pH

1

pH

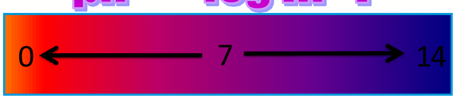
- Why is pH important?
  - Gas and metal solubility
  - Corrosively
  - Coagulation and Flocculation
  - Biological activity
- Many processes depend on pH
  - Drinking water
  - Wastewater
    - Aeration basin – Microorganisms
  - Boiler and Cooling water
  - Industrial applications
  - Environmental

2

pH

- pH
  - Measurement of Hydrogen Ion (H^+) concentration
  - Acid – Increase of Hydrogen Ions (H^+)
  - Base – Increase of Hydroxide Ions (OH^-)
  - pH is defined as the negative log of the molar Hydrogen Ion concentration

$$pH = -\log [H^+]$$



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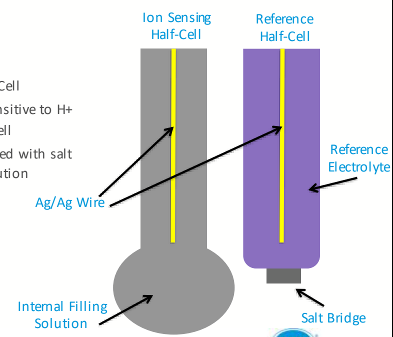
pH

- pH Probes
  - Ion Sensing Half Cell
    - Glass bulb sensitive to H+
  - Reference Half Cell
    - Glass tube filled with salt reference solution



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pH

- pH Probe Calibration
  - Calibration done <u>Every Day</u>
  - Use fresh buffers
- pH Calibration Check
  - Slope of curve = -59.16 mV/Decade, 3mV or 5%
  - pH 4 buffer = ~180mV
  - pH 7 buffer = ~0mV
  - pH 10 buffer = ~ -180mV

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pH

- New pH Probes
  - Requires conditioning in pH 7 Buffer for 30 minutes
- Sample Reading
  - Place probe into sample, stir, and wait for stable reading
  - Rinse with DI water and pat dry with cloth after every measurement
    - Do not cross contaminate samples
- Store pH probe in
  - Electrode Storage Solution (3M KCl)
  - pH 4 buffer
  - Sample or solution with similar ionic strength
  - *Never store in Tap or DI water

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pH

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CONDUCTIVITY

8

Conductivity – Take-Home Messages

- Conductivity is an electrochemical method of analysis.
- The measurement of conductivity is based on the ability of a water to conduct an electrical current.
- Conductivity measurement provides an estimate of a water's TDS.

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Conductivity - Outline

- Introduction to Conductivity
- Theory of Conductivity Measurement
- Conductivity vs. TDS
- Measurement Techniques

10

Why is Conductivity Important?

- Can provide estimate of total dissolved solids (TDS) in an aqueous sample
- TDS is a primary measurement of water quality in many applications
  - Drinking water
  - Irrigation water

12

Traditional TDS Method

- Traditional gravimetric TDS is time consuming - requires a balance, volumetric glassware and drying oven
  - Filter known volume of sample
  - Place in oven
  - Dry sample to a constant weight

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Conductivity and TDS

- Water conductivity can easily and quickly provide a suitable estimate of TDS for most applications.
  - Place probe into sample and obtain reading nearly immediately

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Conductivity - Outline

- Introduction to Conductivity
- Theory of Conductivity Measurement
- Conductivity vs. TDS
- Measurement Techniques

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Theory of Conductivity Measurement

- What is conductivity?
  - Conductivity is the measurement of a solution's ability to conduct an electrical current.

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What are Ions?

- An ion is an atom or molecule that has an electrical charge, either positive or negative.
  - Cation – ion with positive charge
  - Anion – ion with negative charge

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What are Ions?

- Ions in solution are also known as electrolytes, since their presence allows conductance.

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What are Some Common Ions?

CATIONS	ANIONS
Calcium (Ca^{2+})	Chloride (Cl^{-})
Magnesium (Mg^{2+})	Nitrate (NO_3^{-})
Sodium (Na^{+})	Sulfate (SO_4^{2-})
Iron (Fe^{2+})	Phosphate (PO_4^{3-})
Aluminum (Al^{3+})	Bicarbonate(HCO_3^{-})

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Conductivity Applications

- Conductivity is easy to measure and is useful in a wide range of applications.
  - Drinking Water
  - Wastewater
  - Environmental Water (Irrigation Water)
  - Boiler/Cooling Water

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Conductivity Applications

- Conductivity can be related to:
  - Chemical purity of water
  - Amount of dissolved solids in a solution
  - Efficiency of various treatment processes
  - Salt concentration in brine

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How is Conductivity Measured?

- A conductivity probe measures the resistance in a solution.

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How is Conductivity Measured?

- A voltage is applied between the two electrodes immersed in the test solution, and the voltage drop caused by the resistance of the solution is used to calculate its conductivity.

23

How is Conductivity Measured?

- Small voltage drop = High conductivity (or low resistivity)
- Large voltage drop = Low conductivity (or high resistivity)

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Conductivity Units

- The basic unit of measure for conductivity is the siemen (or mho)
  - The unit mho is the reciprocal of ohm (unit of resistance)
- Typical ranges in aqueous solution
  - Millisiemens per cm - mS/cm
  - Microsiemens per cm - µS/cm

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Conductivity - Outline

- Introduction to Conductivity
- Theory of Conductivity Measurement
- Conductivity vs. TDS
- Measurement Techniques

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Measuring TDS

- TDS measurement expresses the total ion concentration in grams/liter (g/L) or milligrams/liter (mg/L).
  - Probe does not identify individual ions
  - It measures the sum total of the concentrations of the ionic components of the solution

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TDS versus Conductivity

- In general: TDS = 0.5 X Conductivity
- This is an empirical factor chosen because of its simplicity and suitability for a wide variety of applications.

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TDS versus Conductivity

- TDS is nearly equivalent to NaCl concentration when using 0.5 conversion factor – but not all solutions are composed of NaCl
  - Need to know temperature and ionic characteristics of a sample to select a more precise factor
- Most natural waters have a factor closer to 0.65 because NaCl is not the only salt in solution

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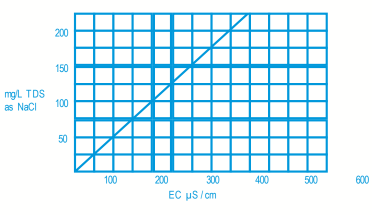
TDS versus Conductivity



30

TDS versus Conductivity

- In reality, the combination of ions present in natural waters gives a factor closer to:

  TDS = 0.65 X Conductivity
- Current Hach conductivity meters can be programmed to accept either factor (or a completely different factor)

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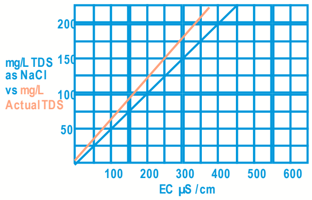
TDS versus Conductivity



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Conductivity - Outline

- Introduction to Conductivity
- Theory of Conductivity Measurement
- Conductivity vs. TDS
- Measurement Techniques

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Calibration

- Calibration required periodically due to aging of the probe electrical components or when a new probe is installed.
- Calibrate using a standard solution with similar conductivity and temperature to a typical sample.
- Can also calibrate by adjusting the cell constant.

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Temperature Compensation

- Conductivity is affected by sample temperature.
- Relate conductivity measurements to a reference temperature: 25 °C (most common)
- A temperature compensation circuit adjusts the measurement value to what it would be at the reference temperature.

36

Temperature Compensation

- Solution temperature is measured by a thermistor in the conductivity probe
  - Automatic temperature compensation for both conductivity and TDS measurements.

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Sample Measurement

- Place probe into sample, being sure that the end of the probe is completely submerged in sample.
- Agitate the probe to remove air bubbles.
- Wait for a stable reading.

39

Probe Storage

- Probe should be stored dry
- When resuming use of the probe after storage, allow time for rewetting.

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Probe Maintenance

- Rinse and dry probe between measurements to avoid contamination
- A dirty probe will affect measurement accuracy – probe may be cleaned with a strong detergent solution or by dipping in a 1:1 hydrochloric acid solution followed by a thorough rinse with DI water.

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Conductivity – Take-Home Messages

- Conductivity is an electrochemical method of analysis.
- The measurement of conductivity is based on the ability of a water to conduct an electrical current.
- Conductivity measurement provides an estimate of the TDS in a water.

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CONDUCTIVITY

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Turbidity

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Turbidity

- Turbidity is an optical property related to the scattering of light as it passes through water.
- Turbidity results from particulate matter suspended in water as well as other constituents, such as gas bubbles, that cause light to scatter. Even pure water will cause some amount of light scatter.

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Turbidity

- A measure of the clarity of the water.
- It is an expression of the optical property that causes light to be scattered and absorbed in water. A directed beam of light sent through a solution with NO particles will arrive at a receptor essentially unchanged.
- Turbidity is an indirect measurement of particulates such as clay, silt, organic matter, algae and other suspended colloidal matter (as large as 50 – 100 microns) as well as microbes.

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Turbidity

- Turbidity does not indicate the number or size of particulates in a sample.
- The water industry uses it as a general indicator of over all quality of filtered water and serves as a process control for the operator.
- Elevated turbidity from filters is not good as those solids may contain bacteria and/or viruses that shield microbes from chlorine.

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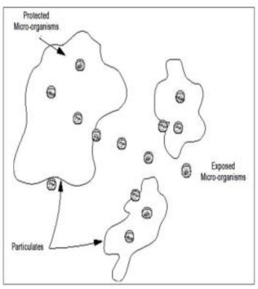
Turbidity



- Supports growth of micro-organisms.
- Reduces effectiveness of chlorination.
- Interferes with physical and microbiological analyses.

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Importance

- High turbidity is unacceptable for aesthetic reasons.
- When operating a filtration plant, it is related to effective coagulation and filtration.
- High turbidity water is unacceptable for consumers and most industrial customers.
- We also want to be sure that we've removed Giardia and Cryptosporidium cysts !!!

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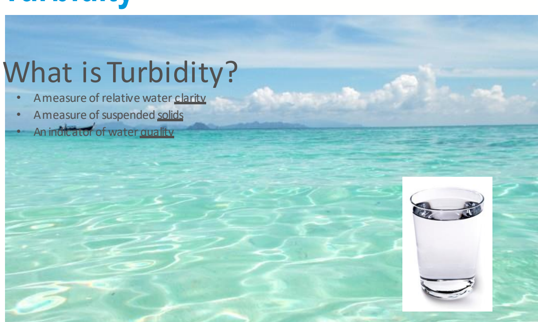
Turbidity

What is Turbidity?

- A measure of relative water clarity
- A measure of suspended solids
- An indicator of water quality



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Turbidity

What Turbidity Is Not:

- A direct measure of total suspended solids (TSS) concentration
- Able to identify the type of particles
- A spectrophotometric analysis

52

What is Turbidity?

- Suspended particles may include
  - Silt
  - Clay
  - Algae and Other Microorganisms
  - Organic Matter
  - Other Minute Particles

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Sanitary Significance of Turbidity

- Solids in Water:
  - Support growth of harmful microorganisms
  - Reduce effectiveness of chemical disinfection
  - Interfere with chemical and biological analysis
  - Have poor aesthetics
  - Are unacceptable for most industrial applications

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Sanitary Significance of Turbidity

- In coagulated, filtered water turbidity generally indicates improper operation. Alum floc may be passing the filters, or floc may be forming in the clear water well instead of the coagulation basin.
- In finished water, turbidity may be due to precipitated calcium carbonate, indicating deposition of scale in pipe lines, or it may be due to iron oxide caused by corrosion of pipe lines.
- In raw water, turbidity affects the quantity of coagulant required for treatment and shortens filter runs.

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Water Quality and Turbidity

- Turbidity measurements must be done either continuously or at least every four hours. The MCL or "Maximum Contaminant Level for turbidity is 0.3 NTU.
- Turbidity testing is used to detect changes in finished and raw water quality, detecting problems in coagulation and sedimentation, and in troubleshooting filtration problems.

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Turbidity Measurements

- Turbidity is measured using a nephelometer.
- A nephelometer is usually referred to as a turbidimeter.
- Turbidimeters measure light that is scattered at a 90 degree angle and also 90 x 360 degree
- Results are expressed in NTUs.

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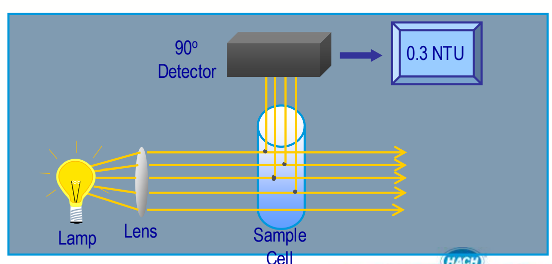
Basic 90º Nephelometer



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Why 90 Degrees?

- Many factors affect light scattering:
  - Particle Size
  - Particle Shape
  - Refractive Index
  - Color of Particles and Fluid
  - Particle Concentration

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Why 90 Degrees?

- Nephelometers attempt to minimize the effects of these factors (size, shape, color of particles) while maximizing measurement accuracy.
  - Example – particle size

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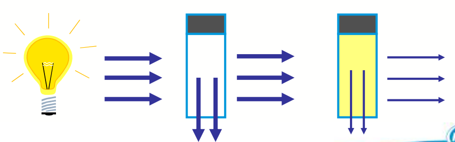
Color of Particles and Solution

- Colored substances absorb light.
- If light is absorbed, then less light reaches the detector and the measured turbidity will be lower.



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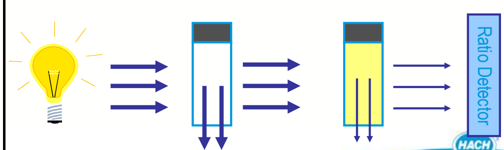
Color of Particles and Solution

- Correct for this with a ratio nephelometer.
- Additional detector measures amount of light absorbed by sample and performs correction.



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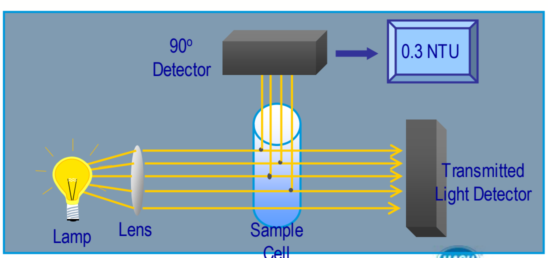
Ratio Nephelometer



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Particle Concentration

- A few large particles may scatter as much light as many small ones.
  - A direct comparison from NTU to mg/L solids may not always be possible

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Particle Concentration

- Extremely high particle concentrations can cause the same light to be scattered by multiple particles.
  - It may reach the point where accurate measurement is impossible.

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Nephelometers - Stability and Range

- Additional detectors increase the range of measurements and add stability
  - Forward scatter
  - Back scatter

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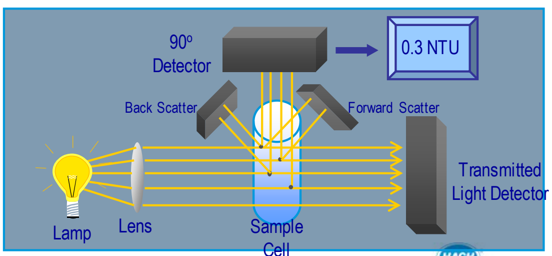
Additional Detectors



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Nephelometers - USEPA Requirements 180.1

- Tungsten-halogen lamp operated at a filament color temperature of 2200-3000K
- Light path through sample ≤ 10cm
- Scattered light detected at 90 ± 30º
- Detector and filter system response peaks between 400-600nm

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Turbidity Measurement EPA approved Hach Method 10258

- Nephelometry with the scattered light collected at 90° to the incident light and 360° around the sample vial.
- No silicone oil
- No indexing

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TU5200

Laser light source at 650nm

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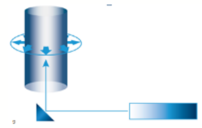
TU5200



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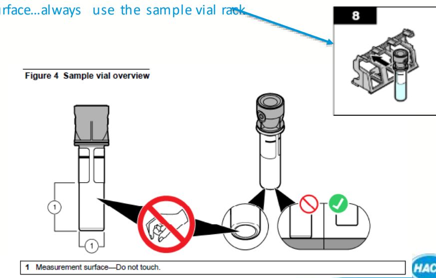
5200

Never touch the sample vial measuring surface and do not set the sample vial on a surface...always use the sample vial rack



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Turbidity Standards

	Calibration	Verification
Before StablCal	Formazin	Gelex
After StablCal	StablCal	StablCal

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Turbidity Standards

- Primary Standards - *Formazin, StablCal*
  - High purity material that serves as a reference for measurement comparison
- Secondary Standards – *Gelex, ICE-PIC (process) Glass Rod Secondary Turbidity Standard <0.1 NTU*

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Primary Standards

- There are others out there - Why are formazin and StablCal optimal primary standards?
  - Particles irregularly shaped and sized
  - More closely representative of particles found in natural water samples

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Primary Standards

- Formazin
  - Purchased as a 4000 NTU concentrate or prepared in lab
  - Diluted immediately prior to use
    - Dilutions unstable
  - EPA approved

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Primary Standards

- StablCal
  - Purchased at the required NTU value
    - Standards range from 0.3 - 4000 NTU
  - No dilution necessary
  - Stable for 1 year
  - EPA approved

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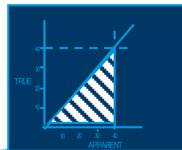
Primary Standards

- When to Use?
  - Calibration
  - Calibration check
    - Certified 0.3, 0.5, 1.0 NTU StablCal



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Secondary Standards

- Gelex Secondary Standards
  - Lab instrument verification
- ICE-PIC Calibration Verification Module
  - For 1720 series on-line turbidimeters
  - Filters inside module simulate a specific turbidity reading
  - Glass Rod Secondary Turbidity Standard <0.1 NTU

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Secondary Standards

- When to Use?
  - Calibration check 1720E and TU5300 or TU5400
  - If 1720 is not used for EPA reporting, ICE-PIC Calibration Verification Module can be used for calibration

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Measuring Turbidity

- Turbidity is just plain different than colorimetry
  - No zero (impossible to measure zero turbidity)
  - Not a comparison measurement
  - Requires calibration on a regular basis

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Measuring Turbidity

- In *theory*, relatively simple to understand
- In *practice*, an accurate measurement is not so simple - especially <1.0 NTU
  - Recognize potential error sources
  - Techniques to minimize error

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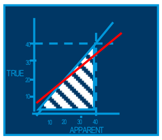
Sources of Error

- Stray Light - Excess light in the system (from any source) contributing to a high turbidity measurement
  - Sample Cells
  - Gas Bubbles
- Improper Calibration



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Gas Bubbles - How to Improve

- Bubbles scatter light and will give a high reading
- Degas Sample
  - Time - let sample sit for a few minutes
  - Ultrasonic bath
  - Draw vacuum

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Stray Light - How to Improve

- Stray light allows more light to reach detector = false high turbidity reading
  - Keep sample compartment and optics clean

85

Calibration - How to Improve

- Improper calibration can lead to inaccurate measurements
  - Calibrate regularly with primary standards at the values recommended by the manufacturer
  - Hach recommends standards no less than 20 NTU - *even if measurements are <1.0 NTU*

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Calibration - Why Calibrate at 20NTU?

- Typical error in standard preparation estimated at about 0.23NTU
  - Small amounts of error (0.23) in a 20NTU standard will not affect accuracy of low level measurements
  - The same amount of error (0.23) in a 0.3NTU standard will greatly affect accuracy of low level measurements

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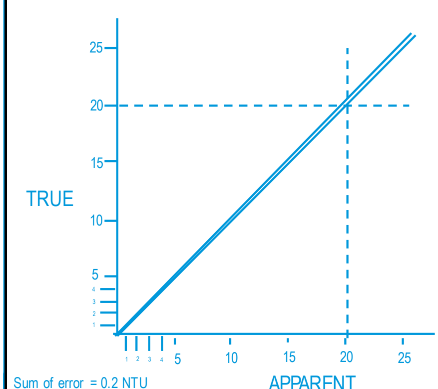

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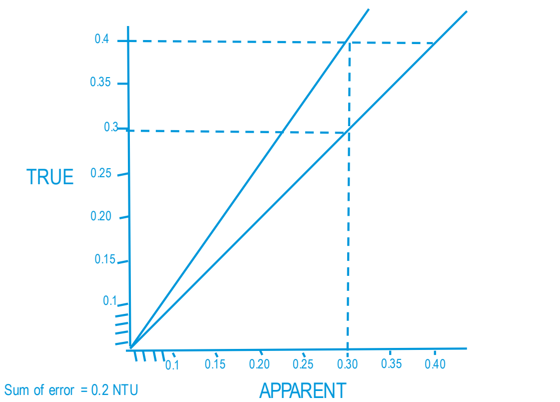

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Hach's Calibration Recommendations

- Do not prepare a low concentration standard for calibration
- Calibrate with recommended standards (20NTU) and verify calibration with certified low-level StablCal standards.

90

Turbidity Measurements

- Clean sample cells
- Use silicone oil with 90° scattered light
- Degas sample
- Maintain instrument
- Follow proper calibration procedure

TL2300 EPA 180.1

Note:
No Silicone oil required or sample cell indexing when using 90° by 360° technology.

TU 5200 CFR1040.10 EPA Method 10258

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Chlorine Testing for Drinking Water Systems

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Introduction to Chlorine Monitoring

- Forms of Chlorine
- Testing Strategies

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Chlorine chemistry & disinfection efficiency

Free Chlorination:

$Cl_2 + H_2O \rightarrow HOCl + OCl^-$ *(strong)*

Chloramination:

$NH_3 + HOCl \rightarrow H_2O + NH_2Cl$

$NH_2Cl + HOCl \rightarrow H_2O + NHCl_2$

$NHCl_2 + HOCl \rightarrow H_2O + NCl_3$

decreasing disinfection efficiency

Organic Amines:

Org N + HOCl OrgN-Cl *(~none)*

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Chlorine Chemistry

- Chlorine is added to water as chlorine gas or as sodium or calcium hypochlorite.

Chlorine Gas:

$$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$$

Sodium Hypochlorite:

$$NaOCl + H_2O \rightarrow Na^+ + HOCl + OH^-$$

95

95

Chlorine Chemistry

- The two chemical species formed by chlorine in water are hypochlorous acid and hypochlorite ion

$$HOCl \leftrightarrow H^+ + OCl^-$$

Hypochlorous Acid *Hypochlorite Ion*

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96

Chlorine Chemistry

- Hypochlorous acid is the stronger disinfectant
- Below pH 7.5 free chlorine exists predominantly in the HOCl form
- Above pH 7.5 free chlorine exists predominantly in the OCl^- form

HOCl ← pH 7.5 → OCl^-

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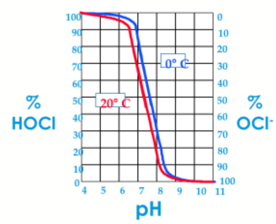
Distribution of ho1 and oc1 – vs. Ph



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Reaction Chemistry

- Chlorine can be present in water as free chlorine and as combined chlorine. Both forms can coexist in the same solution and can be determined together as total chlorine. Free chlorine is present as hypochlorous acid or the hypochlorite ion. Combined chlorine represents a combination of chlorine-containing compounds including but no limited to the following chloramines: monochloramine, dichloramine, nitrogen trichloride and other chloro derivatives.
- The free chlorine reacts directly with the DPD (N,N-diethyl-p-phenylenediamine)to for a pink to red solution.
- When analyzing for total chlorine, the combined forms react with an additional compound – Potassium Iodide (I_3)- oxidizing it to iodine (I_2) in direct proportion to the chloramines present. The iodine and the free chlorine then react with the DPD in still in solution to form the pink or red color.
- The color intensity is proportional to the total chlorine concentration.
- To determine the concentration of the combined chlorine, run a free chlorine test and a total chlorine test. Subtract the results of the free test from those of the total to get the combined forms concentration.

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Reaction Chemistry Free Chlorine

- Free chlorine oxidizes DPD indicator at a pH of 6.3-6.6to form a magenta-colored compound.

Free Cl_2 + DPD → magenta-colored compound.

100

100

Reaction Chemistry Total Chlorine

- Free Chlorine reaction + Potassium Iodide is added to the reagents.
- Chloramines oxidize iodide to iodine which, along with free chlorine, oxidizes DPD to form pink color.

Free Chlorine + Chloramines + KI + DPD → magenta-colored compound.

101

101

Good laboratory Practice

- **Measuring Hints**
  - Analyze immediately after collection
  - Avoid Plastic containers
  - Dedicate different sample cells for Free and for Total Chlorine testing.
  - If chlorine concentration is less than 2 mg/L use the Low Range setting and procedure.

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Good laboratory Practice

- **Measuring Hints**
  - Pretreat glassware by soaking in a dilute bleach solution (1 mL commercial bleach to 1 Liter of D.I. Water for atleast one hour.
    - Thorough rinsing after each use allows for only occasional pre-treatment
    - Air dry the sample cells and sampling containers.

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103

Good laboratory Practice

- **Measuring Hints**
  - If sample turns yellow or shows a flash of pink then goes colorless, dilute the sample and repeat the test.
  - Multiply the result by the dilution factor.

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Sample Collection, Storage and Preservation

- Collect sample by allowing water to flow for at least 5 minutes
- Allow container to overflow with the sample several times
- Cap the sample so there is no headspace
- If transport is absolutely necessary (which is not recommended), chill the sample to 4 degrees C and analyze as quickly as possible.

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Chlorine Standards

106

Standards

- Spec Checks
  - Gel standards that simulate specific chlorine values
  - Used as a calibration check
  - Cannot be used to calibrate an instrument

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Standards

- Standard Solutions
  - Used as accuracy check (standard solution or standard additions)
  - Could be used for calibration

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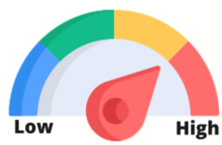
Standards

- Why don't we offer a 1.00mg/L chlorine standard?
  - We offer concentrated solutions, because weaker chlorine solutions are not stable for long periods of time.

109

Standards

- Why are the standard concentrations given in ranges: 25-30 or 50-75mg/L?
  - It is hard to manufacture an exact value. Each lot is tested for chlorine, and the exact value is printed on the box for each lot.



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Standards

- Where are the instructions for using a chlorine standard?
  - In the Accuracy Check (Standard Solution or Standard Additions) section given at the end of every Hach method.

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Chlorine Testing for Drinking Water Systems

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TITRATION

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Titration – Take Home Messages

- Titration is determining the amount of one substance (the sample) by directly measuring the amount of another substance (the titrant) with which it reacts.
- Titration is complete when the endpoint, recognized visually or electrochemically, is reached.
- In a titration, volume measurement is critical.

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Hach Labware for Titrations

- Digital Titrator
- Erlenmeyer flask
- Graduated cylinder
  - Or volumetric pipet

115

Sample Volume and Dilution

- Sample volume must be measured accurately
  - Pipet or graduated cylinder

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Dispensing Titrant

- Digital Titrator
  - Dispensed volume recorded in digits
  - 800 digits = 1mL (±1% volume accuracy)
  - Portable

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Common Titrations

- Alkalinity
- Hardness

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Sample Measurement

- Hach manuals include tables that show how to choose an appropriate sample volume based on the expected analyte concentration.

Range (mg/L as $CaCO_3$)	Sample Volume (mL)	Titration Cartridge (M EDTA)	Catalog Number	Digit Multiplier
10-40	100	0.0800	14364-01	0.1
40-160	25	0.0800	14364-01	0.4
100-400	100	0.800	14399-01	1.0
200-800	50	0.800	14399-01	2.0
500-2000	20	0.800	14399-01	5.0
1000-4000	10	0.800	14399-01	10.0

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Sample Measurement

- If you don't know the expected concentration, pick one that is somewhere in the middle and run a test titration.

Range (mg/L as $CaCO_3$)	Sample Volume (mL)	Titration Cartridge (M EDTA)	Catalog Number	Digit Multiplier
10-40	100	0.0800	14364-01	0.1
40-160	25	0.0800	14364-01	0.4
100-400	100	0.800	14399-01	1.0
200-800	50	0.800	14399-01	2.0
500-2000	20	0.800	14399-01	5.0
1000-4000	10	0.800	14399-01	10.0

120

Sample Measurement

- Optimally, a titration should take between 100-400 digits.
  - Less than 100 digits? – move up on the table to select a more suitable sample volume

Range (mg/L as $CaCO_3$)	Sample Volume (mL)	Titration Cartridge (M EDTA)	Catalog Number	Digit Multiplier
10-40	100	0.0800	14364-01	0.1
40-160	25	0.0800	14364-01	0.4
100-400	100	0.800	14399-01	1.0
200-800	50	0.800	14399-01	2.0
500-2000	20	0.800	14399-01	5.0
1000-4000	10	0.800	14399-01	10.0

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Sample Measurement

- Optimally, a titration should take between 100-400 digits.
  - More than 400 digits? – move down on the table to select a more suitable sample volume

Range (mg/L as $CaCO_3$)	Sample Volume (mL)	Titration Cartridge (M EDTA)	Catalog Number	Digit Multiplier
10-40	100	0.0800	14364-01	0.1
40-160	25	0.0800	14364-01	0.4
100-400	100	0.800	14399-01	1.0
200-800	50	0.800	14399-01	2.0
500-2000	20	0.800	14399-01	5.0
1000-4000	10	0.800	14399-01	10.0

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Hardness

- Traditional measure of the capacity of a water sample to precipitate soap
- Primarily due to the presence of divalent cations
  - Calcium (Ca^{2+})
  - Magnesium (Mg^{2+})

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Importance of Hardness

- Tests available for total hardness and calcium hardness (magnesium by difference)
- Significant in the treatment processes for potable water

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Expressions of Hardness

- Total Hardness
  - Determined by titration with a standard EDTA and Calmagite indicator to an endpoint of a pure blue color at a pH of 10.1.
  - This registers the hardness in solution (calcium and magnesium)

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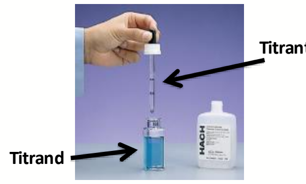
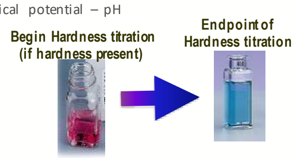
Titration



126

Titration

- Endpoint – Knowing when the right amount of titrant has been added that reacts with all of the titrand.
  - Balance point
  - Indicators
    - Color indicators – visual indication
    - Change in electrical potential – pH
- Color Indicator



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Titration

- Classes of Titrations
  - Neutralization
  - Oxidation-Reduction
  - Precipitation
  - Compleximetric

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Titration

- Neutralization Reactions
  - Involve Acids and Bases
  - End point can be
    - Colorimeteric
    - Electrochemical

Common Reactions
- Acidity
- Alkalinity

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Titration

- Titration Labware
  - Burets, pipettes, and volumetric flasks
  - Class "A" glassware
    - Calibrated for general lab use with a tolerance below 0.05ml in 50ml burette
- Hach Labware for titrations
  - Digital Titrator or Burette
  - Erlenmeyer flask
  - Graduated Cylinder or Volumetric pipette

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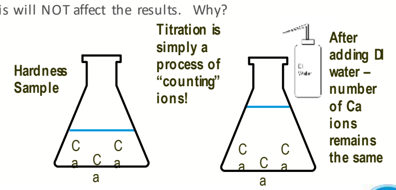
Titration

- Sample ***VOLUME*** matters
  - Must be measured out accurately using pipettes or graduated cylinder
- Deionized water can be added to increase the volume in the flask and/or rinse the sides of the glassware down during the titration
  - This will NOT affect the results. Why?



131

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Titration

- Dispensing Titrant
  - Answer is calculated by the amount of titrant that is added to the solution to reach the endpoint
  - Method to dispense the titrant is based off of the required accuracy of the analysis
    - Drop Count
    - Burette
    - Digital Titrator



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Titration

- Drop Count Titrations
  - Dropper used to dispense Titrant
  - Results are +/- 1 drop or approximately 10%
- Burette Titrations
  - Volume read off of burette
  - Very accurate but not portable
- Digital Titrators
  - Dispensed volume recorded in digits on Digital Titrator
  - 800 Digits = 1ml (+/- 1% volume accuracy)
  - Portable



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Common Titration

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Common Titration

- Alkalinity
- Hardness

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Common Titration

- Alkalinity
  - Acid neutralizing (buffer) capacity of a water
  - Due to the presence of
    - Hydroxides (OH^-)
    - Carbonates (CO_3^{2-})
    - Bicarbonates (HCO_3^-)
  - Important for
    - Drinking Water
    - Wastewater

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Common Titration

- Drinking Water
  - Alkalinity acts as a buffer in coagulation and lime-soda softening
    - D/DBP Rule – TOC % Removal depends upon alkalinity
  - Corrosion Control
    - Langelier and Corrosivity Index

Wastewater
- Important in determining the amenability of waste to the treatment process and control of processes such as anaerobic digestion
- During the process of Nitrification/Denitrification alkalinity is reduced and may be unable to hold the pH of the water is alkalinity reaches 0

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Common Titration

- Phenolphthalein (P) Alkalinity
  - Determined by a titration with a standard sulfuric acid to and end point of pH 8.3
    - Color change = pink to clear
  - Measures total hydroxide and one-half the carbonate present

Total Alkalinity (MO)
- Determined by a titration to an ~pH 4.5
  - Depending on the amount of carbon dioxide present the pH can be 5.1, 4.8, or 3.7
  - Color change = green to gray/violet/pink
- Measures all carbonate, bicarbonate, and hydroxide alkalinity

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Common Titration

- Hardness
  - Traditional measurement of the ability of water to precipitate soap
  - Primarily due to the presence of divalent cations
    - Calcium (Ca^{2+})
    - Magnesium (Mg^{2+})
  - Tests available for Total Hardness and Calcium Hardness (magnesium difference)
  - Significate in the treatment for portable water and wastewater
- Total Hardness
  - Determined by titration with a standard EDTA and Calmagite indicator to an endpoint of a pure Blue color at a pH 10.1
  - Registers the hardness in solution (calcium and magnesium)

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Common Titration

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Titration

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