University of Kerbala
College of Pharmacy
Dep. of Pharmaceutics

Pharmaceutical Calculations

Laboratory Booklet assigned for First year students

By:
ZAID AL-OBAIDI
MSc Pharmaceutical Analysis
Sheffield, UK

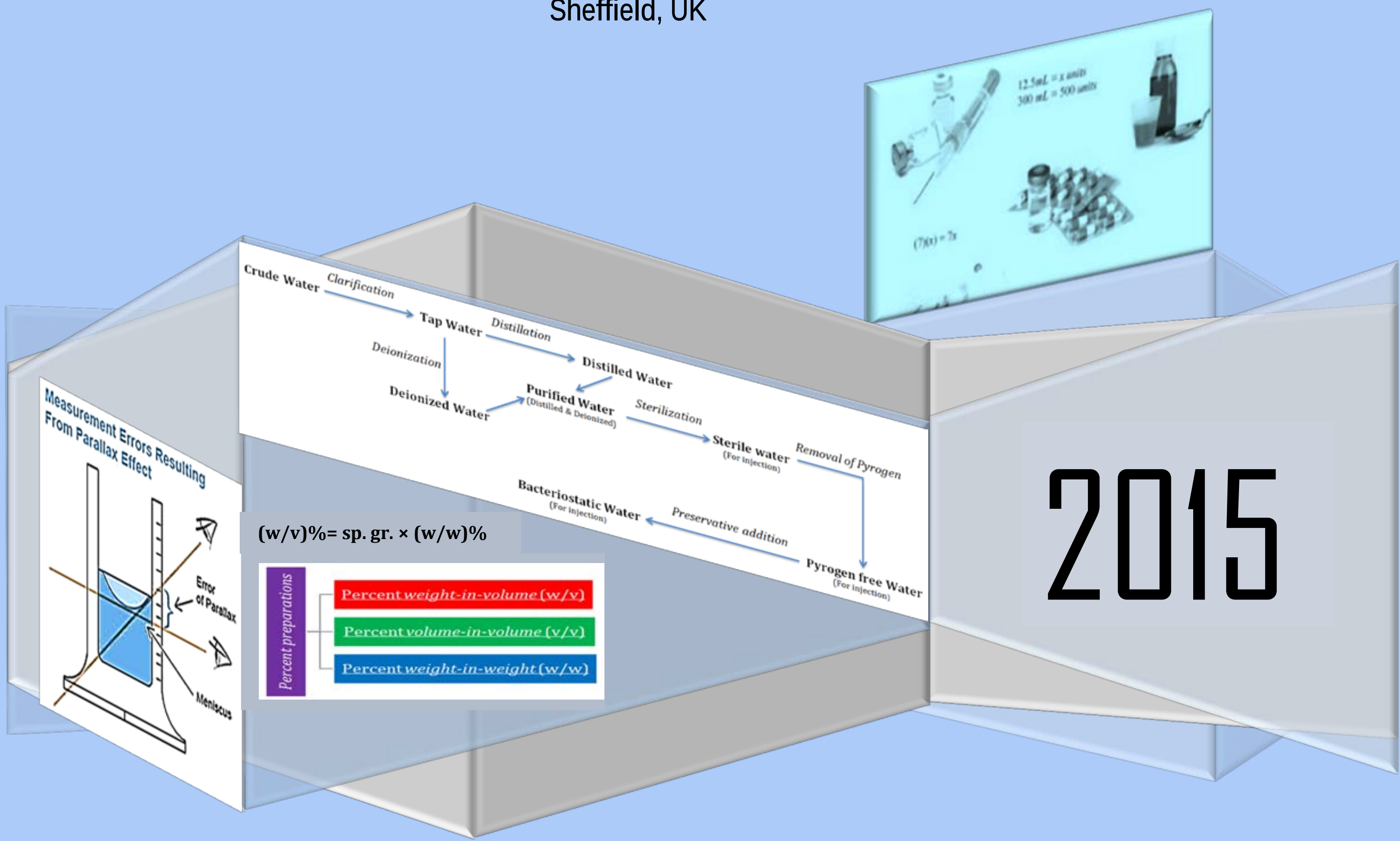

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Table of contents

Lab 1: Laboratory demonstrations.

Instruments and equipments:

It is quite important for the students and the lab workers in general to be familiar with the instruments and equipments those are utilized in different purposes in the lab. The following pictured examples could represent such tools:

1. Glassware and related tools:

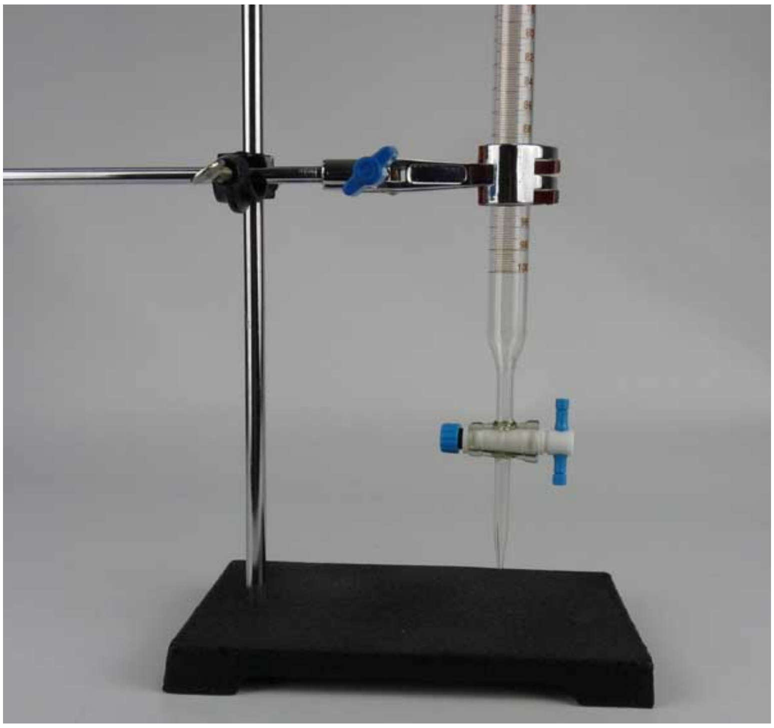
   A. Graduates: These are calibrated in metric measures and are subdivided into the following types:

   1) Cylindrical.

2) Conical.

3) Beakers.

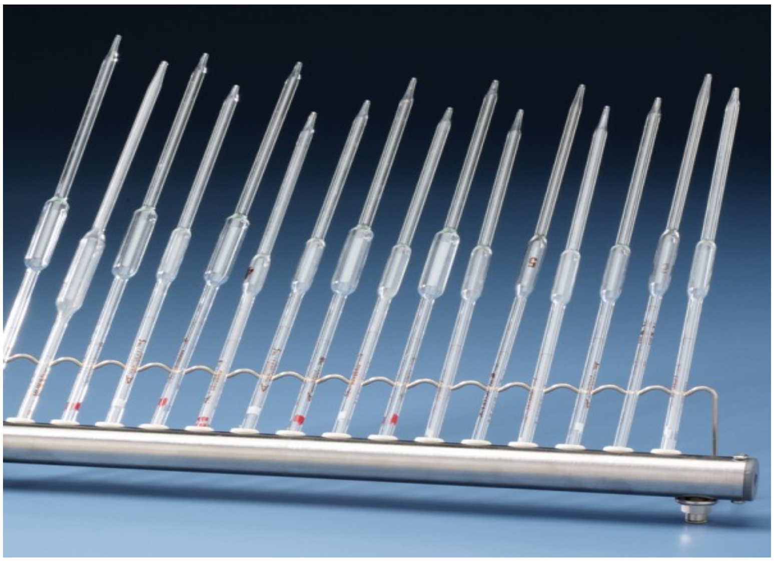
4) Burets (burettes): these are mainly utilized in titrations.



5) Pipets (pipettes): These can be filled by either rubber suction device (recommended) or by suction (not recommended; could be performed for distilled water and inert liquids, but of course not for dangerous liquids e.g. strong acids).

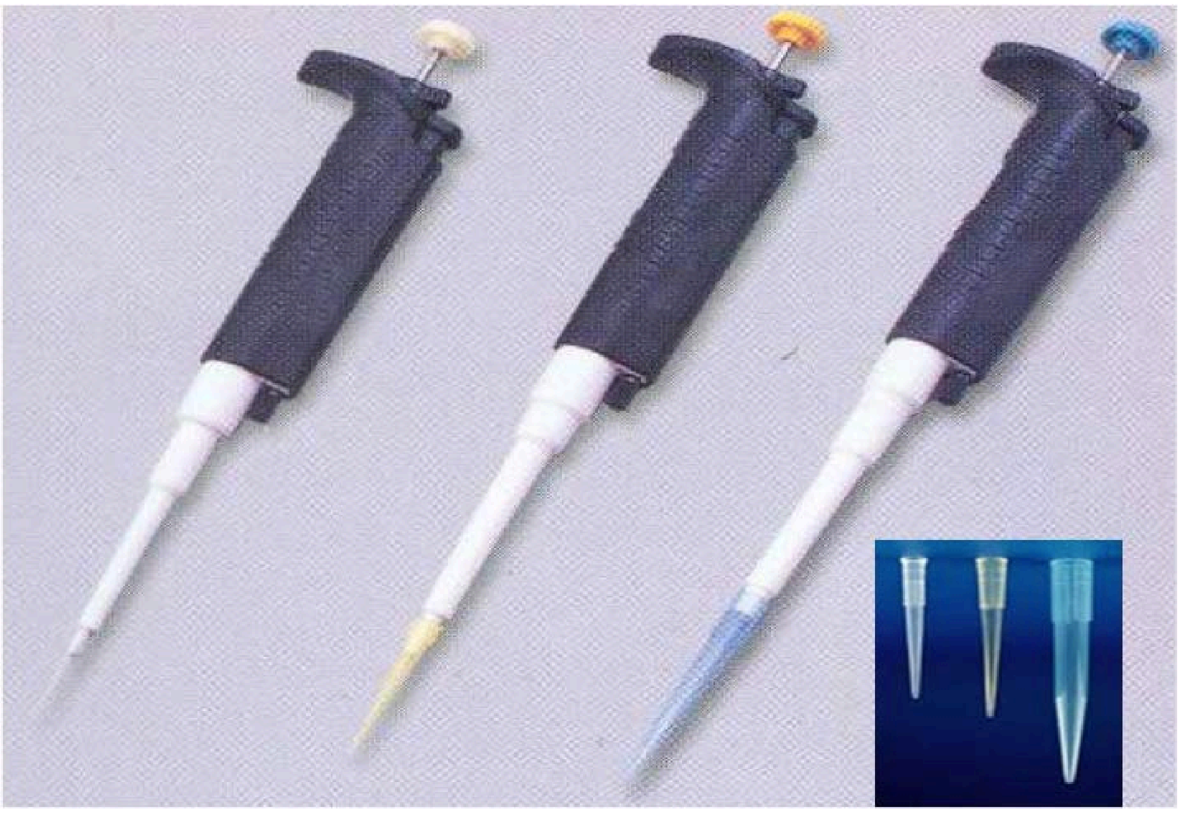
Two types of pipets are available:

i. Bulb pipets: narrow glass tube containing enlarged bulb in the middle with single accurate graduation.



ii. Calibrated pipets: tubes of uniform diameter calibrated in mls.


6) Micropipettes: This kind of pipets is very accurate and is used for very small volumes of liquids. Micropipettes are labeled with colors to indicate the volume range they can measure, so that white, yellow, and blue colors are assigned for 1-10 µL, 10-100 µL, and 100-1000 µL micropipettes respectively. Micropipettes also supplied with disposable tips commonly with the same color of the related micropipettes.



B. Volumetric flasks: these are calibrated to certain and specified volume.

C. Funnels, glass rods (stirrers), and bottles:

2. Domestic measures:

   a. Teaspoonful (tsp.) = 5 mls
   b. Tablespoonful (tbsp.) = 15 mls
   c. Glassful = 240 mls

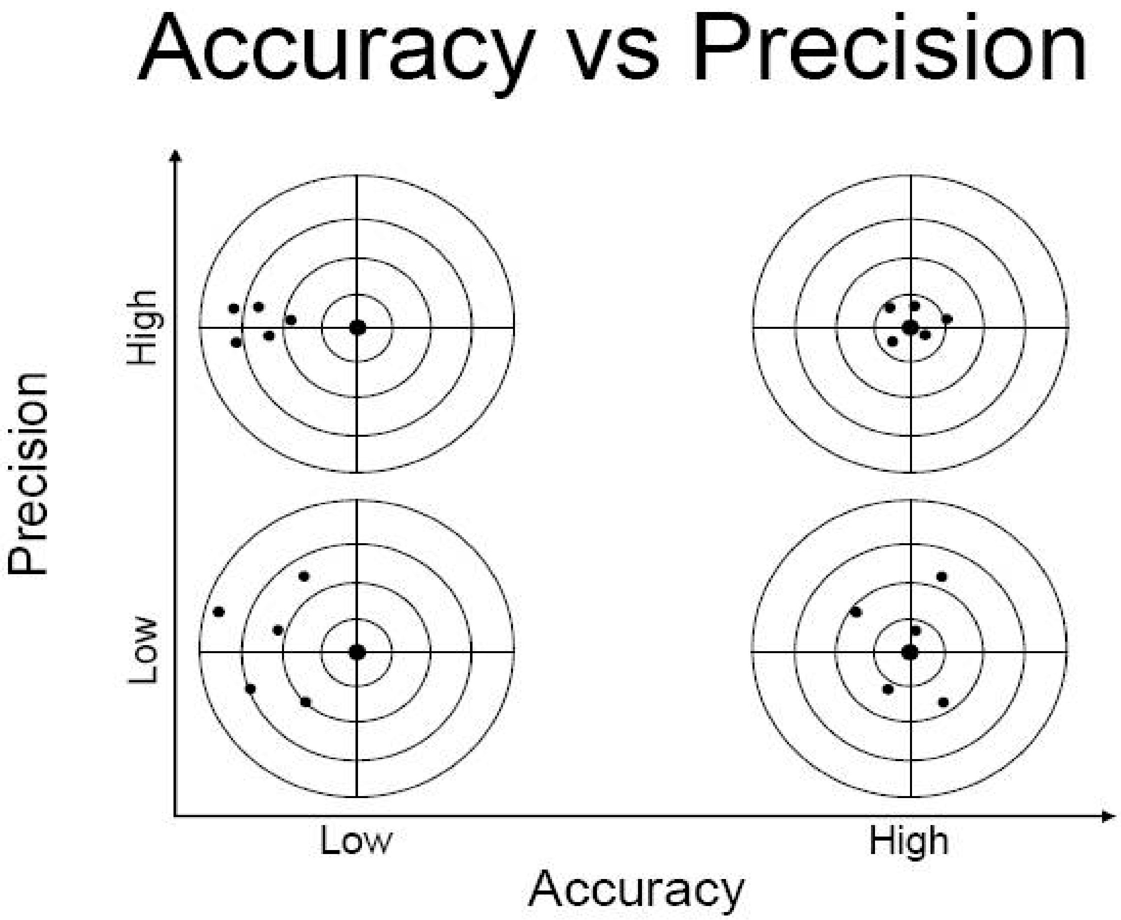
3. Balances:

4. Miscellaneous: washing bottle, mortar and pestle, spatula.

Lab 2: Pharmaceutical measurements.

Accuracy is used to describe the closeness of measurement to the true value.

Precision is the closeness of agreement among a set of results.



The sensitivity of a balance serves as a basis for judging the degree of accuracy of weight.

Types of balances:

l. *Dispensing balance:* used for weighing bulk of chemicals and drugs used in manufactures.

2. *Prescriptions balance:* used for weighing medicinal and other substances for dispensing Prescriptions.

Attributes of prescriptions balance:

- a. Well-constructed.
- b. Pans are removable and are of equal weights.
- c. Should have levelling device.
- d. If it has a "graduated weight beam" the rider should read zero on standing.
- e. The pointer should be sharp.

3. *Analytical balance (sensitive balance):* for analytical weighing and more accurate results.

Care and use of a balance:

Because of its high sensitivity a balance must be regarded as a delicate instrument and used properly in order to maintain its accuracy.

To choose balance location in the laboratory, the following points have to be considered:

1. It should be placed on a firm support, protected from vibration.
2. The room should be kept as far as possible from acid fumes and corrosive vapours.
3. It should be installed in a special balance case; the doors of the case should be closed when the balance is not in use.
4. The object to be weighted is always placed on the left hand pan.
5. Never to place a chemical substance directly in contact with the metallic surface of the balance pan. (Use papers or watch glasses).
6. Hot object should always be cooled to room temperature before placing on the balance pans. The heat radiated from the object interferes with the accuracy by setting up air currents in the balance case.
7. The door of the balance case must be closed before making the final adjustment of weights to prevent air currents.
8. AII weights are to be handled by means of forceps and never touched by fingers.
9. Heavy weights should be placed near the centre of the pan.

Testing the balance:

Before weighing, the following tests should be made:

1- Make certain that the balance is level (Check the spirit level).
2- Test the operation of the beam arrest (it works smoothly and freely).
3- Check the adjustment of the pan.
4- Make certain that the indicator starts at Zero.

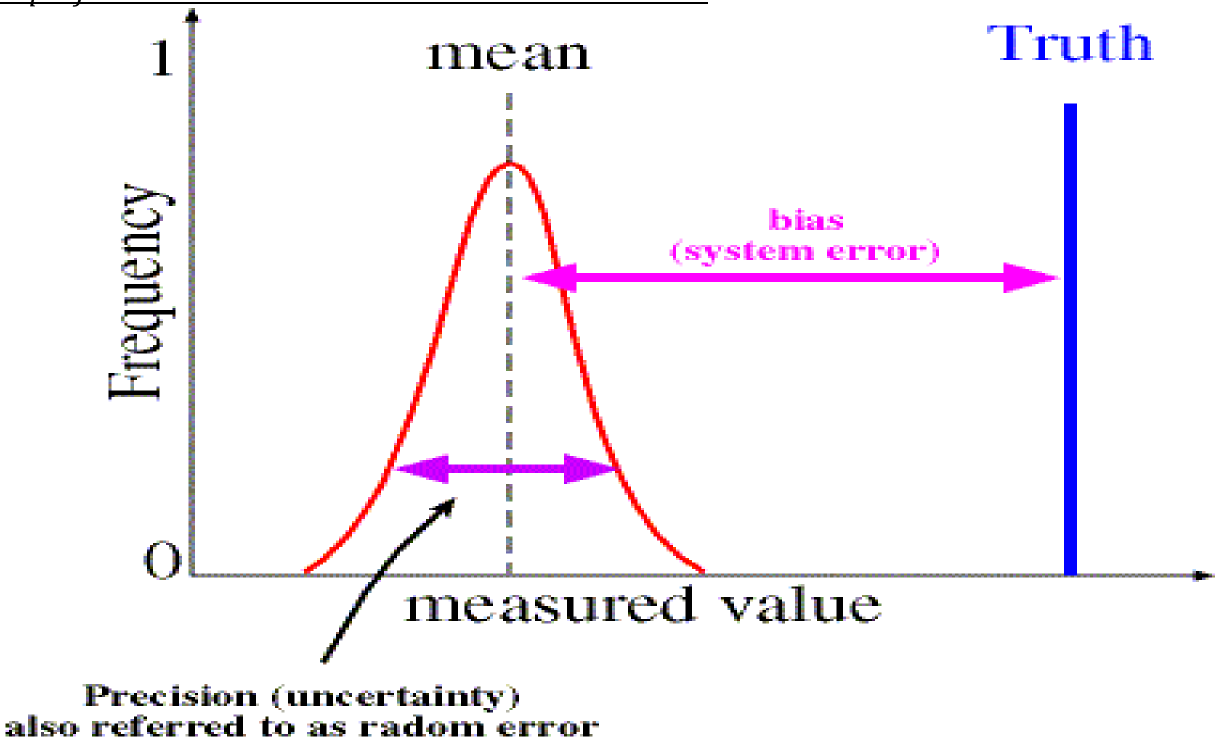
Bias (systematic) and Random (accidental) Errors:

Systematic/bias errors are consistent and repeatable (constant offset)

Random errors arise from random fluctuations in the measurements

To differentiate between the two:

Random errors are reduced when experiment is repeated many times (then just get a mean value).



The systematic error (bias) will not change and the systematic errors are very common type of errors.

$$\text{Absolute Error} = \left| measured - Theoretical \right|$$

$$\text{Percent error} = \left| \frac{measured - Theoretical}{Theoretical} \right| \times 100\%$$

Practical Work:

Name of experiment: Calculating the error in weighing.
Complete the following table via weighing each sample accurately.

	Samples									
No.	1	2	3	4	5	6	7	8	9	10
Wt.										
Error										
Error%										

Lab 3: Volume measurements.

The volume is the space occupied by a given amount of matter. This explains the effect of the diameter of the measuring equipment on the accuracy of the measurement. Considerably, as the surface area increases the height of the liquid decreases giving rise to a higher chance of error.

How to measure a liquid

Basically, liquids in prescriptions can be classified as:

1. Active medicament which is generally prescribed in small volumes.
2. Vehicles to reach the final volume.

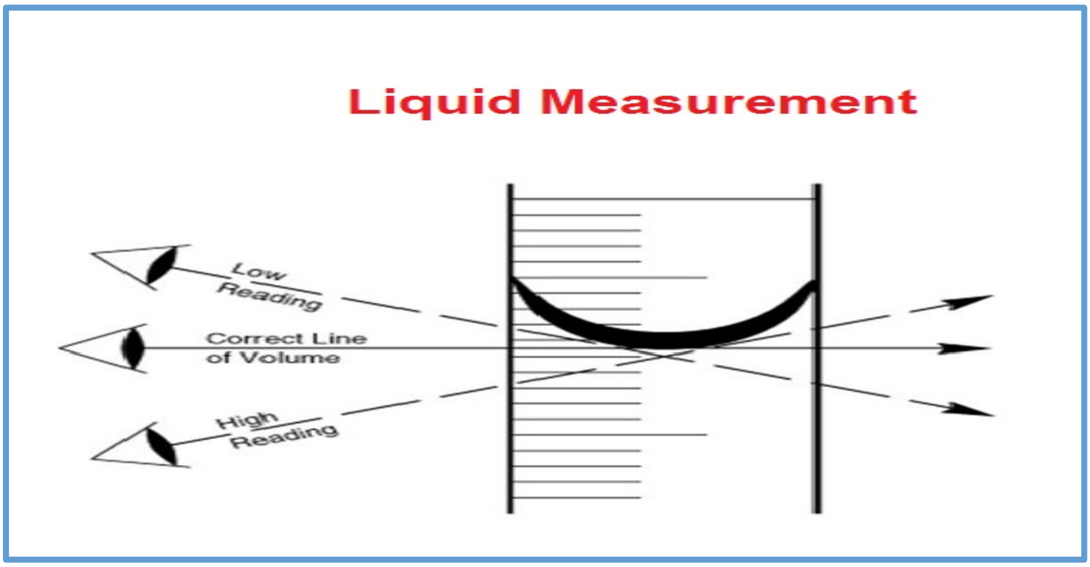
Thus choosing the appropriate measuring equipment is necessary to achieve accurate measures.

Before measuring any liquid it is necessary to be sure that you are using the exact medicament required. Then perform the following steps:

1- While holding the "Liquid medicament" in the right hand, the measuring cylinder is to be held in the left hand.

2- Pour the liquid from the bottle into the graduate until it reaches near the required volume.

3- Raise the graduate to a level of the eyes and continue pouring the liquid in drops until the bottom of the meniscus reaches exactly the required mark.



Sources of error in volume measurement:

1. Using Large graduates for measuring small volumes.
2. The smaller the diameter of the measuring equipment the more the accurate measure.
3. The deviation from the level of the eye during final measuring.

Viscous liquids, oils, acids may be prescribed in weight. To measure such liquids in volume we have to refer to the following equation:

Wt. = V × Sp. Gr.

(Wt. = weight, V= volume, and Sp. Gr. = specific gravity)

Specific gravity is *defined* as the ratio of the density of a substance to the density (mass of the same unit volume) of a reference substance (commonly water).

Example 1: Calculate the sp. gr. of glycerin if you find the weight of 10mL is 12.6g.

(Hint: Sp. Gr. =1.26)

Example 2: Calculate the weight of 12.66 mL of methanol, if its sp. gr. is c.a. 0.79?

(Hint: weight =10 g)

Practical Work: A

Name of experiment: Calculating the error in volume measurement.

Measuring instrument	Theoretical volume	measured volume	Error	% Error
Micro pipette	1000-μL			
Pipette	1mL			
Teaspoonful	5mL			
Tablespoonful	15mL			

Practical Work: B

Name of experiment: Finding the sp. gr. of an unknown solution.

Unknown No.	Volume	Measured weight	Sp. gr.
1	10 mL		
2	10 mL		
3	10 mL		

Lab 4: Preparation of aromatic water.

The British Pharmacopoeia (BP) defines aromatic waters as clear, saturated aqueous solutions of volatile oils or other aromatic or volatile substances.

Aromatic waters are saturated solutions (unless otherwise specified) of volatile oils (e.g. Rose oil, peppermint oil) or other aromatic or volatile substances, e.g. Camphor in purified water.

Aromatic waters are prepared from a number of volatile substances, including peppermint oil, rose oil, orange flower oil, spearmint oil, anise oil, wintergreen oil, camphor and chloroform. Naturally, they possess an odour and taste similar to that plant or volatile substance from which they are prepared. Aromatic waters are clear and free from solid impurities.

Most of the aromatic substances in the preparation of aromatic waters have very low solubility in water and even though water may be saturated, its concentration of aromatic material is still rather small. The volatile substances from which the aromatic waters are to be prepared should be of purest quality.

Aromatic waters can be categorized in two types as:

1. Simple aromatic waters: They contain purified water as a solvent but do not contain alcohol and are mainly used as vehicles e.g. Chloroform water.

2. Concentrated aromatic waters: They contain alcohol as solvent for the volatile constituents. Examples of concentrated aromatic waters are Camphor Water BP, Concentrated Peppermint Water BP, Concentrated Caraway Water BPC, Concentrated Cinnamon Water BPC, Concentrated Dill Water BPC, Concentrated Anise Water BPC etc.

Methods of Preparation:

Aromatic waters may be prepared by distillation or solution of the aromatic substance, with or without the use of dispersing agents. Basically, the following three methods are commonly used:

1. Distillation Method

The distillation method involves the placing of the coarsely ground odoriferous portion of the plant or drug from which the aromatic water is to be prepared in a suitable still, with sufficient purified water. Most of the volume of water is then distilled.

The excess oil collected with the distillate rises to the top of the aqueous product and is removed. This is the common method of preparation of aromatic waters although it is slow and expensive one, e.g. Strong Rose Water NF.

2. Solution Method

This method is simpler, quicker and more economical as compared to distillation method. In this method, aromatic water is prepared by intermittently shaking 2 ml (if liquid) or 2 g (if solid) of the volatile substance with 1000 ml of purified water in suitable container for a period of 15 minutes.

After the period of agitation the mixture is set aside for 12 hours or longer to permit the excess oil and the solid substance to settle. Without further agitation the mixture is passed through a wetted filter paper and purified water added as needed to bring the volume of the filtrate up to the prescribed quantity.

3. Alternative Solution Method

By this method, the volatile oil or suitably comminuted aromatic solid is thoroughly incorporated with 15 g of powdered talc and 1000 ml of purified water is added to this mixture. The resulting slurry is thoroughly agitated several times for the period of 30 minutes and then filtered.
Powdered talc works as filter aid which renders the formulation clearer and also as distributing agent for the aromatic substances that ultimately increases the surface area of aromatic substances exposed to the solvent action of water. The distributing agents should be inert in nature.

Practical Work: A

Peppermint Water

Peppermint oil	2mL
Dist. water ad.	1000mL

Mitte 50mL

Practical Work: B

Concentrated Chloroform Water

Chloroform	10mL
Alcohol 90%	60mL
Distilled Water ad.	100ml.

Mitte 25mL

Practical Work: C

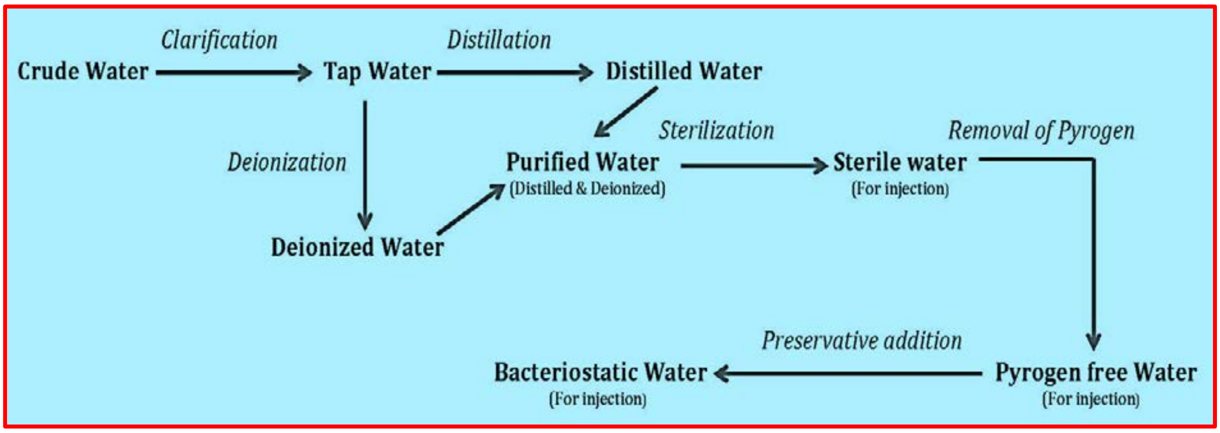
Camphor Water

Camphor	1g
Alcohol 90%	2mL
Dist. Water ad.	1000mL

Mitte 25ml.

Lab 5: Preparation of simple solutions.

A *solution* is a homogeneous mixture composed of only one phase. In such a mixture, a solute is a substance dissolved in another substance, known as a solvent.



- ***In Pharmacy Purified Water should be used***

Simple Solutions can be prepared using the following general method:

1. Weigh the solids and transfer them into a suitable container.
2. Calculate 3/4 (three quarters) of the total volume of the vehicle and subtract from it the volume of any liquid component.
3. Measure the resultant volume of the vehicle and add it to the contents of the container.
4. Stir until the solid medicaments dissolves.
5. Measure the liquid ingredient and add it to the container.
6. Stir until becomes homogenous.
7. Transfer the contents of the container to a suitable measuring cylinder and add a sufficient vehicle to reach the final volume.
8. Transfer the mixture to a suitable "Dispensing bottle".
9. Attach a label with the following instructions:
    a. "For Internal Use" (or "For External Use" if it is)
    b. Prescriber name
    c. Patient name
    d. Directions for use
    e. Medication name/compositions
    f. Date of dispensing and expiration.

Practical Work:

Normal saline preparation:

R_x

Sodium Chloride	0.9 g
Purified Water ad	100 mL

Lab 6: Reducing and enlarging prescription contents.

Pharmacists may have to reduce or enlarge formulas for pharmaceutical preparations in the course of their professional practice or manufacturing activities.

Official (United States Pharmacopeia—National Formulary) formulas generally are based on the preparation of 1000 mL or 1000 g. Other formulas, as those found in the literature, may be based on the preparation of a dosage unit (e.g., 5 mL, 1 capsule) or another quantity (e.g., 100 mL).

Calculations to reduce or enlarge formulas may be performed by a two-step process:

Step1: Using the following equation, determine the factor that defines the multiple or the decimal fraction of the amount of formula to be prepared:

$$\frac{\text{Quantity of formula } (\textit{desired})}{\text{Quantity of formula } (\textit{specified})} = \text{Factor}$$

- ***Factor is named in relation to the general process as "enlarging factor" or "reducing factor"***

A factor greater than 1 represents the multiple of the formula, and a factor less than 1 indicates the fraction of the formula to be prepared.

Step 2: Multiply the quantity of each ingredient in the formula by the factor to determine the amount of each ingredient required in the reduced or enlarged formula.

Example:

If a formula for 1000 mL contains 6 g of a drug, how many grams of drug are needed to prepare 60 mL of the formula?

(Hint: answer = 0.36g)

Practical Work:

Name of experiment: Sodium Bicarbonate ear drops

R_x

Sodium bicarbonate	5g
Glycerin	30mL
Purified water ad.	100mL

Mitte 20ml.

Lab 7: Percentages in calculating prescription contents.

The term percent and its corresponding sign (%) mean "by the hundred" or "in a hundred," and percentage means "rate per hundred"; so 50 percent (or 50%) and a percentage of 50 are equivalent expressions. A percent may also be expressed as a ratio, represented as a common or decimal fraction.

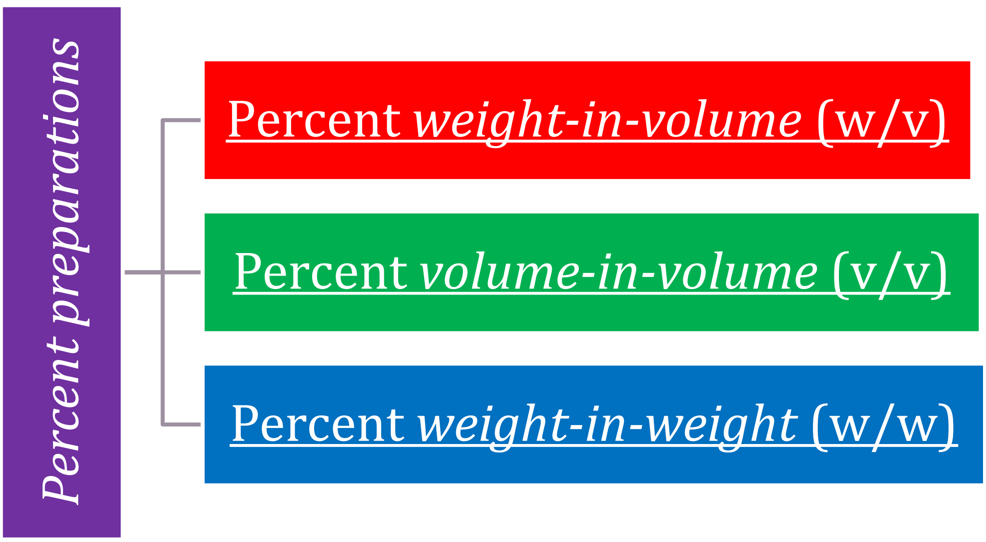
Percentage is an essential part of pharmaceutical calculations. The pharmacist encounters it frequently and uses it as a convenient means of expressing the concentration of an active or inactive material in a pharmaceutical preparation.

Percent Preparations can be classified as follows according to USP:

1. Percent *weight-in-volume* (w/v): expresses the number of grams of a constituent in 100 mL of solution or liquid preparation and is used regardless of whether water or another liquid is the solvent or vehicle. Expressed as: % w/v.
2. Percent *volume-in-volume* (v/v): expresses the number of milliliters of a constituent in 100 mL of solution or liquid preparation. Expressed as: % v/v.
3. Percent *weight-in-weight* (w/w): expresses the number of grams of a constituent in 100 g of solution or preparation. Expressed as: % w/w.

The term percent, or the symbol %, when used without qualification means:

- For solutions or suspensions of solids in liquids, percent weight-in-volume;
- For solutions of liquids in liquids, percent volume-in-volume;
- For mixtures of solids or semisolids, percent weight-in-weight; and
- For solutions of gases in liquids, percent weight-in-volume.



NB:

To convert w/w% to w/v% then the specific gravity is required as shown below:

(w/v)% = (w/w)% × sp. gr.

Examples:

1. What is the w/v% of 10% w/w if the sp. Gr. is 1.1?
   (Answer= 11% w/v)
2. What is the w/w% of 15% w/v if the sp. Gr. is 0.91?
   (Answer= 16.5% w/w)
3. How many grams of dextrose are required to prepare 4000 mL of a 5% solution? (Answer = 200 g)
4. How many grams of potassium permanganate should be used in compounding 250 mL of 0.02%? (Answer = 0.05 g)
5. How many milliliters of liquefied phenol should be used in compounding 240 mL of 2.5%? (Answer = 6 mL)
6. How many grams of a drug substance should be added to 240 mL of water to make a 4% (w/w) solution?
   (Answer = 10 g)

Practical Work:

Name of experiment: Calculating alcohol percentages with the same components, however with different forms.

Procedure:

1. Pour 50mL of absolute alcohol in 100mL graduated cylinder.
2. Add sufficient D.W. up to 100mL.
3. Weigh the resultant 100mL solution.
4. If the sp. gr. of ethanol is c.a. 0.79, then please to fulfill the following table with the missing data.

No.	Ethanol Vol.	Ethanol Wt.	Solution Vol.	Solution Wt.	Solution %		
					(v/v)	(w/v)	(w/w)
1	50 mL		100 mL				

Lab 8: Dilution.

The dilution of a liquid dosage form, as a solution or suspension, may be desired to provide product strength more suitable for use by a particular patient (e.g., pediatric, elderly, those in disease states). The diluent is selected based on its compatibility with the vehicle of the original product; that is, aqueous, alcoholic, hydroalcoholic, or other.

The dilution of a solid dosage form (as a powder or the contents of a capsule) or a semisolid dosage form (as an ointment or cream) also may be performed to alter the dose or strength of a product.

An equation useful in these calculations is:

(1st quantity) **×** *(1st concentration) = (2nd quantity)* **×** *(2nd concentration)*

Or can be simplified to:

$$C_1 \times V_1 = C_2 \times V_2$$

<u>Example Calculations of Stock Solutions:</u>

Example1: If 500 mL of a 15% v/v solution are diluted to 1500 mL, what will be the percentage strength (v/v)? (Answer= 5%)

Example2: If 50 mL of a 1:20 w/v solution are diluted to 1000 mL, what is the ratio strength (w/v)? (Answer= 1:400 w/v)

- ***N.B: A student may find it simpler in solving certain problems to convert a given ratio strength to its equivalent percentage strength.***

Practical Work:

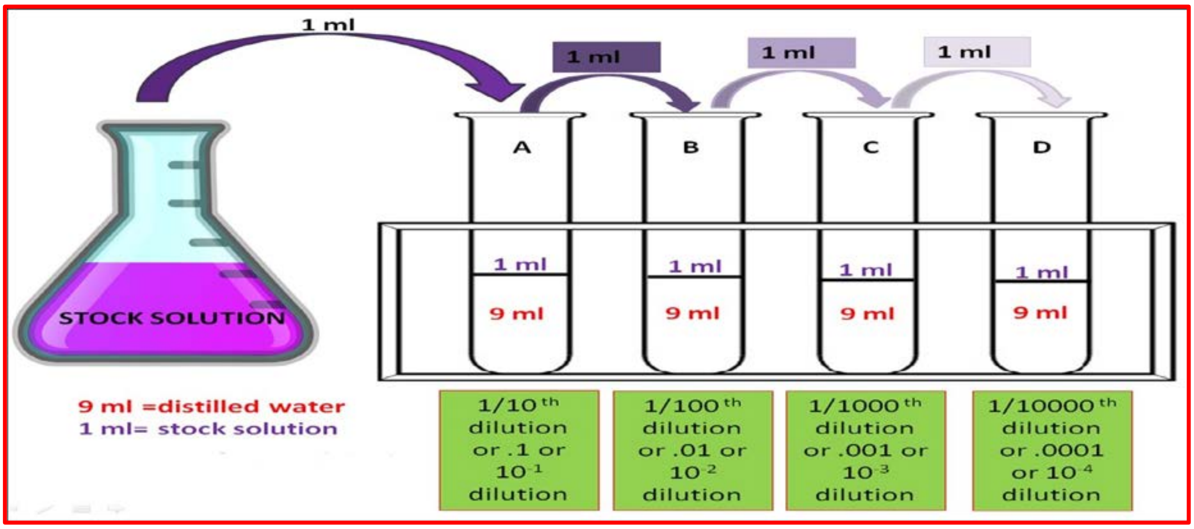
Name of experiment: Preparing different concentrations employing dilution method.

Complete the following table then prepare the concentrations required.

Tube No.	V_2	C_2 (w/v)	C_1 (w/v)	V_1
1	10 mL	0.1%	1%	
2	10 mL	0.01%	1%	
3	10 mL	0.001%	1%	

Lab 9: Stock solutions.

Stock solutions are concentrated solutions of active (e.g., drug) or inactive (e.g., colorant) substances and are used by pharmacists as a convenience to prepare solutions of lesser concentration.



Advantages of stock solution:

i. No requirement for storing different solutions of the same active ingredient.
ii. Ease of preparing the required strength of the medicament when needed.
iii. Saving time and money

Example Calculations of Stock Solutions:

Example1: How many milliliters of a 1:400 w/v stock solution should be used to make 4 liters of a 1:2000 w/v solution? (Answer= 800mL)

Example2: How many milliliters of a 1% stock solution of a certified red dye should be used in preparing 4000 mL of a mouthwash that is to contain 1:20,000 w/v of the certified red dye as a coloring agent? (Answer= 20mL)

Practical Work:

Name of experiment: Preparing 1:10,000 w/v potassium permanganate ($KMnO_4$) solution.

Procedure:

1. Weigh accurately 0.1g of $KMnO_4$ and dissolve in 10mL of D.W.
2. Vortex or stir for about 10 minutes to assure full dissolving.
3. Dilute the resultant 1% stock solution to prepare 100mL of 0.01%.

Lab 10: Alligation Medial and Alligation Alternate.

Alligation is an arithmetical method of solving problems that involves the mixing of solutions or mixtures of solids possessing different percentage strengths.

Alligation Medial: Alligation medial is a method by which the "weighted average" percentage strength of a mixture of two or more substances of known quantity and concentration may be easily calculated. By this method, the percentage strength of each component, expressed as a decimal fraction, is multiplied by its corresponding quantity; then the sum of the products is divided by the total quantity of the mixture; and the resultant decimal fraction is multiplied by 100 to give the percentage strength of the mixture. Of course, the quantities must be expressed in a common denomination, whether of weight or volume.

Example Calculations Using Alligation Medial:

Example1: What is the percentage strength (v/v) of alcohol in a mixture of 3000 mL of 40% v/v alcohol, 1000 mL of 60% v/v alcohol, and 1000 mL of 70% v/v alcohol? Assume no contraction of volume after mixing.

$$0.40 \times 3000 \text{ mL} = 1200 \text{ mL}$$
$$0.60 \times 1000 \text{ mL} = 600 \text{ mL}$$
$$0.70 \times 1000 \text{ mL} = 700 \text{ mL}$$

Totals: 5000 mL 2500 mL

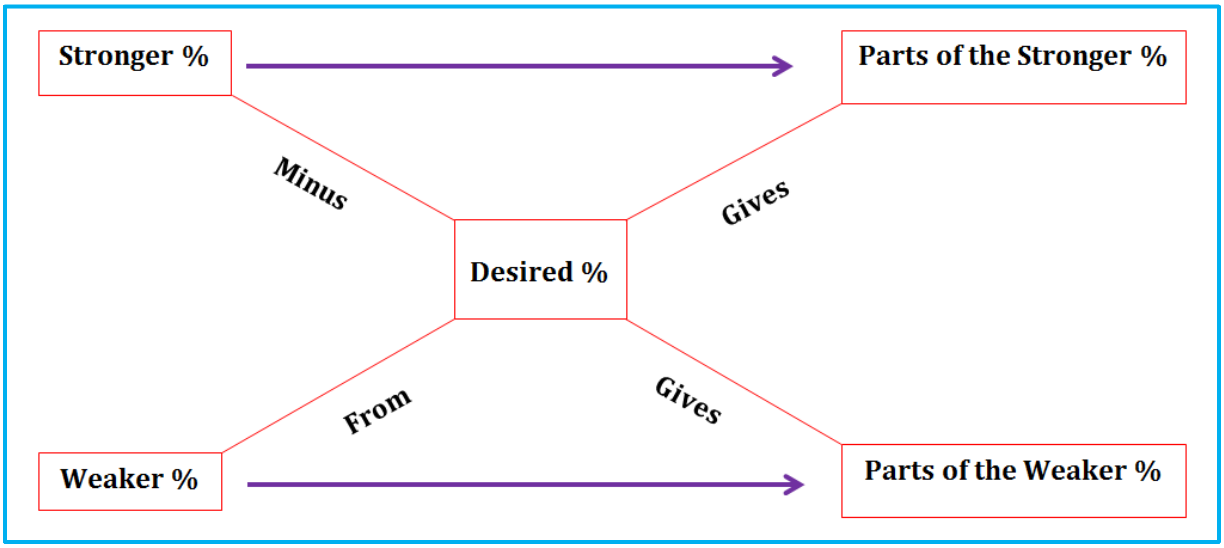
$$\frac{2500 \text{ (mL)}}{5000 \text{ (mL)}} \times 100 = 50\%, \text{ answer.}$$

Example2: What is the percentage of zinc oxide in an ointment prepared by mixing 200 g of 10% ointment, 50 g of 20% ointment, and 100 g of 5% ointment? (Answer= 10%)

Alligation Alternate: Alligation alternate is a method by which we may calculate the number of parts of two or more components of a given strength when they are to be mixed to prepare a mixture of desired strength. A final proportion permits us to translate relative parts to any specific denomination.

The strength of a mixture must lie somewhere between the strengths of its components; that is, the mixture must be somewhat stronger than its weakest component and somewhat weaker than its strongest. As indicated previously, the strength of the mixture is always a "weighted" average; that is, it lies nearer to that of its weaker or stronger components depending on the relative amounts involved.

This "weighted" average can be found by means of an extremely simple scheme, as illustrated in the subsequent diagram.



Example Calculations Using Alligation Alternate

Example1: In what proportion should alcohols of 95% and 50% strengths be mixed to make 70% alcohol? (Answer= 4:5)

Example2: How many grams of zinc oxide should be added to 3200 g of 5% zinc oxide ointment to prepare an ointment containing 20% of zinc oxide? (Answer= 600g)

Practical Work:

Name of experiment: Preparing a required solution concentration employing alligation alternate method.

How many milliliters of 7% (w/v) Copper Sulfate ($CuSO_4$) and 3% (w/v) solutions are required to prepare 20 mL of 6% (w/v) $CuSO_4$ Solution?

Procedure:

1. Calculate the parts required for each of the available percentages.
2. Sum up the parts together.
3. Divide the required volume on the total number of parts.
4. Multiply each number of parts by the result from step 3 above.
5. Then you will get the required milliliters.
6. Prepare the required solution with the specified percentage.