

Certification Examination

Study Guide

Laboratory Analyst Grade II





Grade II Laboratory Analyst Study Guide

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Important Notice: CWEA is pleased that you have purchased this book. We want to remind you that this book is one of many resources available to assist you, and we encourage you to identify and utilize the other resources in preparing for your next test.

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Grade II Laboratory Analyst Study Guide

Table of Contents

1	Introduction	1
2	Certification Program Information and Policies	3
	Technical Certification Program History	3
	Certification Process	3
	Test Administration	3
	Test Dates and Sites	3
	Test Site Admission	4
	Test Security	4
	Test Postponement and Cancellation	4
	Test Result Notification	4
	Issue of Certificate	4
	Certificate Renewal	4
	Accommodations for Physical or Learning Disabilities	4
	Test Design and Format	4
	Test Design	4
	Test Delivery Mechanism	5
	Test Format	5
	Test Pass Point	5
	How Pass Points are Set	5
	Why Use Modified Angoff?	5
	Test Scoring	6
	Item Appeals	6
	Item Appeals	6
	Qualifying for the Test	6
	Table 2-1 Eligibility Criteria for Grade II Laboratory Analyst	6
	Essential Duties	7
3	Skill Sets	9
	Skill Set 1: Laboratory Safety	9
	Skill Set 2: Regulations	10
	Skill Set 3: Sampling Protocol	10
	Skill Set 4: Quality Assurance, Data Interpretation and Laboratory Reports	10
	Skill Set 5: Mathematics and Chemistry	11
	Skill Set 6: Laboratory Instrumentation—Chemical	11
	6.1 General	11
	6.2 UV Visible Spectrophotometry	11
	6.3 Flame AA	11
	6.4 Gaseous Hydride	12



Table of Contents

6.5 Cold Vapor Technique	12
6.6 Graphite Furnace (Electrothermal)	12
6.7 Total Organic Carbon Analyzer	12
6.8 Ion-Selective Electrodes (Probes)	12
Skill Set 7: Chemical Analysis	12
7.1 General	12
7.2 Nitrogen	13
7.3 Phosphorus	13
7.4 Flouride	13
7.5 Oil and Grease	14
7.6 Sulfate	14
7.7 BOD	14
7.8 DO	14
7.9 Hardness, pH, Alkalinity, and Conductivity	14
7.10 COD	14
7.11 Residual Chlorine	14
Skill Set 8: Process Control	14
8.1 General	14
8.2 Chlorination, Chlorine Demand, and Dechlorination	14
8.3 Receiving Waters	15
8.4 Activated Sludge	15
8.5 Sludge Digestion	15
Skill Set 9: Microbiology	15
9.1 General	15
9.2 Sampling	15
9.3 Documentation	16
Skill Set 10: Laboratory Microbiological Techniques	16
10.1 General	16
10.2 Media Preparation	16
Skill Set 11: Microbiological Analysis and Toxicity Tests	16
11.1 General	16
11.2 Coliform: MPN	16
11.3 Coliform: MF Technique	17
11.4 Bioassay/Toxicity	17
Table 3-1 Grade II Laboratory Analyst Primary References	18
4 Test Preparation	25
Basic Study Strategy	25
Multiple Choice Questions	25
Table 4-1 Laboratory Analyst General Information	26
Math Problems	27
Calculators	27
Approach	28
Solutions	28
Equivalentents and Formulas	28
Dimensional Analysis	28
Sample Questions	29



	Math Skills	29
	Arithmetic	30
	Sequential Situations	30
	Algebra	31
5	Diagnostic Test	33
	Introduction	33
	Skill Set 1: Laboratory Safety	33
	Skill Set 2: Regulations	33
	Skill Set 3: Sampling Protocol	34
	Skill Set 4: Quality Assurance, Data Interpretation and Laboratory Results	34
	Skill Set 5: Mathematics and Chemistry	35
	Skill Set 6: Laboratory Instrumentation—Chemical	35
	Skill Set 7: Chemical Analysis	36
	Skill Set 8: Process Control	38
	Skill Set 9: Microbiology	39
	Skill Set 10: Laboratory Microbiological Techniques	40
	Skill Set 11: Microbiological Analysis and Toxicity Tests	40
	Test Answer Key	41
	Skill Set 1: Laboratory Safety	41
	Skill Set 2: Regulations	41
	Skill Set 3: Sampling Protocol	41
	Skill Set 4: Quality Assurance, Data Interpretation and Laboratory Results	41
	Skill Set 5: Mathematics and Chemistry	41
	Skill Set 6: Laboratory Instrumentation—Chemical	42
	Skill Set 7: Chemical Analysis	42
	Skill Set 8: Process Control	42
	Skill Set 9: Microbiology	42
	Skill Set 10: Laboratory Microbiological Techniques	42
	Skill Set 11: Microbiological Analysis and Toxicity Tests	42
	Selected Problem Solutions	43
	Skill Set 4: Quality Assurance, Data Interpretation and Laboratory Results	43
	Skill Set 5: Mathematics and Chemistry	43
	Skill Set 7: Chemical Analysis	43
	Skill Set 8: Process Control	44
	Skill Set 11: Microbiological Analysis and Toxicity Tests	45
6	References	47
	Primary References	47
	Secondary References	48
A	Appendix: You and Wastewater Math	51
	Introduction	51
	Two Facts to Consider	51
	Move Beyond the Math You Know	51



Table of Contents

Practice Problem Solving Strategies	53
Units and Arithmetic	53
Example Problems	54
Take Charge of Your Success	56
Recommendations	56
Test-Taking Strategies	57
Before the Exam	57
At the Exam	58
Negative Thinking About Exams	59

B	Appendix: Glossary of Technical Terms	61
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C	Appendix: Common Acronyms and Abbreviations	63
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S e c t i o n 1

Introduction

The California Water Environment Association (CWEA) Technical Certification Program (TCP) is voluntary; its purpose is to educate, prepare, and test an individual's knowledge within six vocations.

- Plant Maintenance Technology (with two parallel specialties in Electrical/ Instrumentation and Mechanical Technology)
- Laboratory Analysis
- Collection System Maintenance Technology
- Environmental Compliance Inspection
- Industrial Waste Treatment Plant Operations
- Biosolids Land Application Management

CWEA also assists in educating and training wastewater treatment plant operators for the State of California Operator Certification Tests. Upon qualifying and successfully completing a test, an individual is certified in that specialty at one of the grade levels. Levels within a specialty designate technical knowledge for the apprentice, journey, and management levels. Tests are designed to demonstrate minimum competence for a particular grade.

The purpose of this study guide is to provide a description of the knowledge, skills, and abilities (KSA) needed to pass the test. Also included are questions designed to assess candidates' strengths and weaknesses relative to their present KSA. Finally, the study guide provides references used to refresh subject knowledge, or to learn more about particular subject areas not completely understood.

Typically there are two to five primary references for each specialty area, which need to be read and understood. Test questions are generally based on information contained in these references. Secondary references give more information and often provide a different approach to a subject, making it easier to understand.

This study guide is not a compendium of all that may be on the test, so successfully answering questions contained in this guide does not guarantee passing. To successfully pass the Grade II

Laboratory Analyst (Lab Analyst) test, the reference materials presented in this study guide should be thoroughly understood.

This study guide can best be used to help identify strengths and weaknesses and to identify material that may need further study. Comments and suggestions to improve the study guide are always welcome and appreciated. Good luck on the test!



Certification Program Information and Policies

CWEA's mission is to enhance the education and effectiveness of California wastewater professionals through training, certification, dissemination of technical information, and promotion of sound policies to benefit society through protection and enhancement of the water environment.

CWEA is a California nonprofit corporation, a Member Association of the Water Environment Federation (WEF), and a member of the National Organization for Competency Assurance (NOCA).

Technical Certification Program History

TCP was created to offer multilevel technical certification for individuals employed in the water quality field. Tests are written by vocational specialists and administered throughout the year in six different disciplines: Plant Maintenance Technology (with two parallel specialties in Electrical/Instrumentation and Mechanical Technology), Laboratory Analysis, Collection System Maintenance Technology, Environmental Compliance Inspection, Industrial Waste Treatment Plant Operation, and Biosolids Land Application Management.

CWEA first offered a certification program for wastewater treatment plant operators in 1937. The program was administered by CWEA until 1973 when the State of California assumed responsibility. During those 36 years, CWEA awarded 3,915 operator certificates.

The first committees were formed in 1975 to establish a voluntary certification program for water quality professionals specializing in disciplines other than plant operation. The Voluntary Certification Program (VCP) emerged offering specialized certificate programs for Collection System Maintenance Technology, Plant Maintenance Technology, Environmental Compliance Inspection, and Laboratory Analysis, with certifications first issued in April 1976. In the 1980s, two more disciplines were added: Electrical/Instrumentation and Industrial Waste Treatment Plant Operations.

Today, CWEA offers certification in six vocational programs with a total of 22 individual certifications. About 2,000 applications are processed annually and currently over 5,500 certificates are held by individuals in California and neighboring states.

Certification Process

To become certified, *all applicants* must complete the Application for Technical Certification, pay the application fee, have suitable experience and education, and pass the computer-based test. Application instructions and fee schedules are listed on the application. After applications are received at the CWEA office, applicant information is compiled in a database, and reviewed by CWEA staff and Subject Matter Experts for the respective location applied for. If approved, the applicant will receive an acceptance letter. If the application is rejected, the applicant will be notified and asked to supply more information if warranted.

After completion of the computer-based test and grading, applicants are mailed their official test results. Those who pass the exam are mailed certificates and wallet cards.

Test Administration

Test Dates and Sites

Tests are given throughout the year in California, Michigan, and Alaska (see Application for Technical Certification for test schedule). Applicants who are eligible to take the test will be mailed an acceptance letter and with instructions on how to schedule their exam.

Test Site Admission

Certificate candidates are required to show at least one valid government issued photo identification (State driver's license or identification, or passport). Only after positive identification has been



Section 2: Certification Program Information and Policies

made by the testing proctor may a candidate begin the exam. Candidates do not require to show their eligibility letters to enter the test site.

Test Security

All tests are computer-based. No reference material, laptop computers, or cameras are allowed in the test site. Candidates will have access to an on-screen calculator, however, you are welcome to bring your own pre-approved calculator (visit www.cwea.org/cert). Candidates are not allowed to take any notes from the test site. Candidates who violate test site rules may be asked to leave the site and may be disqualified from that test. All violations of test security will be investigated by CWEA and appropriate action will be taken.

Test Rescheduling and Cancellation

To reschedule your application you must submit a written request (a letter stating that you wish to postpone) to postpone to the adjacent testing window. You may only reschedule once without a fee. Additional reschedule requests will require a \$40 fee.

To cancel your application you must submit a written request (a letter stating you wish to cancel your application) to CWEA. The written request must be received at the CWEA office no later than 2 weeks after the approved test window. Full refunds, less the administrative fee, will be made within 4 weeks after the scheduled test date. If you have a scheduled exam with our testing administrator, Pearson Vue, you must contact them 24 hours in advance to avoid losing your exam fee. There are no exceptions to this policy.

Test Result Notification

Test results are routinely mailed to certificate candidates approximately two weeks after the test date. Results are never given over the phone. All results are confidential and are only released to the certificate candidate.

Issue of Certificate/Wallet Card

Certificates and wallet cards are issued to all candidates who pass the test. Certificates are mailed about two to three weeks after result notifications are mailed.

Certificate Renewal

All certificates are renewed annually. The first renewal is due one year from the last day of the month in which the certification test was held. Certificate renewals less than one year past due are subject to the renewal fee plus a penalty fee of 100 percent of the renewal fee. Certificate holders more than one year past due will need to re-test to regain certification. Renewal notices are mailed to certificate holders two months before the due date. It is the responsibility of certificate holders to ensure the certificate(s) remains valid. Continuing education will be required for renewal after 2001.

Accommodations for Physical or Learning Disabilities

In compliance with the Americans with Disabilities Act, special accommodations will be provided for those individuals who provide CWEA with a physician's certificate, or its equivalent, documenting a physical or psychological disability that may affect an individual's ability to successfully complete the certification test. Written requests for special accommodations must be made with the test application along with all supporting documents of disability.

Test Design and Format

Test Design

All certification tests are designed to test knowledge and abilities required to perform the *Essential Duties* listed at the end of this section with minimal acceptable competence.

The *Essential Duties* and Test Content Areas for each certification were determined by a job analysis and meta-analysis of job specifications by two independent psychometric consulting firms. The studies gathered data from onsite visits of over 31 water and wastewater agencies, interviews with 110 water and wastewater professionals, and analysis of more than 300 job specifications. All research was conducted under the guidance of the TCP Committee, vocational sub-committees, and CWEA staff. All test questions are designed to measure at least one area of knowledge or ability that is required to perform an essential duty.



Test Delivery Mechanism

All tests are computer-based format and are written in the English language only.

Test Format

All TCP tests are in multiple choice format (see the sample test questions in this guide for an example). The multiple choice format is considered the most effective for use in standardized tests. This objective format allows a greater content coverage for a given amount of testing time and improves competency measurement reliability. Multiple choice questions range in complexity from simple recall of knowledge to the synthesis and evaluation of the subject matter.

Test Pass Point

The basic minimum score required to pass all tests is 75 percent of possible total points. However, the score may be adjusted downward depending on test complexity. It should be assumed that the passing score is 75 percent and candidates should try to score as high as possible on the test (in other words, always try for 100 percent). The pass point for each vocation and grade level is set independently. Also, each version or form of a test will have its own pass point. Different versions are given each time the certification test is administered.

How Pass Points Are Set

A modified *Angoff Method* is used to determine the pass point for each version of each test. The modified *Angoff Method* uses expert judgments to determine the test difficulty. The easier the test, the higher the pass point; similarly the more difficult the test, the lower the pass point.

The following is an outline of the modified *Angoff Method* (some details have been omitted):

1. A group of Subject Matter Experts (SMEs) independently rates each test question within a given test. The ratings are defined as the probability that an acceptably (minimally) competent person with the requisite education and experience will answer the question correctly. An acceptably (minimally) competent person is defined as someone who safely and adequately performs all job functions and requires no further training to do so.
2. The SMEs review each test question as a group. A consensus is reached for the rating of each test question. The SMEs also review comments submitted in writing by test-takers. Any test question that is judged to be ambiguous, has more than one correct answer, or has no correct answers is eliminated from the scoring process for that test. These test questions are then revised for future use, reclassified, or deleted from the test item bank.
3. After the data are refined, the final step is to calculate the mean, or average, of all the test question ratings. This becomes the overall pass point estimation.

Why Use Modified Angoff?

Each version of a given certification test uses questions from a test item bank. Each of these questions vary in difficulty. Because a different mix of questions is used in each test, the overall difficulty level is not fixed. Thus, it is important to make sure that the varying difficulty level is reflected in the pass point of each test to ensure that test results are reliable. Test reliability is concerned with the reproducibility of results for each version of a given test. In other words, for a test to be reliable it must yield the same result (pass or fail) for the same individual under very similar circumstances. For example, imagine taking a certain grade level test and passing it. Immediately after completing this test, a different version of the same grade level test is taken. If the test is reliable, the same result will be achieved: pass. If a passing grade is not achieved, it is likely that the test is not a reliable measure of acceptable (minimal) competency.

By taking into consideration the difficulty of the test, the modified *Angoff Method* significantly increases the reliability of the test. Also, since each test is adjusted for difficulty level, each test version has the same standard for passing. Thus, test-takers are treated equitably and fairly, even if a different version of the test is taken.

There are other methods for setting pass points. However, for the type of tests administered by CWEA, the modified *Angoff Method* is the best and most widely used.



Section 2: Certification Program Information and Policies

Test Scoring

All tests are electronically scored by CWEA. Most test items are valued at one point. Some test items requiring calculations are worth multiple points varying from two to five (possibly more). After tests are scored, total points are compiled and an overall score is calculated as the sum of all points earned on the test. If the overall score is equal to or greater than the established pass point, the candidate has passed the test. Total points possible for each test vary, but the average is 100 points plus or minus 25.

Test Reviews and Item Appeals

Test Reviews

Any candidate who fails the written test may review the test in person at a time and place determined by CWEA. Notes and any other forms of recording are not allowed during the test review period. Test subject matter is not discussed and score adjustments are not made during the test review.

Item Appeals

Candidates who wish to appeal a specific test item must do so during the test by completing an the Candidate Feedback Review Screen during the exam. Item appeals will be evaluated and appropriate adjustments made to the test content. Candidates submitting feedbacks will not be contacted in regards to the appeal.

Qualifying for the Test

Eligibility criteria are summarized in Table 2-1. Candidates may qualify by meeting either Education/Experience Combination A, B, C, or D. If you do not meet any of the combinations of experience and education, then you do not qualify for Grade II.

Table 2-1 Eligibility Criteria for Grade II Laboratory Analyst

Combination	Education and Certificates	+ Experience
A	None	4 full-time years in laboratory analysis
B	Hold a Grade I Laboratory Analyst Certificate for 1 year	2 full-time years in laboratory analysis
C	Hold an AA/AS degree in a related field	2 full-time years in laboratory analysis
D	Hold a BA/BS, or higher, degree in a related field	1 full-time year in laboratory analysis

The Grade II Lab Analyst certification test is designed to demonstrate competency at the journey level. More specifically, Grade II certification implies competence in the skill sets required to perform the Essential Duties of a journey level Lab Analyst.



Essential Duties

Grade II duties include the essential duties identified in the study guide for Grade I. In addition, the Grade II Laboratory Analyst essential duties include:

- Performs routine laboratory analyses, including atomic absorption (FAA, GFAA, cold vapor, gaseous hydride generation), sulfate, chlorine demand, oil and grease, nitrate, nitrite, ammonia, phosphate, fluoride, TKN, total phosphorus, process control topics (MLSS/SVI, MCRT, F/M, chlorination/dechlorination, volatile acids/alkalinity ratio), microbiological testing (completed test, membrane filter technique), acute bioassay, and total organic carbon.
- Assists in the design/development of new methods and techniques of analysis.
- Calibrates, operates and maintains wastewater laboratory equipment related to subject matter, including field wastewater monitoring equipment.
- Completes basic lab reports.



S e c t i o n 3

Skill Sets

Lab Analysts have many responsibilities that require a foundation of knowledge in basic mathematics, chemistry, and instrumental analysis. Lab Analysts are expected to perform analysis in a safe and accurate manner, correctly interpreting *Standard Methods for Examination of Water and Wastewater* (*Standard Methods*). These duties require great attention to detail. The knowledge, skills, and abilities (KSAs) that are required of Lab Analysts represent the professionalism upon which a career in chemistry and microbiology are built.

Lab Analysts are expected to have mastered the KSAs in laboratory analysis of the Grade I level. Grade I covers basic chemistry and mathematics, preparation of chemical reagents, wet chemistry techniques including titrations, gravimetric analysis, and the use of ion-selective electrodes and other simple instruments.

Grade II Lab Analysts are expected to prepare microbiological media and be familiar with coliform analysis (MPN) and Heterotrophic Plate Count. Lab Analysts should be knowledgeable regarding sampling techniques and the specific sample handling and storage required for various samples. At any career level, laboratory safety is fundamental to Lab Analysts.

To be successful in the laboratory, Lab Analysts must maintain the following work habits: the ability to train and supervise the work of others; the skill to communicate clearly and concisely, both orally and in writing in the English language; and the ability to establish and maintain effective working relationships with those contacted in the course of work. In addition to having developed and practiced the skills of the Grade I Lab Analyst, candidates seeking Grade II certification need the KSAs included in the skill sets described below.

Table 3-1, presented at the end of this section, cross-references each skill set with a specific chapter, section, and/or page of applicable references to assist the candidate in better understanding the subject matter. Please note that the first reference in Table 3-1, *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, is not the most recent edition, but is the one referenced by EPA regulations, and therefore is the basis for developing the certification test questions.

Skill Set	1	Laboratory Safety
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Lab Analysts are required to perform essential duties in a safe manner and should be aware of common laboratory hazards including physical, chemical, and biological dangers. Lab Analysts should use safe lab techniques, laboratory safety equipment, and personal protective equipment.

Lab Analysts should be able to properly read and understand Material Safety Data Sheets (MSDS) and safety labeling on chemical bottles. Familiarity with the terms PEL, TWA, LC₅₀ and LD₅₀, as well as acute toxicity is necessary. Lab Analysts should understand the components of the Chemical Hygiene Program, including responsible parties.

Lab Analysts should be knowledgeable about safety regulations, including: OSHA Hazard Communication Standard, 29 CFR 1910.1200 (especially section (h) *Laboratory Standard*); OSHA Occupational Exposures to Hazardous Chemicals in Laboratories Standard, 29 CFR 1910.1450 (*Lab Right to Know*), including chemical hygiene programs; and Hazardous Waste Operations and Emergency Response, 29 CFR 1910.120.



Section 3: Skill Sets

Skill Set 2 Regulations

The California Department of Health Services certifies laboratories through the Environmental Laboratory Accreditation Program (ELAP). Inspectors conduct site visits to document the ability to submit scientifically valid data. The *Pre-Visit Guidelines* specify the criteria for achieving certification. Lab Analysts should be familiar with these requirements for proper laboratory maintenance and quality control.

Wastewater plant laboratories perform analysis for plant operation information, and to comply with the plant's discharge permit. Waste Discharge Requirements and National Pollutant Discharge Elimination System (NPDES) permits are regulated under the authority of the State Water Resources Control Board and issued by the Regional Water Quality Control Boards.

EPA-approved analytical methods are listed in 40 CFR 136. Although most methods in *Standard Methods* are approved by the EPA, some are not. 40 CFR 136 specifies which methods may be used.

Skill Set 3 Sampling Protocol

Lab Analysts collect samples of wastewater, sludge, receiving water, and industrial waste in accordance with established laboratory procedures. Standard physical, chemical and biological tests are performed on treated and polluted water, potable water, industrial and domestic wastewater, and related materials. These tests require using proper sampling and preservation techniques.

Proper sampling and sample collection protocol requires attention to detail that starts before Lab Analysts enter the laboratory. The correct type of container must be properly washed, rinsed, or sterilized for the analyte of interest. Preservatives or dechlorinating chemicals may be required. Preservation is limited to a few techniques, each with a specialized purpose, (e.g., the prevention of adsorption onto glass containers). In the field, a representative sample should be taken for grab or composite sample. Lab Analysts may be required to combine individual samples to create a

composite based on sample flow. Lab Analysts are responsible for filling out chain-of-custody forms and sample labels accurately and completely.

Questions that Lab Analysts may ask to assure compliance with sampling protocol are:

- What type of container is required (glass, plastic, vial, etc.)?
- How should the container be washed and rinsed (soap and water, solvent, or acid rinsed)?
- Does the analysis require a sterilized container and sampling technique?
- Does the sample require dechlorination? What is the dechlorinating agent?
- Does the sample require preservatives? Chemical or temperature?
- How should the sample be stored in transit, and in the laboratory?
- What is the holding time of the sample?
- What elements are required on the sample label, chain-of-custody form, and sample log-book?

Skill Set 4 Quality Assurance, Data Interpretation, and Laboratory Reports

Accuracy and precision of laboratory analysis are confirmed through the commitment to quality assurance. For laboratory data from blanks, duplicates, and spikes, Lab Analysts can chart the quality control trends using control charts with warning and control limits. Lab Analysts should be familiar with the concepts of accuracy, precision, standard deviations, relative error, recovery, confidence intervals, and proper use of significant figures.



Skill Set	5	Mathematics and Chemistry
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Chemistry requires a mathematical foundation for reporting data, determining results, and preparing reagents. The mathematics required in day-to-day laboratory operations is not difficult, yet still must be thoroughly mastered. In reporting data, it is important that the results are expressed correctly in terms of units (e.g. mg/L, ppb, percent, NTU or pH); in terms of constituent measured (e.g., acid volatility is reported as mg/L of acetic acid, alkalinity is reported as mg/L of calcium carbonate); and in terms of correct significant figures.

Lab Analysts are required to use formulas to determine results from analytical data, including alkalinity, residual chlorine and hardness, biochemical oxygen demand (BOD), percent solids, temperature conversions, etc. Formulas are also used to calculate sludge volume index (SVI), mean cell residence time (MCRT), and chlorine dosages.

Lab Analysts are most often required to employ mathematics in the preparation of laboratory solutions. These solutions require knowledge regarding molarity and normality, equivalents, molecular and formula weights, and serial dilutions. Standardization is often required of a freshly prepared reagent. This involves the preparation of a primary standard solution from dry reagent, and then titration of the solution in question by the primary standard.

Skill Set	6	Laboratory Instrumentation—Chemical
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6.1 General

Lab Analysts should know the principles and practices of qualitative and quantitative chemistry, using a variety of laboratory instrumentation and equipment, including ultra violet (UV)/visible light spectrophotometer, atomic absorption (AA), AA using the cold vapor technique, AA using gaseous hydride generation, graphite furnace (or electrothermal), total organic carbon analyzer, and ion-selective probes. Lab Analysts' tasks include calibrating, operating, and maintaining laboratory instrumentation.

When learning about new instrumentation techniques, it is a good idea to start with the most basic information. *Standard Methods* often has a good discussion of the basic principles, interferences, and instrument components of instrumental techniques. Some quantitative analytical chemistry textbooks provide in-depth information. General theory, instrument components, and operation provide a basic foundation for Lab Analysts.

Questions Lab Analysts may ask to become familiar with an instrument and its use are:

- What is the name of the instrument?
- What are the components of the instrument?
- What is the theory behind the instrument?
- How is the instrument calibrated?
- Does it use a standard curve?
- How are the standards prepared and used?
- How are the results detected and then interpreted?
- How are the instrument and its accessories maintained?
- What special gases, effluent, or reagents are used with the instrument?

6.2 UV Visible Spectrophotometry

Lab Analysts who use spectrophotometric analytical techniques should be aware of the theory behind UV and visible absorption, including Lambert's/Beer's Law. Familiarity with the instrument's components and various light sources, and an understanding of instrument operation is key. Lab Analysts should know how to calibrate the instrument by constructing a standard curve and how to adjust for zero absorbance. Determination of nitrogen, phosphorus, sulfate and other constituents may incorporate spectrophotometric analytical techniques.

6.3 Flame AA

Lab Analysts should be aware of the theory behind AA, including what is actually being measured. Analysts should be familiar with instrument components, flames (fuels and oxidants), and light sources, and should understand instrument operation, including sensitivity and detection limits. Lab Analysts should know how to calibrate the instrument and construct a standard curve.



Section 3: Skill Sets

Correct sample preparation, whether it is filtered or digested, is important to analytical technique. Matrix modifiers and standard additions are techniques sometimes required to assure analytical accuracy.

Flame AA utilizes different fuel sources to create flames most suitable to the metal of interest. *Standard Methods* provides a good discussion of AA and different flame conditions.

6.4 Gaseous Hydride

Lab Analysts should be aware of the theory behind gaseous hydride generation, and the instrument and operations, including sensitivity and detection limits. Lab Analysts should know how to calibrate the instrument and construct a standard curve. Correct sample digestion is important to the analytical technique. *Standard Methods* provides a good discussion of hydride generation atomic absorption for selenium and arsenic.

6.5 Cold Vapor Technique

Lab Analysts should be aware of the theory behind cold vapor technique used for mercury. Familiarity with instrument components and an understanding of instrument operation, including sensitivity and detection limits, is necessary. Lab Analysts should know how to calibrate the instrument and construct a standard curve. Correct sample digestion is important to the analytical technique.

6.6 Graphite Furnace (Electrothermal)

Lab Analysts using graphite furnace should be aware of the theory behind an electrothermal technique. Lab Analysts should be familiar with instrument components and understand instrument operation, including sensitivity and detection limits, calibration, and construction of a standard curve. Correct sample preparation, whether it is filtered or digested, is important to the analytical technique. *Standard Methods* provides a good discussion of graphite furnace AA.

6.7 Total Organic Carbon Analyzer

There are two methods for analyzing total organic carbon: the combustion-infrared method and the persulfate-UV oxidation method. Lab Analysts should be knowledgeable about the different forms of carbon, especially total carbon, total organic carbon, and inorganic carbon, as well as the methodology for achieving separate results for the latter two. Lab Analysts should understand the operation of the instruments, their components, and the gases used in analysis.

6.8 Ion-Selective Electrodes (Probes)

Determination of ammonia, nitrate, fluoride and other constituents may incorporate ion-selective analytical techniques. Lab Analysts should be aware of potentiometric techniques and the theory of ion-selective electrodes. This includes understanding the Nernst Equation. Lab Analysts should be familiar with instrument components, and understand instrument operation, construction of a standard curve, and the relationship between a semi-log plot of the millivolt reading against a concentration on the logarithmic scale.

Skill Set	7	Chemical Analysis
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7.1 General

Standard Methods is a compilation of many methods, some of which are approved for wastewater analysis by the EPA. EPA-approved methods must be followed in detail, unless the laboratory has submitted a request for modifications.

Each analytical method has its own areas of difficulty. For each method, *Standard Methods* details areas of interferences or matrix problems. Reading additional literature can help isolate specific problem areas. References include *Lectures on Wastewater Analysis and Interpretation* and college textbooks. (See Section 6, References in this study guide.) Lab Analysts should be familiar with typical interferences, matrix problems, and how to approach them.



Lab Analysts should understand and be able to perform the following tests found in *Standard Methods*: nitrite, nitrate, ammonia, total Kjeldahl nitrogen, phosphorus, fluoride, oil and grease, sulfate, BOD, dissolved oxygen (DO), alkalinity, hardness, turbidity, chemical oxygen demand (COD), chlorine demand, and residual chlorine.

Questions Lab Analysts may ask to become familiar with a method and its use are:

- What is the name of the method?
- What type of test is it (colorimetric, titrimetric, gravimetric, etc.)?
- What is the basic summary of the method?
- What is the basic sequence of the method?
- What is being measured and what is being reported? (For example, the BOD test, dissolved oxygen is being measured, but the calculated BOD is reported. In the hardness test, calcium and magnesium are measured, but the calculated hardness is reported.)
- What are the reagents (e.g. standards, titrants, color-reacting reagents) and what are their functions?
- What is the chemical theory behind the chemical reaction?
- Are there chemical or other special hazards?
- What is the sampling protocol (including preservation, containers, holding time, etc.)?
- Is any sample pretreatment required?
- Are there any interferences that affect the method and how are they mitigated?
- Are there sources and treatments of erroneous test results?
- What are the limits of the method (e.g., concentration, linear range)?
- Are there restrictions on the test (e.g., dissolved oxygen depletion must be greater than 2 with at least 1 mg/L remaining)?
- What are the reporting units? (For example, conductivity is reported as micromho/cm at 20°C.)
- How are the results calculated from laboratory data?
- How are the results interpreted?

Regarding titrations:

- What is the type of titration (e.g., acid-base)?
- What is the titrant and its normality?
- How is the titrant standardized?
- What is the indicator or endpoint (color change, pH, amperometry, etc.)?

Regarding standard curves:

- How many standards are required?
- What is the range of standards required?
- What is the curve's linear range, or other restrictions?

7.2 Nitrogen

In the maintenance and operation of the plant, nitrogen analysis is useful in the maintenance and operation of the plant to prevent or maintain nitrification. Lab Analysts should be familiar with total Kjeldahl nitrogen (TKN), ammonia, nitrite, and nitrate analyses. Some methods require a distillation step prior to analysis. Lab Analysts should be familiar with colorimetric and ion selective electrode instrumentation, and aware that results for nitrogen compounds are often reported as elemental nitrogen.

7.3 Phosphorus

Lab Analysts should be familiar with the different forms of phosphorus, including reactive phosphorus, acid-hydrolyzable phosphorus, organic phosphorus, and total, dissolved, and suspended forms of phosphorus. *Standard Methods* clearly outlines the analytical steps for differentiating the various forms of phosphorus, and describes the environmental sources and influences of phosphorus. Lab Analysts should be aware that results for orthophosphate are often reported as elemental phosphorus. Lab Analysts should be familiar with colorimetric instrumentation and theory.

7.4 Fluoride

Lab Analysts should be familiar with both the ion-selective electrode method and the SPADNS method of determining fluoride, as well as ion-selective electrode theory and ionic strength buffers. Each test has its own range of analysis (concentration) and vulnerability to interferences. Lab Analysts should know when pre-distillation is necessary.



Section 3: Skill Sets

7.5 Oil and Grease

Lab Analysts should be knowledgeable about the definitions of oil and grease. They should understand the solvent extraction technique to separate the oil and grease compounds from the water phase and the current solvents that can be used.

7.6 Sulfate

Sulfate determination requires the use of a standard curve and utilizes colorimetric techniques to perform a turbidimetric measurement. Lab Analysts should be knowledgeable about the reaction of sulfate with barium chloride and its resulting product.

7.7 BOD

BOD is an involved test, requiring sample pre-treatment for pH and residual chlorine, seeding to provide sufficient bacterial population, and nitrification inhibition for carbonaceous BOD. Test results are subject to restrictions that may cause rejection of the whole sample run or just rejection of individual results. A Winkler azide modification titration is often used to calibrate the DO meter. Buffered dilution water is used to dilute samples to provide a consistent pH throughout the five-day incubation period. Lab Analysts should have a thorough understanding of the test.

7.8 DO

DO measurements are the basis for the BOD determination, and are used to control operations in the treatment plant. Either the Winkler azide modification or the DO meter can be used. Lab Analysts should be familiar with test techniques.

7.9 Hardness, pH, Alkalinity, and Conductivity

Lab Analysts should be familiar with the concepts and theory behind conductivity and pH, including the instrumentation involved. Similarly, Lab Analysts should be familiar with the concepts and theory of alkalinity and hardness determinations. Alkalinity and hardness are titrimetric methods which depend on chemical reactions and utilize titrants and color changing indicators to identify the endpoints. Alkalinity can be separated into several components depending on the endpoint.

7.10 COD

Lab Analysts should be familiar with the calculations, disposal hazards, and chemicals involved in the reactions of this colorimetric determination. A calculation is required to convert laboratory data into a reportable result. This test poses a hazardous waste disposal problem.

7.11 Residual Chlorine

Lab Analysts should be knowledgeable about the various forms and definitions of residual chlorine and the various tests used for determination, including which test is best suited for which matrix. Two of the more popular tests are the back-titration iodometric method and the amperometric titration, each with their own calculations.

Skill Set	8	Process Control
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8.1 General

The purpose of chemical analysis is two-fold: to meet the reporting requirements of the NPDES permit, and to provide information to the treatment plant staff so that they can make operational decisions to maximize plant efficiency. Lab Analysts should have a basic knowledge of how wastewater treatment plants operate, their effect on the environment, and how results apply to plant operations.

8.2 Chlorination, Chlorine Demand, and Dechlorination

Lab Analysts should be familiar with the concepts of chlorination and dechlorination; various forms of chlorine and their definitions; and chlorine demand and the factors that influence demand. These factors are part of the reporting requirements for chlorine demand. Lab Analysts should understand the chlorination and dechlorination process, including the chemicals used. Lab Analysts should know the definitions of disinfection, sterilization, and breakpoint chlorination. Calculations are required to determine chlorine dosage rates and disinfection rates.



8.3 Receiving Waters

Receiving waters are sensitive to effluent discharges and, in California, are regulated by the State Water Resources Control Board. Lab Analysts should have a basic understanding of the effects effluent discharges can have on receiving waters and of the standard tests used to measure these impacts. Some pollutants become nutrients in the natural environment and, in excess, may lead to aquatic habitat imbalances. Sufficient dissolved oxygen in receiving waters is important for aquatic health and is affected by several environmental and chemical factors.

8.4 Activated Sludge

Laboratory results provide the treatment plant staff with valuable information regarding the operation of the activated sludge process. Laboratory data is used to calculate mixed liquor suspended solids (MLSS), food to microorganism ratio (F/M), mean cell residence time (MCRT), and sludge volume index (SVI) values. Nitrification and denitrification conditions can exist in the aeration basins. Lab Analysts should be familiar with terms used by plant staff, such as coagulation, flocculation, bulking, pin floc, *Nocardia*, organisms, filamentous bacteria, and biomass. Similarly, Lab Analysts should be familiar with how the operators use laboratory results to control the activated sludge process.

8.5 Sludge Digestion

Lab Analysts should be familiar with terminology relating to the digestion of sludge, such as anaerobic, aerobic, anoxic, buffering capacity, mesophilic bacteria, biosolids, biodegradation, and dewatering. Several laboratory tests are used to measure the performance of an anaerobic digester, including volatile acids, alkalinity, and pH. Lab Analysts should be aware of the relationships of the test results to plant operations, and be able to identify unusual test results that may indicate of potential digester upsets.

Skill Set	9	Microbiology
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9.1 General

Microbiology vocabulary is extensive. Terms such as facultative anaerobe, pathogen, enteric, parasite, and others should be understood by Lab Analysts. Some definitions of bacteria can be very specific, describing their environmental preferences, appearance, and behavior in a given medium. Coliform, the most commonly tested organism, has such a complete description.

9.2 Sampling

Sampling for microbiological analysis is similar to sampling for chemical analysis, with two distinct differences. First, the sampling equipment must be sterilized prior to use and sterile sampling techniques must be used. Second, the analytical method may require that the sample is dechlorinated to protect the bacteria population from chlorine exposure.

Questions Lab Analysts may ask to become familiar with sampling protocol are:

- What type of container (usually autoclavable plastic) is used?
- How should the container be washed?
- How should the container be sterilized (time, temperature, temperature ranges, pressure, etc.)?
- Will the sample require dechlorination?
- What sampling technique is appropriate for microbiological samples (representative stream flows with sterile technique)?
- How should the sample be stored in transit and in the laboratory?
- What is the sample holding time?
- How should the sample be labeled?
- How should the chain-of-custody form be filled out?



Section 3: Skill Sets

9.3 Documentation

Record keeping in the laboratory is essential to protecting the integrity of the sample's result. In addition to sample labels, chain-of-custody forms, and sample logs, the laboratory equipment used for analysis requires monitoring. Temperature logs are required for ovens, incubators, water baths, autoclaves, and refrigerators. Media logs track date of purchase, storage conditions, etc.

Skill Set	10	Laboratory Microbiological Techniques
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10.1 General

Lab Analysts should have knowledge of the methods and equipment required to sterilize glassware used for microbiological determinations. Sterilizing techniques require knowledge of ovens and autoclaves, required temperature ranges, pressure settings, and time-durations of the sterilization cycles. The microbiology laboratory uses incubators, water baths, refrigerators, ovens, and autoclaves. Each piece of equipment must be monitored daily for temperature. Suitability of reagent-grade, laboratory-supplied water for analysis is very important. Several constituents are measured daily and others are measured at less frequent intervals.

10.2 Media Preparation

Lab Analysts are required to know the methods for analyzing various bacteria. Each method specifies the media used and its preparation.

Questions Lab Analysts may ask to become familiar with media preparation are:

- What are the name and type of the media used?
- What organisms are the media being used for?
- How are the dry media stored (conditions and time)?
- How are the prepared media stored (conditions and time)?
- How are the media prepared (acceptable pH ranges, sterilization temperature, range, time, pressure, etc.)?
- What type of glassware is used (pour plates, tubes, etc.) for each type of test?

Skill Set	11	Microbiological Analysis and Toxicity Tests
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11.1 General

Common microbiological analyses performed by Lab Analysts include Most Probable Number (MPN—including Presumptive Test, Confirmed Test and Completed Test), membrane filter (MF) technique for total and fecal coliform, and total plate count or heterotrophic plate count.

Questions the Lab Analysts may ask to become familiar with microbiological analysis and toxicity tests are:

- What is the name of the test?
- What organism does the test measure?
- What is a brief summary of the method?
- Which media are used?
- How are the media presented (pour plates, tubes, etc.)?
- Is the sample diluted or used at full strength?
- How are the media inoculated (serial dilution, streaking, etc.)?
- For how long do the inoculated media incubate (temperature, range, time)?
- What does a positive result look like (bubbles, colony appearance)?
- How are positive results quantified or counted?
- Are calculations required for a reportable result?
- What are the reporting units for the analysis (e.g., number of colonies per 100 mL)?

11.2 Coliform: MPN

Lab Analysts should know the definition of the coliform organism and its role in determining water contamination. The test has three phases: presumptive, confirmed, and completed. Completed phase includes gram stain techniques to confirm results. Lab Analysts should know the materials used and the conditions required by each of these analyses, from the preparation of the media through incubation and identification of positive and negative results.



11.3 Coliform: MF Technique

The MF technique processes samples through a specialized filter to capture the organisms. Depending on the organism, the filter is then placed in either an agar-filled Petri dish, or a media-saturated absorbent pad, and incubated. Lab Analysts should be familiar with this analysis from the preparation of the media through incubation and identification of positive and negative results.

11.4 Bioassay/Toxicity

Bioassay and toxicity tests use static or flow-through conditions with control organisms and reference toxicants. Although many different tests are published, fish toxicity analyses are commonly used. Lab Analysts should understand the terminology used in running these tests and reporting the results.



Section 3: Skill Sets

Table 3-1 Grade II Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Operation of Wastewater Treatment Plants	Water & Wastewater Laboratory Techniques	Lectures on Wastewater Analysis and Interpretation	Other (see footnotes)
1	Laboratory Safety					
1.0	General	1090 A–J, especially A, B, E, and H; 1100	Chapter 14, especially 14.2, 14.3, 14.4, 14.5, 14.6, 14.9; Chapter 16.2			OSHA Regulations ^b 29 CFR 1910.1200, 29 CFR 1910.1450(e); Handbook ^d Chapter 14, Appendix A
2	Regulations					
2.0	General				Lecture 1, pgs. 1–36; Appendix A, B	40 CFR 136 ^c
3	Sampling Protocol					
3.0	General	1060 A, B, C; Table 1060:l	Chapter 16.3		Lecture 2, pgs. 41–44	Handbook ^d Chapter 10
4	Quality Assurance, Data Interpretation, and Laboratory Reports					
4.0	General	1010; 1020 A, B; 1030 A, B, C; 1050 A, B		Chapter 10, pgs. 177–188	Lecture 2, pgs. 37–52; Lecture 21, pgs. 375–390	Handbook ^d Chapters 1, 6, 7
5	Mathematics and Chemistry					
5.0	General	1050 Older Editions Part 102 Sections 1, 3, 4, 5	Chapter 16.11	Chapter 6, 7, 9; Appendix A, B		

- a. Complete reference information given in Section 6.
- b. *OSHA Regulations (Standards – 29 CFR)*
- c. *40 CFR (CFR Title 40: Protection of Environment)*
- d. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*



Table 3-1 Grade II Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Operation of Wastewater Treatment Plants	Water & Wastewater Laboratory Techniques	Lectures on Wastewater Analysis and Interpretation	Other (see footnotes)
6	Laboratory Instrumentation—Chemical					
6.1	General					Handbook ^d Chapter 3; See appendix for examples of textbooks applicable to the topic.
6.2	UV Visible Spectrophotometry		Chapter 16.17	Chapter 8, pgs. 155–160		Handbook ^d Section 3.6; Look in textbook index under spectrometry, spectrophotometer, visible spectra, ultraviolet spectra, etc.
6.3	Flame AA	3010; 3020; 3030; 3110; 3111			Lecture 3, pgs. 53–74	Handbook ^d Section 6.65; Look in textbook index under atomic absorption, spectrometry, flame emission.
6.4	Gaseous Hydride	3114 A, B			Lecture 3, pg. 60	(Often excluded from text-books.) Look in textbook index under hydride generation, gaseous hydride generation, arsenic, selenium.

a. Complete reference information given in Section 6.

d. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*



Section 3: Skill Sets

Table 3-1 Grade II Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Operation of Wastewater Treatment Plants	Water & Wastewater Laboratory Techniques	Lectures on Wastewater Analysis and Interpretation	Other (see footnotes)
6.5	Cold Vapor Technique				Lecture 3, pg. 60	
6.6	Graphite Furnace (Electrothermal)				Lecture 3, Pgs. 55–58	Look in textbook index under atomic absorption, electrothermal atomizers, electrothermal atomization, graphite furnace.
6.7	Total Organic Carbon Analyzer	5310 A, B, C	Chapter 16.5.18		Lecture 6, pgs. 144–146	Handbook ^d Section 3.7; Look in textbook index under carbon analyzer, carbon automatic analyzer, total organic content analyzer, thermal analysis.
6.8	Ion-Selective Electrodes (Probes)	4500-H ⁺ B.2.A, B, C; 4500-F ⁻ A, C; 4500-NO ₃ ⁻ A, D 4500-NH ₃ A, D		Chapter 8, pgs. 165–167	Lecture 7, pgs. 167–171; Lecture 14, pgs. 269–272	Handbook ^d Section 3.3; Look in textbook index under electrodes, ion-selective electrodes, potentiometric determinations, pH.

a. Complete reference information given in Section 6.

d. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*



Table 3-1 Grade II Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Operation of Wastewater Treatment Plants	Water & Wastewater Laboratory Techniques	Lectures on Wastewater Analysis and Interpretation	Other (see footnotes)
7	Chemical Analysis					
7.2	Nitrogen				Lecture 8, pgs. 159–186	
7.2	Ammonia	4500-NH ₃ A, B, C, D	Chapter 16.5.10	Chapter 8, pgs. 127–128	Lecture 8, pgs. 159–186	
7.2	Nitrite	4500-NH ₃ A, B		Chapter 8, pgs. 165–167	Lecture 8, pgs. 159–186	
7.2	Organic Nitrogen (TKN)	4500-N _{org} A, B, C			Lecture 8, pgs. 159–186	
7.3	Phosphorus	4500-P A, B, C	Chapter 16.5.12	Chapter 8, pgs. 155–160	Lecture 9, pgs. 187–195	
7.4	Fluoride	4500-F ⁻ A, B, C, D		Chapter 8, pgs. 155–160	Lecture 12, pgs. 235–244	
7.5	Oil and Grease	5520 A, B			Lecture 15, pgs. 303–308	Method 1664 ^e (EPA-821/B-94-004b)
7.6	Sulfate	4500-SO ₄ ⁼ A, E			Lecture 10, pgs. 210–214	Methods ^f 375.4 Sulfate-Turbidimetric
7.7	BOD	5210 A, B	Chapter 16.5-3		Lecture 6, pgs. 123–138	
7.8	DO	4500-O A, C	Chapter 16.5-7			
7.9	Hardness, pH, Alkalinity, and Conductivity				Lecture 14, pgs. 261–292	
7.9	Alkalinity	2320 A, B	Chapter 16.5-2		Lecture 14, pgs. 261–292	
7.9	Total Hardness	2340 A, C			Lecture 14, pgs. 261–292	

a. Complete reference information given in Section 6.

e. *Method 1664 - N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease and Total Petroleum Hydrocarbons)*, April 1995

f. *Methods for Chemical Analysis of Water and Wastes*



Section 3: Skill Sets

Table 3-1 Grade II Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Operation of Wastewater Treatment Plants	Water & Wastewater Laboratory Techniques	Lectures on Wastewater Analysis and Interpretation	Other (see footnotes)
7	Chemical Analysis					
7.9	Conductivity	2510 A, B	Chapter 16.5-14		Lecture 14, pgs. 261-292	Handbook ^d Sections 3.3,3.4
7.9	pH	4500-H ⁺ A, B	Chapter 16.5-8		Lecture 14, pgs. 261-292	
7.10	COD	5220 A, C, D	Chapter 16.5-3		Lecture 6, pgs. 139-143	
7.11	Residual Chlorine (Free, Combined)	4500-Cl A, B, D	Chapter 16.5-5		Lecture 11, pgs. 219-234	
8	Process Control					
8.1	General				Lecture 20, pgs. 369-373	
8.1	Process Control Calculations				Lecture 20, pgs. 369-373	
8.2	Chlorine Demand, Chlorination, and Dechlorination	2350 A, B	Chapter 10, especially 10.02, 10.05, 10.06, 10.8, 10.81, 10.850, 10.851; Figure 10.2		Lecture 11, pgs. 219-234	
8.3	Receiving Waters	4500-P A.1 4500-NO ₃ ⁻ 4500-NH ₃				
8.4	Activated Sludge	2710 A, C, D, F				
8.5	Sludge Digestion	2720 A, C				

a. Complete reference information given in Section 6.

d. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*



Table 3-1 Grade II Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Operation of Wastewater Treatment Plants	Water & Wastewater Laboratory Techniques	Lectures on Wastewater Analysis and Interpretation	Other (see footnotes)
9	Microbiology					
9.1	General				Lecture 17, pgs. 329–340	Handbook ^d Chapters 2, 4, 12, 14; Appendix A
9.2	Sampling	9030; 9040; 9060 A.1, A.2, A.3, B				Handbook ^d Chapter 10
9.3	Documentation	1060 B.2; 9030 B				Handbook ^d Chapter 12
10	Laboratory Microbiological Techniques					
10.2	Media Preparation	9050 C; 9215 A.6; 9221 B 1, 2, 3; 9221 E.1				
11	Microbiological Analysis and Toxicity Tests					
11.1	General	9020 I				
11.2	Coliform: MPN	9221 A, B, C				
11.2	Fecal Coliform	9221 E	Chapter 14.4-6			
11.3	Coliform: MF Technique	9222 A, B				
11.4	Bioassay/ Toxicity					Handbook ^d Chapter 13

a. Complete reference information given in Section 6.

d. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*



S e c t i o n 4

Test Preparation

This section provides tips on the how candidates should prepare for the test, information on the test question format and the math skills likely to be needed, and a table of equivalents and formulas.

Basic Study Strategy

To prepare adequately for the test, candidates need to employ discipline and develop good study habits. Ample time to prepare for the test should be allowed. Candidates should establish a study schedule and stick to it. One or two nights a week for one or two months should be sufficient in most cases. Spend one or more hours studying in quiet surroundings or in small groups of two or three serious candidates. Efforts should be directed to the test subject areas that are not being performed on a day-to-day basis.

It is especially important for candidates to obtain access to the reference materials listed under the Primary References heading in Section 6 of this study guide. Many of these materials are likely to be available in the work place and in technical libraries. Some references, such as codes and regulations, are available on-line as well. For a list of links to on-line resources, see the Certification Resource Links page on the CWEA website at www.cwea.org/tcp/resources.

Candidates should study at the certification level being sought after. There is no advantage to spending time studying material that will not be on the test. Refer to Section 3 of this study guide for topics that will be covered.

While using this study guide, be sure to understand the answers to all the sample and diagnostic test questions. It may also be helpful to use the skill set descriptions in Section 3 to devise additional questions for further study. Discuss the questions with others. Not only is this a good study technique, it is also an excellent way to learn.

It is not necessary, but it can certainly be helpful, to memorize all the formulas and equivalents used in working out the solutions for questions involv-

ing calculations. Table 4-1 lists many, but not all, of these formulas and conversion factors. When the test is administered, a sheet listing some, but not all, of the relevant formulas and equivalents will be provided as part of the test materials. So that candidates may determine which formulas and equivalents will actually be on the sheet included with the test booklet, copies of these sheets are provided on the CWEA website at www.cwea.org/tcp/resources. (The set of equivalents and formulas on the sheet provided with the test may not be exactly the same as the set included in Table 4-1.)

Multiple Choice Questions

All test questions are written in multiple-choice format. At first glance, the multiple-choice problem may seem easy to solve because so much information is given, but that is where the problem lies. The best answer must be chosen from the information provided. Here are some tips that may help solve multiple-choice problems.

1. Read the question completely and closely to determine what is being asked.
2. Read all the choices before selecting an answer.
3. Look for key words or phrases that often, but not always, tip off correct or incorrect answers:

Absolute Words

(Suspect as a wrong choice)

Always	Never	None
Totally	All	

Limiting Words

(Often a correct choice)

Few	Occasionally
Some	Generally
Often	Usually
Many	Possible



Section 4: Test Preparation

Table 4-1 Laboratory Analyst

General Information

Element Symbols and Atomic Weights ^a			Conversion Factors	
Element	Symbol	Atomic Weight		
Aluminum	Al	27	1 gal. = 8.34 lbs.	
Arsenic	As	75	1 cu. ft. = 7.48 gal.	
Calcium	Ca	40	1 lb. = 454 grams	
Carbon	C	12	MPN	
Chlorine	Cl	35.5	Dilutions: 10 mL, 1.0 mL, 0.1 mL	
Chromium	Cr	52	<u>Combination of Positives</u>	<u>MPN Index</u>
Copper	Cu	63.5	5 - 3 - 0	80
Hydrogen	H	1	5 - 5 - 3	900
Iodine	I	126.9	5 - 5 - 5	> 1600
Magnesium	Mg	24	Abbreviations	
Nickel	Ni	59	AA = Atomic Absorption	
Nitrogen	N	14	AE = Atomic Emission	
Oxygen	O	16	mL = Milliliter	
Phosphorus	P	31	mg = Milligram	
Potassium	K	39	L = Liter	
Silver	Ag	108	g = Gram	
Sodium	Na	23	GC = Gas Chromatography	
Sulfur	S	32	F = Formal	
			M = Molar	
			N = Normal	
			MGD = Million Gallons per Day	

a. Source: *Standard Methods, 18th Edition*



- Never make a choice based on the frequency of previous answers. If the last ten questions have not had a “b” answer, don’t arbitrarily select “b”. Instead use logic and reasoning to increase the chances of choosing the best answer.
- Reject answers that are obviously incorrect and choose from the remaining answers.

Example

The straight line distance from the center of a circle to the outer edge is called the:

- diameter
- circumference
- chord
- radius

It is possible to reason out the answer by having some knowledge of geometry and studying the questions and the four provided answers. The question is asking for the name of a line or distance that is inside of the circle. Circumference is the distance around the outside of the circle, so this is an obvious incorrect answer.

- Make an educated guess.
Never reconsider a choice that has already been eliminated. This means that answer “b” should not be considered. Look for key phrases or words that give a clue to the right answer. Chord, answer “c,” chord refers to a straight line inside of the circle, but it does not necessarily go through the center of the circle, so this answer can be eliminated.
Answers “a” and “d” are distances that are measured as straight lines and either start or go through the center of a circle. The diameter goes through the center rather than starting from the center. Radius, answer “d” is the correct answer and is defined as the straight line distance from the center to the outer edge of a circle.
- Skip over questions that are troublesome. Mark these questions for later review.
- When finished with the test, return to the questions skipped. Now think! Make inferences. With a little thought and the information given, the correct answer can be reasoned out.

- Under no circumstances leave any question unanswered. There is no penalty for incorrect answers. However, credit is given only for correct answers.
NO ANSWER=WRONG ANSWER
- Keep a steady pace. Check the time periodically.
- Remember to read all questions carefully. They are not intended to be “trick questions”; however, the intent is to test candidates’ knowledge of and ability to understand the written language of this profession.

Math Problems

Math problems on the certification tests are meant to reflect the type of work encountered in the water quality field. Although there is no specific math section on the test, many questions will require some calculations such as volume, ratios, and conversion of units. By far, the greatest number of applicants who fail the certification tests do so by failing to complete the math problems. Completing the math problems will be greatly simplified by using a calculator and the approach suggested in the following paragraphs.

Calculators

A scientific calculator may be used during the test; however, a four-function (add, subtract, multiply and divide) calculator is adequate for completing any of the certification tests. Additional functions (e.g., square root) are not necessary, but may be helpful in some situations. The most important factor in effectively using a calculator is the candidate’s familiarity with its use prior to the time of the examination. Confidence in the calculator and a full understanding of how to properly operate it are a must. The best way to gain confidence is to obtain the calculator early and use it frequently.

Completing the sample problems in this section as well as the diagnostic test in Section 5 will improve proficiency. Additional use will also help. For example, calculate the gas mileage when filling a vehicle’s tank. Check the sales tax calculation on each purchase. Balance a checkbook, or check a paycheck. The calculator chosen should have large enough keys so that the wrong keys



Section 4: Test Preparation

are not accidentally punched. Be certain there are new batteries in the calculator, or use a solar powered calculator with battery backup.

Approach

The solution to any problem requires understanding of the information given, understanding of what is being requested, and proper application of the information, along with the appropriate equations to obtain an answer. Any math problem can be organized as follows:

Given or Known

All information provided in the problem statement that will be used to get the correct answer.

Find

A description of the answer that is being requested.

Sketch

If possible, sketch the situation described in the problem statement showing size and shape (dimensions).

Equation

A listing of the equation or equations that will be used to generate the answer.

Assumption(s)

Stated assumptions of key information needed to answer a math problem with missing information. This occurs frequently on higher-grade tests.

Answer

This is where the answer is clearly identified.

Advantages to using this approach to organize math problems are that it helps to organize thoughts, breaks the problem solution into a series of smaller steps, and reduces chances of making errors.

Solutions

Solutions to math problems are like driving routes from Los Angeles to San Francisco: there are many different routes that can be taken. Some routes are shorter or less complicated than others. Only certain routes end up in San Francisco.

Solutions to sample problems given in this study guide are the most common solutions. If a different solution arrives at the correct answer, then it can be used as well.

Equivalents and Formulas

Familiarity with the equivalents (conversion factors) and formulas in Table 4-1 is important. Pay special attention to the units of measure that are used in the formulas. A correct answer will not be obtained unless the correct units of measure are used.

Check the units, arithmetic, and answer so that:

1. the units agree;
2. the answer is the same when the arithmetic is repeated; and
3. the answer is reasonable and makes sense.

Dimensional Analysis

When setting up an equation to solve a math problem, the trick is to have clearly in mind what units the answer should be in. Once the units have been determined, work backwards using the facts given and the conversion factors known or given. This is known as dimensional analysis, using conversion factors and units to derive the correct answer.

Remember, multiplying conversion factors can be likened to multiplying fractions. The denominator (the number on the bottom of the fraction) and the numerator (the number on the top of the fraction) cancel each other out if they are the same, leaving the units being sought after.

Example

If a company runs a discharge pump rated at 50 gallons per minute all day, every day for a year, what is the discharge for the year in millions of gallons per year (MGY)?

Given: pump rating = $50 \frac{\text{gal}}{\text{min}}$

Find: discharge = MGY

Calculations

Convert gal/min to million gal/yr, convert gallons to million gallons, and minutes to years.

What is known about minutes and years? There are 60 minutes in an hour, 24 hours in a day, and 365 days in a year. Put that into an equation, and multiply each conversion factor so the unneeded units are cancelled out:

$$50 \frac{\text{gal}}{\text{min}} \times 60 \frac{\text{min}}{\text{hr}} \times 24 \frac{\text{hr}}{\text{day}} \times 365 \frac{\text{days}}{\text{yr}} \times$$

$$1 \frac{\text{MG}}{1,000,000 \text{ gal}} = 26.28 \text{ MGY}$$



Sample Questions

The following sample math problems are intended to demonstrate unit conversion techniques. Although they are general wastewater problems, the questions may not be specific to any vocation.

- How many gallons of water will it take to fill a 3 cubic foot container?

$$3 \text{ cubic feet} \times 7.48 \frac{\text{gallons}}{\text{cubic feet}} = 22.4 \text{ gallons}$$

- If a gallon of gasoline weighs 7.0 pounds, what would be the weight of a 350 gallon tank full of gasoline?

$$350 \text{ gallons} \times 7.0 \frac{\text{pounds}}{\text{gallon}} = 2,450 \text{ pounds}$$

- The rated capacity of a pump is 500 gallons per minute (GPM). Convert this capacity to million gallons per day (MGD).

$$500 \text{ GPM} \times 1 \frac{\text{MGD}}{694 \text{ GPM}} = 0.72 \text{ MGD}$$

- A chemical feed pump is calibrated to deliver 50 gallons per day (GPD). What is the calibrated chemical feed in gallons per minute (GPM)?

$$\frac{50 \text{ gal}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} = 0.035 \text{ GPM}$$

- A chemical feed pump delivers 50 mL per minute (mL/min). Determine the chemical feed in gallons per day (gpd).

$$\frac{50 \text{ mL}}{\text{min}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ gallon}}{3.785 \text{ L}} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{24 \text{ hr}}{\text{day}} = 19 \text{ GPD}$$

- A cyanide destruction process is designed to treat 30 pounds of cyanide per 24-hour operational day. How many pounds of cyanide can be treated during an 8-hour shift?

$$\frac{30 \text{ lbs CN}}{\text{day}} \times \frac{8 \text{ hr}}{\text{shift}} \times \frac{1 \text{ day}}{24 \text{ hr}} = 10 \text{ lbs CN/shift}$$

Math Skills

Grade II Lab Analyst candidates must be skilled in arithmetic, statistics, and algebra. Lab Analysts must be able to build upon the skills learned for Grade I to perform more complex calculations for work-related tasks in general chemistry, preparing standard solutions, reporting laboratory data, assisting plant operations, and any other job-related math task that may fall within the Skill Sets listed in Section 3.

Grade II general chemistry math problems will require Lab Analysts to understand how to determine:

- Weight of a dry reagent required to make a solution of a specified volume or normality (eq/L), given the molecular formula of the reagent, molecular weights, and the oxidation reduction reaction.
- Concentration of a diluted solution in mg/L or ppm following serial dilutions on an initial concentration.
- Volume of concentrated acid that contains a specified weight (g) of pure acid given specific gravity, % weight to weight, and molecular weights for the elements in the acid.
- Weight (g) of a dry reagent required to make a solution, given the molecular formula, molecular weights, and the final concentration of one of its elemental constituents.

Problems using laboratory data will require Lab Analysts to memorize the formulas in *Standard Methods* for the analytical methods outlined in the skill sets covered in Section 3 of this study guide. These types of problems will require Lab Analysts to determine:

- BOD concentration, given the initial and final DO concentrations. Lab Analysts must memorize the acceptance criteria for DO depletion in the blank and in the diluted samples, and the calculations used for seeded and non-seeded samples.
- Sulfates, chlorine demand, nitrogen, phosphorus, fluoride, and TOC from the formulas given in *Standard Methods*.
- Concentration of an unknown solution, given absorbance versus concentration information from a standard curve.



Section 4: Test Preparation

- Concentration of bacterial counts from a serially diluted sample, given the serial dilutions and the final plate (colony) counts.

Problems using information to monitor plant operations require Lab Analysts to determine:

- Percent removal and pounds removed of total suspended solids in the primary clarifier, given influent and effluent TSS (mg/L) and flow (MGD).
- Removal of suspended solids (lbs/day), given flow (MGD), percent removals from each treatment step (primary and secondary clarifiers), and the total suspended solids (mg/L) in the final effluent.
- SVI (Sludge Volume Index) given MLSS (mg/L) and the results of the 30-minute settling test (mL).
- SVI given lab data for TSS (filter weights: tare and with residue, sample volume) and the results of the 30-minute settling test (mL).
- Concentration of a constituent of a composite of two influent lines, given the concentration and the flow of each line.

A thorough review of the types of mathematics required for the test is beyond the scope of this study guide. Consult an appropriate text (see Section 6, References) if there is unfamiliarity with any specific math skills. Appendix A provides general strategies for approaching math problems and math anxiety, as well as resources for remedial study.

Arithmetic

Candidates should be able to understand and perform the following calculations either manually or with a calculator:

1. Addition and subtraction of whole numbers, fractions, and decimals.
2. Multiplication and division of whole numbers, fractions, and decimals.

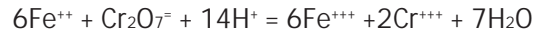
Be prepared to apply these basic skills to work-related problems. The following example problem requires application of chemistry knowledge, application of basic arithmetic, and the ability to convert units.

Example

Potassium dichromate ($K_2Cr_2O_7$) is to be used in the COD test. How many grams would it take to make 2.0 liters of 0.5 N solution?

Molecular weights: K=39, Cr=52, O=16

Hint:



To determine the answer to this problem, Lab Analysts must understand oxidation-reduction reactions and normality. From the equation given, it can be determined that each chromate ion accepts a total of six electrons. A 1.0 normal solution would contain 1/6 gram molecular weight of potassium dichromate per liter. A 0.5 normal solution would contain 1/2 of the above weight. Calculate as follows.

Determine the molecular weight: $K_2Cr_2O_7$

$$(39 \times 2) + (52 \times 2) + (16 \times 7) \\ = 294 \text{ g } K_2Cr_2O_7/\text{mole}$$

Then set up a unit factor equation:

$$\frac{294 \text{ g } K_2Cr_2O_7}{1 \text{ mole}} \times \frac{1 \text{ mole}}{6 \text{ equivalents}}$$

$$\times \frac{0.5 \text{ equivalent}}{1 \text{ L}} \times 2.0 \text{ L} = 49 \text{ g } K_2Cr_2O_7$$

Sequential Situations

Mathematics skills often require an understanding of sequential thought. Examples of this type of problem include serial dilutions in the laboratory, and serial removal of pollutants as wastewater is processed through sequential levels of treatment (primary, secondary, and tertiary).

Example

A bacterial culture was sampled and serially diluted prior to spread-plating onto triplicate plate-count agar plates. The dilutions were as follows. One mL of the original sample was added to 99 mL of solution B. One mL of solution B was added to 9 mL of solution C. Five mL of solution C was added to 5 mL of solution D. This final mix was plated in triplicate at 0.1 mL per plate. The plates were incubated at 35°C for 2 days before colonies were counted. The counts obtained were 57, 61, and 48 colonies per respective plate. Using the plate counts obtained, calculate the original concentration of the bacterial culture in CFU/mL.



Section 4: Test Preparation

First, calculate the dilution factor by multiplying together each serial dilution:

1 mL of A in 99 mL of B = 1:100 or 10^{-2} dilution

1 mL of B in 9 mL of C = 1:10 or 10^{-1} dilution

5 mL of C in 5 mL of D = 1:1 or 0.5 dilution

0.1 mL of D per plate is 1:10 or 10^{-1} dilution

$10^{-2} \times 10^{-1} \times 0.5 \times 10^{-1} = 0.5 \times 10^{-4}$

Second, find the average of the colony counts:

$$\frac{57 + 61 + 48}{3} = 55 \text{ colonies}$$

Third, divide the colony counts by the dilution:

$$\frac{55 \text{ colonies}}{0.5 \times 0.0001} = 1 \times 10^6 \text{ CFU/mL}$$

Algebra

Candidates should be able to perform basic applied algebra such as solving for one unknown in an equation. Remember that the unknown must be in the numerator and by itself on one side of the equation with all knowns on the other side.

Example

A treatment plant receives 90 MGD of flow from Influent Line #1 and 10 MGD of flow from Influent Line #2. The flow from Influent Line #1 has a BOD of 300 mg/L and a suspended solids of 500 mg/L. The Influent Line #2 flow has a BOD of 2,000 mg/L and a suspended solids of 5,000 mg/L. What are the resultant BOD and suspended solids concentration of the mixture?

There are at least two ways this problem can be worked. One way is to compute the separate mass contributions by each flow, total them, and calculate the resultant concentration from the combined flow. The example below shows this method and is followed by a method using ratios.

First, calculate the pounds of BOD/day of the combined flow.

Influent Line #1: $300 \text{ mg/L} \times 90 \text{ MGD} \times 8.34$
= 225,180 pounds BOD/day

Influent Line #2: $2,000 \text{ mg/L} \times 10 \text{ MGD} \times 8.34$
= 166,880 pounds BOD/day

Total = 391,980 pounds BOD/day

Second, calculate the concentration of BOD in mg/L.

$$\frac{391,980 \text{ pounds BOD/day}}{8.34 \times 100 \text{ MGD}} = 470 \text{ mg/L}$$

Repeat these steps for suspended solids.

First, calculate the pounds SS/day of the combined flow.

Influent Line #1: $500 \text{ mg/L} \times 90 \text{ MGD} \times 8.34$
= 375,300 pounds SS/day

Influent Line #2: $5000 \text{ mg/L} \times 10 \text{ MGD} \times 8.34$
= 417,000 pounds SS/day

Total = 792,300 pounds SS/day

Second, calculate the concentration of SS in mg/L.

$$\frac{792,300 \text{ pounds SS/day}}{8.34 \times 100 \text{ MGD}} = 950 \text{ mg/L}$$

A shorter way to work this problem is to use ratios. The combined flow is 100 MGD (90 MGD + 10 MGD). 90/100 of the total flow is from Influent Line #1 and 10/100 comes from Influent Line #2 flow.

Calculate the BOD in mg/L for the combined flow.

$$\frac{90 \text{ MGD}}{100 \text{ MGD}} \times 300 \text{ mg/L} = 270 \text{ mg/L}$$

$$\frac{10 \text{ MGD}}{100 \text{ MGD}} \times 2000 \text{ mg/L} = 200 \text{ mg/L}$$

$$270 + 200 = 470 \text{ mg/L}$$

Calculate the SS in mg/L for the combined flow.

$$\frac{90 \text{ MGD}}{100 \text{ MGD}} \times 500 \text{ mg/L} = 450 \text{ mg/L}$$

$$\frac{10 \text{ MGD}}{100 \text{ MGD}} \times 5,000 \text{ mg/L} = 500 \text{ mg/L}$$

$$450 + 500 = 950 \text{ mg/L}$$



S e c t i o n 5

Diagnostic Test

Introduction

This section provides a diagnostic test to assist those studying for the Grade II Lab Analyst certification test in evaluating their current knowledge level in the skill sets presented in Section 3.

The example questions in the diagnostic test represent the type of knowledge that may be required to successfully pass the certification test. They are based on information contained in Section 6, References, and are arranged according to the skill sets presented in Section 3. However, passing the diagnostic test does not guarantee passing the certification test.

Note that this diagnostic test can be used to help Lab Analysts create additional questions for further study. For example, if a question asks about the components of an atomic absorption spectrophotometer, the Lab Analyst can inquire about the components of other types of instruments. A question that asks for the definition of a specific term used for toxicity analysis may prompt a Lab Analyst to become familiar with toxicity terminology in general.

Diagnostic test answers, the applicable skill sets, and selected solutions are presented at the end of this section. Candidates should take the diagnostic test, mark wrong answers, and record the skill sets for questions missed. Using Table 3-1, candidates should review the references to improve their knowledge of the subjects, especially in areas where they answered diagnostic test questions incorrectly.

Skill Set	1	Laboratory Safety
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1. Standard phenylarsine oxide solution (PAO):
 - a. should be handled with caution because it is a severe poison.
 - b. should be handled with caution because it is highly corrosive.
 - c. should be handled with caution because it is highly acidic.
 - d. requires only routine laboratory safety considerations.
2. Which of the following practices is important in storing and handling flammable liquids?
 - a. Segregate flammable liquids from other hazardous materials
 - b. Remove all nonworking quantities from the bench top and store them under the counter or in a laboratory storage cabinet
 - c. Minimize ignition sources whenever flammable liquids are being stored or handled
 - d. Segregate flammable liquids from other hazardous materials and minimize ignition sources whenever flammable liquids are being stored or handled

Skill Set	2	Regulations
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1. A wastewater discharge (NPDES) permit is issued under the authority of the:
 - a. Office of Drinking Water (ODW).
 - b. Environmental Laboratory Accreditation Program.
 - c. State Water Resources Control Board.
 - d. Department of Toxic Substances Control.



Section 5: Diagnostic Test

2. The methods of analysis that are approved (promulgated) for use on most wastewater samples are found listed in:
 - a. Standard Methods for the Examination of Water and Wastewater.
 - b. 40 CFR 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants.
 - c. EPA/SW-846 Test Methods for Evaluating Solid Waste—Physical/Chemical.
 - d. EPA/600/4-79/020 Methods for Chemical Analysis of Water and Wastes.

Skill Set	3	Sampling Protocol
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1. Sample protocol for residual chlorine includes:
 - a. preserving the sample with sodium thio-sulfate for a 7-day holding time.
 - b. preserving the sample at 4°C for a 7-day holding time.
 - c. preserving the sample at 4°C for a 28-day holding time.
 - d. no preservation and immediate analysis.
2. Sample containers typically are made of plastic or glass, but one material may be preferred over the other. Which of the following statements is correct?
 - a. Silica and sodium may be leached from plastic but not from glass, and trace levels of metals may adsorb onto the walls of glass containers.
 - b. Silica and sodium may be leached from plastic but not from glass, and trace levels of metals may adsorb onto the walls of plastic containers.
 - c. Silica and sodium may be leached from glass but not from plastic, and trace levels of metals may adsorb onto the walls of glass containers.
 - d. Silica and sodium may be leached from glass but not from plastic, and trace levels of metals may adsorb onto the walls of plastic containers.

Skill Set	4	Quality Assurance, Data Interpretation, and Laboratory Reports
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1. Of the four possible outcomes of bias and precision:
 - a. only the condition of low bias and high precision is accurate.
 - b. only the condition of low bias and low precision is accurate.
 - c. only the condition of high bias and high precision is accurate.
 - d. only the condition of high bias and low precision is accurate.
2. Chain-of-custody:
 - a. replaces the need for sample container labels.
 - b. must include field notes regarding sampling conditions.
 - c. is the ability to trace sample possession and handling from collection through analysis and final disposition.
 - d. is the ability to trace sample handling techniques from preservation through extraction or digestion to analysis.
3. What is the most correct answer to the following addition problem?
 $10.623 + 2.16 + 200.5 + 1478 =$
 - a. 1691.28
 - b. 1691.3
 - c. 1691
 - d. 1690



Skill Set	5	Mathematics and Chemistry
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1. What is the weight of anhydrous KH_2PO_4 required to make 100 mL of solution containing 15.0 mg/L phosphorus (P)?
 - a. 6.6 g
 - b. 6.6 mg
 - c. 3.4 g
 - d. 0.34 mg
2. Oxidation refers to:
 - a. a gain in electrons with a corresponding decrease in oxidation number.
 - b. a loss in electrons with a corresponding decrease in oxidation number.
 - c. a gain in electrons with a corresponding increase in oxidation number.
 - d. a loss in electrons with a corresponding increase in oxidation number.
3. A standard solution is prepared from a 0.100% stock solution of a pure metal. Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. What is the concentration of the standard solution?
 - a. 0.005 mg/L
 - b. 0.050 mg/L
 - c. 0.500 mg/L
 - d. 5.00 mg/L
2. In atomic absorption, for a particular element to absorb light at its characteristic wavelength, the atoms must be:
 - a. ionized.
 - b. reduced to their ground-state.
 - c. complexed.
 - d. oxidized.
3. Analysts use a matrix modifier to retain analytes on the platform at higher charring temperatures, volatilize matrix components at lower charring temperatures, and stabilize analytes on the platform allowing more rapid temperature equilibrium between the furnace wall and atomic vapor:
 - a. when using gaseous hydride generation technique.
 - b. when using cold vapor technique.
 - c. in stabilized-temperature platform ceramic furnace atomic absorption technique.
 - d. in stabilized-temperature platform graphite furnace atomic absorption technique.
4. Do not report values above the highest standard of a standard curve unless:
 - a. no instrument parameters have been changed.
 - b. the value is less than 1.5 times the highest standard.
 - c. an initial demonstration of greater linear range has been made.
 - d. all of the above criteria are met.

Skill Set	6	Laboratory Instrumentation—Chemical
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1. UV/Visible spectroscopy utilizes which principles?
 - a. Nernst Equation
 - b. Bernoulli's Law
 - c. Henry's Law
 - d. Beer's Law
5. According to the Lambert's/Beer's Law:
 - a. absorbance is proportional to concentration.
 - b. transmittance is proportional to concentration.
 - c. transmittance is proportional to absorbance.
 - d. transmittance is independent of concentration.



Section 5: Diagnostic Test

6. In flame AAS, sensitivity is defined as:
 - a. the analyte concentration that provides an absorbance reading of 0.0044 units.
 - b. the analyte concentration that falls at the middle of the calibration range.
 - c. the smallest difference in concentration that a spectrophotometer can distinguish between two samples.
 - d. the lowest concentration that can be measured reliably.
7. Which of the following parameters cannot be measured using a specific-ion electrode?
 - a. Nitrate
 - b. Fluoride
 - c. Chemical oxygen demand
 - d. Ammonia
8. Preliminary treatment for acid-extractable metals would consist of:
 - a. filtering the sample, acidifying the filtrate, and analyzing directly.
 - b. filtering the sample, digesting the filter and residue on it, and performing analysis.
 - c. adding 5 mL of a 50% hydrochloric acid solution to a 10 mL sample, heating 15 minutes on a steam bath, filtering, and then diluting to 100 mL.
 - d. adding 5 mL of a 50% nitric acid solution to a 10 mL sample, heating until almost evaporated and nitrous oxide fumes develop, filtering, and then diluting to a 100 mL volume.

Skill
Set

7

Chemical Analysis

1. In the BOD determination, the restrictions regarding accepting or rejecting analysis values are:
 - a. the blank must not deplete more than 0.2 mg/L dissolved oxygen, and the samples must deplete at least 1 mg/L and have at least 2 mg/L dissolved oxygen remaining.
 - b. the blank must not deplete more than 0.2 mg/L dissolved oxygen, and the samples must deplete at least 2 mg/L and have at least 1 mg/L dissolved oxygen remaining.
 - c. the blank must not deplete more than 2 mg/L dissolved oxygen, and the samples must deplete at least 2 mg/L and have at least 1 mg/L dissolved oxygen remaining.
 - d. the blank must not deplete more than 2 mg/L dissolved oxygen, and the samples must deplete at least 1 mg/L and have at least 2 mg/L dissolved oxygen remaining.
2. In the amperometric method for analyzing residual chlorine, the endpoint is reached when:
 - a. the color changes from clear to pinkish red in response to a measured addition of standard phenylarsine oxide (PAO).
 - b. the voltmeter registers the millivolt readings peak and then starts to go back down in response to a measured addition of standard phenylarsine oxide (PAO).
 - c. the microammeter needle registers the millivolt readings peak and then starts to go back down in response to a measured addition of standard phenylarsine oxide (PAO).
 - d. the microammeter needle makes a smaller deflection response to a measured addition of standard phenylarsine oxide (PAO).



Section 5: Diagnostic Test

3. In the COD titrimetric determination, the sample is refluxed in strongly acid solution with a known excess of potassium dichromate. After the sample has cooled, the residual dichromate is titrated with:
 - a. ferroin.
 - b. ferrous ammonium sulfate.
 - c. mercuric sulfate.
 - d. sulfuric acid.
4. In Method 1664 for grease and oil, which solvent is used for extracting the oil from the water phase?
 - a. Hexane
 - b. Methylene chloride
 - c. Pentane
 - d. Ethyl alcohol
5. Total Kjeldahl nitrogen (TKN) is defined as the total sum of:
 - a. Nitrate and nitrite
 - b. Nitrate and ammonia
 - c. Organic nitrogen and ammonia
 - d. Organic nitrogen and nitrate
6. In the preliminary distillation step for ammonia nitrogen:
 - a. the sample is steamed at an acidic pH to release the ammonia.
 - b. the sample is steamed at a neutral pH to release the ammonia.
 - c. the distilled ammonia is captured in a basic solution.
 - d. the distilled ammonia is captured in an acidic solution.
7. Total phosphorus may be defined analytically as:
 - a. orthophosphate, reactive, and acid-hydrolyzable phosphorus.
 - b. reactive, condensed, and dissolved phosphorus.
 - c. reactive, acid-hydrolyzable, and organic phosphorus.
 - d. orthophosphate, condensed, and organically bound phosphates.
8. Potassium dichromate ($K_2Cr_2O_7$) is to be used in the COD test. How many grams would it take to make 0.5 liters of 0.25 N solution?
Molecular weights: K=39, Cr=52, O=16
Hint:
 $6Fe^{++} + Cr_2O_7^{=} + 14H^+ = 6Fe^{+++} + 2Cr^{+++} + 7H_2O$
 - a. 6.125 g
 - b. 24.5 g
 - c. 49.0 g
 - d. 220.6 g
9. If the anticipated BOD (unseeded) of a wastewater sample is 120 mg/L, what is the sample volume giving nearest to 50% oxygen depletion in a 300 mL bottle? (initial DO = 8 mg/L)
 - a. 1 mL
 - b. 3 mL
 - c. 10 mL
 - d. 15 mL



Section 5: Diagnostic Test

10. A dechlorinated effluent sample was analyzed for BOD. Two dilutions were prepared. In the first, 30 mL of effluent was seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. In the second, 50 mL of effluent was likewise seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. A separate seed control was prepared by diluting 5 mL of seed into a 300 mL BOD bottle. The samples were incubated at 20°C for 5 days.

Sample Size (mL)	Initial DO (mg/L)	Final DO (mg/L)
0 mL Blank	7.8	7.8
30 mL Sample	7.8	4.6
50 mL Sample	7.8	2.6
5 mL Seed	7.7	5.0

Given the information above, what is the average BOD to be reported?

- a. 15 mg/L
 - b. 22 mg/L
 - c. 25 mg/L
 - d. 32 mg/L
11. A 200 mL sample of chlorinated effluent is analyzed with an amperometric titrator for total residual chlorine. KI and pH 4 buffer are added to the sample. 5.0 mL of 0.00564 N PAO is added to the sample and back-titrated to the endpoint with 0.6 mL of 0.0282 N iodine (I₂) solution. Calculate the total residual chlorine in mg/L.
- a. 0.5 mg/L residual chlorine
 - b. 2.0 mg/L residual chlorine
 - c. 4.0 mg/L residual chlorine
 - d. 4.4 mg/L residual chlorine
12. Potassium permanganate is a(n):
- a. reducing agent.
 - b. oxidizing agent.
 - c. acidifying agent.
 - d. neutralization agent.

Skill Set	8	Process Control
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1. The most oxidized form of nitrogen which may be found in waters and wastewaters is:
 - a. organic nitrogen.
 - b. ammonia.
 - c. nitrate.
 - d. nitrite.
2. A 24-hour composite sample from a primary clarifier had an influent TSS of 220 mg/L and an effluent TSS of 90 mg/L. How many pounds of solids were removed if the flow was 12.5 MGD, and what was the percent removal?
 - a. 13,600 pounds removed, 41% removal
 - b. 13,600 pounds removed, 59% removal
 - c. 22,900 pounds removed, 41% removal
 - d. 22,900 pounds removed, 59% removal
3. In an activated sludge plant aeration basin, the MLSS is 1,600 mg/L and the reading of the 30-minute settling test is 370 mL in a 2,000 mL sample. The SVI is:
 - a. 23 mL/g.
 - b. 34 mL/g.
 - c. 116 mL/g.
 - d. 231 mL/g.
4. During the nitrification process, *Nitrobacter* and *Nitrosomonas* bacteria:
 - a. require free molecular oxygen.
 - b. can use nitrate oxygen.
 - c. do not require free molecular oxygen.
 - d. oxidize organic nitrogen.



Section 5: Diagnostic Test

5. In a secondary plant, a grab sample of mixed liquor was brought to the laboratory to be determined for total suspended solids. In the total suspended solids determination the tare weight of the filter paper was 0.0910 g. The dry weight of the paper and 10 mL of dried sample was 0.1094 g. After 30 minutes the sludge in the mixed sample settled to 230 mL in a 1 L graduated cylinder. What is the SVI of the mixed liquor?
- 8 mL/g
 - 125 mL/g
 - 184 mL/g
 - 8,000 mL/g
2. *Escherichia Coli* was chosen as an indicator organism because:
- its presence indicates that conditions are right for harmful (pathenogenic) bacteria also to be present.
 - it can easily be identified because it produces gas bubbles in Lauryl Tryptose Broth (LTB), and does not produce gas bubbles in Brilliant Green Bile (BGB).
 - it is a disease-causing organism normally found in the mammalian intestinal tract.
 - it is the only member of the coliform group of bacteria that can be identified using the multiple tube fermentation technique (MPN).

Skill Set	9	Microbiology
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1. Appropriate holding-time and temperature protocol for microbiological examination of samples is:
- hold temperature of all stream pollution, drinking, and wastewater samples below 4°C during a maximum transport time of 4 hours; refrigerate these samples upon receipt in the laboratory and process within 2 hours.
 - hold temperature of all stream pollution, drinking, and wastewater samples below 10°C during a maximum transport time of 4 hours; refrigerate these samples upon receipt in the laboratory and process within 2 hours.
 - hold temperature of all steam pollution, drinking, and wastewater samples below 4°C during a maximum transport time of 6 hours; refrigerate these samples upon receipt in the laboratory and process within 2 hours.
 - hold temperature of all steam pollution, drinking, and wastewater samples below 10°C during a maximum transport time of 6 hours; refrigerate these samples upon receipt in the laboratory and process within 2 hours.
3. The membrane filter (MF) technique is used because:
- it is highly reproducible, can be used to test relatively large sample volumes, and yields numerical results more rapidly than the multiple-tube procedure (MPN).
 - it is superior to the multiple-tube procedure (MPN) because sample turbidity does not affect the MF technique.
 - it is a superior technique for use on water samples that contain high levels of noncoliform bacteria.
 - it is able to detect total coliforms that have been stressed by the presence of toxic metals, or toxic organic compounds such as phenols.
4. Methods for differentiation of the coliform group are available. Such differentiation is generally considered of limited value in assessing drinking water quality because:
- the presence of any coliform bacteria renders the water potentially unsatisfactory and unsafe.
 - fecal streptococci and enterococci can be identified, but not enumerated.
 - the results cannot yield information concerning the possible source of pollution in the water.
 - fecal members of the coliform group may be expected to survive longer in an unfavorable environment than nonfecal members.



Section 5: Diagnostic Test

Skill Set	10	Laboratory Microbiological Techniques
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1. The most correct sterilizing conditions for dry glassware in closed metal containers are:
 - a. autoclave at 121°C at 15 psi for 15 minutes.
 - b. autoclave at 121°C at 15 psi for 30 minutes.
 - c. dry heat oven at 170°C for one hour.
 - d. dry heat oven at 170°C for two hours.
2. Opened bottles of dehydrated media should be stored in a desiccator and used up or discarded after:
 - a. 1 month.
 - b. 3 months.
 - c. 6 months.
 - d. 1 year.

Skill Set	11	Microbiological Analysis and Toxicity Tests
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1. Fecal coliform bacteria:
 - a. are the cause of dysentery, a water-borne disease in humans.
 - b. are the cause of cholera, a water-borne disease in humans.
 - c. are bacteria found in the feces of warm-blooded animals.
 - d. are pathogenic bacteria found in the intestinal tract of warm-blooded animals.
2. What is the definition for the total coliform group?
 - a. All of the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose in 24–48 hours at 35°C
 - b. All of the aerobic and facultative anaerobic, gram-negative, spore-forming, rod-shaped bacteria that ferment lactose in 24–48 hours at 35°C
 - c. All of the aerobic and facultative anaerobic, gram-positive, nonspore-forming, rod-shaped bacteria that ferment lactose in 24–48 hours at 35°C
 - d. All of the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment alcohol in 24–48 hours at 35°C



3. A bacterial culture was sampled and serially diluted prior to spread-plating onto triplicate plate count agar plates. The dilutions were as follows: one mL of the original sample was added to 99 mL of Solution B. One mL of solution B was added to 9 mL of Solution C. Five mL Solution C was added to 5 mL Solution D. This final mix was plated in triplicate at 0.1 mL per plate. The plates were incubated at 35°C for 2 days before colonies were counted. The counts obtained were 52, 64, and 43 colonies per respective plate. Calculate the original concentration of the bacterial culture in CFU/mL.
- 3×10^6 CFU/mL
 - 3×10^5 CFU/mL
 - 1×10^{-1} CFU/mL
 - 1×10^6 CFU/mL
4. A gram stain of a pure culture of *E. coli* would show:
- gram-negative rods.
 - gram-positive rods.
 - filamentous bacteria.
 - gram-negative cocci.
5. A test designed to enumerate all types of bacteria in a water sample is called:
- multiple tube fermentation test.
 - selective media test.
 - heterotrophic plate count.
 - petri dish assay.

Test Answer Key

Skill Set	1	Laboratory Safety
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No.	Answer	Skill Set
1	a	1.0
2	d	1.0

Skill Set	2	Regulations
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No.	Answer	Skill Set
1	c	2.0
2	b	2.0

Skill Set	3	Sampling Protocol
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No.	Answer	Skill Set
1	d	3.0
2	c	3.0

Skill Set	4	Quality Assurance, Data Interpretation, and Laboratory Reports
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No.	Answer	Skill Set
1	a	4.0
2	c	4.0
3	c	4.0

Skill Set	5	Mathematics and Chemistry
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No.	Answer	Skill Set
1	b	5.0
2	d	5.0
3	c	5.0



Section 5: Diagnostic Test

Skill Set	6	Laboratory Instrumentation—Chemical
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No.	Answer	Skill Set
1	d	6.2
2	b	6.3
3	d	6.6
4	c	6.1
5	a	6.2
6	a	6.2
7	c	6.7
8	c	6.3

Skill Set	7	Chemical Analysis
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No.	Answer	Skill Set
1	b	7.6
2	d	7.10
3	b	7.9
4	a	7.4
5	c	7.2
6	d	7.2
7	c	7.3
8	a	7.9
9	c	7.6
10	c	7.6
11	b	7.10
12	b	7.9

Skill Set	8	Process Control
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No.	Answer	Skill Set
1	c	8.3
2	b	8.1
3	c	8.4
4	a	8.4
5	b	8.4

Skill Set	9	Microbiology
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No.	Answer	Skill Set
1	d	9.2
2	a	9.2
3	a	9.3
4	a	9.3

Skill Set	10	Laboratory Microbiological Techniques
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No.	Answer	Skill Set
1	d	10.1
2	c	10.2

Skill Set	11	Microbiological Analysis and Toxicity Tests
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No.	Answer	Skill Set
1	c	11.2
2	a	11.2
3	d	11.2
4	a	11.1
5	c	11.1



Selected Problem Solutions

Skill Set 4 Quality Assurance, Data Interpretation and Laboratory Reports

3. What is the most correct answer to the following addition problem?

$$10.623 + 2.16 + 200.5 + 1478 =$$

$$10.623 \quad 3 \text{ decimal places}$$

$$2.16 \quad 2 \text{ decimal places}$$

$$200.5 \quad 1 \text{ decimal place}$$

$$1478. \quad 0 \text{ decimal places}$$

$$1691.283 \quad \text{Round to } 1691.$$

The sum must be rounded off to 1691, no decimals, because one of the addends, 1478, has no decimal places.

Skill Set 5 Mathematics and Chemistry

1. What is the weight of anhydrous KH_2PO_4 required to make 100 mL of solution containing 15.0 mg/L phosphorus (P)?

Molecular weight of KH_2PO_4 is

$$(39 \times 1) + (1 \times 2) + (31 \times 1) + (16 \times 4) = \frac{136 \text{ g}}{\text{mole}}$$

Weight of KH_2PO_4

$$= \frac{136 \text{ g } \text{KH}_2\text{PO}_4}{\text{mole } \text{KH}_2\text{PO}_4} \times \frac{\text{mole } \text{KH}_2\text{PO}_4}{\text{mole P}} \times \frac{\text{mole P}}{31 \text{ g P}}$$

$$\times \frac{1 \text{ g P}}{1,000 \text{ mg P}} \times \frac{15 \text{ mg P}}{1,000 \text{ ml}} \times \frac{1,000 \text{ mg}}{1 \text{ g}} \times 100 \text{ ml}$$

$$= 6.6 \text{ mg}$$

3. A standard solution is prepared from a 0.100% stock solution of a pure metal ("M"). Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. What is the concentration of the standard solution?

The concentration of stock solution A is $0.100\% = 1,000 \text{ ppm or mg/L}$. Therefore:

$$\frac{1,000 \text{ mg "M"}}{1,000 \text{ mL sol. A}} \times \frac{10 \text{ mL sol. A}}{1,000 \text{ mL sol. B}}$$

$$\times \frac{5 \text{ mL sol. B}}{100 \text{ mL sol. C}} \times \frac{1,000 \text{ mL sol. C}}{1 \text{ L sol. C}}$$

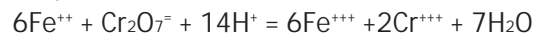
$$= 0.500 \text{ mg/L}$$

Skill Set 7 Chemical Analysis

8. Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) is to be used in the COD test. How many grams would it take to make 0.5 liters of 0.25 N solution?

Molecular weights: K=39, Cr=52, O=16

Hint:



To determine the answer to this problem, you must understand oxidation-reduction and normality. From the equation given, it can be determined that each ion accepts a total of six electrons. A 1.0 normal solution would contain 1/6 gram molecular weight of potassium dichromate per liter. A 0.25 normal solution would contain 1/4 of the above weight. Calculate as follows:

Molecular weight of $\text{K}_2\text{Cr}_2\text{O}_7$ is

$$(39 \times 2) + (52 \times 2) + (16 \times 7) = \frac{294 \text{ g}}{\text{mole}}$$

$$\frac{294 \text{ g } \text{K}_2\text{Cr}_2\text{O}_7}{1 \text{ mole}} \times \frac{1 \text{ mole}}{6 \text{ equivalent}} \times \frac{0.25 \text{ equivalent}}{1 \text{ liter}}$$

$$\times 0.5 \text{ Liters} = 6.125 \text{ g } \text{K}_2\text{Cr}_2\text{O}_7$$



Section 5: Diagnostic Test

10. A dechlorinated effluent sample was analyzed for BOD. Two dilutions were prepared. In the first, 30 mL of effluent was seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. In the second, 50 mL of effluent was likewise seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. A separate seed control was prepared by diluting 5 mL of seed into a 300 mL BOD bottle. The samples were incubated at 20°C for 5 days.

Given the initial DO and final DO data shown in the table, what is the average BOD to be reported?

First, calculate the depletion by subtracting the final DO from the initial DO.

Sample Size (mL)	Initial DO (mg/L)	Final DO (mg/L)	Depletion (mg/L)
0 mL Blank	7.8	7.8	0.0
30 mL Sample	7.8	4.6	3.2 (DO _i - DO _f)
50 mL Sample	7.8	2.6	5.2 (DO _i - DO _f)
5 mL Seed	7.7	5.0	2.7 (B _i - B _f)

Next, each sample (volume) needs to be calculated separately using the equation below. In the final step, the two results are averaged.

$$\text{BOD, mg/L} = \frac{(\text{DO}_i - \text{DO}_f) - (\text{B}_i - \text{B}_f) f}{P}$$

where f = ratio of seed in diluted sample to seed in seed control, and P = decimal volumetric fraction of sample used.

Ratio of seed in diluted sample to seed in seed control = $(0.5/300) / (5/300) = 0.1$

For the 30 ml sample

$$\begin{aligned} \text{BOD} &= \frac{(7.8 - 4.6) - (7.7 - 5.0) \times 0.1}{(30/300)} \\ &= (3.2) - (2.7 \times 0.1) \times \frac{300}{30} = 29.3 \end{aligned}$$

For the 50 ml sample

$$\begin{aligned} \text{BOD} &= \frac{(7.8 - 2.6) - (7.7 - 5.0) \times 0.1}{(50/300)} \\ &= (5.2) - (2.7 \times 0.1) \times \frac{300}{50} = 29.6 \end{aligned}$$

$$\begin{aligned} \text{Average BOD, mg/L} &= \frac{(29.3 + 29.6)}{2} \\ &= 29.4 \text{ mg/L} = 29 \text{ mg/L} \end{aligned}$$

11. A 200 mL sample of chlorinated effluent is analyzed with an amperometric titrator for total residual chlorine. KI and pH 4 buffer are added to the sample. 5.0 mL of 0.00564 N PAO is added to the sample and back-titrated to the endpoint with 0.6 mL of 0.0282 N iodine (I₂) solution. Calculate the total residual chlorine in mg/L.

One mL of 0.00564 N PAO reacts with 1 mg/L of chlorine in a 200 mL sample. The iodine solution of 0.0282 N is five times stronger than the PAO.

mg/L Cl₂ =

$$\frac{(5.0 \text{ mL } 0.00564 \text{ N PAO} - 5(0.6 \text{ mL } 0.0282 \text{ N I}_2))200}{200 \text{ mL sample}}$$

$$\text{mg/L Cl}_2 = \frac{(5.0 - 5(0.6))200}{200}$$

= 2.0 mg/L total residual chlorine

Skill Set	8	Process Control
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2. A 24-hour composite sample from a primary clarifier had an influent TSS of 220 mg/L and an effluent TSS of 90 mg/L. How many pounds of solids were removed if the flow was 12.5 MGD, and what was the percent removal?

$$\begin{aligned} \text{lbs/day} &= 8.34 \times \text{mg/L} \times \text{flow in MGD} \\ &= 8.34 \times (220 - 90) \times 12.5 \\ &= 13,553 \text{ lbs/day removed} \end{aligned}$$

Round to 13,600.

$$\frac{\text{TSS}_{\text{inf}} - \text{TSS}_{\text{eff}}}{\text{TSS}_{\text{inf}}} \times 100 = \% \text{ removal}$$

$$\frac{220 - 90}{220} \times 100 = 59\% \text{ removal}$$



3. In an activated sludge plant aeration basin, the MLSS is 1,600 mg/L and the reading of the 30-minute settling test is 370 mL in a 2,000 mL sample. The SVI is:

$$\begin{aligned} \text{SVI, mL/g} &= \frac{\text{settled sludge vol, mL}}{\text{sample vol, L}} \times \frac{1}{\text{SS, mg/L}} \times \frac{1,000 \text{ mg}}{\text{g}} \\ &= \frac{370 \text{ mL}}{2 \text{ L}} \times \frac{\text{L}}{1,600 \text{ mg}} \times \frac{1,000 \text{ mg}}{1 \text{ g}} = 116 \text{ mL/g} \end{aligned}$$

5. In a secondary plant, a grab sample of mixed liquor was brought to the laboratory to be determined for total suspended solids. In the total suspended solids determination the tare weight of the filter paper was 0.0910 g. The dry weight of the paper and 10 mL of dried sample was 0.1094 g. After 30 minutes the sludge in the mixed sample settled to 230 mL in a 1 L graduated cylinder. What is the SVI of the mixed liquor?

$$\begin{aligned} \text{TSS} &= \frac{\text{mg residue}}{1 \text{ L sample}} \\ &= \frac{(0.1094 \text{ g} - 0.0910 \text{ g})}{10 \text{ ml sample}} \times \frac{1,000 \text{ ml}}{\text{L}} \times \frac{1,000 \text{ mg}}{\text{g}} \\ &= 1,840 \text{ mg/L} \end{aligned}$$

$$\begin{aligned} \text{SVI} &= \frac{\text{settleable solids, mL/L}}{\text{TSS, mg/L}} \\ &= \frac{230 \text{ mL/L}}{1,840 \text{ mg/L}} \times \frac{1,000 \text{ mg}}{\text{g}} \\ &= 125 \text{ mL/g} \end{aligned}$$

Skill Set	11	Microbiological Analysis and Toxicity Tests
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3. A bacterial culture was sampled and serially diluted prior to spread-plating onto triplicate plate count agar plates. The dilutions were as follows: one mL of the original sample was added to 99 mL of Solution B. One mL of solution B was added to 9 mL of Solution C. Five mL Solution C was added to 5 mL Solution D. This final mix was plated in triplicate at 0.1 mL per plate. The plates were incubated at 35°C for 2 days before colonies were counted. The counts obtained were 52, 64, and 43 colonies per respective plate. Calculate the original concentration of the bacterial culture in CFU/mL.

Calculate the dilution factor by multiplying together each serial dilution.

1 mL in 99 mL is a 1:100, or 10^{-2} dilution

1 mL in 9 mL is a 1:10, or 10^{-1} dilution

5 mL in 5 mL is a 1:1, or 0.5 dilution

mL in 1 mL is a 1:10, or 10^{-1} dilution

$$10^{-2} \times 10^{-1} \times 0.5 \times 10^{-1} = 0.5 \times 10^{-4}$$

Find average of colony counts.

$$\frac{(52 + 64 + 43)}{3} = 53 \text{ colonies}$$

Divide colony counts by dilution.

$$\frac{53 \text{ colonies}}{0.5 \times 10^{-4}} = 1 \times 10^6 \text{ CFU / mL}$$



References

This section provides titles and information on primary and secondary references found useful in obtaining Grade II Laboratory Analyst certification. Because primary references contain most of the information needed for the certification test, it is recommended that candidates obtain access to them for personal use.

Many of these publications may be reviewed and purchased on-line from their publishers or from electronic book retailers. Others may be found in a wastewater treatment plant library or in a college or university library. In addition, see the CWEA Certification Resource Links page at www.cwea.org/tcp/resources for links to resources available on-line and any updates or changes to the information and URLs listed below.

Primary References

Standard Methods for the Examination of Water and Wastewater, 18th Edition
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206
www.wef.org

Please note that the 18th Edition is not the most recent edition, but is the one referenced by EPA regulations, and therefore is the basis for developing the certification test questions.

Operation of Wastewater Treatment Plants, Volumes I and II
Office of Water Programs
California State University, Sacramento (CSUS)
6000 J Street
Sacramento, CA 95819-6025
916/278-6142
www.owp.csus.edu

Water and Wastewater Laboratory Techniques
Order No: P15124WW
Pub Date: 1995
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206
www.wef.org

Lectures on Wastewater Analysis and Interpretation
Genium Group, Inc.
1171 Riverfront Center
Amsterdam, NY 12010
800/842-1843
genium@genium.com

OSHA Regulations (Standards – 29 CFR)
Available online at:
www.osha.gov/pls/oshaweb/
Available in print or on CD from:
Government Institutes, Inc.
4 Research Place, Suite 200
Rockville, MD 20850
301/921-2300

40 CFR (CFR Title 40: Protection of the Environment)
Available on-line at:
www.epa.gov/epahome/cfr40.htm

Handbook for Analytical Quality Control in Water and Wastewater Laboratories
U.S. Environmental Protection Agency, 1979
EPA-600/84-79-019
NTIS Order No: PB297451
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
800/553-6847 (Call to Order)
www.ntis.gov



Section 6: References

Method 1664 – N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease and Total Petroleum Hydrocarbons), April 1995

U.S. Environmental Protection Agency
EPA-821/B-94-004b
NTIS Order No: PB95239232
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
800-553-6847
www.ntis.gov
On-line version available at
www.epa.gov/ost/methods

Methods for Chemical Analysis of Water and Wastes

U.S. Environmental Protection Agency, Revised
March 1983
EPA-600/4-79-020
NTIS Order No: PB84128677
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
800-553-6847
www.ntis.gov (use NTIS order number search for products received by NTIS before 1990)
On-line version available at
www.epa.gov/clhtml/pubtitle.html

Secondary References

The information contained in the Primary References listed above provides a solid base of knowledge for the Lab Analyst. The additional sources of information listed below may also be helpful for candidates seeking to broaden or refresh their knowledge in specific areas.

Operation of Municipal Wastewater Treatment Plants – MOP 11, 5th Edition (3 volumes)

Order No: M05110WW
Pub Date: 1996
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800-666-0206
www.wef.org

Water Supply Operations Series Part V: Basic Science Concepts and Applications, Textbook

ISBN 0-89867-796-3
Catalog No: 1959
American Water Works Association (AWWA)
6666 West Quincy Avenue
Denver, CO 80235
800-926-7337
www.awwa.org

Laboratory Safety Pocket Handbook

Genium Publishing Corporation
1171 Riverfront Center
Amsterdam, NY 12012
800-243-6486
genium@genium.com

Microbiological Skills for Water and Wastewater Analysis

Douglas W. Clark, 1985
Miscellaneous Report: M16
New Mexico Water Resources Research Institute
New Mexico State University
Box 30001, MSC 3167
Las Cruces, New Mexico 88003-9001
505-646-4337 (Order by Phone)
http://wrri.nmsu.edu

Microbiological Methods for Monitoring the Environment – Water and Wastes

Edited by R.H. Bordner, J.A. Winter,
and P.V. Scarpino
U.S. Environmental Protection Agency, 1978
EPA-600/8-78-017
NTIS Order No: PB290329
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
800-553-6847 (Order by Phone)
www.ntis.gov (use NTIS order number search for products received by NTIS before 1990)

Basic Laboratory Skills for Water and Wastewater Analysis

Douglas W. Clark
Technical Report: TR125
New Mexico Water Resources Research Institute
New Mexico State University
Box 30001, MSC 3167
Las Cruces, New Mexico 88003-9001
505-646-4337 (Order by Phone)
http://wrri.nmsu.edu



*Math Text for Water and Wastewater
Technology, 2nd Edition*
Wright's Training
P.O. Box 515
Elmira, CA 92625
707/448-3659
download form to order at:
www.wrights-trainingsite.com

Applied Math for Wastewater Plant Operators
Joanne Kirkpatrick Price
ISBN 0877628092
CRC Press
800-272-7737
www.crcpress.com



You and Wastewater Math

by Cheryl Ooten, Mathematics Professor, Santa Ana College, Ooten_Cheryl@rsocd.org

Example math problems found in Appendix A are representative of general wastewater math and are designed to illustrate a math problem solving strategy, not specific math skills. Examples given in this appendix may not be like the problems given on the test for your discipline. However, the problems are typical of types of problems you may encounter, including, but not limited to, basic algebra (solving one equation for one unknown), story problems, and plane and solid geometry (area and volume problems). For specific kinds of math skills and problems you may encounter on the certification test, please review Sections 3, 4, and 5 of this study guide.

Introduction

Now is the time for you to begin preparation for the math portion of your technical certification exam. This Appendix provides suggestions to take charge of:

- n Your math skills
- n Your attitudes toward math
- n Your test-taking skills

By doing this, you can improve your performance in successfully completing the math questions on the certification exam.

Two Facts to Consider

First, since early childhood, you have used math mostly without giving it a second thought. Knowing your age, counting, comparing sizes and shapes, adding your money, and subtracting to get change are math skills.

You drive the streets judging distances, speeds, and times. You estimate if you can afford a vacation or a car and when you can retire. You compare volumes and areas as you build and do jobs around the work site. You even measure volume

in putting toothpaste on your toothbrush. You use statistics as you watch sports and consider things like RBIs in baseball or field goal percentages in basketball. All of these are mathematical skills many people take for granted.

Second, if you think math is hard, please know that math becomes hard for *everyone* at some point. You are not alone. There are math problems that have been unsolved for hundreds of years even though they have been attempted by competent, well-informed mathematicians who may work at them for decades. Those are not the problems you need to work unless you are curious. When you work at your appropriate level, you find a combination of easy ideas and hard ideas.

You may get discouraged comparing your speed and understanding in math with others. Those people who appear to do math easily have, most likely, done those specific problems, or ones like them, many, many times.

You will want to study and progress at your “growing edge”—the skill level where you have a bit of discomfort with new material, but where you are not totally overwhelmed. You can expect challenges that trouble you, but that can be overcome. Instead of saying “I cannot do math,” decide now to begin learning enough math to make work and test-taking easier.

Move Beyond the Math You Know

To move beyond your routine skill level in math, consider the following points:

You Have Skills.

You already have many math skills and can build on that base. It is best and easiest to build on what you already know.

Basics are Important.

Going back over the basics of what you know will build confidence and help you progress and add new math skills to your ability to solve math problems.



Math Progresses Logically.

There are many different areas of math and each builds on itself as well as on the others. If you cannot do a particular problem, it may be because you have missed something basic to that one area along the way. Working your way up slowly and cumulatively in math is the fastest way to gain skills.

Words Count.

Each and every word and symbol in math means something. You need to find out those meanings and then practice them. If you do not know what “mgd” or “psi” means, or which units measure “flow”, it is harder to do problems involving them. It can seem like a foreign language.

Brains are Unique.

Each individual brain is wired differently, causing each person to think and learn differently. The more you know about the way you as a specific individual learn, the more you will permit yourself to do what it takes to learn math. Some people need to do many written repetitions. Some need to walk or move around as they do math. Some need to talk out loud. Others need to draw pictures. Some need to work problems with other people. Some need to use words and some need to use symbols. In order to focus on how to move forward, think about what works for you or where learning has been difficult for you.

If you are an independent learner, you might find a basic math book at your library to work through on your own. You may be able to study with your own children to learn some math together or with your friends and colleagues. You may have an old math book you used a long time ago that could be helpful, and you may come to remember what you learned from it.

Assessment Helps.

Assess your skill level honestly. Math placement tests are available at your local college and through private educational agencies to help you determine where your skills are and where you can best get help to make comfortable progress.

You are Not Alone.

No one promises that math will always be easy or interesting for you. For most people, working on math is a challenge. Persevering and pushing personal limits allows you to experience the satisfaction of success.

Get help when you get discouraged or experience confusion. Remember this is just a momentary problem in a sequence of ideas that you are confronting. Do not buy into the myth that you have to do math alone. Do not believe it is demeaning for you to admit you do not understand. You can have fun if you lighten up as you progress. Working with others is an outstanding way to improve math skills.

Questions are Essential.

Make a list of people with whom you feel comfortable discussing your math questions. They may be your colleagues, teachers, fellow students, friends, or family members—even your children. Do not ask just anybody; pick people who are helpful and positive or non-judgmental about your questions.

Mistakes Happen.

Expect mistakes up front. As you learn anything new, you will make errors. Do not blame your mistakes on math itself! In any new endeavor you need to allow yourself to crawl before you can walk. Successful people in all fields know this. Trial and error is the basis of all learning.

You can learn more from your mistakes than from repeated successes. Making errors gives you feedback by showing you what you do not understand. Learn to value and accept those errors and use them to find out what areas of your learning need more work. Correct them and then move on with new knowledge.

Learning Math is Not a Competitive Game.

Physicist Albert Einstein, politician Winston Churchill, and inventor Thomas Edison were all considered slow in school. Musical composer Ludwig Van Beethoven and scientist Louis Pasteur probably had learning disabilities. What all five certainly had was determination and patience to persevere. Only compete with yourself, pushing yourself forward, in learning math.

There is Hope for Those with Learning Disabilities.

If you really have a hard time learning, you might ask your local college or a private learning specialist to assess you for a learning disability. Many colleges and universities do free testing and training for their students. You can also purchase this kind of assistance from private consultants. Much is now known about learning disabilities and how to help people who have them. Learning



disabilities often become just learning differences as students learn to honor and use their own thinking and learning styles.

Math Success and Test-Taking Success are Not the Same.

Many math students understand and can work math problems, but have difficulty in test-taking situations. It is possible to know math and still fail exams. These people may find Section 4, Test Preparation very helpful. Conscious practice of both math skills and test-taking skills can make a big difference in your score.

Resources are Available.

Resources exist for all types of math. You will need to decide whether you will work on your math skills independently or with the help of some structure such as a math course or a tutor. Different strategies may work better at different stages in your progress.

Your local community college has inexpensive math courses. Some colleges even have math courses specifically for water and wastewater professionals. Professional organizations sponsor training conferences and seminars which include math courses specific to the field. Many agencies can provide in-house training and many agencies will provide individual help with all aspects of test taking.

Community Colleges

Community colleges offer several types of services including:

- n Math Placement Testing
- n Math Courses
- n Water Utility Science Courses
- n Math Anxiety Reduction Courses
- n Testing and Training for those with Learning Disabilities

Professional Organizations

Organizations such as the California Water Environment Association (CWEA), American Water Works Association, and American Public Works Association also provide opportunities to practice your math skills and network with others:

- n Technical Certification Training Classes and Annual Conferences
- n CWEA Study Guides

At Work

Ask for help and suggestions from others who have taken math courses or are skilled in the work area similar to the one you are trying to prepare or improve. Ask your supervisor for advice on how to prepare and how much time on the job you can have to prepare. Ask your supervisor to provide training classes for the areas that you are wanting to improve. Ask those managing other departments, agencies, or local professional organizations for help in getting the training you need.

Materials

Any basic math book or instructional manual that you can beg, borrow, or buy, including:

- n Courses from Ken Kerri, Office of Water Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819
- n Price, Joanne Kirkpatrick. *Basic Math Concepts for Water and Wastewater Plant Operators, 2nd Edition*. Lancaster, Pennsylvania: Technomic, 1991; currently CRC Press LLC.
- n Smith, Richard Manning. *Mastering Mathematics: How to Be a Great Math Student*, 3rd Ed. Pacific Grove, CA: Brooks/Cole, 1998.
- n Zaslavsky, Claudia. *Fear of Math*. New Brunswick, NJ: Rutgers University Press, 1994.

Practice Problem Solving Strategies

Wastewater math deals with only a handful of basic types of problems that involve moving liquids and semi-solids from place to place, and manipulating, storing, and treating these substances along the way.

So basically, understanding area, volume, slope, rates, concentrations, costs, and time elements that occur in wastewater treatment 24 hours per day, 365 days per year, pretty much covers what you need to know.

Units and Arithmetic

All wastewater math problems can be solved by simple arithmetic—adding, subtracting, multiplying, and dividing. You can become proficient with



wastewater math by paying careful attention to the units in the problems as you write down your strategies, and then using a calculator to do the needed arithmetic.

Units

Units such as cubic feet, gallons, gpm, and mgd are important in wastewater math problems. Paying attention to the units will tell you whether to multiply or divide. Also, the units will often help you know what numbers to multiply or divide.

Notice in each example that doing math operations on the units produces the correct units in the answer. Many people do the math on the units first to figure out the correct procedure before they ever do the math on the numbers.

Multiplying

Multiplying is important. There are several symbols for multiplication. They are •, x, and ().

For example,

$$2 \cdot 3 = 2 \times 3 = (2)(3) = 6$$

Dividing

Dividing is important to wastewater math because units often used such as MGD, cfs, ppm, GPM, psi, mg/L, GPD/sq ft, and % are really division problems.

“Per” stands for “divided by.”

$$\text{MGD} = \frac{\text{millions gallons}}{\text{day}}$$

$$\text{cfs} = \frac{\text{cubic feet}}{\text{second}}$$

$$\text{ppm} = \frac{\text{parts}}{\text{million}}$$

$$\text{GPM} = \frac{\text{gallons}}{\text{minute}}$$

$$\text{psi} = \frac{\text{pounds}}{\text{square inch}}$$

$$\text{mg/L} = \frac{\text{milligrams}}{\text{Liter}}$$

$$\text{GPD/square foot} = \frac{\text{gallons/day}}{\text{square foot}}$$

$$10\% = \text{ten percent} = \frac{10}{100}$$

Example Problems

Example 1

Plant No. 1 measured a flow of 3.5 million gallons in half a day. If the peak flow (hydraulic) capacity of the plant is 8 mgd, is there need for concern?

Using the conversion factor

$$\text{mgd} = \frac{\text{million gallons}}{\text{day}}$$

divide 3.5 million gallons by half a day.

$$\text{mgd} = \frac{3.5 \text{ million gallons}}{.5 \text{ day}} = 7 \text{ mgd}$$

7 mgd is less than the peak flow capacity, 8 mgd. There is no need for concern yet.

Example 2

- a. Find the number of gallons in 10 cubic feet.

Since we can pour 7.48 gallons into a 1 cubic foot container, that means that 7.48 gallons = 1 cubic foot. We can use either factor:

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}} \text{ or } \frac{1 \text{ cu ft}}{7.48 \text{ gal}}$$

to convert cubic feet units into gallons or vice versa

$$\frac{10 \text{ cu ft}}{1} \times \frac{7.48 \text{ gal}}{1 \text{ cu ft}} = \frac{(10 \text{ cu ft})(7.48 \text{ gal})}{1 \text{ cu ft}}$$

$$= 74.8 \text{ gal}$$

Notice that using the first factor allows the unit “cu ft” to cancel out leaving the answer in gallons.

- b. Find the number of cubic feet in 10 gallons.

Notice that using the second factor allows the unit “gal” to cancel out leaving the answer in cubic feet.

$$\frac{10 \text{ gal}}{1} \times \frac{1 \text{ cu ft}}{7.48 \text{ gal}} = \frac{(10 \text{ gal})(1 \text{ cu ft})}{7.48 \text{ gal}}$$

$$= 1.34 \text{ cu ft}$$

You will notice how important it was in these examples to consider the units in deciding whether to multiply or divide by 7.48.



Example 3

- a. Find the detention time for a basin with 675,460 gal if the flow is 1,000,000 gal/day.

Flow is always a rate which is division. Units like gpd or cfs are both division.

The formula for the basin detention time is:

$$Dt = \frac{\text{volume}}{\text{flow}}$$

$$Dt = \frac{675,460 \text{ gal}}{1,000,000 \text{ gal/day}}$$

$$= \frac{675,460 \text{ gal}}{1} \times \frac{\text{day}}{1,000,000 \text{ gal}} = 0.675 \text{ days}$$

- b. Find the detention time for a 426 cubic foot basin if the flow is 1,000 cfs.

$$Dt = \frac{426 \text{ cu ft}}{1,000 \text{ cfs}} = \frac{426 \text{ cu ft}}{1,000 \text{ cu ft/sec}}$$

$$= \frac{426 \text{ cu ft}}{1} \times \frac{\text{sec}}{1,000 \text{ cu ft}} = 0.426 \text{ sec}$$

Example 4

Find the number of gallons of an 11% polymer needed to produce 100 gallons of a 0.75% solution.

Use the formula $C_1V_1=C_2V_2$ where C=concentration or % and V=volume.

You can let the volume you are looking for (i.e. the number of gallons of 11% polymer) be represented by V_1 . Then $C_1=11\%$ or 0.11, $C_2=0.75\%$ or 0.0075, and $V_2=100$ gallons.

Using the formula $C_1V_1=C_2V_2$, you have $(0.11)(V_1) = (0.0075)(100)$

Notice to find V_1 , you do the opposite of multiplying (i.e. dividing) by 0.11 on both sides. You then have

$$\frac{(0.11)(V_1)}{0.11} = \frac{(0.0075)(100)}{0.11}$$

and using a calculator, $V_1=6.82$. So, the amount needed is 6.82 gallons.

Example 5

How many hours will it take to empty a 43,000 cubic foot tank if it empties at a rate of 2.7 cubic feet per second?

Notice that dividing 43,000 cubic feet by 2.7 cubic feet per second would make the cubic feet unit cancel out. This would give us the time in seconds. To convert seconds into hours, use the factors

$$\frac{1 \text{ min}}{60 \text{ sec}} \text{ and } \frac{1 \text{ hr}}{60 \text{ min}}$$

The work is given below. Notice how the units cancel out leaving the answer in hours.

$$\text{Time} = \frac{43,000 \text{ cu ft}}{2.7 \text{ cu ft/sec}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ hr}}{60 \text{ min}}$$

$$= 4.42 \text{ hr}$$

Example 6

Find the number of gallons of water in a rectangular basin 200 feet long, 50 feet wide, and 12 feet deep.

First, find the volume of the rectangular basin by multiplying length by width by height. Volume = (200 ft)(50 ft)(12 ft) = 120,000 cubic feet or cu ft or ft^3 .

You now have a problem similar to Example 2. How many gallons are there in 120,000 cubic feet? Use the factor

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}}$$

to convert cubic feet into gallons.

$$\text{Volume} = \frac{120,000 \text{ cu ft}}{1} \times \frac{7.48}{1 \text{ cu ft}}$$

$$= 897,600 \text{ gal}$$



Example 7

A cylindrical tank is full to 3 feet below the top at 10 a.m. and empty at 4 p.m. If the tank is 50 feet tall with a diameter of 70 feet, find the volume (in gallons) of the liquid at 10 a.m. and the rate of flow from the tank in gallons per minute.

For a math problem with many words, I recommend always first writing down what you are trying to find:

- (1) First, find the number of gallons of water in the tank at 10 a.m.
- (2) Second, find the rate of flow in gal/min.

Drawing a sketch helps some people understand the problem and helps to keep track of the data.

I also like to write down and interpret the details that are given to me like:

Full to 3 ft below the top at 10 a.m.

Empty at 4 p.m.

Takes 6 hours to empty

- a. First, to find the volume in gallons at 10 a.m., use the formula for volume of a cylindrical tank which is $V=(\text{area of the base}) \times (\text{height})$.

To find the area of the base of the tank which is a circle, multiply 0.785 times the diameter squared.

$$\text{So, the area of the base} = 0.785(70^2) = 3,846.5 \text{ sq ft.}$$

The height at 10 a.m. is 47 feet because the tank is filled to 3 feet below the top.

$$\text{Volume} = (\text{area of the base})(\text{height}) = (3846.5 \text{ ft}^2)(47 \text{ ft}) = 180,785.5 \text{ ft}^3$$

However, you want the volume in gallons so use the factor

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}}$$

to convert.

$$\begin{aligned} \text{Volume in gallons} &= 180,785.5 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} \\ &= 1,352,275.54 \text{ gal} \end{aligned}$$

- b. Second, to determine the rate of flow in gallons per minute, divide the number of gallons by the number of minutes it took the tank to empty. It took 6 hours to empty. To convert 6 hours to minutes, use $60 \text{ min} = 1 \text{ hr}$ or factors

$$\frac{60 \text{ min}}{1 \text{ hr}} \text{ or } \frac{1 \text{ hr}}{60 \text{ min}}$$

to convert. You want the hour unit to cancel out, so you will use the first factor. The time becomes:

$$\frac{6 \text{ hrs}}{1} \times \frac{60 \text{ min}}{1 \text{ hr}} = 360 \text{ min}$$

Rate of flow in gal per minute =

$$\frac{1,352,275.54 \text{ gal}}{360 \text{ min}} = 3,756.32 \text{ gal per min}$$

Take Charge of Your Success

The key to progress with math is to consciously take charge of your thoughts and actions. Then, instead of letting math control you, you control math and you take charge of your success.

Recommendations

Ask Questions.

Be active and assertive. Learning is not a spectator sport. You cannot learn well from the sidelines. Get involved. Work problems and keep asking questions until they become clear. In classes and seminars, ask questions on confusing procedures.

Take It Easy.

When you get stuck working problems, hang in for a while and then take a break. Go back later, begin at the beginning with a clean sheet of paper and a different point of view. Just because you do not understand at first does not mean understanding will not come. Math learning requires time to settle into your brain. Being able to live with uncertainty for a while is a good math skill to have.

Keep a List.

Write down your resources (books, tutors, people to answer questions, people who understand) so that you can consult them when you get discouraged. You are not alone. Find helpful people with whom you are comfortable. Form a network with others working toward the same goals as you.



Find Yourself.

Discover your own unique ways of learning. Experiment with new ones. If a method does not work, find others. Ask different people how they learn math or do a problem. They will often feel honored and pleased that you asked them and you might get a breakthrough idea.

Be Positive.

Listen to what you say to yourself inside your head. It is difficult to work well if you are saying, “I will never get this” or “I cannot do math.” Change those negative messages to neutral ones like “I have not learned this yet” or “I cannot do this particular problem yet.”

Reward Yourself.

Acknowledge your progress—every little bit! Pat yourself on the back for each and every problem you work. Notice what you know now that is new that you did not know two weeks ago. Maybe even write it down to document your growth.

Learn From Mistakes.

Remember that errors are part of the learning process. Pay attention to them and figure out where they happened and how to fix them.

Keep It Real.

Be realistic with your expectations of yourself—your math level, your life commitments, and your time constraints. Do not beat yourself up for being a human being.

Use Technology.

Learn to use a calculator and use it appropriately for calculations with large numbers and decimals. Each brand of calculator is different, so keep your manual for reference. Take spare batteries to exams.

Start Easy.

Practice the easier math problems to warm up each time you begin your math study. This builds confidence and strengthens those math pathways in your brain.

Use Paper.

Keep scratch paper available and expect to use it for your math work. You need empty space on paper to think and do calculations.

Promote Emotional Well Being.

Patience, self-care, and humor will make your math work so much easier. Your brain will work better too.

Be Healthy.

You are making new connections in your brain as you practice math, so sufficient sleep and healthy foods are important. Having fresh drinking water available and breathing fresh air also helps you think better.

Test-Taking Strategies

There are many actions you can take before, during, and after exams that will improve your test-taking performance and outlook. Remember that math skills and test-taking skills are different from each other. This section will help you become conscious of your thoughts and actions regarding test preparation. Use these suggestions to take charge and approach your test confidently.

If you find yourself thinking negative thoughts about your coming exam, skip to the last section and read “Negative Thinking about Exams” first.

Before the Exam**Work Problems.**

Diligently prepare and practice. Repeat solving problems to gain speed and confidence. This takes work and time—sometimes many hours, even days. Going in to an exam with the knowledge that you have worked lots of problems boosts confidence. Prep time is invaluable.

Relax.

Practice relaxation daily for about at least ten minutes using breathing. Sitting or lying comfortably, breathe slowly in through your nose counting to five and then out through your mouth counting to ten. If you feel dizzy, breathe normally for a while. Deep breathing activates chemicals in your body that help you relax and feel better. Any type of regular meditation, yoga, or slow stretching while breathing deeply can help facilitate your relaxation response. Practicing daily will help you control your adrenaline level during your exam. Using relaxation consciously during an exam frees up the thinking part of your brain. (Do not practice these deep breathing exercises while you are driving.)



Stay Active.

Daily walks or biking or whatever aerobic exercise you use consistently prepares your body for your exam by relieving stress and keeping your state of mind positive. Your mind and your body are connected so tightly that they are nearly the same.

Rehearse.

Do a dress rehearsal for your exam. Write or have someone assist you in writing a practice test with problems and questions that you think might be on the real exam. Use questions from the diagnostic test in Section 5 of this study guide. Give yourself this practice test in an environment as close to your testing situation and schedule as possible. Time it and then correct it to learn from your errors.

Plan Ahead.

Plan ahead carefully so that you will get to the exam early—do not be in a rush. Know exactly how to get there and what you will wear so that you are comfortable. You might want to wear your “lucky” shirt or bring a photograph of people who care about you and believe in you. WHATEVER you can do to increase your sense of comfort and security, do it. Ahead of time, pack a Testing-Taking Kit with sharp pencils, pens, a ruler, erasers, tissues or handkerchief, a bottle of water, extra calculator batteries, and anything else you think you might need that is allowed at the test.

Care For Your Body.

Optimal food and rest are individual preferences. Plan these ahead of time. Some research has shown that a brisk walk before an exam has raised test results. Some research has shown that eating a few candies (not chocolate) right before an exam has raised test results. Protein appears to be essential for clear thinking. Be in charge of what happens to you before the exam. Do not let outside influences take charge of you for this little time before your test.

At the Exam

Do a Data Dump.

Bring a short list of formulas or facts you find difficult to remember. Look at them before the test. Visualize them going into a holding tank in your brain. Practice making them subject to recall. If you are not allowed to use notes on the exam, be sure to put the list away so that your honesty is not questioned. When you receive your test, quickly write these formulas or facts on your exam paper. Now you do not have to expend any energy trying to recall them later when you need them.

Ignore Others.

Ignore all of the other people at the exam—before, during, and maybe even after. Different people have different ways of dealing with their anxiety during tests. Some people get a little hyper and try to rub off their anxiety on everyone else. Do not take on someone else’s anxiety. Your test is not a competition, so what other people do will not affect your score. Often the first person to leave an exam gets a very low score, while the last person to leave gets a very high score. Take your time. Pay no attention to other people’s behavior.

Breathe.

When you feel stuck or tense, take a deep breath. Let it all go as you expel the air. (The more you have practiced relaxation and deep breathing before the exam, the more you will relax during the test.)

Take Time Out.

Take short breaks during the exam to close your eyes, breathe deeply, and stretch your neck and arms. Massaging your temples, scalp, and the back of your neck will increase blood flow with oxygen to your brain to help you think better. A few isometric exercises can release tension too.

Use Your Subconscious Mind.

If a problem makes no sense, read it and go on. Ideas will come to you as the problem sinks into your subconscious mind while you continue with the test.

Trust.

Let each question reach into your mind for the answer. Remind yourself that you know everything you need to know for now.



Strategize.

Do the easy problems and questions first. Make pencil marks by the questions to which you want to return.

Use Time Wisely.

Do not work on one problem for a long time. Often a question further into the exam will act as a “key” to unlock a previous problem. Tell yourself that you have all of the time you need. Let go of the rest of your life during the exam. You can deal with all that later.

After the Exam, Let the Results Go.

You have used a lot of energy and may be low and off balance. You may wish to pass up discussing the exam with others so you can take care of yourself. Going to the bathroom, drinking some water, and eating something can help you feel normal again. You may have set much of your life aside to prepare for this exam. Refresh yourself and get your life back. You can deal with the test results later when your priorities are in order again.

Negative Thinking About Exams

Here are negative thoughts math students often think before test-taking. Put a check mark by the examples familiar to you. Recognizing the distorted thinking in each example can help you change negative thoughts to neutral or positive ones. If you need more assistance with overwhelming negative thoughts, I recommend the book *Feeling Good* by David Burns (WholeCare, 1999).

“I Will Fail.”

Unless you have a crystal ball and can see into the future OR unless you have made a definite plan NOT to prepare for the test OR unless you plan to “freeze up” during the exam, you have no way of knowing whether you will fail or not. Worrying about the future only takes energy from today.

“I Will Panic During the Test.”

It is not uncommon to be excited. An exam is a process during which you will experience many thoughts, feelings, and body sensations. Actors get nervous, yet they still perform. If you do panic, let panic leave you. It will. No one dies from panicking during an exam.

Preparation by practicing problems, asking questions, and reviewing gives you confidence and skills that you need. Taking a dress rehearsal test and trying to panic can help you practice dealing

with out-of-control feelings. Learning some relaxation techniques to use before and during the exam calms you and aids clear thinking. The more you prepare yourself ahead, the more you are in charge and feel relaxed.

“I Cannot Do Math.”

Math is a very broad subject involving many different skills. If you can recognize shapes, tell time, and know where the front and back of a classroom are, you can already do math. There are many more math skills that you have and many that you do not have YET. There are also many that you will never choose to acquire. Instead of thinking so absolutely about math, find areas where you can grow and learn new skills instead of paralyzing yourself with this broad generalization.

“I Am Stupid.”

Name calling is seldom productive. Occasionally you may feel stupid because you do not know something or you mess up. What really is happening is that you are being human and humans are not stupid. Educators recognize the need to change how everyone thinks about intelligence. They recognize that there are many different kinds of intelligence including:

- n bodily/kinesthetic
- n verbal/linguistic
- n naturalist
- n logical/mathematical
- n visual/spatial
- n interpersonal
- n intrapersonal
- n musical/rhythmic

This comes from the work of Howard Gardner. (Gardner, Howard. *Multiple Intelligences: The Theory in Practice*. New York: Basic Books, 1993.)

You are a wonderful combination of these talents—not just an IQ number. IQ Tests are limited because they only measure a few types of intelligence and ignore the rest. We are not all the same and cannot possibly know all there is to know in every situation. Between now and the exam, there are many questions you can get answered as well as many new skills you can practice and master if you use the skills and intelligence that you have.



Appendix A: You and Wastewater Math

“I Will Forget Everything.”

Forgetting does not mean something is gone from your mind forever. The right cue will often help you remember what you need to know. Your exam will be filled with cues—words and symbols—that will trigger formulas and ideas you have practiced.

Expecting to forget “everything” is foretelling the future and making a broad generalization. Even most people with amnesia caused by illness or injury do not forget “everything.” If you are extremely worried about your memory, *The Great Memory Book* by Karen Markowitz and Eric Jensen (The Brain Store, 1999) can be of assistance to you.

“Math Tests Are Tricky.”

Math students who rely on memorizing the material rather than understanding it are usually the ones who think tests are tricky. You will use your memory to add to your understanding of how to do the math. Your math problems will contain many units such as mgd or ft³ or psi. Learning how to skillfully convert back and forth between units of measure will take a lot of the trickiness away from your test problems. Practicing using your calculator will help too.

“There Is So Much I Do Not Know.”

This will always be the case the rest of your life. It is the human condition. Taking a deep breath and finding the level where you can begin to learn will improve your feelings and your confidence.



Glossary of Technical Terms

Accuracy: The nearness of a number to true value.

Acid: A compound which liberates hydrogen ions, and has a pH below 7.

Aliquot: A portion of a sample with an exact volume.

Alkalinity: The measurement of a sample's capacity to neutralize acid.

Amperometry: The measurement of electrical current.

Analyte: The element or ion compound that is being measured; the element of interest.

Atomic Weight: The sum of the number of protons and the number of neutrons in the nucleus of an atom. Atomic weights of elements are found on periodic tables.

Autoclave: The instrument used to sterilize samples and equipment by use of heat and steam under pressure.

Base: A compound which liberates hydroxide ions and has a pH above 7.

Batch: A group of samples prepared and analyzed at the same time.

Blank: A sample (usually deionized water) that is taken through all the steps of analysis to monitor for contamination in the process.

Calibration: The use of known standards to create an analytical curve based on the measured characteristic (e.g. absorbance) of the standards. The calibration is used to determine the measured characteristic of unknown samples.

Calibration Standards: A sequence of standard solutions of known concentration used to create a calibration curve.

Celsius: Temperature measurement scale where the freezing point of water is 0° and the boiling point of water is 100°. On this scale, room temperature is about 21°C, while on the Fahrenheit scale it is about 70°F.

Clean Water Act (CWA): The federal Clean Water Act sets the framework for the imposition of industrial wastewater control programs on municipalities and the regulation of industrial users. Sections 307(b) and (c) of the CWA set the authority for the U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to POTWs.

Coliform: A bacteria used as an indicator organism for tests of bacteriological purity.

Colorimetric: An analysis technique that compares color density to concentration. Color developing chemicals are added to both known standards and unknown samples.

Composite Sample: A collection of individual samples obtained at regular intervals, based either on flow or time. The individual samples are combined proportionally.

Compound: A substance composed of two or more different chemical elements.

Conductivity: The reciprocal of electrical resistivity, related to electrical current density. In water samples dissolved salts contribute to conductivity.

Culture Medium: The nutrient material prepared for growth of microorganisms in a laboratory.

Density: The relationship between weight and volume, e.g., grams per centimeter or pounds per gallon.

Desiccant: A chemical, such as calcium chloride, used in a desiccator to absorb moisture.

Desiccator: An airtight cabinet filled with desiccant, which provides a low-humidity environment in which samples may cool without absorbing atmospheric water.

Dilution: The process of reducing the concentration of a solution.

Duplicate: A second aliquot of a sample, which is treated the same as the first to determine the precision of the method.



Appendix B: Glossary of Technical Terms

Filtration: An analytical technique that is used to separate suspended solids from liquids (including dissolved solids). The solids (residue) are retained on the filter. The liquid (filtrate) passes through the filter.

Grab Sample: An individual sample collected to represent the flow at a given moment in time.

Gravimetric: An analytical technique that uses weight (mass) as the primary measurement to make lab determinations.

Hot Air Sterilization: Sterilization by the use of an oven at 170° for approximately 2 hours.

Inoculation: The act of introducing microorganisms into a culture medium.

Linear Range: The range of concentrations through which an analytical curve is linear.

Log/Work Book: A written record of sample receipt, preparation of standards, or documentation of other actions taken in the laboratory.

Material Safety Data Sheets (MSDS): Sheets providing information about manufactured chemicals, as required by the Hazard Communication Rule.

Media, Medium: The nutrient material prepared for growth of microorganisms in a laboratory.

Microorganism: A living organism too small to be seen with the naked eye, e.g., bacteria, fungi, protozoa, microscopic algae, viruses.

Molarity: Moles per liter, a measure of concentration.

Molecular Weight: The sum of the atomic weights of all atoms making up a molecule.

Most Probable Number (MPN): A statistical determination of the number of coliform per 100 mL of water.

National Pollutant Discharge Elimination System (NPDES): The federal permitting program designed to control all discharges of pollutants from point sources into U.S. waterways, as required under CWA, through the issuance of permits by either a federal or a state agency. NPDES permits regulate discharges into navigable waters from all point sources of pollution, including industries, municipal wastewater treatment plants, sanitary landfills, large agricultural feedlots, and return irrigation flows.

Normality: A measure of the concentration of a solution.

pH: The hydrogen ion (H⁺) concentration; the measure of the relative acidity or alkalinity of a solution on a scale from 0 (acidic) to 14 (basic).

Pathogen: A disease-causing organism.

Potentiometric: The measurement of the electric potential difference of a cell (voltage).

Pour Plate Method: A method of inoculating a solid nutrient medium by mixing bacteria in the melted medium and pouring the medium into a Petri dish to solidify.

Precision: The agreement of results for a sample and its replicates (duplicates).

Reagents: Chemicals and the solutions made from them.

Relative Percent Difference (RPD): The difference between two numbers divided by their mean. RPD statistically compares two values for closeness.

Reproducibility: The ability to reproduce the same results using an analytical method.

Serial Dilution: The process of diluting a sample several times in a sequential manner.

Spectrophotometer: An instrument used to measure the absorbance of light.

Standard Curve: The curve which plots concentrations of known standards versus measured characteristics (e.g., absorbance). The curve is used to determine the concentration of unknown samples based on their measured characteristics.

Standard Deviations: A statistical measurement of how closely data are clustered about the mean value.

Streaking: The technique (streak plate method) of isolating a culture by spreading microorganisms over the surface of a solid culture medium.

Titration: An analytical technique that involves the use of a standard of known concentration and volume to determine the concentration of a sample with known volume. This technique utilizes a buret.

Turbidimeter: The instrument used to measure the cloudiness of a sample. The instrument, also called a Nephelometer, provides results in NTUs (Nephelometric Turbidity Units).



A p p e n d i x C

Common Acronyms and Abbreviations

AA	atomic absorption	cfs	cubic feet per second
AC power	alternating current	CH ₄	Methane
AC	acre	CIU	Categorical Industrial User
AF	acre-foot (feet)	CM	common mode
AFY	acre-foot per year	CMOM	Capacity Management, Operations, and Maintenance
AMSA	Association of Metropolitan Sewerage Agencies	COD	chemical oxygen demand
ANSI	American National Standards Institute	CPU	central processing unit
APHA	American Public Health Association	CRWA	California Rural Water Association
AS	activated sludge	CSP	confined-space permit
ASCE	American Society of Civil Engineers	CT	current transformer
ASME	American Society of Mechanical Engineers	CWA	Clean Water Act
ASTM	American Society for Testing and Materials	CWEA	California Water Environment Association
AWT	advanced wastewater treatment	DAF	dissolved air flotation
AWWA	American Water Works Association	DO	dissolved oxygen
BECP	Business Emergency and Contingency Plan	DOHS	California Department of Health Services
BNR	biological nutrient removal	DV/DT	($\Delta V/\Delta T$) The change in voltage per change in time.
BOD ₅	biochemical oxygen demand after 5 days	DMF	dry weather flow
BTU	British thermal unit	DMR	Department of Water Resources
C	Celsius	EIS	Environmental Impact Statement
Cal-OSHA	California Occupational Safety and Health Act	EMF	electromotive force or voltage
Cal-EPA	California Environmental Protection Administration	EPA	U.S. Environmental Protection Agency
CBOD	carbonaceous biochemical oxygen demand	F	Fahrenheit
CCE	carbon chloroform extract	F/M	food to microorganism ratio
CCR	California Code of Regulations	ft	feet (foot)
cf	cubic feet (foot)	ft ²	square foot
CFR	Code of Federal Regulations	ft ³	cubic feet
		FTU	formazin turbidity unit
		GAC	granular activated carbon
		gal	gallon



Appendix C: Common Acronyms and Abbreviations

GFI	ground fault interrupter	min	minute
GPD	gallons per day	MIS	Manufacturing Information System
GPM	gallons per minute	mL	milliliter
GTAW	gas tungsten arc welding	MLSS	mixed liquor suspended solids
H ₂ S	hydrogen sulfide	MLVSS	mixed liquor volatile suspended solids
HCP&ERP	Hazard Communications Program and Emergency Response Plan	MMI	Man Machine Interface
hp	horsepower	MOP	Manual of Practice
HPLC	high-performance liquid chromatography	MPN	most probable number
Hz	Hertz	MS	mass spectrometer
IC	ion chromatograph	MSDS	Material Safety Data Sheets
ICP	inductively coupled plasma	MTBF	mean time between failures
IEEE	Institute of Electrical and Electronics Engineers	MTTR	mean time to repair
IIPP	Injury and Illness Prevention Plan	N	normal
IML	Interface Management Language	NEC	National Electrical Code
JTU	Jackson Turbidity Unit	NEMA	National Electrical Manufacturers Association
K	Kilo, a prefix meaning 1,000	NEPA	National Environmental Policy Act
KVA	kilovolt amperes	NM	Normal Mode
kw	kilowatt	NOCA	National Organization for Competency Assurance
kwh	kilowatt hour	NOD	nitrogenous oxygen demand
L	liter	NPDES	National Pollutant Discharge Elimination System
lb	pound	NPSH	net positive suction head
M	Mega, a metric prefix meaning 1,000,000	NTU	nephelometric turbidity unit(s)
m	meter	O&M	operation and maintenance
M	mole or molar	OCT	Operator Certification Test (State of California)
MA	millamps	OMR	operations, maintenance, and replacement
MBAS	methylene blue active substance	OCC	Office of Operator Certification (SWRCB)
MCL	maximum contaminant level	OSHA	Occupational Safety and Health Administration/Act
MCLG	maximum contaminant level goal	OTE	oxygen transfer efficiency
MCRT	mean cell residence time	P	Pico, a metric prefix meaning one millionth of a millionth, or one trillionth (10 ⁻¹²)
MDL	method detection limit	PC	personal computer
MG	million gallons		
mg	milligram		
mg/L	milligrams per liter		
MGD	million gallons per day		



Appendix C: Common Acronyms and Abbreviations

PCB	polychlorinated biphenyls	SWRCB	(California) State Water Resources Control Board
pH	potential of hydrogen	TAC	Technical Advisory Committee
P&ID	pipng and instrumentation diagram	TC	total carbon
PID	proportional gain, integral action time and derivative action time	TCP	Technical Certification Program
PLC	Programmable Logic Controller	TDS	total dissolved solids
POTW	Publicly Owned Treatment Works	TF	trickling filter
PPB	parts per billion	THD	total harmonic distortion
PPE	Personal Protective Equipment	TIC	total inorganic carbon
PPM	parts per million	TMDL	total maximum daily load
prct	percent	TOC	total organic carbon
psi	pound per square inch	TOD	total oxygen demand
PSIA	pounds per square inch absolute	TS	total solids
PSID	pounds per square inch differential	TSS	total suspended solids
PSIG	pounds per square inch gage	TU	turbidity unit
PVC	polyvinyl chloride (pipe)	μ	micro, a metric prefix meaning one millionth
QA/QC	quality assurance/quality control	UPS	uninterruptible power supply
RAS	return activated sludge	USB	universal serial bus
RBC	rotating biological contactor	USEPA	United States Environmental Protection Agency
RCP	reinforced concrete pipe	V	volt
RFI	Radio Frequency Interference	VAC	volts of alternating current
RMS	root mean square	VCP	vitrified clay pipe
RTD	resistance temperature device	VFD	variable frequency drive
RWQCB	Regional Water Quality Control Board (State of California)	VOC	volatile organic chemicals
SCADA	Supervisory Control and Data Acquisition	VOM	volt Ohm meter
SCR	semiconductor (or silicon) controlled rectifier	VSR	volatile solids reduction
SD	standard deviation	VSS	volatile suspended solids
SDI	sludge volume index	W	watt
sec	second	WAN	wide area network
SI	System Internationale D'Unites (metric units)	WEF	Water Environment Federation
SS	suspended solids	WRP	water reclamation plant
SSO	sanitary sewer overflow	WWF	wet weather flow
SVI	sludge volume index	WWTF	wastewater treatment facility
SVR	sludge volume ratio	WWTP	wastewater treatment plant (same as POTW)
		yr	year



CWEA is pleased that you have purchased this book.

We want to remind you that this book is one of many resources available to assist you, and we encourage you to identify and utilize the other resources in preparing for your next test.

Your comments, questions, and suggestions are welcome.



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