1 pound apoth (lb) = 5760 grains (gr)
1 ounce ( )	= 8 drachms ( )	
1 drachm ( )	= 3 scruples (ɜ)	
1 scruple (ɜ)	= 20 grains (gr)	

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- **Measurements of volumes**

1 gallon (c)	= 4 quart
1 quart	= 2 pint (o)
1 pint (o)	= 20 fluid ounce
1 fluid ounce	= 8 fluid drachm
1 fluid drachm	= 3 fluid scruple
1 fluid scruple	= 20 minims

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The Metric System:

- **'Kilogram'** is taken as the standard weight (mass).

1 kilogram (kg)	= 1000 grams (g)	Kilo = 1000	Greek word
1 hectogram (hg)	= 100 grams (g)	Hecto = 100	Greek word
1 dekagram (dg)	= 10 grams (g)	Deka = 10	Greek word
1 gram (g)	1 gram (g)		
1 decigram (dcg)	1/10 gram (g)	Deci = 1/10	Latin word
1 centigram (cg)	1/100 gram (g)	Centi = 1/100	Latin word
1 milligram (mg)	1/1000 gram (g)	Milli = 1/1000	Latin word
1 microgram (µg)	10^{-6} gram (g)	Micro = 10^{-6}.	
1 nanogram (ng)	10^{-9} gram (g)	Nano = 10^{-9}.	

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- **Measurement of volume**
- 'Litre' is taken as the standard of volume.

1 liter (L, lit)	1000ml
1 microliter (µl)	1/1000 ml

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Conversion Table:

Domestic measures	Metric System	Imperial system
1 drop	0.06ml	1 minim
1 teaspoonful	5 ml	1 fluid drachms
1 desert spoonful	8 ml	2 fluid drachms
1 tablespoonful	15 ml	4 fluid drchms
1 wine-glassful	60 ml	2 fluid ounces
1 teacupful	120 ml	4 fluid ounces
1 tumblerful	240 ml	8 fluid ounce

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Weight Measure Conversion Table:

1 kilogram	= 2.2 pounds (lb)
1 ounce apoth.	= 30 g
1 pound avoir.	= 450 g
1 grain	= 65 mg

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Percentage Solutions:

- The concentration of a substance can be expressed in the following three types of percentages:
- **Weight in volume (w/v):** Required to express concentration of a solid in liquid.
- **Weight in weight (w/w):** Required to express concentration of a solid in solid mixture.
- **Volume in volume (v/v):** Required to express concentration of a liquid in another liquid.

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- **Weight in volume (w/v)**
- In this case the general formula for 1%(w/v) is:

		The formula is actually:	
Solute	1part by weight	Solute	1 g
Solvent upto	100 parts by volume	Solvent upto	100 ml

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Exercise1: Calculate the quantity of sodium chloride required for 500ml of 0.9% solution.

Ans: 0.9%w/v solution of sodium chloride = $\frac{0.9g\ \text{Sodium chloride}}{100ml\ \text{solution}}$

So 500ml solution will contain $\frac{0.9g\ \text{Sodium chloride}}{100ml\ \text{solution}}$ x 500ml

$$= \frac{0.9g \times 500ml}{100ml} = \frac{0.9 \times 500}{100} g = 4.5\ g \text{ sodium chloride}$$

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Weight in weight (w/w)

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Solute	1part by weight	Solute	1 g
Solvent upto	100 parts by weight	Solvent up to	100 g

Volume in volume (v/v)

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		The formula is actually:	
Solute	1part by volume	Solute	1 ml
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Calculation By Allegation Method:

- This types of calculation involves the **mixing of two similar preparations, but of different strengths, to produce a preparation of intermediate strength.**
- The name is derived from the Latin *alligatio,* meaning the act of attaching and hence referes to the lines drawn during calculation to bind quantities together.

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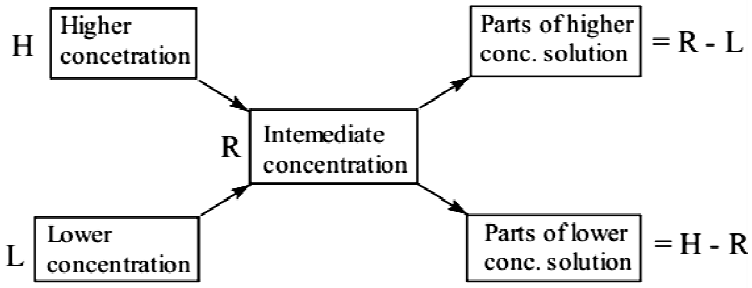
- Method:



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***Example*:**

Prepare 600ml of 60%v/v alcohol from 95% v/v alcohol.

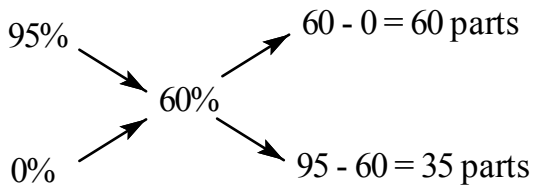
Higher concentration = 95%

Required concentration = 60%

Lower concentration = 0% (i.e. water)

So from allegation method it is obtained:

Volume of 60% alcohol solution = 600ml



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$$\therefore \text{the volume of 95\% alcohol required}$$

$$= \frac{\text{Parts of 95\% alcohol}}{\text{Parts of water + parts of 95\% alcohol}} \times 600\text{ml}$$

$$= \frac{60}{35+60} \times 600\,\text{ml} = 379\text{ml}$$

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Proof Spirits:

- For excise (tax) purpose, the strength of alcohol in indicated by *degrees proof*.
- ***The US System*: Proof spirit** is 50% alcohol by volume (or 42.49% by weight).
- ***The British / Indian system*: Proof spirit** is **57.1%** ethanol by volume (or 48.24% by weight).
- *Definition*: **Proof spirit** is that mixture of alcohol and water, which at 51^0F weighs 12/13^{th} of an equal volume of water.
- [N.B. Density of proof spirit = 12/13 of density of water at 51^0F = 0.923 g/ml]

100 degree proof alcohol = 57.1% v/v alcohol

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- If the strength of the alcohol is above 57.1%v/v alcohol then the solution is called ***"over proof"***.
- If the strength of the alcohol is below 57.1%v/v alcohol then the solution is called ***"under proof"***.
- In India, the excise duty is calculated in terms of Rupees per litre of proof alcohol.
- So any strength of alcohol is required to be converted to *degree proof*. We shall follow the British System

Conversion of strength of alcohol from *%v/v* to degrees proof as per Indian system.

$$\text{Strength of alcohol} = \frac{\%v/v\text{ strength}}{57.1\%v/v} \times 100$$

Conversion of strength of alcohol from degrees proof to *%v/v* as per Indian system.

$$\text{Strength of alcohol in \%v/v} = \frac{\text{Strength of alcohol in degree proof} \times 57.1}{100}$$

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Example 1:Find the strength of 95%v/v alcohol in terms of proof spirit.

Strength of alcohol = $\frac{95\%v/v}{57.1\%v/v}$ x 100 = 166.34 degree proof = (166.34-100) degrees over proof = 66.34 ^{0} op

Example 2:Find the strength of 20%v/v alcohol in terms of proof spirit.

Strength of alcohol = $\frac{20\%v/v}{57.1\%v/v}$ x 100 = 35.03 degree proof = (100-35.03) degrees under proof = 64.97 ^{0} up

Example 3:Calculate the real strength of 30^0op and 40^0up.

30^0op = (100 + 30) = 130 deg proof Therefore the strength of alcohol = $\frac{130 \times 57.1}{100}$ = 74.23%v/v

40^0op = (100 – 40) = 60 deg proof Therefore the strength of alcohol = $\frac{60 \times 57.1}{100}$ = 34.26%v/v

Example 4:How many proof gallons are contained in 5 gallon of 70%v/v alcohol?

1 proof gallon = 1 gallon proof alcohol = 1 gallon of 100 degrees proof alcohol

70% v/v alcohol = $\frac{70\%}{57.1\%}$ x 100 degrees proof alcohol

= 122.59 degrees proof alcohol

= $\frac{122.59}{100}$ proof alcohol = 1.226 proof alcohol

5 gallons 70%v/v alcohol = 5 gallons of 1.226 proof alcohol

= 6.13 proof gallon

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Isotonic Solutions:

- ***Osmosis*:** If a solution is placed in contact with a semipermeable membrane the movement of the solvent molecules through the membrane is called *osmosis*.
- An ideal *semipermeable* membrane only lets the solvent molecules to pass through it but not the solute molecules.
- The biological membranes are not ideal semipermeable membranes.
- They are selectively permeable; they give passage to some solutes while stop the passage of others. In case of biological membranes another term *tonicity* is used.
- ***Isotonicity*:** A solution is isotonic with a living cell if there is no net gain or loss of water by the cell, when it is in contact with this solution.

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- If a living cell is kept in contact with a solution and there is no loss or gain of water by the cell then the solution is said to be *isotonic* with the *cell*.
- It is found that the osmotic pressure of 0.9%w/v NaCl solution is same as blood plasma. So 0.9%w/v NaCl solution is *isotonic* with plasma.
- **Tonicity**:

A. Isotonic: When a solution has same osmotic pressure as that of 0.9%w/v NaCl solution.

B. Paratonic: Not isotonic

(a) Hypotonic: The osmotic pressure of the solution is higher than 0.9%w/v NaCl solution

(b) Hypertonic: The osmotic pressure of the solution is lower than 0.9%w/v NaCl solution

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- ***Test of tonicity:***
- A red blood corpuscle is placed in a solution and after some time it is viewed under microscope.

Observation	Conclusion	Mechanism
The shape and size of the cell remained unchanged	The solution is isotonic	Osmotic pressure of the cell fluid and the solution are same. No movement of water occurs across the cell membrane.
The size of the cell increased(swelling) and may burst.	The solution is hypotonic.	Osmotic pressure of the cell fluid is more than the solution. Water molecules moved from the solution to the interior of the cell, so the cell swelled.
The size of the cell is reduced(shrinks) or shrinked.	The solution is hypertonic.	Osmotic pressure of the cell fluid is less than the solution outside. Water molecule moved from the interior of the cell to the solution.

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Importance of Adjustment of Tonicity in Pharmaceutical Dosage Forms:

- ***Solution for intravenous injection*:** The injection must be isotonic with plasma, otherwise the red blood corpuscle may be haemolysed.
- ***Solution for subcutaneous injection*:** Isotonicity is required but not essential, because the solution is coming in contact with fatty tissue and not in contact with blood.
- ***Solution for intramuscular injection*:** The aqueous solution may be slightly hypertonic. This will draw water from the adjoining tissue and increase the absorption of the drug.
- ***Solution for intracutaneous injection*:** Diagnostic preparations must be isotonic, because a paratonic solution may cause a false reaction.

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- ***Solutions for intrathecal injection*:** Intrathecal injections are introduced in the cavities of brain and spinal chord. It mixes with the cerebrospinal fluid (CSF). The volume of CSF is only 60 to 80ml.
- ***Solutions for nasal drops*:** Aqueous solutions applied within the nostril may produce irritation if it is paratonic. So nasal drops must be isotonic with plasma.
- ***Solutions for ophthalmic use*:** Only one or two drops of ophthalmic solutions are generally used. So it is not essential for eyedrops to be isotonic. Slight paratonicity will not produce great irritation because the eyedrops will be diluted with the lachrymal fluid.

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Calculations for Adjustment of Tonicity:

- It is difficult and time consuming to determine the osmotic pressure of a solution. So some indirect methods are adopted to compare between two isotonic solutions. Two solutions will produce same osmotic pressure if both contain the same numbers of *ultimate units*. These units may be as follows:
- **These units may be molecules in case of substances those do not ionize.**
- **These units may be ions in case of substances those ionize.**
- **These units may be both ions and unionized molecules in case of weak electrolytes.**

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- Tonicity of a solution can be adjusted by the following methods:
  - **Freezing point depression method (ΔT_f)**
  - **Sodium chloride equivalent method (*E*)**
  - **Isotonic solution V-Value method**

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Question Bank

2 Marks

1. What will be the effect of administering hypertonic & hypotonic solution parenterally?
2. In what proportion 50% & 90% alcohol be mixed to make 60% alcohol?
3. How will you prepare 70% alcohol solution by using 95% & 20% alcohol?
4. What is proof strength of 80% v/v & 45% v/v ethanol?
5. Calculate the percent strength of 40 over proof & 30 under proof.
6. In what proportion should 3%, 5%, 15% & 20% alcohol to be mixed to obtain 10% alcohol?
7. Define proof spirit.*
8. Define isotonicity & proof spirit.
9. Define Hypertonic & Hypotonic solution.

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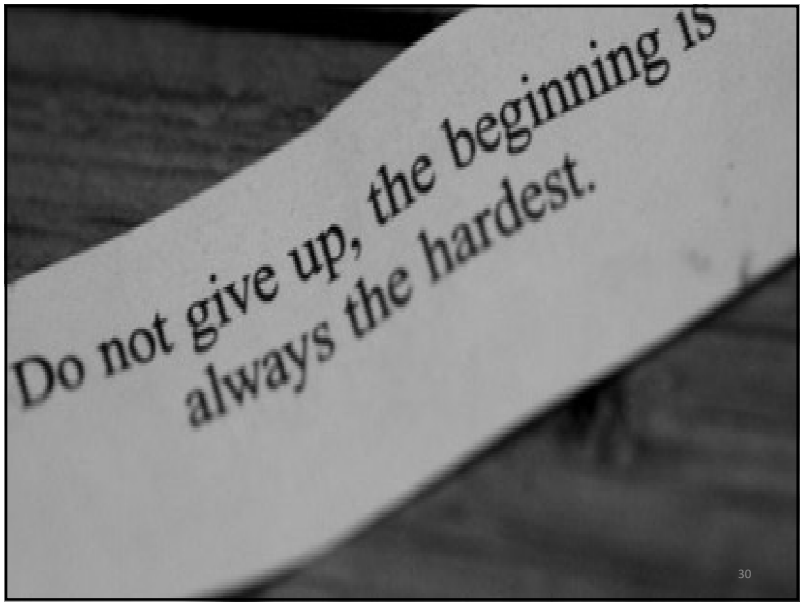

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