

Spring 2015

Water and Environmental Chemistry Laboratory



WEEM 1310

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Syllabus

Water and Environmental Chemistry Lab

WEEM 1310

Sunday & Monday 14:00-17:00

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Course text: None required. This manual is work in progress and will be handed out a week ahead of conducting each experiment. In addition some experiment will undergo modification and updating. Please be patient as the manual and our laboratory evolve. You are encouraged to check your GJU mail a head of each lab. Notes and changes will be sent via e-mail.

Reference texts: Same text as the WEEM 131

Course objective: This course is designed to introduce first-year water and environment engineering students to experiments that demonstrate principles that are learned in WEEM131 course. Student will learn technical skills, how to use and calibrate measurement devices, how to conduct experiment that test samples for physical and chemical characteristics, and how to write a report.

Grading:

*Attendance/participation	12
Written lab reports	18
Lab quizzes & Pre Lab	20
Midterm	20
Final	30

Reports:

Reports on experiments will be due **ONE WEEK** after the experiment is completed, at the beginning of each class. Reports submitted after 14:00 on will be counted as one day late. Late reports are accepted for only 2 days and will be penalized 35 points per day. No report after that day will be accepted at all.

Schedule:

Week Order	Date	List of Experiment**
1 st Week	1 st & 2 nd March	Orientation and Safety Glassware / EXCEL / Report
2 nd Week	8 th & 9 th March	Exp 1 pH/ Conductivity
3 rd Week	15 th & 16 th March	Exp 2 Color / Turbidity
4 th Week	22 nd & 23 rd March	Exp 3 Acidity
5 th Week	29 th & 30 th March	Exp 4 Alkalinity
6 th Week	5 th & 6 th April	Exp 5 Chloride
7 th Week	12 th & 13 th April	Exp 6 Total Hardness
8 th Week	19 th & 20 th April	Midterm
9 th Week	26 th & 27 th April	Exp 7 The Solubility Product Constant
10 th Week	3 rd & 4 th May	Exp 8 Dissolved Oxygen (A)/ Dissolved Oxygen (B)
11 th Week	10 th & 11 th May	Exp 9 Biochemical Oxygen Demand
12 th Week	17 th & 18 th May	Exp 10 Chemical Oxygen Demand
13 th Week	24 th & 25 th May	
14 th Week	31 st May & 1 st June	Finals

**** Note that experiment order or even can be change according to the instructor.**

Course Policies: The following course policies must be followed. At the discretion of the instructor or teaching assistances, non-complacence with course policy may negatively impact your final course grade.

- **Preparation:** Before coming to the laboratory, read the description of the experiment and relevant background material must be read. For each experiment, be prepared to complete a short quiz covering the objective of work, theory and procedure, the quiz may also cover the previous experiment.
- **Attendance and work:** Attendance is compulsory for all labs during the semester. If an emergency arises, you must inform the instructor and the TA before class and arrangements will be made since there will be no remake of any lab. Unexcused absence count as zero on the quiz, experimental work and lab reports. **No** written report will be accepted **without attending** the experiment. Exceeding one lab absence will mean expelling from the lab.
The experimental work is an individual effort, unless told otherwise. When laboratory work is completed, you are to write your own reports with **NO SHARING OF WRITTEN WORK.**
- **Integrity:** Each student work and behavior is assumed to hold the highest standards of honesty. Cheating, fabrication, plagiarism, and helping the others to commit these actions are all forms of dishonesty and they are wrong. You are

prohibited from using old reports and files from previous years. You are prohibited from copying sections from any resources including other students' work, text books, and websites. All resources, including figures downloaded from the internet must be cited. First instances of plagiarism will negatively impact your final course grad; in other words, no warning will be given for plagiarism cases and a NEGATIVE grade will be given to such cases.

- Midterm and Final: The midterm exam will be a practical/oral test; details will be given previous to conducting the test. The final test will be a written one.
- Safety: Safety in laboratory is tantamount to good laboratory practice. No rule, unless augmented with safety awareness and good sense, will protect you from accidents.

**Bottom line**

Maintain high standards for your own work. Start work early so the temptation to cut corners does not arise. If you have questions or concerns, do not hesitate to ask the instructor or TAs.



The following practices will be exercised in the laboratory:

1. On laboratory days, long pants must be worn, and shoes must be closed-toe (no sandals). If students dressed inappropriately, they will be asked to change before the beginning of the experiment. If not, they will be prohibited from the conducting the experiment and will lose marks based on that.
2. In the laboratory, safety glasses, white apron are required as well as gloves.
3. You are to bring only your manual, calculator and pen into the lab. Your back bags, hand bags will all be gathered away and not allowed to be put on the lab benches
4. Smoking, eating or drinking are not allowed in the laboratory. GUM chewing is included!
5. Cell phones are to be shut down during the lab, or they will be confiscated during other labs for students who break the rule.
6. Report all injuries and accidents to the instructor or TAs immediately, no matter how minor.
7. Each student is responsible of cleaning his/her station all the time. Marks will be deducted from your work if the station and glassware were left dirty.

Please refer to the sheets concerning the safety rules that MUST be conducted in the lab.

Students must affirm that they have read and understood the laboratory safety manual and sign the agreement given by the lab supervisor.

SAFETY RULES AND REGULATIONS

The rules and regulations that follow are universal for the laboratories. In addition to becoming familiar with these, take note of safety warnings given with each specific experiment.

Horseplay

Repeated incidents are unprofessional, and will result in a grade penalty.

General rules: no person may work alone in the lab, supervision is needed all time. No work outside regular lab hours is permitted without specific permission. Visitors are not allowed in the labs.

Clothing: shorts and skirts should not be worn to the lab. Avoid wearing expensive clothes. Sandals or open –toe shoes are not acceptable. Confine long hair, or any loose clothing or accessories.

Eye protection: safety glasses are a required item to be worn in all areas of the laboratories. The wearing of contact lenses in the laboratory is strongly discouraged, even when eye protection is worn. There is a distinct possibility that chemicals may infuse under the contact lens and cause irreparable damage. Students who consistently violate the eye protection policy are subject to dismissal from the lab .

There are EYE-WASH stations located in lab. If chemicals enter your eyes, flush them immediately at the station. Water might leak out onto the floor from the wash station – ignore it, while trying not to slip on the water.

Housekeeping: All designated experimentation areas should be left in a neat orderly state at the conclusion of an experiment. The following items should be checked;

- a) All excess water should be removed from the floor.
- b) All loose paper should be picked up and deposited in trashcans.
- c) All working surfaces (tables, chairs, etc.) should be cleaned if needed.
- d) All miscellaneous items should be returned to their proper initial locations.
- e) All glassware should be washed prior to returning to the cabinet.
- f) All scales should have weights removed and scale arms locked.
- g) All manholes (sewers) should have their lids closed.
- h) All drums or containers used should be checked.
- i) Check all valves and electrical units. Turn off what is required.

Chemicals: In several of the experiments, chemicals are required to perform the experiment. Students should check with their instructor as to where to get these chemicals and what safety precautions, if any, are to be taken in conjunction with the

use of these chemicals. They should be able to get the Material Safety Data Sheet (MSDS) for all chemicals.

- i. In the case of gases being used, be sure you understand the nature of the hazards associated with the gas and do not deviate from the procedures as outlined, either oral or written, by the instructor.
- ii. Do not use mouth suction to fill pipettes.
- iii. Label all containers to avoid errors and read labels carefully.
- iv. Never remove shared chemicals from their original locations, others will need them.
- v. Waste chemicals are placed in receivers and are not discharged in the drain, unless told otherwise.

Electrical: In many instances electrical extension cords are required for the operation of auxiliary equipment. Special precautions should be taken when using these cords. When an electrical extension cord is checked out, be sure to examine its condition. If you find frayed or broken wires, insulation broken, prongs bent, no ground, etc., do not use but return to the stockroom, pointing out the faults to the TAs. When using extension cords, be sure they do not lie on the floor, in particular, when the floor is wet, but are safely supported in such a fashion that they are not a bodily hazard. When making electrical connections, be sure the area you are standing in is dry.

Accidents: Even with the greatest safety precautions accidents DO happen. Be sure you are familiar with the locations of safety showers and medical first aid kits. **If** an accident happens, inform your instructor and TA immediately. In the case of a serious accident, do not attempt first aid if you are not familiar with the proper technique, but do attempt to make the person comfortable until aid arrives. All chemicals spills are to be reported and directions must be followed for containment and cleanup. Whenever your skin (hands, arms, face,...) comes into contact with laboratory chemicals, wash it quickly and thoroughly with soap and warm water.

Unauthorized Areas: Do not touch unauthorized equipment, chemicals or experiments.

Food or Drink: Food and drink are forbidden in laboratories, that includes chewing gum and applying makeup. DO NOT taste chemicals, if instructed to smell chemicals do so by carefully fanning the top of test tube or bottle so that a little of the vapor is directed towards your nose.

Smoking: Smoking is not permitted.

Ventilation: Be sure that hoods are functioning, and that your work areas are properly ventilated.

Safety Shower: In the event of a chemical spill on your body, or if your clothes catch fire, quickly move to the safety shower, stand under it, and pull the chain. A large volume of water will fall onto your head. Get help immediately!!

Obligation: Each student has a professional obligation to contribute a full and honest effort in the group execution of experiments and reports. Consistent failure to observe this rule is considered unprofessional behavior, and will be penalized.

SIGN AND DATE THIS AS A REMINDER OF PROCEDURES YOU WILL BE PRACTICING DURING WATER AND ENVIRONMENTAL CHEMISTRY LAB.

AGREEMENT

- I have read and agree to follow all of the safety rules set forth in this contract. I realize that I must obey these rules to insure my own safety, and that of my fellow students and instructors. I will cooperate to the fullest extent with my instructor and fellow students to maintain a safe lab environment. I will also closely follow the oral and written instructions provided by the instructor. I am aware that any violation of this safety contract that results in unsafe conduct in the laboratory or misbehavior on my part may result in being removed from the laboratory.

No.	Student Name	Reg. No.	Date	Signature

THIS IS A COPY OF THE AGREEMENT YOU WILL HAVE TO SIGN BEFORE WORKING IN WEEM LABS.

[Bring:

Notebook
Safety Glasses
Calculator
Lab Coat
Lab Manual
Pen
Soap, And Your
Own Towel]



The measurement of trace constituents in water demands methods capable of maximum

LAB WARE

sensitivity. In addition to sensitive methods, however, there are other areas that require special consideration. One such area is that of the cleanliness of laboratory glassware. Obviously, the very sensitive analytical systems are more sensitive to errors resulting from the improper use or choice of apparatus, as well as to contamination effects due to an improper method of cleaning the apparatus.

Types of Glassware

Laboratory vessels serve three functions:

1. Storage of reagents
2. Measurement of solution volumes
3. Confinement of reactions.

For special purposes, vessels made from materials such as porcelain, nickel, iron, aluminum, platinum, stainless steel, and plastic may be employed to advantage. Glass, however, is the most widely used material of construction.

There are many grades and types of glassware from which to choose, ranging from student grade to others possessing specific properties such as super strength, low boron content, and resistance to thermal shock or alkali. The mainstay of the modern analytical laboratory is a highly resistant borosilicate glass, such as that manufactured by Coming Glass Works under the name "Pyrex".

The use of plastic vessels, containers, and other apparatus made of Teflon, polyethylene, polystyrene, and polypropylene has increased markedly. Some of these materials, such as Teflon, are quite expensive. However, Teflon stopcock plugs have practically replaced glass plugs in burettes, separatory funnels, etc., because lubrication to avoid sticking or "freezing" is not required. Polypropylene, a methylpentene polymer, is available as laboratory bottles, graduates, beakers, and even volumetric flasks. It is crystal clear, shatterproof, autoclavable, and chemically resistant.

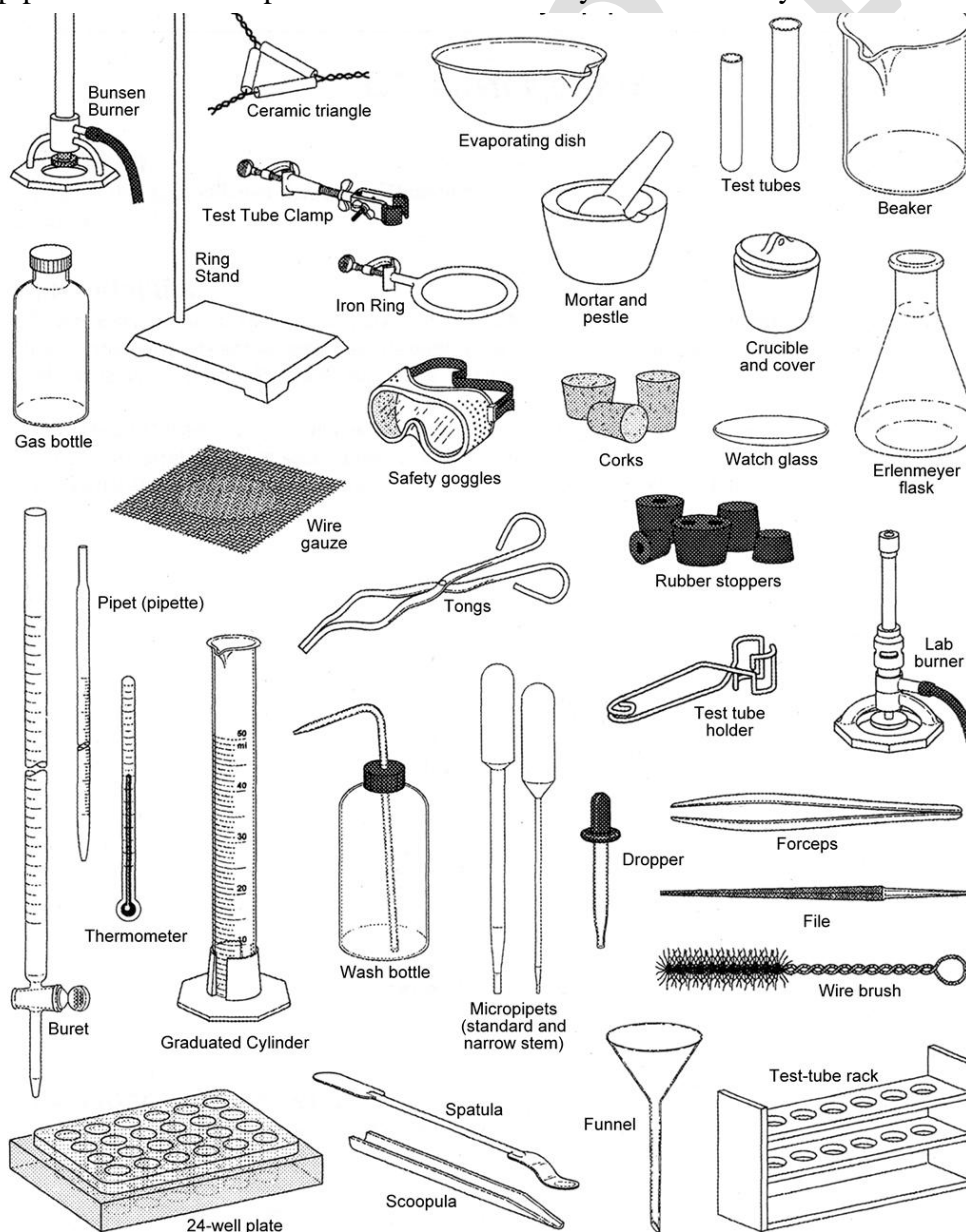
The following are some points to consider in choosing glassware or plasticware:

- a. Unless instructed otherwise, borosilicate or polyethylene bottles may be used for the storage of reagents and standard solutions.
- b. Dilute metal solutions are prone to plate out on container walls over long periods of storage. Thus, dilute metal standard solutions must be prepared fresh at the time of analysis.
- c. For some operations, disposable glassware is entirely satisfactory.

- d. Plastic bottles of polyethylene and Teflon have been found satisfactory for the shipment of water samples. Strong mineral acids (such as sulfuric acid) and organic solvents will readily attack polyethylene and are to be avoided.
- e. Borosilicate glassware is not completely inert, particularly to alkalis. Therefore; standard solutions of silica, boron, and the alkali metals are usually stored in polyethylene bottles.

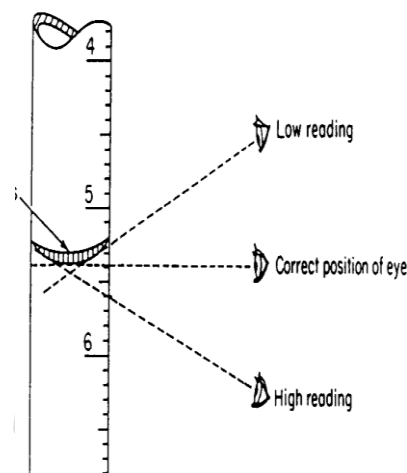
Volumetric Analyses

By common usage, accurately calibrated glassware for precise measurements of volume has become known as volumetric glassware. This group includes volumetric flasks, volumetric pipettes, and accurately calibrated burettes. Less accurate types of glassware including graduated cylinders and serological and measuring pipettes also have specific uses in the analytical laboratory when exact



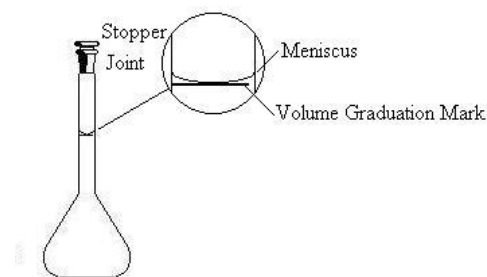
volumes are unnecessary.

The precision of volumetric work depends in part upon the accuracy with which volumes of solutions can be measured. There are certain sources of error that must be carefully considered. The volumetric apparatus must be read correctly; that is, the bottom of the meniscus should be tangent to the calibration mark.



There are other sources of error, however, such as changes in temperature, which result in changes in the actual capacity of glass apparatus and in the volume of the solutions.

The capacity of an ordinary glass flask of 1000-ml volume increases 0.025 ml/deg with rise in temperature, but if the flask is made of borosilicate glass, the increase is much less. One thousand milliliters of water or of most 0.1N solutions increases in volume by approximately 0.20 ml/deg increase at room temperature. Thus solutions must be measured at the temperature at which the apparatus was calibrated. This temperature (**usually 20°C**) will be indicated on all volumetric ware.



Volumetric Flask

There may also be errors of calibration of the apparatus; that is, the volume marked on the apparatus may not be the true volume. Such errors can be eliminated only by recalibrating the apparatus or by replacing it.

Volumetric apparatus is calibrated to contain or to deliver a definite volume of liquid. This will be indicated on the apparatus with the letters "TC" (TO CONTAIN) or "TD" (TO DELIVER). Volumetric flasks are calibrated to contain a given volume and are available in various shapes and sizes.

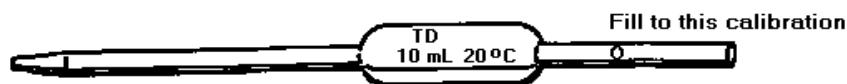
- A. Volumetric pipettes are calibrated to deliver a fixed volume. The usual capacities are 1 through 100 ml although micropipettes are also available.

In emptying volumetric pipettes, they should be held in a vertical position and the outflow should be unrestricted. The tip of the pipette is kept in contact with the wall of the receiving vessel for a second or two after the free flow has stopped. *The liquid remaining in the tip is not removed; this is most important.*

- B. Measuring and serological pipettes should also be held in a vertical position for dispensing liquids; however, the tip of the pipette is only touched to the wet surface of the receiving vessel after the

outflow has ceased. For those pipettes where the small amount of liquid remaining in the tip is to be blown out and added, indication is made by a frosted band near the top.

Volumetric Pipets



Measuring Pipets

Mohr pipet



Serological pipet



C. Burettes are used to deliver definite volumes. The more common types are usually of 25- or 50-ml capacity, graduated to tenths of a milliliter, and are provided with stopcocks. For precise analytical methods in microchemistry, microburettes are also used.

Automatic burettes with reservoirs are also available ranging in capacity from 10 to 100 ml. Reservoir capacity ranges from 100 to 4,000 ml.



General Rules regarding the manipulation of a burette:

- Do not attempt to dry a burette that has been cleaned for use, but rinse it two or three times with a small volume of the solution with which it is to be filled.
- Do not allow alkaline solutions to stand in a burette because the glass will be attacked, and the stopcock, unless made of Teflon, will tend to freeze.
- A 50-ml burette should not be emptied faster than 0.7 ml/s, otherwise too much liquid will adhere to the walls and as the solution drains down, the meniscus will gradually rise, giving a high false reading.
- In the case of all apparatus for delivering liquids, the glass must be absolutely clean so that the film of liquid never breaks at any point. Careful attention must be paid to this fact or the required amount of solution will not be delivered.

It should be emphasized that improper use or reading of burettes can result in serious calculation errors.

Cleaning of Glass and Porcelain

The method of cleaning should be adapted to both the substances that are to be removed, and the determination to be performed.



Water-soluble substances are simply washed out with hot or cold water, and the vessel is finally rinsed with successive small amounts of distilled water. Other substances more difficult to remove may require the use of a detergent, organic solvent, dichromate cleaning solution, nitric acid, or **AQUA REGIA** (25 percent by volume concentrated HNO_3 in concentrated HCl).

In all cases it is good practice to rinse a vessel with tap water as soon as possible after use. Material allowed to dry on glassware is much more difficult to remove.

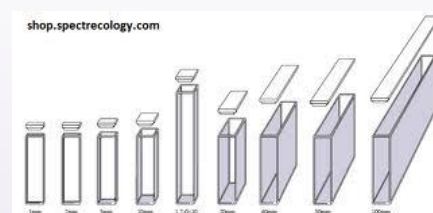
Dichromate cleaning solution (chromic acid) is a powerful cleaning agent; however, because of its destructive nature upon clothing and upon laboratory furniture, extreme care must be taken when using this mixture. If any of the solution is spilled, it must be cleaned up immediately.

A persistent greasy layer or spot may be removed by acetone or by allowing a warm solution of sodium hydroxide, about 1 g per 50 ml of water, to stand in the vessel for 10 to 15 min; after rinsing with water, dilute hydrochloric acid, and water again, the vessel is usually clean. Alcoholic potassium hydroxide is also effective in removing grease. To dry glass apparatus, rinse with acetone and blow or draw air through it.

Glassware may be dried for immediate use by rinsing with redistilled acetone. Otherwise glassware may be oven dried or drip dried. Glassware should be stored immediately after drying to prevent any accumulation of dust and stored inverted or with mouth of glassware covered with foil.

Special Cleaning Requirements

Absorption cells, used in spectrophotometers, should be kept scrupulously clean, free of scratches, fingerprints, smudges, and evaporated film residues.



Glassware to be used for phosphate determinations should not be washed with detergents containing phosphates. This glassware must be thoroughly rinsed with tap water and distilled water.

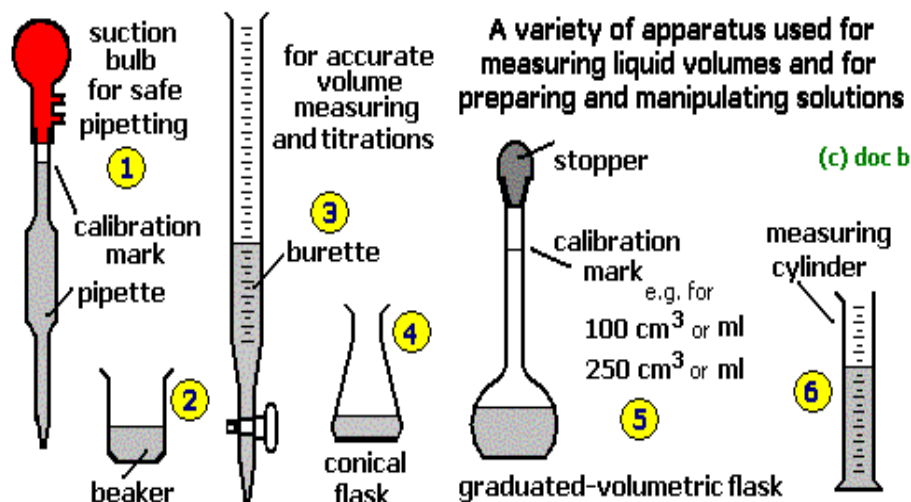
Bottles to be used for the collection of samples for organic analyses should be rinsed successively with chromic acid cleaning solution, tap water, distilled water, and, finally, several times with a redistilled solvent such as acetone. Caps are washed with detergent, rinsed with tap water, distilled water, and solvent. Liners are treated in the same way as the bottles and are stored in

Disposable Glassware

When the risk of washing a pipette for reuse becomes too great, as in the case of use with toxic materials, or when the cost of washing glassware becomes prohibitive, disposable vessels may be the answer, provided they meet the necessary specification. Various types are available including bacteriological, serological, and microdilution pipettes. Disposable glassware generally is made of soft glass although plastic vessels and pipettes are also available.

Glassware Proper Usage:

1. **Graduated cylinders** are used to measure small volume of liquids and solution for experiments.
2. **Pipettes** (moher/ graduated) are used to deliver any precise volume within its range. A detailed way of using the pipette is described next:
 - a. Prepare the pipette: clean the pipette with soap solution; rinse with several portion of tap water then with deionized water. No water droplets should adhere to the inner wall of the pipette. Transfer the liquid or solution that you intend to pipette from the reagent bottle to a beaker. Dry the pipette tip with a clean, dust free towel or tissue. Rinse through the pipette tip into a waste beaker. Using the pipette pump (never use your OWN MOUTH) draw 2-3 ml volumes into the pipette as rinse. Roll each rinse around in the pipette so that the solution washes the entire surface of the inner wall. Deliver each rinse through the pipette tip into a waste beaker.
 - b. Fill and operate the pipette: to fill the pipette, place the tip well below the surface of the solution in the beaker. Then using the pipette pump, draw the solution into the pipette until its level is 3-5 mm above the mark.
 - c. Deliver the solution: remove the tip from the solution, dry the tip with a dust free towel, and holding the pipette in a vertical position over a waste beaker, control the delivery of the excess solution from the pipette by lightly pressing the release bottom until the meniscus is at the mark. Remove any suspended droplet on the pipette tip by touching the inside wall of the waste beaker. Deliver the solution to the receiving vessel; keep the tip above the level of liquid and against the wall of the receiving vessel. Do not blow or shake out the Last bit of solution that remains in the tip; this liquid has been included in the calibration of the pipette.
 - d. Clean the pipette: once the use of pipette is complete, rinse the pipette several times with deionized water. Roll each rinse to flush the inner wall of the pipette and drain through the tip.

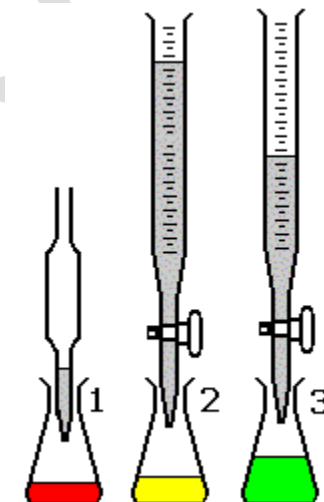


3. **Burettes:** It may be used when samples of various sizes must be dispensed or measured precisely.

The burette consists of a narrow calibrated glass tube, fitted at the bottom with a valve for controlling the flow of liquid. The valve is commonly called stopcock.

A burette must be cleaned before use. If the burette is not completely clean, the level of precision is not attained.

- Clean the burette with soap and water, using a special long handed burette brush to scrub the interior of the glass. Then rinse the burette with tap water.
- Do not attempt to admit water directly to the burette from the water tap. Fill a beaker with tap water, and pour from the beaker into the burette.
- Finally, rinse the burette several times with distilled water. Before use, the burette should again rinse with distilled water.



Many of the reagent solutions used in burette may attack the glass of the burette if they are not removed. This would destroy the calibration.

A common mistake made by junior students is to fill the burette with the reagents solution to be dispensed to exactly the 0.00 mark. This is not necessary or desirable in most cases and is a waste of time. The burette should be filled to a level that is comfortable for you to read (based on your height). The precise initial liquid level reading of the burette should be taken before the solution is dispensed and again after the liquid is dispensed. The reading should be made to the exact and precise ml. The volume of the liquid dispensed is then obtained by simple subtraction of the two volume readings.



TECHNIQUES IN PREPARATION SOLUTIONS

There are five units of concentration that are particularly useful to chemists. The first three: Molality, Molarity and Normality are dependent upon the mole unit. The last two: percent by volume and percent by weight have nothing to do with mole, only weight or volume of the solute or substance to be diluted, versus the weight or volume of the solvent or substance in which the solute is diluted. Percentages can also be determined for solids within solids.

1. Molarity "M"

The molar unit is probably the most commonly used chemical unit of measurement. Molarity is the number of moles of a solute dissolved in a liter of solution. A molar solution of sodium chloride is made by placing 1 mole of a solute into a 1-liter volumetric flask.

$$M = \frac{\# \text{ moles of solute}}{1 \text{ L of solvent}}$$

2. Molality "m"

The molal unit is not used nearly as frequently as the molar unit. A molality is the number of moles of solute dissolved in one kilogram of solvent. Be careful not to confuse molality and molarity. Note that the solvent must be weighed unless it is water.

$$m = \frac{\# \text{ moles of solute}}{1 \text{ Kg of solvent}}$$

3. Normality "N"

A measure of concentration that is equal to the gram equivalent weight per liter of solution. Gram equivalent weight is a measure of the reactive capacity of a molecule.

$$N = \frac{\# \text{ eq. wt.}}{1 \text{ L of solvent}}$$

For acid reactions, a 1 M H_2SO_4 solution will have normality (N) of 2 N because 2 moles of H^+ ions are present per liter of solution. For sulfide precipitation reactions, where the SO_4^{2-} ion is the important part, the same 1 M H_2SO_4 solution will have a normality of 1 N.

4. **Percent by weight:** To make up a solution based on percentage by weight, one would simply determine what percentage was desired.

For example, a 20% by weight aqueous solution of sodium chloride, and the total quantity to be prepared.

If the total quantity needed is 1 kg, then it would simply be a matter of calculating 20% of 1 kg which, of course is:

$$0.20 \text{ NaCl} * 1000 \text{ g/kg} = 200 \text{ g NaCl/kg.}$$

In order to bring the total quantity to 1 kg, it would be necessary to add 800g water.

5. **Percent by volume:** Solutions based on percent by volume are calculated the same as for percent by weight, except that calculations are based on volume. Thus one would simply determine what percentage was desired (for example, a 20% by volume aqueous solution of sodium chloride) and the total quantity to be prepared.

If the total quantity needed is 1 liter, then it would simply be a matter of calculating 20% of 1 liter which, of course is:

$$0.20 \text{ NaCl} * 1000 \text{ ml/l} = 200 \text{ ml NaCl/l.}$$

Percentages are used more in the technological fields of chemistry (such as environmental technologies) than they are in pure chemistry.

Dilution

When preparing a dilution, decide the volume and molar concentration of the resulting solution you require. Use the following equation to determine how much of the concentrated reagent is needed to prepare the diluted solution,

$$\text{No. of moles (reagent)} = \text{No. of moles (dilution)}$$

$$M_{\text{Reagent}} \times V_{\text{Reagent}} = M_{\text{Dilution}} \times V_{\text{Dilution}}$$

Where M is molarity and V is volume.

Slowly add the calculated volume of concentrated reagent to the proper-size volumetric flask half filled with distilled or de-ionized water and swirl the flask to mix. Once the solution is at room temperature, dilute to the mark with water and invert the flask several times to mix.

Dilution Factor (DF)

Dilution: is the mixing of a small accurately measured sample with a large volume of sterile water or normal saline called (diluent or dilution blank)

$$\text{Dilution} = \frac{\text{Volume of Sample}}{\text{Total Volume of (sample + diluent)}}$$

$$\text{Dilution Factor DF} = \frac{\text{Total Volume of (sample + diluent)}}{\text{Volume of sample}}$$

LAB REPORT

Cover Page

Write the Name of your University, School, Department, Subject Name then Identify yourself and your partner/s, write you ID number, Date of Performing the experiment, Date of Submitting the report.

Purpose/ Objective

This gives the objective of the Experiment. What concept or skill was highlighted by this Experiment. Ask yourself "Why did we do this activity? What was I supposed to learn or practice?" Sometimes the purpose can be stated in one sentence. Other times it may be necessary to add some extra information to narrow the scope of the activity.

Introduction/ General Information

Based on your text books, write about the subject of the experiment, an introduction has been already included so you may either add to it or you can write a new one. You need to paraphrase any material you take from the manual.

Materials & Reagents

This should be a sentence or two that lists the materials that were needed to carry out this activity. This could also be in the form of a table.

Procedure

This is probably one of the most difficult parts of the report for the beginner. Most of the writing you have done up to this point has included a lot of descriptive language. Technical writing is very "cut and dried" by comparison. All you are trying to convey is a mental picture of what you did. Ordinal phrases are not necessary. The order of events is conveyed by the sentence order in the description. Remember that your audience should be able to repeat your procedure if they wish to do so. Write your description of what was done so that the reader can visualize the set-up. Be sure to include reference to any equipment that you used (The mass was taken on a balance.) A diagram or picture of the apparatus may be helpful but should not replace a good verbal description. Be very specific in your instructions. Emotions (This was hard. or this was fun.) are not necessary and detract from the purpose of this section.

Observations & Data

This section should include only those things that you saw, heard, touched, or smelled (taste is out since we never taste anything in a science lab). This includes both

quantitative (numerical) and qualitative (sensual, not emotional) observations. Quantitative observations are best presented in data tables.

Qualitative observations may be organized in table form or paragraph form.

The goal of this section is to present the data that was collected in the activity in a clear and easily understood format. Units are necessary for any measurement. If you are unsure about whether something should be included in the data section, ask yourself "How did I get this piece of information? What instrument did I use to collect this information?" If you are giving a value that you did not measure directly (such as density) it should not be included as data.

Analysis of Data/ Results

This is the section where you will show any calculations that you made using the data you collected. Give the formula you will use for each type of calculation. You should show which measurements you are plugging into each calculation and then show the solution. **Once you have shown a sample calculation, you may use a data table to show other calculated values of the same type.** This is also the appropriate place to explain how the measurements relate to each other. This is the proper place to discuss anything that happened during the activity that may have affected your measurements.

You should also, mention the sources of error, and their effect on the results that were attained during the experiment.

Conclusions

This is the section of your report where you discuss how the purpose of the activity relates to the analysis of your data. In other words, what did you learn. Stick to the facts; do not comment on whether or not you enjoyed the activity. Be specific in your statements. If the results of the activity were not satisfactory, suggest how the activity could be improved to give better data. Did the activity raise questions that cannot be answered with the data you collected? This is the place to mention them. Remember, conclusions are connections that are not obvious on the surface.

Attachment

You have to attach the lab report that was signed by the RTA so that the report can be accepted. A penalty of deducting three marks will be given for each report missing the data sheet.

Finishing touches

1. Be sure you have filled in the information in the header. Give your name, your partner's name and the date you did the activity.
2. Proofread one last time to be sure that you have used correct grammar and punctuation. Remember that Spell Check on the computer will not catch a word that is used incorrectly if it is spelled correctly (there-their).

[1] pH OF WATER

pH Is a way of expressing the hydrogen ion H^+ concentration of a solution. As acids and bases in a solution dissociate to yield hydrogen ions H^+ and hydroxyl ions OH^- , pH is used to indicate the intensity of the acidic or alkaline condition of a solution. Water with pH value of 7 has an equal value of these two ions and is considered to be neutral solution. If a solution is acidic, the concentration of H^+ ions exceeds that of OH^- . In a basic solution, the concentration of OH^- ions exceeds that of the H^+ ions.



$$K = [H^+][OH^-] / [H_2O] \dots(3.2)$$

K : Dissociation constant

It is found that pure water dissociates to yield a concentration of hydrogen ions equal to about 10^{-7} mol/l. Since the concentration of H_2O is extremely large and constant we multiply it with K to produce K_w :

$$K_w = [H^+][OH^-] \dots\dots (3.3)$$

And for pure water $K_w = 1 \times 10^{-14}$

If we take the log of H^+

$$pH = -\log [H^+] \dots\dots\dots (3.4)$$

$$pOH = -\log [OH^-] \dots\dots (3.5)$$

pH	Effect
3.0-4.5	Unlikely that fish can survive for more than few hours, although some plants and invertebrates can be found
4.5-5.0	Most fish eggs won't hatch
5.0-5.5	Metals (Al, Pb) normally trapped in sediments are released into the acidified water in forms toxic to aquatic life. Decomposers bacteria begin to die, plankton disappear, snails and calms are absent, mats of fungi replace bacteria in the substrate
6.0-6.5	Unlikely to be harmful to fish unless free carbon dioxide is high (in excess of 100 mg/l)
6.5-8.2	Optimal for most organisms
8.2-9.0	Unlikely to be directly harmful to fish, but indirect effects can occur due to chemical changes in the water
9.0-10.5	If persist for long periods it can be harmful to certain types of fish
10.5-11.0	Rapidly lethal to some types of fish
11.0-11.5	Rapidly lethal to all species of fish

Table (1.1): pH ranges vs. effect on ecosystem

On a pH scale of 0 to 14, a value of 0 is the most acidic and 14 is most basic. A change in pH from 7 to 8 in a lake or a stream represents a ten-fold increase in the OH⁻ ion concentration.

Rainfall generally has a pH value between 5 and 6.5. It is acidic due to the presence of dissolved carbon dioxide and air pollutants, such as sulfur dioxide or nitrogen oxides (NO_x). If the rain water flows over soil containing hard water minerals, its pH usually increases. Bicarbonate ions, HCO₃⁻ resulting from limestone deposits react with water to produce OH⁻ ions, according to the equation:



As a result, streams and lakes are often basic, with pH values between 7 and 8, sometimes as high as 8.5.

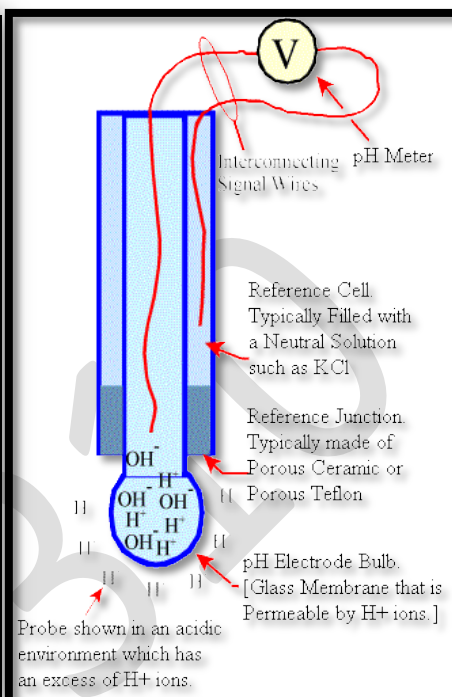
The measure of pH of a body of water is very important as an indication of water quality, because of the sensitivity of aquatic organisms to the pH of their environment. Small changes in pH can endanger many kinds of plants and animals; for example, trout and various kinds of nymphs can only survive in waters that have pH range from 7 to 9. If the pH of the waters in which they live is outside of that range, they may not survive or reproduce.

Changes in pH can also be caused by: 1. algae blooms (more basic) 2. industrial process resulting in a release of bases or acids (raising or lowering pH), 3. the oxidation of sulfide containing sediments (more acidic).

In the field of water supplies, pH is a factor that must be considered in chemical coagulation, disinfection, water softening, and corrosion control. In wastewater treatment employing biological processes, pH must be controlled within a range favorable to the particular organism involved.

pH can be measured in many ways like indicators, or meters employing the glass electrode. pH measurements can be made in a wide variety of materials and under extreme conditions, provided that attention is paid to the type of electrode used. Measurements of pH values above 10 and at high temperatures are best made with special glass electrodes designed for such services. The electrode is normally (Calibrated) with buffer solution of known pH values.

The pH element is a thin glass membrane that is permeable by H^+ ions. The electrode is filled with a neutral solution, which by definition contains an equal number of H^+ and OH^- ions. When the probe is immersed in an H^+ rich environment (acidic) the glass membrane is permeated by the H^+ ions which exert a positive potential on the sensing electrode. This potential difference is measured by a pH meter and converted to a pH output. Likewise, when the probe is immersed in an alkaline environment there exists within the probe a higher H^+ concentration than outside of the probe. This causes H^+ ions within the probe to migrate outside of the probe which leaves an excess of OH^- ions within the probe. A negative potential is thus sensed by the pH meter.



Time required:

An hour or less depending on the number of samples determined

Equipment and Reagents:

- pH meter
- Universal indicator
- Buffer solutions for the calibration of pH meter: pH 4.0, pH 6.0 and pH 9.0
- Litmus paper

Significant Experimental Hazards

- Student should be aware of hazards associated with the use of all glassware (cuts).
- Student should be aware of hazards associated with the samples (some might be extremely acidic or basic)

Procedure:

- (1) Insert the litmus paper in the sample for 10 seconds, then compare the color with the standard colors and determine the pH of each sample.
- (2) Calibrate the pH meter by using the two buffer solution provided. You should initially wash the electrode with distilled water from a wash bottle and then gently dry the electrode with a laboratory tissue. Place the electrode in pH 4 buffer solution and gently swirl the solution until a stable reading is obtained. Remove the electrode, rinse with distilled water, dry with a tissue and insert the electrode into the pH 7 buffer solution, swirl the solution until a stable reading is obtained and adjust the meter as necessary. Repeat these readings until the pH meter is correctly calibrated for both buffer solutions.
- (3) Insert the (cleaned and dried) pH electrode into the sample, swirl the sample gently until a stable reading is obtained within about 1 min. also write the temperature value at the time of measurement occasionally, the pH value will 'drift' i.e. slowly but continuously increase or decrease. If drifting occurs, record that the pH is drifting and note the pH limits over a certain (identified) period of time. You may also need to re-calibrate the electrodes.
- (4) Take great care not to bring the sample vessels into contact with membrane (bulb) of the electrode.
- (5) If you are determining the pH of more than one sample, it is most efficient to prepare and determine all of the samples together.
- (6) Take care to write all the information given for each sample, to use it later in the discussion.

Issues to consider for your practical report

- What are the potential sources of error in this analytical determination? How could they be overcome?
- What are alternative methods for determining the pH of aqueous samples? How do they compare to this method?
- What are typical pH values of drinking water in Jordan? How do your data compare with these values?
- What are the main sources of acidity or alkalinity in water and wastewater? (state the answer in your introduction)
- What type of aqueous samples has typically had a pH > 7 or pH < 7?
- What are the potential health and environmental effects if any of extreme pH values? (for humans)
- Discuss the effect of the parameters on the reading of pH
- Decide which is the precise and most accurate method of pH measuring.
- Calculate the concentrations of H^+ and OH^- in each of the samples.
- Calculate the pOH of each sample.

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Experiment (1): pH of Water Experimental Results	
Name	Date
ID No.	Group

Run	Room Temp.			Low Temp.	High Temp.	NOTES
	T (°C)	pH (indicator paper)	pH Meter Reading			
	T (°C)	pH (indicator paper)	pH Meter Reading			
	T (°C)	pH (indicator paper)	pH Meter Reading			
1						
2						
3						
4						

Observations and calculations:

WEEM 1310

[2] CONDUCTIVITY IN WATER

Conductivity, k , is a measure of the ability

of an aqueous solution to carry an electric current. This ability depends on the presence of ions; on the total concentration, mobility, and valence; and on the temperature of measurement. Ionic current of the sample is a function of dissolved solids concentration. The conductivity of a solution is proportional to the concentration. Solutions of most inorganic compounds are relatively good conductors. Conversely, molecules of organic compounds that do not dissociate in aqueous solution conduct a current very poorly, if at all.

Conductivity is measured with a probe and a meter. A voltage is applied between the two electrodes in the probe immersed in the sample water. The drop in voltage caused by the resistance in water is used to calculate the conductivity per centimeter.

Conductivity (G) is the inverse of resistivity (R) is determined from the voltage and current values according to ohm's law.

$$G = 1/R$$

$$G = k (A/L)$$

Where the unit of R is ohm and G is ohm^{-1} (moh), A is the surface area, cm^2 and L is the distance between the electrodes, cm. The meter converts the probe measurements to micro mhos per cm and displays the result to the user. The unit of conductivity are $1/\text{ohm-cm}$ or mho per centimeter, but customarily is reported in microohms per centimeter ($\mu\text{mho/cm}$). In the international system of units (SI) the reciprocal of the ohm is siemens (S) and conductivity is reported as millisiemens per meter mS/m and microsiemens per centimeter $\mu\text{S/cm}$ or $\mu\text{S/m}$

Environmental significance:

Conductivity itself is of little interest to a water analyst but it is an invaluable indicator of the range into which hardness and alkalinity are likely to fall, and also of the order of the total dissolved solids (TDS) content of the water.

The measurement is used regularly to check the purity of distilled and deionized waters used in the laboratories used in the laboratory for making up solutions.

Electrical conductivity measurements are often employed to monitor desalination plants.

It is useful to assess the source of pollution

In coastal regions, conductivity data can be used to decide the extent of intrusion of sea water into the ground water.

Conductivity data is useful in determining the suitability of water and wastewater for disposal on land. Irrigation waters up to 2 millisiemens/cm conductance have been found to be suitable for irrigation depending on soils and climatic characteristics.

It is also possible using conductivity measurements to run checks on accuracy of the common chemical determinations carried out in laboratories.

Time required:

An hour or less depending on the number of samples determined.

Equipment and Reagents:

Conductivity meter

0.1 % (wt) NaCl standard.

Significant Experimental Hazards

- Student should be aware of hazards associated with the use of all glassware (cuts).

Procedure:

- (1) Wash the conductivity electrode with distilled water before using it; dry it so that it won't change the concentrations of samples by carrying either solid or water droplets.
- (2) Immerse the electrode in the beakers containing NaCl standard mixtures given in the laboratory, write the concentration of each beakers and the measured conductivity with the units plus the temperature of each solution.
- (3) Wash the electrode before using it for the other sample and repeat the procedure that was carried out earlier.
- (4) Write all the information given for each sample.

Calculations:

- I. Using the results of conductivity for the NaCl standard, Draw a chart containing the concentration of NaCl versus the measured conductivity and construct the best trend line and calculate the equation relating the Total Dissolved solids against the conductivity.
- II. After establishing the relation between the TDS and the conductivity estimate the TDS of the rest of the samples.

Issues to consider for your practical report

- What are the potential sources of error in this analytical determination? How could they be overcome?
- What are alternative methods for determining the TDS of aqueous samples? How do they compare to this method?
- What are typical conductivity and TDS values of drinking water in Jordan? How do your data compare with these values?
- What are the main sources of TDS in water and wastewater?
- What are the potential health and environmental effects if any of extreme TDS values?
- What is the common conductivity reading for deionized, distilled, drinking and waste water?

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Experiment (2): Conductivity of Water
Experimental Results

Name	Date
ID No.	Group

Sample ID	k ($\mu\text{S}/\text{cm}$) or (mS/cm)				Notes
	Salinity	$T_1 (^{\circ}\text{C})$	$T_2 (^{\circ}\text{C})$	$T_3 (^{\circ}\text{C})$	
	P1				
	P2				
	P3				
	P4				

Observations and Calculations:

WEEM1310

[3] TURBIDITY IN WATER

Turbidity can be defined as the waters that contain

suspended matter that interferes with the passage of light through the water or in which visual depth is restricted. Turbidity is a principal physical characteristic of water and may be caused by a wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence.

In general the materials that cause turbidity may range from purely inorganic substances to those that are largely organic in nature. This disparity in the nature of the material causing turbidity makes it impossible to establish hard and fast rules for removal.

Turbidity may be caused by a wide variety of materials. In glacier-fed rivers and lakes most of the turbidity is due colloidal rock particles produced by the grinding action of the glacier. As rivers descend from mountains area onto plains, they receive contributions of turbidity from farming and other operations that disturb the soil. Under flood conditions great amounts of topsoil are washed to receiving streams. Much of this material is inorganic in nature and includes clay and silt, but considerable amounts of organic matter is included. As the rivers progress towards the ocean, they pass through urban areas where domestic and industrial wastewaters, treated or untreated, may be added. The domestic waste may add great

quantities of organic and some inorganic materials that contribute turbidity. Street washings contribute much inorganic and some organic turbidity. Organic materials reaching rivers serve as food for bacteria, and the resulting bacteria growth and other microorganisms that feed upon the bacteria produce additional turbidity. Inorganic nutrients such as nitrogen and phosphorous present in wastewater discharges and agricultural runoff stimulate the growth of algae, which also contribute turbidity.

Sources of Turbidity

Soil Erosion

Silt
Clay

Urban Runoff

Road grime
Rooftops
Parking lots

Industrial waste

Sewage treatment effluent
Particulates

Abundant bottom-dwellers

Stirring up sediments

Organics

Microorganisms
Decaying plant and animals
Gasoline or oil from roads

Table (3.1): Sources Of Turbidity And Its Types



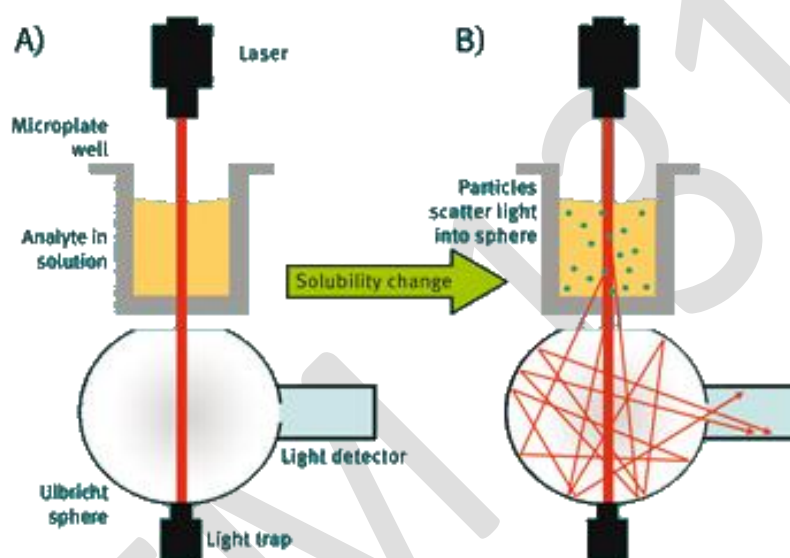
Turbidity is an important consideration in public water supplies for three major reasons:

1. Aesthetics: Any turbidity in the drinking water is automatically associated with possible wastewater pollution and the health hazards occasioned by it.
2. Filterability: Filtration of water is rendered more difficult and costly when turbidity increases. High turbidity shortens filter runs and increases cleaning costs.
3. Disinfection: To have an effective disinfection there must be contact between the agent and the organisms that the disinfectant is to kill, in cases in which turbidity is caused by municipal wastewater solids, many of the pathogenic organisms may be encased in the particles and protected from the disinfectant, and thus more disinfectant must be applied.

Application of turbidity data:

1. **Water supply:**
Water supplies obtained from rivers usually require chemical flocculation because of high turbidity. Turbidity measurements are used to determine the effectiveness of the treatment produced with different chemicals and the dosage needed. Thus, they aid in selection of the most effective and economical chemical to use. Such information is necessary to design facilities for feeding the chemicals and for their storage.
2. **Domestic and industrial waste treatment:**
The suspended solids determination is usually employed in waste treatment plants to determine the effectiveness of suspended solids removal. The determination is slow and time consuming, and in plants employing chemicals treatment, changes in chemical dosages have to be made rather frequently. Turbidity measurements can be used to gain the necessary information. By their use, chemical dosages can be adjusted to use the minimum amount of chemicals while producing a high quality effluent.

Turbidity is measured in many ways, but the main method to determine it, is by using a Nephelometer, Turbid Meter. Nephelometer measures the scattering light from particles with and uses the Nephlo Turbidity Unit (NTU). In the instrument, a light source illuminates the sample and one or more photoelectric detectors are used with a readout device to indicate the intensity of scattered light at right angles to the path of the incident light. Earlier SiO_2 was used as a standard but now it is customary to use a particular Formazin polymer suspension as a standard. Samples with turbidities greater than max. NTU reading are diluted with turbidity free water until values within the range of instrument. The turbidity is then determined by multiplying the measured turbidity by the dilution factor.



Schematic diagram of the measurement principle of the NEPHELOMETER: A clear solution with minimal scattering results in low signal (A). A solution with particles scatters light and results in higher signal (B).

Time required:

An hour or less depending on the number of samples determined.

Equipment:

- Turbidity meter, standards
- Empty vial to hold the samples
- Clean and dry wipe

Significant Experimental Hazards

- Student should be aware of hazards associated with the use of all glassware (cuts.)

Procedure:

- (1) Calibrate the turbidimeter according to the model you are using (write in detail since each device has a different procedure and different standards.)
- (2) Wipe the vials containing the standards and the samples with a clean cloth so that finger tips or the dirt won't affect the reading of the turbidity meter.
- (3) Place the vials containing the standards in the turbidimeter and wait till its calibrated; you should be able to get the total suspended solids for each standard from the instructor.
- (4) Place the sample vials after cleaning it in the turbidimeter and record the results in your table.

Calculations:

- I. Using the results of turbidimeter for the standards, Draw a chart containing the total suspended solids (TSS) (mg/l) versus the measured turbidity
- II. construct the best linear trend line and calculate the equation relating the TSS against the turbidimeter.
- III. After establishing the relation between the TSS and the turbidity estimate the TSS of the samples.

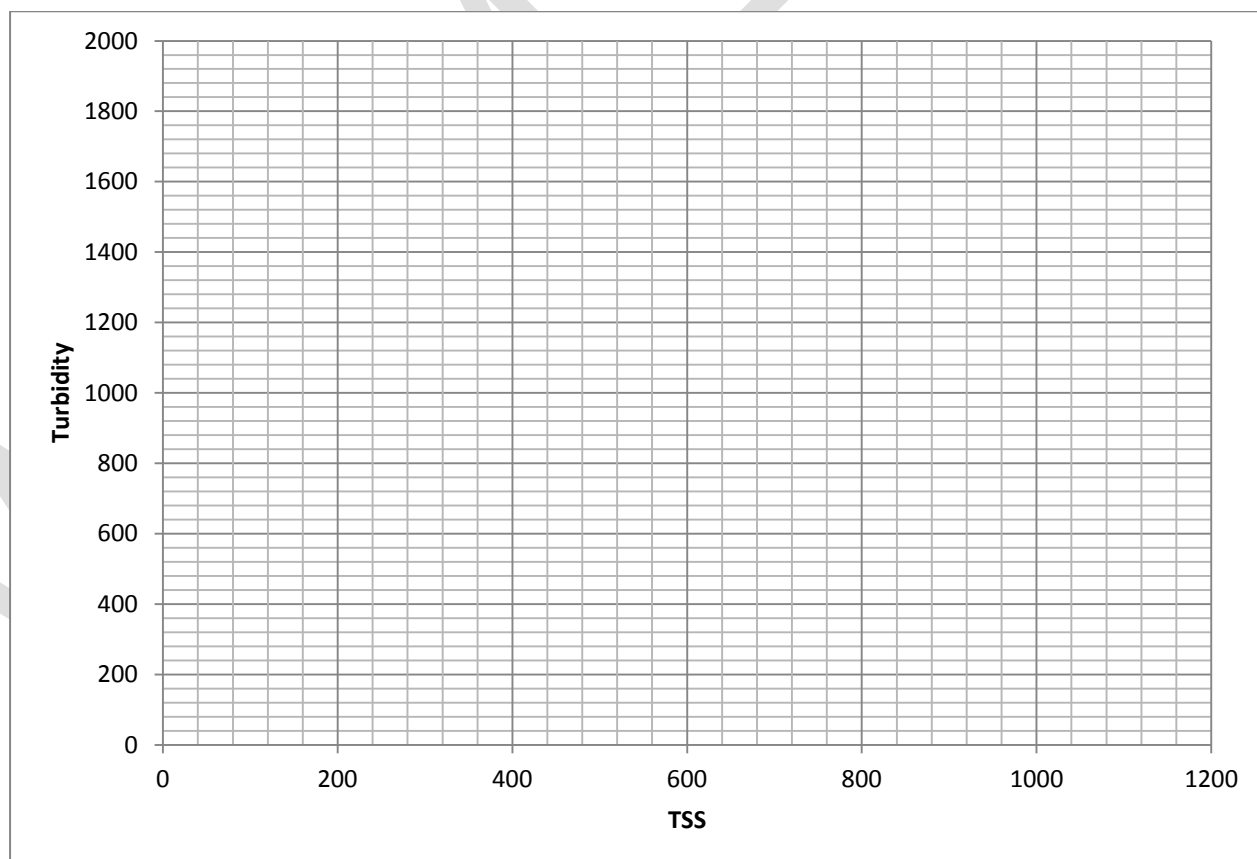
Issues to consider for your practical report

- What are the potential sources of error in this analytical determination? How could they be overcome?
- What are the alternative methods for determining the turbidity of aqueous samples? How do they compare to this method?
- What are typical turbidity and TSS values of water in Jordan? How do your data compare with these values? (Drinking, surface and ground water)
- What are the main sources of TSS in water and wastewater?
- What are the potential health and environmental effects if any of extreme turbidity values?

Experiment (3): Turbidity of Water
Experimental Results

Name	Date
ID No.	Group

Sample ID	TSS (mg/l)	Turbidity (NTU)	NOTE
ST1	0.0	>0.02	
ST2	17.95	10.00	
ST3	179.64	100.00	
ST4	1437.26	800.00	
ST5	3144.03	1750.00	
Distilled water			
Tap water			
A			
B			
C			



Observations & Calculations:

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