CLASS I WASTEWATER LABORATORY ANALYST EXAMINATION STUDY GUIDE-2008

SPECIFIC LABORATORY ANALYSES INCLUDED ON CLASS I EXAM

- Acidity
- Alkalinity
- BOD/CBOD
- Chlorine Residual
- Color
- Dissolved Oxygen
- Fecal Coliform
- Microscopic/Biological Examination/Activated Sludge
- Odor
- Oxygen Uptake
- pH
- Sludge Density Index
- Sludge Volume Index
- Solids
  - Settleable Solids
  - Mixed Liquor Suspended Solids [MLSS]
  - Mixed Liquor Volatile Suspended Solids [MLVSS]
  - Total Suspended Solids [TSS]
  - Total Solids
  - Total Dissolved Solids
  - Total Volatile Solids
  - Volatile Suspended Solids
  - Percent Total Solids
  - Percent Volatile Solids
- Temperature
- Turbidity
- Volatile Acids

SAMPLING

GENERAL LABORATORY INFORMATION AND PROCEDURES

CHEMISTRY

BIOLOGY

SAFETY

QUALITY CONTROL/QUALITY ASSURANCE

RULES AND REGULATIONS

PLANT OPERATIONAL INFORMATION

REFERENCES

- 18th Edition of the Standard Methods for the Examination of Water and Wastewater
- 19th Edition of the Standard Methods for the Examination of Water and Wastewater
- 20th Edition of the Standard Methods for the Examination of Water and Wastewater
- U. S. EPA Approved Methods for Wastewater Analysis
- 40 CFR Part 136
- Water Environment Federation [WPCF] Manual of Practice No. 11
- Operation of Wastewater Treatment Plants, California State University, Sacramento [Sacramento Manual]

SPECIFIC LABORATORY ANALYSES INCLUDED ON CLASS I EXAM

Acidity

Define acidity and its source(s).

Describe the test procedure for acidity including reagents, holding time, and calculation.

Given appropriate laboratory data, be able to calculate acidity.

Alkalinity

Define alkalinity and its source(s).

Describe the test procedure for alkalinity including reagents, holding time, endpoint, calculation and reporting value units.

Describe the applications of the total alkalinity test in various wastewater treatment plant processes.

Given appropriate laboratory data, be able to calculate alkalinity.

Be familiar with the "use" or purpose of each reagent used in the test (indicator, titrant, etc.)

BOD [Biochemical Oxygen Demand] and Carbonaceous BOD [CBOD]

Explain the following aspects of the procedure for determining BOD/CBOD:

a) Dilution Water (characteristics, reagents, requirements)
b) Reason for use of special dilution water
c) Justification of each constituent in the dilution water
d) Dilution of the sample for analyses
e) Choice of dilutions if given expected BOD value
f) Cleaning of the BOD bottles
g) Pretreatment of samples
h) Dilution techniques
i) Sample incubation procedures
j) Analysis of dissolved oxygen content
k) Calculation of BOD
l) Calculation of Seed correction
m) Seed depletion requirements
n) Interpretation of results and meaning of results
o) Maximum and minimum depletion rule for reporting values
p) Glucose/glutamic acid
q) Seed (purpose, sources, seeded vs. unseeded samples)
r) Nitrification inhibitor effects on BOD test [CBOD] and appropriate use of nitrification inhibitor [including the impact of the presence of nitrifying bacteria on the BOD test]

Define carbonaceous oxygen demand.

Define nitrogenous oxygen demand.

Given the appropriate laboratory data, be able to calculate a BOD and/or CBOD.

Chlorine Residual

Explain the significance of the chlorine residual analysis for wastewater treatment plants.

Define disinfection.

Define chlorine demand, chlorine residual and chlorine dosage and know the relationship between the three.

What are the two main forms of chlorine used in the disinfection of wastewater?

Explain the chemical reaction and the compounds formed during chlorination/disinfection of a wastewater effluent including which conditions and compounds are most favorable for disinfection to occur.

State the physical and chemical properties of chlorine.

What are chloramines and how are they formed in chlorinated waters?

Describe the following methods for determining chlorine residual including interferences, endpoint determination, sample pretreatment requirements and method selection:
a) DPD method
b) Amperometric Titration method

List three things that will contribute to the loss of residual chlorine from samples.

Define: free chlorine and combined chlorine

Color

Define the following:
a) true color
b) apparent color

Describe each EPA approved method for color analysis.

Dissolved Oxygen [D.O.]

Explain the significance of the dissolved oxygen test in:
a) surface waters
b) activated sludge basin
c) POTW effluents

Explain the following as they relate to the dissolved oxygen test:
a) holding time
b) preservation
c) special sampling techniques
d) approved methods for analysis

Describe how to perform the Winkler test for dissolved oxygen including each of the following:
a) sampling techniques and sample containers
a) sample reagents addition procedure and resulting color development
b) titration, standardization and indicator reagents
c) titration volume, procedure and calculation
d) special sample pretreatment for activated sludge

Describe the proper procedure for calibrating a dissolved oxygen meter.

FECAL COLIFORM

Describe an indicator organism and explain the significance of indicator organisms.

What are coliform bacteria?

What are fecal coliform bacteria and where do they originate?

List two EPA approved methods for Fecal Coliform analysis of wastewater.

Explain the following aspects of the procedure for determining fecal coliform using the membrane filter technique:
a) sampling techniques
b) required pretreatment or preservation of sample
c) preparation of dilution water

d) specialized equipment, media and appropriate sterilization conditions
e) incubation requirements [time, temperature, conditions]
f) choice of dilutions
g) minimum number of dilutions
h) calculation of colonies per 100 mls for a specific dilution
i) calculation of reportable value
j) blanks
k) preparation of sample containers

Explain the following aspects of the procedure for determining fecal coliform using the multiple tube fermentation technique:
a) sampling techniques
b) required pretreatment or preservation of sample
c) preparation of dilution water
d) equipment and media sterilization procedures
e) presumptive test
f) confirmation test
g) preparation and use of specific media
h) incubation requirements [time, temperature, conditions]
i) use and application of MPN table and calculation of reportable value
j) blanks

What units are Fecal Coliforms reported in when using:
a) multiple tube fermentation technique
b) membrane filter technique

What factors contribute to the coliform count in streams and rivers other than the discharge of wastewater effluents?

Be able to calculate a geometric mean for fecal coliform when given appropriate data.

Describe the proper techniques for ensuring the sterility of glassware used in microbiological analyses.

What problem is most likely indicated by having a clean initial blank but a contaminated end blank when analyzing for Fecal Coliform by membrane filter?

At what temperature range should Fecal Coliforms be incubated when using:
a) membrane filter technique
b) multiple tube fermentation technique

Know the method prescribed colony count range for fecal coliform vs. total coliform when using membrane filter method

MICROSCOPIC/BIOLOGICAL EXAMINATION/ACTIVATED SLUDGE

List and describe the basic groups of activated sludge microorganisms and under what conditions each will flourish.

Differentiate between the following types of organisms and describe their significance in wastewater treatment:
a) algae
b) rotifers
c) nematodes
d) psycoda larvae
e) stalked ciliates
f) free-swimming ciliates
g) flagellates

ODOR

Describe the following as they pertain to the threshold odor test procedure:
a) principle of the test
b) odor-free water

c) TON [Threshold Odor Number]
d) test procedure
e) calculation and interpretation of results

OXYGEN UPTAKE

Describe the oxygen uptake procedure.

Describe the significance of the oxygen uptake test results as it relates to the activated sludge process in a wastewater treatment plant.

Describe the importance of using "in-house" bacteria for the test.

pH

Define pH.

Describe the proper procedure for calibrating a pH meter.

What pH meter accuracy and reproducibility is acceptable for routine laboratory work? (i.e., to what pH unit measurement)

Identify the pH values associated with:
a) acid solutions
b) base solutions
c) neutral solutions
d) typical domestic wastewater

Define buffer.

List the three pH standard buffers typically used in pH analyses.

SLUDGE DENSITY INDEX

Define Sludge Density Index and describe the procedure used to calculate SDI.

Explain the implication of SDI results as they relate to the activated sludge treatment process.

Explain the relationship between SDI and SVI.

SLUDGE VOLUME INDEX

Define Sludge Volume Index and describe the procedure used to calculate SVI [including the reporting value units].

Explain the implications of SVI results as they relate to the activated sludge treatment process [including values which would indicate various "types" of sludge...old vs. young, etc.].

Describe the procedures for performing an activated sludge settleability test and the implications of various settling characteristics.

SOLIDS

Define the following as they relate to each other and to wastewater treatment plant processes including any appropriate sampling locations:
Settleable Solids
Mixed Liquor Suspended Solids [MLSS]
Mixed Liquor Volatile Suspended Solids [MLVSS]
Total Suspended Solids [TSS]
Total Solids
Total Dissolved Solids
Total Volatile Solids
Volatile Suspended Solids
Percent Total Solids

Percent Volatile Solids

Describe the procedures employed in the determination of each type of solids in wastewater and given appropriate data, calculate the concentration of each type of solids:
a) Settleable Solids
b) Mixed Liquor Suspended Solids [MLSS]
c) Mixed Liquor Volatile Suspended Solids [MLVSS]
d) Total Suspended Solids [TSS]
e) Total Solids
f) Total Dissolved Solids
g) Total Volatile Solids
h) Volatile Suspended Solids
i) Percent Total Solids
j) Percent Volatile Solids

What is the proper temperature for:
a) muffle furnace
b) total solids analysis
c) dissolved solids analysis
d) volatile solids analysis
e) total suspended solids analysis

TEMPERATURE

Explain how to calculate the following conversions:
a) degrees Fahrenheit to degrees Centigrade
b) degrees Centigrade to degrees Fahrenheit

What is a "certified" thermometer?

Describe the procedure to calibrate general use laboratory thermometers with a "certified" thermometer. Explain the reason for this procedure.

TURBIDITY

Define turbidity.

Describe the instrumentation and the procedure used to determine turbidity.

List and explain the units of measurement for turbidity.

Describe the procedure and reagents used to determine volatile acids by the following methods:
a) chromatographic method
b) distillation method

VOLATILE ACIDS

Explain the application of the volatile acids and alkalinity tests in sludge and wastewater and be able to calculate the volatile acids and alkalinity if given the appropriate data.

Know how to calculate the volatile acids to alkalinity ratio, the appropriate ratio range of a properly operating digester and how each component impacts the ratio.

Describe the appropriate digester sampling location for volatile acids.

SAMPLING/PRESERVATION/HOLDING TIMES

What is the purpose of sampling procedures?

What are the differences between a grab and a composite sample?

Define the following types of samples and know the proper use of each:

A) Grab
B) Flow proportional composite samples
C) Timed [or time proportional] composite samples
D) Continuous composite samples
E) "Split" sample
F) Duplicate sample

Describe circumstances and specific parameters when grab and composite samples may be required and/or desirable.

Explain the importance of the following in sampling:
A) Cleanliness of containers and measuring devices
B) Accuracy of records [labels, locations, name of sampler, time data, type sample, weather, other information]
C) Refrigeration of samples
D) Chemical Preservation of Samples
E) Chain-of-Custody

What are the objectives of routine process control monitoring and how do they determine the monitoring procedures that are to be implemented?

What are the objectives of compliance monitoring and how do they determine the monitoring procedures that are to be implemented?

Describe factors which must be considered in establishing sampling frequency.

Describe techniques and precautions necessary to collect representative samples of wastewater.

Be familiar with the sample types, container requirements, preservation requirements and holding times listed in 40 CFR Part 136 for the parameters listed in the Class I study material.

GENERAL LABORATORY INFORMATION AND PROCEDURES

What is the most representative sample type?

List the five pieces of information which should be included on a sample label.

Why should you leave headspace [with the exception of VOA vials] when filling a sampling container?

What temperature is generally used in preservation/refrigeration of samples and what is the purpose of storage at this temperature?

What measurements must be performed on a sample immediately after it has been collected?

Know the names of the instrumentation, major instrument components and/or apparatus and operational theory used to conduct analyses for the parameters listed in the Class I study material.

Explain the importance of information on chemical reagent bottles and describe what information should be included on chemical reagent bottle labels?

Explain why distilled water, and/or Deionized water is necessary in laboratory analytical techniques.

Differentiate between distilled, Deionized and tap waters and outline proper uses of each in laboratories.

Describe how to prepare the following:
a) ammonia free water
b) carbon dioxide free water
c) distilled water
d) Deionized water

Describe proper techniques for washing and special pre-cleaning of glassware and the importance of such.

Describe the importance of the following in the care and use of analytical balances:
a) Balance being level
b) Supported on a solid surface
c) Use of clean weights and handling procedures
d) Careful cleaning of balance
e) Use of standard weights
f) Calibration method
g) Re-zeroing the balance

What type/design of balance is the most accurate?

Describe proper procedures for performing titrations.

Describe the proper way to read a meniscus.

Describe the differences between volumetric and graduated glassware and be able to describe when you should use each type (pipets, flasks, etc.).

Describe the calibration conditions and procedures for each of the following and be able to explain how to accurately read and use each of the following:
a) pipettes [including the definition of TC or TD on a pipette]
b) burettes
c) graduated cylinders
d) dissolved oxygen meters
e) volumetric glassware [i.e. flasks, pipettes, etc.]

Given drawings, diagrams or narrative, identify and be able to describe the use for each of the following items of laboratory equipment:
a) graduated cylinder
b) beaker
c) pipet (Mohr and volumetric)
d) burette
e) flask
f) BOD bottle
g) funnel
h) evaporating dish
i) Imhoff cone
j) Bunsen burner
k) Gooche crucible
l) volumetric and serological pipettes
m) desiccator
n) separatory funnels
o) petri dishes
p) tongs, clamps, forceps
q) Erlenmeyer and volumetric flasks
r) fume hood
s) test tube
t) membrane filter and funnel assembly
u) condensers
v) spectrophotometer
w) muffle furnace

Explain the importance of mixing samples properly and removing representative aliquots.

Describe the appropriate writing instrument that should be used on all laboratory benchsheets and laboratory records.

The pore size for filters/filter paper used in the laboratory is measured in what units?

Know how to calculate/determine the following: arithmetic average, mean, mode, range

CHEMISTRY

Define and be able to demonstrate a working knowledge of the following:
- a) Normal solution.
- b) Molar solution
- c) atom
- d) molecule
- e) element
- f) organic chemical/material
- g) inorganic chemical/material
- h) buffer
- i) gram atomic weight
- j) specific gravity
- k) molecular weight
- l) equivalent weight

Explain the significance of the following common elements and compounds in wastewater treatment operations/laboratories. Know the chemical symbols for each one.
- a) oxygen [O]
- b) carbon [C]
- c) phosphorus [P]
- d) nitrogen [N]
- e) sodium [Na]
- f) carbon dioxide [CO_2]
- g) hydrogen [H]
- h) hydrogen sulfide [H_2S]
- i) chlorine [Cl]
- j) methane [CH_4]
- k) sulfur [S]
- l) ammonia nitrogen [NH_3-N]
- m) sulfuric acid [H_2SO_4]
- n) sodium Thiosulfate [$Na_2S_2O_3$]
- o) phenylarsine oxide
- p) hydrochloric acid [HCl]
- q) sodium hydroxide [NaOH]
- r) nitric acid [HNO_3]
- s) ozone [O_3]
- t) potassium [K]

Given the appropriate laboratory data, be able to work problems involving the following conversions/calculations:
- a) Normality to molarity OR molarity to normality
- b) Normality to mg/l OR mg/l to normality
- c) mg/l to percent OR percent to mg/l
- d) weight per volume to obtain mg/l concentration
- e) acid/base titration to obtain normality
- f) pounds to mg/l OR mg/l to pounds
- g) significant figures
- h) Kg to pounds OR pounds to kg
- i) standard dilutions using the following: volume X concentration = volume X concentration
- j) density and volume to mass
- k) significant figures
- l) volume occupied by kilogram of water
- m) Know that: ppm = mg/l and ppb = ug/l and ppt = ng/l
- n) kilograms to grams OR kilograms to micrograms OR grams to micrograms OR grams to kilograms

BIOLOGY

Define the following:
- a) Anaerobic bacteria
- b) Aerobic bacteria
- c) Facultative bacteria
- d) Pathogenic bacteria
- e) Indicator organism

Be familiar with some of the diseases that can be caused by water-borne pathogenic bacteria.

SAFETY

Explain the purpose of each of the following precautions in the laboratory:
- a) Discarding broken or chipped glassware
- b) Using a ventilated hood when working with volatile solvents, bases

or acids
c) Storing solvents in an explosion proof can
d) Not handling chemicals with bare hands
e) providing emergency eye wash and shower
f) Using a face shield or goggles
g) Labeling all chemicals
h) providing proper ventilation
i) Prohibiting smoking and eating in the laboratory
j) Providing fire extinguishers in accessible locations
k) Using tongs and heat-resistant gloves to remove items from hot plates, ovens or furnaces
l) Using absorbent, inert material for acid or base spills
m) Chemical disposal

Why should you always use a rubber bulb or other mechanical means to pipette wastewater and chemicals solutions?

What is an "MSDS", what is its purpose and what do the Letters MSDS stand for?

Explain the following safety/emergency procedures:
a) artificial respiration [mouth-to-mouth respiration]
b) victim rescue procedures
c) acid/base splashed on skin
d) acid/base splashed in eyes

Describe the proper storage of:
a) Flammable solvents
b) Concentrated Acids
c) Concentrated Bases
d) Oxidizers

What percent oxygen concentration is necessary in air to sustain life?

Describe appropriate measures taken before entering a confined space.

Which chemical would you use to detect a chlorine leak? Describe the procedure.

List the different classes of fires and what materials are involved. Describe the different types of fire extinguishers and explain the uses and dangers of each.

Describe the safety hazards and appropriate precautions associated with:
a) receiving stream sampling
b) making a solution of sodium hydroxide
c) diluting concentrated acids
d) mixing vaporous chemicals
e) "oxygen deficient" and "oxygen enriched" as they relate to atmospheric safety.

Describe the "cap color coding system" and list the universal colors for the most commonly used acids and chemicals.

QUALITY CONTROL/QUALITY ASSURANCE

What is quality control and why is it important?

What is a quality control graph and why is it used?

Define and explain the use and importance of the following:
a) duplicate samples
b) spike samples
c) blanks [sample blanks, trip blanks]
d) accuracy
e) precision
f) "standard solution"
g) “repeatability” of an instrument

Describe the types of records which should be maintained of daily laboratory procedures, data and equipment.

What are interferences and how do they affect analytical data?

What essential QA/QC tests are needed for each analytical run?

Define each of the following and know the difference: Quality Control and Quality Assurance

RULES AND REGULATIONS

Where can the approved methods list for wastewater analyses be found?

Describe the information that is contained in 40 CFR Part 136.

Given appropriate laboratory data, calculate a weekly average value for permit compliance reporting.

Explain the reporting requirement if additional samples have been taken and analyzed for an NPDES reportable parameter.

What are the 5 most common POTW effluent tests required in NPDES permits.

Where can the required compliance tests and pollutant limits be found for a POTW?

Why must a laboratory analyst sign and date each analysis on the day it was completed?

PLANT OPERATIONAL INFORMATION

Define sedimentation.

Define activated sludge.

Define and list the characteristics of "old sludge" including laboratory test results which would be associated with the problem.

Define and list the characteristics of "young sludge" including laboratory test results which would be associated with the problem.

Identify the purpose and importance of the following laboratory tests in the operation of activated sludge systems:

a) 30 minute settleability
b) dissolved oxygen
c) mixed liquor suspended solids [MLSS]
d) mixed liquor volatile suspended solids [MLVSS]
e) pH
f) temperature
g) oxygen uptake rate [OUR]

Define "biodegradable".

Calculations Study Guide for Class I Wastewater Analyst "Needs to Know"

Acidity:

$$\text{Acidity (mg CaCO3/L)} = \frac{[(A)(B)-(C)(D)](50000)}{\text{ml Sample}}$$

Where A = ml NaOH titrant
B = Normality of NaOH
C = ml of H2SO4 used
D = Normality of H2SO4

Note Report the final pH with result

Alkalinity:

$$\text{Alkalinity (mg CaCO3/L)} = \frac{(A)(N)(50000)}{\text{ml Sample}}$$

Where A = ml Standard Acid used
N = Normality of Standard Acid

for low Alkalinities -

$$\text{Total Alkalinity (mg CaCO3/L)} = \frac{[(2)(B)-(C)](N)(50000)}{\text{ml Sample}}$$

Where B = ml titrant to reach first endpoint
C = ml titrant to reach pH 0.3 below endpoint for B
N = Normality of Standard Acid

Biochemical Oxygen Demand (BOD/CBOD) :

Unseeded -

$$\text{BOD5 (mg/L)} = \frac{(D1-D2)}{P}$$

Seeded -

$$\text{BOD5 (mg/L)} = \frac{(D1-D2)-(B1-B2)(F)}{P}$$

Where B1 = initial DO of seed control (Blank)
B2 = final DO of seed control (Blank)
D1 = initial DO of prepped sample
D2 = final DO of prepped sample
F = Ratio of seed in prepped sample to seed in blank (% seed in sample / % seed in Blank)
P = Decimal volume fraction of sample used (1% = 0.01, 10% = 0.10, 50% = 0.50, etc.)

Note If a Nitrification inhibitor is used, report the result as CBOD.

Residual Chlorine :

Iodometric Method I -

$$\text{mg Cl2/L} = \frac{(A+B)(N)(35450)}{\text{ml Sample}}$$

Where A = ml titrant used for sample
B = ml titrant (positive or negative) used for Blank
N = Normality of Thiosulfate ($Na_2S_2O_3$)

Iodometric Method II -

with Iodine titrant -

$$\text{mg Cl2/L} = \frac{[A-(5)(B)](200)}{\text{ml Sample}}$$

Where A = ml of .000564 reductant
B = ml of .0282 N Iodine

with Iodate titrant -

$$\text{mg Cl2/L} = \frac{(A-B)(200)}{\text{ml Sample}}$$

Where A = ml of Thiosulfate ($Na_2S_2O_3$)
B = ml of Iodate titrant used

Amperometric Titration -

$$\text{mg Cl2/L} = \frac{(\text{ml .000564 N phenylarsine})(200)}{\text{ml Sample}}$$

Low Level Amperometric Titration -

$$\text{mg Cl2/L} = \frac{(A)(N)(200)}{(B)(.000564)}$$

Where A = ml titrant at equivalence point
B = ml Sample
N = Normality of phenylarsine

Coliforms :

$$\text{MPN/100 ml} = \frac{(\text{MPN value from table})(10)}{\text{largest sample vol. in ml}}$$

By Multiple tube

$$\text{Coliform colonies/100ml} = \frac{(\text{Coliform colonies counted})(100)}{\text{ml Sample filtered}}$$

By Membrane Filter

Sludge Volume Index = $\frac{(\text{Settled Sludge Volume in ml/L})(1000)}{(\text{Mixed Liquor Suspended Solids in mg/L})}$

Sludge Density Index = $\frac{\text{TSS in mg/L}}{(\text{Settled Sludge Volume in ml/L})(10)} = \frac{100}{\text{SVI}}$

`

Specific Oxygen Uptake (mg/g/hr) = $\frac{(\text{O2 consumption rate in mg/L/min})(60\ \text{min/hr})}{\text{VSS in g/L}}$

Solids :

MLSS in ppM = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Wt. of filter + Residue in mg
B = Wt. of filter in mg (tare wt.)

TSS in ppM = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Wt. of filter + Residue in mg
B = Wt. of filter in mg (tare wt.)

TDS in ppM = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Wt. of dish + Residue in mg
B = Wt. of dish in mg (tare wt.)

TS in ppM = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Wt. of dish + Residue in mg
B = Wt. of dish in mg (tare wt.)

VS in ppM = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Wt. of dish + Residue in mg before ignition
B = Wt. of dish + Residue in mg after ignition

VSS in ppM = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Wt. of filter + Residue in mg before ignition
B = Wt. of filter + Residue in mg after ignition

COD:

open reflux method -

COD (mg/L) = $\frac{(A-B)(M)(8000)}{\text{ml Sample}}$ Where: A = ml FAS used to titrate the blank
B = ml FAS used to titrate the Sample
M = Molarity of FAS titrant

COD by closed reflux / titration method -

COD (mg/L) = $\frac{(A-B)(M)(8000)}{\text{ml Sample}}$ Where: A = ml FAS used to titrate the blank
B = ml FAS used to titrate the Sample
M = Molarity of FAS titrant

COD by closed reflux / colorimetric method -

COD (mg/L) = $\frac{(\text{mg O2 in final sample volume})(1000)}{\text{ml Sample}}$

mg Oil & Grease/L = $\frac{(A-B)(1000)}{\text{ml Sample}}$ Where: A = Total gain in wt. of tarred flask in mg
B = Wt. of residue in solvent blank in mg

Phosphorous:

Vanadomolybdophosphoric Acid colorimetric method

$$\text{mg P/L} = \frac{(\text{mg P in 50 ml final volume})(1000)}{\text{ml Sample}}$$

Stannous Chloride direct method

$$\text{mg P/L} = \frac{(\text{mg P in 104.5 ml final volume})(1000)}{\text{ml Sample}}$$

Stannous Chloride Extraction method

$$\text{mg P/L} = \frac{(\text{mg P in 50 ml final volume})(1000)}{\text{ml Sample}}$$

Ascorbic Acid method

$$\text{mg P/L} = \frac{(\text{mg P in 58 ml final volume})(1000)}{\text{ml Sample}}$$

Ammonia Nitrogen:

Nesslerization -

$$\text{mg NH3-N/L} = \frac{(A)(B)}{(\text{ml sample})(C)}$$

Where: A = ug NH3-N in tested solution
B = Total volume distillate collected in ml, including acid absorbent
C = Volume of distillate used in Nesslerization in ml

Phenate method -

$$\text{mg NH3-N/L} = \frac{(A)(B)(D)}{(C)(S)(E)}$$

Where: A = Absorbance of sample
B = ug NH3-N in standard
C = Absorbance of standard
S = Volume of sample used in ml
D = Total volume distillate collected in ml, including acid absorbent, neutralizing agent, and NH3 free water added.
E = Volume, in ml, of distillate used in color development.

Titrimetric method -

For liquid samples, $\text{mg NH3-N/L} = \frac{(A - B)(280)}{\text{ml sample}}$

For sludge or sediment samples, $\text{mg NH3-N/L} = \frac{(A - B)(280)}{\text{grams dry wt. sample}}$

Where: A = ml H_2SO_4 titrated for sample
B = ml H_2SO_4 titrated for blank

Ammonia Selective Electrode -

mg NH3-N/L = (A) (B) [(101 + C)/101]

Where: A = dilution factor
B = mg NH3-N/L from calibration curve
C = ml of 10N NaOH added past 1 ml.

Nitrite Nitrogen:

Colorimetric method -

Prepare a standard curve by plotting Absorbance of standards vs. concentration of NO_2-N. Compute sample concentration directly from curve.

Nitrate Nitrogen:

Cadmium reduction method -

Prepare a standard curve by plotting Absorbance of standards vs. concentration of NO_3-N. Compute sample concentration directly from curve.

Definitions:

Anion - A negatively charged ion

Atom - The smallest possible unit of an element.

Aerobic - Needs Oxygen to live, uses air.

Anaerobic - Lives without Oxygen.

Catalyst - Effects the rate of a chemical reaction but is not itself consumed by the reaction.

Cation - A positively charged ion.

Colloid - A material that when mixed with a liquid solvent, forms a system that is between a true solution and a suspension. The particles are held in suspension by virtue of their size and/or their charge.

Colorimetric Procedure - A procedure that uses the law that intensity of color in certain solutions is proportional to the amount of substance in the solution.

Compound - A substance composed of atoms or ions from two or more elements in chemical combination.

Coagulant - A substance that induces precipitation of solids or semi-solids from solution, to coagulate.

Element - A material that is made up of only one type of atom.

Equivalent - The amount of a material that can accept or donate one mole of electrons.

Facultative - Bacteria that can live either with or without Oxygen.

Gram Atomic Weight - The weight in grams of one mole of a given element.

Gram Equivalent Weight - The weight in grams of one equivalent of a given substance. The Gram Molecular Wt. divided (also Formula Wt.) by the number of charge changes in the reaction.

Gram Molecular Weight - The weight in grams of one mole of a compound. The sum of all the atomic weights represented by the chemical formula.

Gravimetric - Using mass (weight) to determine analytical results.

Molar Solution - A solution containing one mole solute per Liter solution.

MPN - Most Probable Number. Used to report statistical prediction of bacterial densities in Multiple Tube methodologies.

Normal Solution - A solution containing one Equivalent solute per Liter solution.

pH - The log of the reciprocal of the Hydrogen ion concentration. This value is taken to represent the acidity or alkalinity of an aqueous solution.

Solute - In a solution, the substance(s) uniformly dispersed in the solvent.

Solvent - A substance capable of dissolving another substance.

Titration - The measured addition of a standard solution of known strength until the reaction is complete to measure the concentration of a substance.

Let's look at what is involved in moving from one concentration type to another.

$$\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{Liters solution}}$$

To determine the number of moles solute,

$$\text{moles} = \frac{\text{Wt. in grams of solute}}{\text{gram molecular wt. of solute}}$$

$$\text{Normality (N)} = \frac{\text{Equivalents of solute}}{\text{Liters of solution}}$$

To determine the number of Equivalents solute,

$$\text{Equivalents} = \frac{\text{Wt. in grams of solute}}{\text{gram Equivalent wt. of solute}}$$

To determine the number of gram Equivalent wt. of solute,

$$\text{gram Equivalent wt.} = \frac{\text{gram molecular wt. of solute}}{\text{\# of charge changes in solute's reaction}}$$

Example: H2SO4 (Sulfuric Acid) is the solute, its gram molecular wt. is 98.
It gives two (2) H+ ions for a total charge change of 2.

$$\text{gram Equivalent wt.} = \frac{\text{gram molecular wt.}}{\text{charge change}} = \frac{98}{2} = 49$$

Now let's try converting from a Molarity concentration to Normality. Again let's use H2SO4 as the solute.
The solution is 0.5 M, what is its Normality ?

$$0.5\text{ M} = \frac{\text{0.5 moles H2SO4}}{\text{Liter solution}}$$

$$\frac{\text{(0.5 moles H2SO4) (98 grams H2SO4)}}{\text{(Liter solution) (1 mole H2SO4)}} = \frac{\text{49 gram H2SO4}}{\text{Liter solution}}$$

$$\frac{\text{(49 gram H2SO4) (1 Equivalent H2SO4)}}{\text{(Liter solution)(49 grams H2SO4/Equivalent)}} = \frac{\text{1 Equivalent H2SO4}}{\text{Liter solution}} = \text{1.0 Normal H2SO4}$$

Let's try just calculating a Normality. The solute will be NaOH, which has a gram molecular wt. of 40. It will accept one H+ ion for a total charge change of 1. That means the gram equivalent wt. is the same as the gram molecular wt.
What would the normality be of a solution containing 10.0 grams NaOH per 250ml?

$$\text{Normality} = \text{N} = \frac{\text{\# of Equivalents}}{\text{Liters solution}}$$

$$\text{\# of Equivalents} = \frac{\text{Wt. in grams of solute}}{\text{gram Equivalent wt. of solute}}$$

In our case the gram Equivalent wt. of solute is equal to the gram Molecular wt. of solute.

Therefor ... $\frac{10g}{40g} = 0.25$ Equivalents

and $\frac{\text{0.25 Equivalents}}{\text{0.25 Liters}} = 1.0\text{ N}$

Practice Problems

1) To prepare the titrant for Ammonia-Nitrogen analysis, an analyst weighs out 1.20 grams of concentrated (98%) Sulfuric Acid (H_2SO_4), and brings it to 1000ml in lab pure water. If the molecular weight of this diprotic acid is 98, calculate the Normality of the solution this analyst has prepared.

ANSWER: 0.024N H_2SO_4

2) To standardize the acid prepared in problem #1, the analyst weighs out 0.0550 grams of previously dried Sodium Carbonate (Na_2CO_3), molecular weight = 106. This was mixed with water and titrated to endpoint using 46.50ml of the prepared acid. Calculate the standardized Normality of this acid.

ANSWER: 0.022N H_2SO_4

3) a. An analyst has a 2.00N Sodium Hydroxide (NaOH) solution. She transfers 50.0ml of this solution to a 1000ml volumetric flask and brings it to volume with lab pure water. Calculate the Normality of the new NaOH solution.

ANSWER: 0.1N NaOH

b. An analyst has a 1000 mg Cu/L solution. She transfers 1.5ml of this solution to a 250ml volumetric flask and brings it to volume with lab pure water. Calculate the concentration of this new solution.

ANSWER: 6.0 mg Cu/L

4) If a Nitrate + Nitrite-Nitrogen sample has between 9.0 and 14.5 mg N/L, which of the following would be the best dilution to use in the analytical run if the calibration standards are 0.05, 0.50, 1.00, and 1.50 mg N/L.

a. 5ml sample brought to 2000ml
b. 50ml sample brought to 100ml
c. 20ml sample brought to 250ml Correct Answer = c
d. 10ml sample brought to 50ml