

Certification Examination

Study Guide

Laboratory Analyst Grade III





Grade III 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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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 III

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 twice yearly 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 written 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 vocation applied for. If approved, the applicant will receive an eligibility letter stating test site information. 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 twice a year on the fourth Saturday of January and July 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 instructions on how to schedule their exam.



Section 2: Certification Program Information and Policies

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 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 closed-book. No reference material, programmable calculators, computers, or cameras are allowed in the test site. Candidates may bring only a calculator and three No. 2 or softer pencils. All writing and notes must be in the test booklet. 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 your application once with a fee. Additional postponements will require a \$40 reschedule fee. 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.

To cancel your application you must submit a signed 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 testing window. Full refunds, less the administrative fee, will be made within 4 weeks after the scheduled test date. 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.

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



Section 2: Certification Program Information and Policies

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.

Item Appeals

Candidates who wish to appeal a specific test item must do so during the test by completing the Candidate Feedback Review Screen during the exam. Item appeals will be evaluated and appropriate adjustments made to the test context. Candidates submitting feedback 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 III.

Combination	Education and Certificates	+ Experience
A	None	6 full-time years in laboratory analysis
B	Hold a Grade II Laboratory Analyst Certificate for 2 years	4 full-time years in laboratory analysis
C	Hold an AA/AS degree in a related field	4 full-time years in laboratory analysis
D	Hold a BA/BS, or higher, degree in a related field	3 full-time years in laboratory analysis

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

Essential Duties

Grade III duties include the essential duties identified in the study guides for Laboratory Analyst Grades I and II. In addition, the Grade III Laboratory Analyst essential duties include:



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- Performs routine laboratory analysis, including ion chromatography, ICP/AES, spectrophotometry, gas liquid chromatography, total organic carbon, chronic toxicity tests, water suitability and inhibitory residue, and microscopic examination of activated sludge.
- Plans, prioritizes, assigns, supervises and reviews work performed and data generated on the chemical, biological, and bacteriological analyses of wastewater, biosolids, soils, and industrial pretreatment waste samples.
- Provides preliminary written reports on results, reviews data prepared by lower level staff, reviews literature on technical issues, and prepares reports on special projects.
- Maintains the quality assurance program as specified by the CDHS/ELAP and other regulatory agencies.
- Participates in the selection, training and evaluation of staff; participates in the monitoring of employee performance objectives; assists in the preparation of employee performance reviews; interprets and implements agency policies and procedures.
- Analyzes and interprets laboratory data and recommends process changes to water and wastewater treatment plants to ensure quality standards.
- Assists in special investigations involving wastewater, soils, biosolids, industrial pretreatment, and process controls, and makes recommendations as appropriate.



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- Provides or coordinates staff training, and works with employees to correct deficiencies.
- Participates in the preparation and administration of the laboratory budget, submits budget recommendations, and monitors expenditures.
- Assists in the preparation, organization, and completion of monthly, quarterly, and annual wastewater discharge and biosolids reports.



S e c t i o n 3

Skill Sets

Grade III Laboratory Analysts have many responsibilities that require a foundation of knowledge in basic mathematics, chemistry, microbiology, 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)*, EPA methods, and regulatory mandates. In addition to mastering all the wet chemistry methods and routine bacteriological determinations, Lab Analysts must demonstrate competency in advanced chemistry and instrumental analysis. These duties require great attention to detail.

Regardless of the size of the laboratory, or the specific duties that have been assigned, Lab Analysts have a responsibility to master certain concepts regarding the overall functioning of the laboratory that extend beyond chemical and microbiological analysis. In addition to having mastered the Grade I and II skill sets, Grade III Lab Analysts will need to develop supervisory skills. The knowledge, skills, and abilities that are required of Lab Analysts embody the professionalism that a career in chemistry and microbiology demands.

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

General Career Development

Grade III Lab Analysts are expected to possess a truly comprehensive level of knowledge, skills and abilities (KSAs). Candidates preparing for Grade III certification should understand that the guidance on KSAs offered in this study guide must be supplemented by a thorough mastery of the KSAs required for Lab Analysts at the Grade I and II levels. The knowledge and experience expected of Grade III Lab Analysts represents a level of professionalism that includes a deeper knowledge of most of the functions of a water or wastewater laboratory.

Lab Analysts are expected to have previously mastered most of the physical and wet chemistry methods for common water and wastewater analyses. Principles of quality assurance, data quality, method development, sampling, and laboratory health and safety, as presented in *Standard Methods*, Part 1000, should be thoroughly understood (Grades I and II).

Lab Analysts should already possess a strong understanding of many of the methods for determining physical and aggregate properties as listed in Part 2000 of *Standard Methods* (Grade I). Many analytical methods learned in the early phases of one's career continue to be revisited, such as BOD, phosphorus, residual chlorine, etc.

Lab Analysts should be thoroughly knowledgeable about metal analysis by flame atomic absorption or emission spectroscopy, graphite furnace, gaseous hydride generation, and cold vapor technique (*Standard Methods*, Part 3000) (Grade II). Principles of analysis for determination of inorganic non-metallic constituents (*Standard Methods*, Part 4000) include the use of spectrophotometers, ion-selective electrodes, titrations, etc., and require knowledge of color development, standard curves, and distillations (Grade I and II).



Section 3: Skill Sets

Fish bioassay (*Standard Methods* 8910) requires the understanding of the terminology and principles of toxicity (*Standard Methods* 8010) (Grade II). Lab Analysts should understand microbiological examination of coliform bacteria using the most probable number (MPN) method (Grade I and II) and the membrane filter technique (Grade II) (*Standard Methods* 9221, 9222 and 9225), as well as heterotrophic plate count (*Standard Methods* 9215) (Grade I). Lab Analysts should understand proper use of laboratory equipment, preparation of media, quality of laboratory water, and other foundational knowledge necessary in culturing and determining bacteria (*Standard Methods* 9010 through 9060) (Grade I).

This body of knowledge develops the foundation upon which Lab Analysts continue to build careers in water and wastewater laboratory analysis. It is at the Grade III level that Lab Analysts continue developing knowledge of instrumentation and more complex colorimetric analysis, chromatographic techniques, regulations, and principles of supervision.

Skill Set	2	Wet Chemistry
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Lab Analysts should be thoroughly familiar with the standard operating procedures for the analyses performed. *Standard Methods* contains many of the methods used in the laboratory. Each method begins with a general discussion section and continues with details such as equipment required, interferences, sampling and preservation details, the procedure, and calculations necessary to convert laboratory data to reportable values. Lab Analysts are expected to be familiar with an extensive variety of manual methods for determining pollutants in wastewater, including surfactants, phenols, and cyanide. Lab Analysts are also expected to be familiar with EPA methods where applicable.

Lab Analysts may be expected to know the way in which different compounds relate to one another. For example, Lab Analysts should understand the relationship between hardness, alkalinity and calcium carbonate, or the affect of pH on ammonia. Lab Analysts should know how various constituents (e.g., nitrogen and phosphorus) in an effluent discharge affect the environment. Surfactants (MBAS, *Standard Methods* 5540 A and B),

cyanide, (colorimetric method, *Standard Methods* 4500-CN A, B, C, and E) and phenols (direct photometric method, *Standard Methods* 5530 A, B, and D) make use of extractions, distillations, and complex colorimetric analysis. In addition to the ability to follow the basic recipe steps of standard operating procedures, Lab Analysts must move beyond the “how to” stage of analytical chemistry toward understanding the chemical principles behind the methods. For example, Lab Analysts should understand why a certain method is chosen for a given matrix or constituent concentration or why interferences must be controlled and how they are controlled.

Lab Analysts continue to acquire knowledge concerning the details of sampling technique as familiarity with new methods expands. For example, organic sampling techniques may include special instructions for container selection and preparation (washing and rinsing), for collecting samples with zero headspace, etc. Lab Analysts should understand the reason why special sampling techniques are required or why various preservatives prevent sample degradation. Understanding the details of sampling enhances legally defensible sampling protocol.

Skill Set	3	Laboratory Instrumentation
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Lab Analysts should have the ability and skills to perform laboratory analyses that include proper wet chemistry and instrumental techniques. *Standard Methods* often has a good discussion of the basic principles and theory, instrument components, and interferences of instrumental techniques. Some of the quantitative analytical chemistry textbooks provide in-depth information. Instrumental analysis textbooks provide information in great detail. The general theory, instrument components, calibration and operation provide a basic foundation. Lab Analysts should possess a deeper knowledge of how to control interferences, proper quality control, instrument troubleshooting, and how to choose the best method, instrument, or accessory for a particular matrix.

Lab Analysts are expected to have the knowledge, skills, and abilities to operate and maintain laboratory equipment, such as ion chromatographs (IC), gas chromatographs, high-performance liquid chromatographs (HPLC), and inductively coupled



plasma emission spectrophotometers (ICP/AES). In addition, Lab Analysts must be skilled in the use of ultraviolet (UV)/visible spectrophotometers, total organic carbon analyzers, ion-selective probes, and atomic absorption spectrophotometers (AAS), including various techniques such as flame AA, cold vapor technique, gaseous hydride generation, and graphite furnace (electrothermal).

The categories of questions Lab Analysts should ask themselves to assure familiarity with an instrument and its use are listed below:

3.1 Theory

- What is the name of the instrument?
- What does the instrument measure (metals, organics, volatiles, specific compounds, ions, etc.)?
- When is it an advantage to use this technology over others?
- What is the approximate detection limit?
- How do similar technologies compare (AA versus GFAA or ICP/AES)?
- What is the theory behind the instrument?

3.2 Instrument Components

- What are the components of the instrument (burner heads, columns, detectors)?
- What accessories are associated with the instrument?
- How are the results detected? Are there a variety of detectors to choose from?
- What carrier gases or eluents are used to carry the sample through the column?
- How is the sample introduced into the instrument so that it may be read by the detector? (For example, chromatography utilizes carrier gasses; atomic absorption atomizes the sample with heat in the light path.)
- How are the instrument and its accessories maintained?

3.3 Calibration, Quantification, and Quality Control

- How is the instrument calibrated (standard curve)?
- How is quality control incorporated into the analysis (internal standards, surrogate standards)?
- How are the results qualified, and quantified (retention time, peak height, transmission/absorption, comparison to a standard curve, etc.)?
- Are blanks or background correction techniques used?

3.4 Sample Preparation

- How are the samples pre-treated (digestion, filtration, distillation, extraction, concentration, purge and trap, etc.)?
- How are difficult matrices dealt with (high dissolved solids, matrix modifiers)?
- What are the types of interferences and how are they corrected?
- Are there special sampling techniques (preservatives, zero-head space, holding time, etc.)?

Skill Set	4	Specific Instrumentation Techniques
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Lab Analysts should be knowledgeable about atomic absorption and chromatography techniques. They should understand the instrument theory, components, sample preparation requirements, calibration, operation, maintenance, quantification, and quality control.

4.1 Atomic Absorption (AA) Techniques

This technique encompasses flame and emission AA spectroscopy, gaseous hydride generation, cold vapor technique, and graphite furnace.

Lab Analysts should be aware of the theory behind atomic absorption spectroscopy and its variations, including what is actually being measured. Lab Analysts should know why certain elements or matrices respond better to one technique over another. For example, Lab Analysts should know why lead is often analyzed by graphite furnace.



Section 3: Skill Sets

Lab Analysts should be familiar with instrument components, flames (fuels and oxidants), light sources, and background correction. Lab Analysts should understand instrument operation, including sensitivity and detection limits and the various forms of interferences. Lab Analysts should know how to calibrate the instrument and construct a standard curve.

Correct sample preparation is important to analytical technique (whether the sample is filtered, digested, oxidized, etc.). Matrix modifiers and standard addition techniques are sometimes required to ensure analytical accuracy.

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

Lab Analysts should be aware of the theory behind gaseous hydride generation for arsenic and selenium. Correct sample digestion is important to this analytical technique. *Standard Methods* provides a good discussion of hydride generation atomic absorption for selenium and arsenic.

Lab Analysts should be aware of the theory behind cold vapor technique for mercury analysis. Correct sample digestion also is important to the analytical technique.

Lab Analysts should be aware of the theory behind graphite furnace atomic absorption, an electrothermal technique. *Standard Methods* provides a good discussion of graphite furnace atomic absorption.

4.2 Inductively Coupled Plasma/Atomic Emission Spectroscopy (ICP/AES)

Lab Analysts should be familiar with the theory of using plasma as an excitation source for atomic emission. The components of the instrument may vary with the instrument design, and the way samples are measured at various wavelengths may vary with detectors of various designs. Lab Analysts should be aware of which metals are best suited for ICP analysis.

4.3 Gas Chromatography

Two common groups of compounds analyzed by gas chromatography are pesticides (EPA Method 608) and polynuclear aromatic hydrocarbons (EPA Method 610). Refer to the list of questions Lab Analysts should ask themselves to assure familiarity with sample preparation, quality control, sampling technique, etc.

Lab Analysts should understand the theory behind chromatography and be familiar with the importance of the instrument components such as injection ports, carrier gases, columns, oven, and detectors. Lab Analysts should know which of several detectors are used for which compounds. Lab Analysts should understand separation theory and the relationship between retention time, peak height, peak area, etc.

Sampling techniques are critical because the samples are easily contaminated by the improper choice of container material. Volatile samples require special containers. Sample extraction from a water-based sample to a solvent-based concentrate may require several steps. Purge and trap techniques are necessary for some compounds. Lab Analysts also should be familiar with quality control protocol.

4.4 High-Performance Liquid Chromatography (HPLC)

Lab Analysts should be familiar with the theory, instrument components, calibration, sample preparation, and quality control. Like gas chromatography, HPLC instrument components include a mobile phase supply system, sample injection system, a column, and a choice of detectors. Lab Analysts should know which detectors are used to determine various compounds.

4.5 Ion Chromatography (IC)

Ion chromatography utilizes the same components as any chromatographic instrument; however a suppression column is used with basic or acidic effluents. Lab Analysts should be familiar with the theory, instrument components, calibration, sample preparation, and quality control for this instrument.



Skill Set	5	Microbiological Analysis
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Lab Analysts should be knowledgeable regarding coliform and fecal coliform analyses, including media preparation, equipment monitoring, identification of positive results, and calculation of laboratory data to reportable results.

Lab Analysts should have mastery of the fundamental techniques for maintaining the equipment and labware used for bacteriological analysis, including MPN analysis and heterotrophic plate count. Grade III Lab Analysts should thoroughly understand tests for inhibitory residue and water suitability to avoid potential chemical interference during microbiological testing. These tests can be found under a variety of names. The names used by two sources are as follows:

- Inhibitory Residue Test: This test is called Test Procedure for Suitability of Detergents used in Washing in *Microbiological Methods for Monitoring the Environment*. The same test is referred to by *Standard Methods* as Test for Inhibitory Residues on Glassware and Plastic.
- Water Suitability Test: This test is called the Water Suitability Test in *Microbiological Methods for Monitoring the Environment*, while *Standard Methods* refers to this same test as Test for Bacteriological Quality of Reagent Water.

Skill Set	6	Biomonitoring and Toxicity
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Lab Analysts should be familiar with bioassay monitoring and toxicity testing. This branch of analysis has specific terminology, which Lab Analysts should be familiar with. Fish toxicity testing is the most common toxicity test.

Lab Analysts should be knowledgeable about toxicity test design, which may include flow through, static or static renewal techniques, and chronic (long term) or acute toxicity testing. Lab Analysts should be familiar with the use of reference toxicants and control organisms.

Skill Set	7	General Chemistry, Mathematics, Quality Control, and Statistics
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7.1 Chemistry and Mathematics

Lab Analysts should possess a strong background in mathematics, chemistry, microbiology, and quality control. Confidence in math skills is a necessity for the Lab Analysts, even though the mathematics required in the laboratory is not complex. In the laboratory, mathematics is combined with knowledge of chemistry. This combination of fundamental knowledge must be mastered to calculate report results from laboratory data, evaluate quality control data, generate monthly and annual reports, and calculate values necessary for plant operations.

Lab Analysts should be able to evaluate and interpret laboratory data, using mathematical calculations. Using formula reactions, molecular weights, and stoichiometry, Lab Analysts should know how to prepare reagents which involve complex reactions, and make dilutions. Lab Analysts should be able to calculate results using formulas given in *Standard Methods*, including residual chlorine, and BOD.

Often laboratory data is used in calculations to provide information to operations staff for efficient plant management. Lab Analysts should be familiar with the following types of calculations: sludge production, loading calculations, theoretical oxygen demand, clarifier overflow rates, plant removals and removal rates of regulated constituents, chlorination feed rates, residual chlorine, and dechlorination dosages.



Section 3: Skill Sets

7.2 Quality Assurance/Quality Control

Lab Analysts require knowledge of quality assurance plans, and associated quality control. Quality control includes the use of blanks, spikes, duplicate (replicate) samples, and standards. Lab Analysts should understand the significance that quality control results have in disclosing contamination or problems with accuracy and precision. Lab Analysts should be familiar with various types of standards used for inorganic and organic analysis and internal and external checks.

Lab Analysts should know the elements of a quality assurance program and the importance of standard operating procedures (SOP). Lab Analysts should be familiar with how to use and construct control charts with upper and lower warning and control limits. They should have mastery of statistical concepts, such as accuracy, precision, standard deviation, and how to determine a method detection limit (MDL).

Skill Set	8	Process Control
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Laboratory documentation, sampling, and analysis results assist in many facets of wastewater treatment plant (WWTP) operations, ranging from the pretreatment program, through WWTP process control and understanding the potential impacts of WWTP effluent on the environment.

An important part of protecting the plant from toxic, inhibitory, or pass-through substances is the pretreatment (also known as industrial waste or source control) program. Lab Analysts should understand why sampling, documentation, approved methods, and proper quality control are needed for legally defensible results.

Lab Analysts are required to interpret laboratory data to provide support to operations staff for proper process control. Lab Analysts should have a thorough knowledge of wastewater treatment, as well as the ability to interpret laboratory data in order to make suggestions regarding plant operations. Lab Analysts should be familiar with the stages of wastewater treatment, including which pollutants are removed during each stage of treatment and which pollutants remain in the effluent that is discharged to the environment.

Lab Analysts can help plant operation staff by analyzing digester gases and sludge to determine optimum digester operations; by analyzing ammonia to determine the amount of nitrification and denitrification; and by analyzing solids to determine changes to chemical feed rates or daily sludge production. Further, laboratory analyses can help determine sludge disposal options or reuse of biosolids options governed by federal and state regulations.

Laboratory data is used to calculate residual chlorine, chlorine and sulfur dioxide feed rates, residual chlorine in pounds/day and other disinfection/dechlorination-based calculations. Lab Analysts should be familiar with various forms of chlorine, such as free and combined.

Microscopic analysis of activated sludge can show floc appearance, clarity of supernatant liquid, types and distribution of protozoa, and presence or absence of filamentous bacteria. Lab Analysts should be familiar with common microorganisms found in the plant and whether they indicate positive or negative trends in secondary treatment process control. For example, Lab Analysts should be able to identify the plant conditions associated with *Nocardia* filaments.

Receiving waters are sensitive to effluent discharges. Discharges are regulated in California by the State Water Resources Control Board. Some pollutants become nutrients in the natural environment, and an excess of these can lead to aquatic imbalances. Other constituents cause chronic or acute harm to aquatic life, or may be toxic to the environment. Lab Analysts should have a good understanding of the effects plant discharge can have on receiving waters, and the standard tests used to measure these impacts.



Skill Set	9	Safety and Regulations
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Grade III Lab Analysts are required to have mastery of the day-to-day safety protocols learned as Grade I and II Lab Analysts, understand the applicable safety, environmental, and laboratory regulations and the permits affecting wastewater treatment plant operations, and be able to interpret and implement regulatory programs that affect the laboratory.

9.1 Safety

Safety is a primary consideration in any job; in the laboratory, safety takes on greater significance due to the chemical and biological hazards present. All laboratory staff should be diligent in the use of personal protective equipment and be thoroughly familiar with the use of laboratory safety- and health-related equipment such as fume hoods and fire extinguishers.

With experience and increased responsibility, Lab Analysts are expected to be fully aware of safe working practices, including knowledge of first aid and chemical waste management. Lab Analysts must know the types of materials that may be thrown away as trash, poured down the sink, neutralized prior to disposal, or saved for off-site hazardous waste disposal. Lab Analysts also should be knowledgeable about the regulations that govern hazardous waste disposal, including the length of time and the quantities of waste that may be stored in the laboratory prior to disposal.

Lab Analysts have the responsibility of understanding and implementing safety regulations and policies in the laboratory. Several OSHA regulations have been modified to meet the specific needs of laboratory conditions. Lab Analysts should be familiar with the regulations that protect laboratory workers from acute and chronic health problems; chemical hygiene; employee right-to-know; and the handling and disposal of hazardous materials and waste.

9.2 Regulations and Permits

Lab Analysts also should understand other regulations and permits affecting laboratory operations that are issued by the various regulatory agencies. These agencies include the U.S. Environmental Protection Agency (EPA), California State Water Resources Control Board (SWRCB), Regional Water Quality Control Boards (RWQCBs), and California Department of Health Services (DOH). Lab Analysts should thoroughly understand 40 CFR 136 for laboratory procedures and the overall concepts in 40 CFR 403 for pretreatment programs. Intimate knowledge of the plant's own Waste Discharge Requirements or National Pollutant Discharge Elimination System permit will help Lab Analysts understand the four areas of typical laboratory involvement. Lab Analysts should be familiar with sampling and reporting permit requirements for plant influent, effluent, and solids, as well as environmental (down-stream, ocean, biosolids disposal site) monitoring, and the pretreatment program.

9.3 Programs and Plans

Lab Analysts should be aware of the mandated programs and plans, including the Emergency Response Program, Injury and Illness Prevention Plan, Chemical Hygiene Plan, Quality Assurance Program, and California Department of Health Services Environmental Laboratory Accreditation Program (ELAP). Each one of these plans requires Lab Analysts to understand, track, and (where necessary) implement corrective action for these programs. For example, Lab Analysts should be aware that to receive and maintain accreditation, laboratories are subject to inspection audits in order to assure that they are complying with quality control requirements and are adhering to EPA-approved methods. Performance evaluation samples are analyzed to confirm that laboratories are able to accurately analyze constituents for which they are certified.



Section 3: Skill Sets

Skill Set	10	Supervision
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Lab Analysts should know general principles of supervision. Tasks involved include hiring, monitoring, evaluating, and reviewing performance of staff members. As supervisors, Lab Analysts should be knowledgeable about the goals and objectives involved in giving a successful performance evaluation, and should support upper management by implementing agency policies and procedures. Supervisors should provide a comfortable working environment for the laboratory staff, which includes freedom from sexual, racial, or other forms of harassment. As first line supervisors, Lab Analysts should be knowledgeable regarding progressive discipline, and should understand how to handle personal conflicts. Supervisors are also responsible for training, correcting employee mistakes, and evaluating the performance of staff members. Initial training and corrective training assure that analyses are performed correctly.

In addition to supervising people, Lab Analysts should be knowledgeable about designing monitoring projects; planning, scheduling and assigning work tasks; writing reports; and monitoring the laboratory budget. Monitoring the budget may include tracking expenditures or performing a cost per analysis assessment to justify additional staff or the purchase of new instrumentation.



Table 3-1 Grade III Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
2	Wet Chemistry					
2.0	Surfactants (MBAS)	5540 A, B	Lecture 15, pgs. 310–313			Methods ^b 425.1 Methylene Blue Active Substances (MBAS)
2.0	Cyanide	4500-CN ⁻ A, B, C, E	Lecture 13, pgs. 245–259			Methods ^b 335.2 Cyanide Total–Colorimetric, Automated UV
2.0	Phenols	5530 A, B, D	Lecture 16, pgs. 321–328			Methods ^b 420.1 Phenolics, Total Recoverable–Spectrophot/MBTH
3	Laboratory Instrumentation					
3.0	UV/VIS Spectrophotometer				Chapter 16 16.17	Handbook ^c Chapter 3
3.0	Total Organic Carbon (TOC)	5310 A, B, C	Lecture 6, pgs. 144–146		Chapter 16 16.11	Handbook ^c Chapter 3
4	Specific Instrumentation Techniques					
4.1	Atomic Absorption Techniques	3010, 3020, 3030, 3110, 3111, 3114 A and B, 3112, and 3113	Lecture 3			Handbook ^c Chapter 3
4.1	Purge and Trap Sample Preparation Techniques	6040, 6210, 6220, 6230				

- a. Complete reference information given in Section 6.
 b. *Methods for Chemical Analysis of Water and Wastes*
 c. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*



Section 3: Skill Sets

Table 3-1 Grade III Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
4.1	Quality Control for Organic Compounds					Handbook ^c Chapter 8
4.1	Sampling for Organic Compounds	6010 A, 1060	Lecture 2, pgs. 41-44			Handbook ^c Chapter 8
4.2	Inductively Coupled Plasma/Atomic Emission Spectroscopy (ICP/AES)	3120 A, B	Lecture 3, pgs. 62-73			40 CFR 136 ^d Appendix C
4.3	Gas Chromatography	6010, 6020, 6040	Lecture 4			
4.3	Pesticides, EPA Method 608	6410 B				40 CFR 136 ^d Appendix A, Method 608
4.4	High-Performance Liquid Chromatography	6440 A, B 6010 A, B, C				
4.5	Ion Chromatography	4110 A, B				
5	Microbiological Analysis					
5.0	Inhibitory Residue Test	9020 A, B especially B.3.a(2)				Microbiological Methods ^e Part IV 5.1.3 pg. 199
5.0	Water Suitability Test	9020 A, B Especially B.3.c(v)				Microbiological Methods ^e Part IV 5.3 pg. 200

- a. Complete reference information given in Section 6.
- c. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*
- d. *40 CFR (CFR Title 40: Protection of Environment)*
- e. *Microbiological Methods for Monitoring the Environment - Water and Wastes*



Table 3-1 Grade III Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
6	Biomonitoring and Toxicity					
6.0	Acute and Chronic Toxicity	8010 A, B, C, D, F (F.3), G (G.1, G.2) 8020 8910	Lecture 18	Chapter 14, pgs. 421-422		
6.0	Fish Toxicity	8910				Handbook ^c Chapter 13, Methods for Measuring ^f Section 9
7	General Chemistry, Mathematics, Quality Control, and Statistics					
7.2	Quality Assurance and Statistics	1010, 1020, 1030, 1040, 1050	Lectures 2, 22, 23	Chapter 14		Handbook ^c Chapters 6, 7
8	Process Control					
8.0	Wastewater Characteristics				Chapter 2	
8.0	Receiving Waters				Chapter 13 13.0, 13.1, 13.3, 13.4	
8.0	Chlorination and Dechlorination	2350 A, B 4500-Cl A, B, D	Lecture 11 pgs. 219-234	Chapter 23 pgs. 819-823, 840-841, 847-848	Chapter 10 10.00-10.06, 10.6, 10.8, 10.810, 10.850, 10.851 Figure 10.2	

- a. Complete reference information given in Section 6.
- c. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*
- f. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*



Section 3: Skill Sets

Table 3-1 Grade III Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
8.0	Activated Sludge	2710 A, C, D, F	Lecture 20 pgs. 369–373	Chapter 17	Chapter 11 11.0–11.051, 11.50, 11.51, 11.65, 11.70–11.74, 11.90–11.94, Table 11.67 Glossary Chapter 16 16.45	
8.0	Activated Sludge Microbiology		Lecture 17 pgs. 341–342	Chapter 17 pgs. 564–567	Chapter 11 11.93, 11.94, 11.95, 11.96	
8.0	Anaerobic Digesters	2720 A, C		Chapter 27 pgs. 961–966, 997–998, Table 27.9 (1, 2, 3)	Chapter 12 12.0, 12.2, 12.3, 12.43, Tables 12.2 and 12.44 (1, 2, 3) Chapter 16 16.46	
8.0	Liquid Processes Sampling			Chapter 14		
8.0	Solid Processes Sampling			Chapter 25		
8.0	Sludge and Biosolids		Lecture 19 pgs. 361–368	Chapters 24 and 25	Chapter 12 12.8	40 CFR 503 ^d Test Methods ^g
9	Safety and Regulations					
9.1	MSDS					OSHA Regulations ^h 29 CFR 1910.1200

a. Complete reference information given in Section 6.

d. 40 CFR (CFR Title 40: Protection of Environment)

g. Test Methods for Solid Waste, Physical/Chemical Methods, EPA Publication SW-846

h. OSHA Regulations (Standards – 29 CFR)



Table 3-1 Grade III Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
9.1	Laboratory Safety	1090 A–J especially A, B, C		Chapter 5 especially pgs. 109–110	Chapter 14 (omit 14.2, 14.5, and 14.6) Chapter 16 16.2	Handbook ^c Chapter 14, Appendix A
9.1	OSHA			Chapter 5		
9.2	Laboratory Procedures					40 CFR 136.3 ^d
9.2	Laboratory Records			Chapter 6 especially pgs. 125, 129–132	Chapters 18 and 19	
9.2	NPDES Permits			Chapter 2 Chapter 6 pg. 122		
9.2	Industrial Waste Pretreatment			Chapter 4 Chapter 6 pgs. 123, 129		40 CFR 403 ^d
9.2	Agencies: EPA, SWRCB		Lecture 1	Chapter 2 Chapter 3 pgs. 30–32		
9.3	Chemical Hygiene Plan			Chapter 2		OSHA Regulations ^h 29 CFR 1910.1450
9.3	ELAP					ELAP Program Statutes and Regulations ⁱ
9.3	Emergency Response Plan			Chapter 3 pgs. 33–38		

a. Complete reference information given in Section 6.

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

d. *40 CFR (CFR Title 40: Protection of Environment)*

h. *OSHA Regulations (Standards – 29 CFR)*

i. *ELAP Program Statutes and Regulations*



Section 3: Skill Sets

Table 3-1 Grade III Laboratory Analyst						
Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
10	Supervision					
10.0	Staff Training		Lecture 23	Chapter 3 pgs. 24–30 Chapter 6 pgs. 141–142		Handbook ^c Chapter 9 Supervision ^j Chapter 13 pgs. 369–373 Supervisory Management ^k Lesson 5, Section 1
10.0	Personnel Evaluations			Chapter 3 pgs. 24–30		Supervision ^j Chapter 14 pgs. 380–415 Supervisory Management ^k Lesson 5, Section 2
10.0	Discipline			Chapter 3 pgs. 24–30		Supervision ^j Chapter 18 Chapter 20 pgs. 579–607 Supervisory Management ^k Lesson 6
10.0	Harassment Policies			Chapter 3 pgs. 24–30		Supervision ^j Chapter 17 pgs. 485–511 Supervisory Management ^k Lesson 6

- a. Complete reference information given in Section 6.
- c. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*
- j. *Supervision: Concepts and Practices of Management*
- k. *Supervisory Management in the Water/Wastewater Field*



Table 3-1 Grade III Laboratory Analyst

Primary References ^a						
No.	Skill Set	Standard Methods for the Examination of Water and Wastewater, 18th Edition	Lectures on Wastewater Analysis and Interpretation	Operation of Municipal Wastewater Treatment Plants	Operation of Wastewater Treatment Plants	Other (see footnotes)
10.0	Budgets			Chapter 3 pgs. 38-43		Supervision ^j Chapter 7 pgs. 197-198 Supervisory Management ^k Lesson 4, Section 2
10.0	Testing Programs			Chapter 3 pgs. 52-53		Supervision ^j Chapter 7 Supervisory Management ^k Lesson 4
10.0	Assigning Work					Supervision ^j Chapter 8 pgs. 209-324 Supervisory Management ^k Lesson 4
10.0	Interpreting Results		Lesson 21 pgs. 375-390			
10.0	Writing Reports			Chapters 6 and 14		

- a. Complete reference information given in Section 6.
- j. *Supervision: Concepts and Practices of Management*
- k. *Supervisory Management in the Water/Wastewater Field*



Section 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 III Lab Analyst candidates must be skilled in arithmetic, statistics, and algebra. Lab Analysts must be able to build upon the skills learned for Grades I and II 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.

In addition to the problem solving skills required of Grades I and II Lab Analysts, Grade III general chemistry problems will require Lab Analysts to understand how to determine:

- 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.
- Concentration of 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.
- Solubility product of a saturated solution, given the grams of solute per liter and the molecular weight.

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 or non-seeded samples.
- Residual chlorine by back-titration given the lab data necessary to use the formula given in *Standard Methods*.
- Chloride, hardness, alkalinity, sulfates, chlorine demand, nitrogen, phosphorous, fluoride, and TOC.



Section 4: Test Preparation

- Concentration of an unknown solution, given absorbance versus concentration information from a standard curve.
- 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:

- Sulfur dioxide (lbs/day) required, given molecular weights, plant flow (MGD), and desired chlorine residual (mg/L).
- Chlorine feed rate (lbs/day), given plant flow (MGD), chlorine demand (mg/L), and desired residual chlorine (mg/L).
- Hypochlorite flow rate (gal/day), given chlorine dosage (lb/day), percentage of compound that is chlorine, and solution density (lb/gal).
- Dosage of alum (lbs/MG), given plant flow (gallons/day) and feed rate of alum (lbs/hour).
- Sludge production (cubic feet/day), given population, influent settleable solids (mL/L), per capita contribution to total flow (gals/day), and the conversion factor 7.48 gal = 1 cubic foot.
- 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.

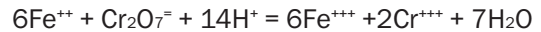
Be prepared to apply these basic skills to work-related problems. The following example problem requires application of chemistry knowledge, application of basic arithmetic, and the ability to convert units.

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



Section 4: Test Preparation

at 0.1 mL per plate. The plates were incubated at 25°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.

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.

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

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

$$\text{Total} = 391,980 \text{ pounds BOD/day}$$

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.

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

$$\text{Influent Line \#2: } 5,000 \text{ mg/L} \times 10 \text{ MGD} \times 8.34 = 417,000 \text{ pounds SS/day}$$

$$\text{Total} = 792,300 \text{ pounds SS/day}$$

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.

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

$$\frac{10 \text{ MGD}}{100 \text{ MGD}} \times 2,000 \text{ mg/L} = 200 \text{ mg/L}$$

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

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 III 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	2	Wet Chemistry
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1. Which of the following techniques is used to isolate anionic surfactants (as MBAS) from the sample matrix?
 - a. Atomization
 - b. Chelation
 - c. Distillation
 - d. Extraction
2. In the cyanide determination, which one of the following is not an interference?
 - a. Carbonates
 - b. Chromate ions
 - c. Fatty acids
 - d. Sulfides
3. Which of the following is not a major interference in phenol determination?
 - a. Hydroxy derivatives of benzene
 - b. Oils and tars
 - c. Oxidizing agents, such as chlorine
 - d. Sulfur compounds, such as hydrogen sulfides and sulfur dioxide



Section 5: Diagnostic Test

4. A freshly prepared sodium hydroxide (NaOH) solution is standardized against primary standard potassium acid phthalate ($\text{KHC}_8\text{H}_4\text{O}_4$). 0.8000 grams of potassium acid phthalate was dissolved into 50 mL CO_2 -free water. 2-3 drops of phenolphthalein were added. The sample was titrated to a faint pink endpoint with 22 mLs sodium hydroxide. What is the normality of the sodium hydroxide?

Molecular weights: K=39, H=1, C=12, O=16, Na=23

- a. 3.580 N
- b. 1.156 N
- c. 1.980 N
- d. 0.086 N

Skill Set	3	Laboratory Instrumentation
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Skill Set	4	Specific Instrumentation Techniques
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- 1. What does an ICP source consist of?
 - a. An electrically heated atomizer with programmable temperature ramping capability
 - b. A cavity-type microwave with programmable temperature ramping capability
 - c. A flowing stream of argon gas ionized by an applied radio frequency
 - d. A hydride reactor cell purged with a flowing stream of argon gas
- 2. In atomic absorption the higher temperature of a nitrous oxide-acetylene flame is required to disassociate molecules in which metal?
 - a. Aluminum
 - b. Calcium
 - c. Silver
 - d. Zinc
- 3. In gas chromatography, electron capture detectors (ECD) are used to detect which of the following compounds?
 - a. Polynuclear aromatic hydrocarbons
 - b. Halogenated volatile hydrocarbons
 - c. Chlorinated hydrocarbon pesticides
 - d. Phenols
- 4. Why is methylene chloride replaced by hexane in sample preparation for analyses detected by GC electron capture detection (ECD)?
 - a. Methylene chloride is carcinogenic
 - b. Chlorine compounds are detected by ECD
 - c. Methylene chloride is unable to separate organic compounds from water-based samples
 - d. Methylene chloride is unable to migrate through capillary columns
- 5. Which of the following methods is used to determine pesticides?
 - a. EPA Method 1664
 - b. Standard Methods 5230
 - c. Standard Methods 1664
 - d. EPA Method 608
- 6. What analysis uses the purge and trap technique?
 - a. Polyaromatic hydrocarbon analysis
 - b. Volatile organic compound analysis
 - c. Pesticide analysis
 - d. Organic acid analysis



Skill Set	5	Microbiological Analysis
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1. The test for inhibitory residues on glassware and plasticware determines the toxic or stimulatory effects of dishwashing detergents used for bacterial analysis. Which bacterial genera is used for this test?
 - a. *Escherichia*
 - b. *Citrobacter*
 - c. *Enterobacter*
 - d. *Klebsiella*
2. The Water Suitability Test (Test for Bacteriological Quality of Reagent Water) determines the toxic or stimulatory effects of the distilled or deionized water system. Which bacteria genera is used for this test?
 - a. *Escherichia*
 - b. *Citrobacter*
 - c. *Enterobacter*
 - d. *Klebsiella*

Skill Set	6	Biomonitoring and Toxicity
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1. Short-term toxicity tests are inappropriate for:
 - a. obtaining toxicity data as rapidly and inexpensively as possible.
 - b. obtaining an estimation of overall toxicity.
 - c. screening test solutions or materials for which toxicity data do not exist.
 - d. determining chronic toxicity.

2. Basic requirements for toxicity tests do not include:
 - a. adequate space and well planned holding, culturing and testing equipment and facilities.
 - b. an adequate source of health experimental organisms.
 - c. documented re-use of control test organisms.
 - d. an abundant supply of water of desired quality.
3. A test in which solutions and test organisms are placed in test chambers and kept there for the duration of the test is called a:
 - a. flow through test.
 - b. range finding test.
 - c. static test.
 - d. definitive test.
4. A test in which solution is replaced continuously in test chambers through the test duration is called a:
 - a. flow through test.
 - b. range finding test.
 - c. static test.
 - d. definitive test.
5. A preliminary test designed to establish approximate toxicity of a solution is called a:
 - a. flow through test.
 - b. range finding test.
 - c. static test.
 - d. definitive test.
6. A toxicity test designed to establish concentration at which a particular end point occurs is called a:
 - a. flow through test.
 - b. range finding test.
 - c. static test.
 - d. definitive test.



Section 5: Diagnostic Test

Skill Set	7	General Chemistry, Mathematics, Quality Control, and Statistics
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1. Which of the following types of control samples may be used to determine accuracy?
 - a. Method blank
 - b. Calibration standard
 - c. Certified reference material
 - d. Duplicate
2. Which of the following types of control samples may be used to determine precision?
 - a. Method blank
 - b. Calibration standard
 - c. Certified reference material
 - d. Duplicate

Skill Set	8	Process Control
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1. The average flow in a treatment plant is 3.1 MGD. A chlorine residual of 4.0 mg/L is maintained and the effluent must be dechlorinated before discharging. If an excess of 0.5 mg/L of sulfur dioxide is required after dechlorination, how many lbs/day of sulfur dioxide must be added?
Molecular weights: O=16, S=32, Cl=35.5
1 gal = 8.34 lbs.
 - a. 96 lbs SO₂/day
 - b. 150 lbs SO₂/day
 - c. 106 lbs SO₂/day
 - d. 160 lbs SO₂/day

2. A plant serving a city of 50,000 population has an influent settleable solids of 10 mL/L. If per capita contribution to the plant flow is 100 gallons/day, how much sludge is produced in the plant in cubic feet?
7.48 gal = 1 cubic foot
 - a. 6.68 cu ft
 - b. 374 cu ft
 - c. 6,684 cu ft
 - d. 70,600 cu ft
3. Which of the following formulas determines chlorine demand?
 - a. Chlorine dose + chlorine residual = chlorine demand
 - b. Chlorine dose - chlorine residual = chlorine demand
 - c. Breakpoint chlorine - chlorine dose = chlorine demand
 - d. Chlorine dose - breakpoint chlorination = chlorine demand
4. What is the most important measurable parameter to judge the performance of an anaerobic sludge digester?
 - a. pH
 - b. Volatile solids reduction
 - c. Volatile acids
 - d. Alkalinity



Skill Set 9 Safety and Regulations

1. What is a multicopy shipping document that accompanies hazardous waste shipments called?
 - a. Small quantity generator
 - b. Chain-of-custody
 - c. Manifest
 - d. DOT Form 200
2. The HAZWOPER Standard, 29 CFR 1910.120 addresses which of the following situations?
 - a. Regulates shipments of hazardous waste
 - b. Regulates the disposal of radioisotopes
 - c. Characterizes toxicity and lists organic compounds, metals, and herbicides considered to be hazardous waste
 - d. Requires documentation of training for the handling of major spills and acutely hazardous materials
3. A waste is considered hazardous if it has at least one of the following properties:
 - a. ignitability, reactivity, toxicity, and is carcinogenic.
 - b. ignitability, corrosivity, acidity, and toxicity.
 - c. ignitability, corrosivity, reactivity, and toxicity.
 - d. ignitability, corrosivity, reactivity, and conductivity.

Skill Set 10 Supervision

1. Performance standards do not place emphasis on which of the following?
 - a. Quality of product
 - b. Personality characteristics
 - c. Unit costs
 - d. Time requirements
2. Of the following inquiries during an interview, which one is appropriate?
 - a. "Do you have any physical disabilities?"
 - b. "By whom were you referred for a position here?"
 - c. "Are you currently employed?"
 - d. "Are you a United States Citizen?"
3. You are asked to determine the cost per test of the COD analysis. Use the following information:

The base salary of an analyst is \$30,000; employer paid benefits add 35% to the base salary; administrative overhead adds another 45% to the base salary; there are 10 paid holidays, 15 days paid vacation leave, and 12 days paid sick leave per year; the hourly salary is determined by dividing the monthly salary by 174. Each COD test requires an average of 20 minutes of labor from sample preparation to cleanup. Costs for chemicals, glassware, and equipment use average \$1.00 per test. Disposal costs average \$2000/year for reagents from 1,000 tests.

What is the total cost per test?

 - a. \$ 8.62/test
 - b. \$ 9.62/test
 - c. \$10.62/test
 - d. \$11.62 /test



Section 5: Diagnostic Test

Test Answer Key

Skill Set	2	Wet Chemistry
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No.	Answer
1	d
2	b
3	a
4	d

Skill Set	3	Laboratory Instrumentation
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Skill Set	4	Specific Instrumentation Techniques
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No.	Answer
1	c
2	a
3	c
4	b
5	d
6	b

Skill Set	5	Microbiological Analysis
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No.	Answer
1	c
2	c

Skill Set	6	Biomonitoring and Toxicity
-----------	----------	----------------------------

No.	Answer
1	d
2	c
3	c
4	a
5	b
6	d

Skill Set	7	General Chemistry, Mathematics, Quality Control, and Statistics
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No.	Answer
1	c
2	d

Skill Set	8	Process Control
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No.	Answer
1	c
2	c
3	b
4	b

Skill Set	9	Safety Regulations
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No.	Answer
1	c
2	d
3	c

Skill Set	10	Supervision
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No.	Answer
1	b
2	b
3	d



Selected Problem Solutions

Skill Set 2 Wet Chemistry

4. A freshly prepared sodium hydroxide (NaOH) solution is standardized against primary standard potassium acid phthalate (KHC₈H₄O₄). 0.8000 grams of potassium acid phthalate was dissolved into 50 mL CO₂-free water. 2–3 drops of phenolphthalein were added. The sample was titrated to a faint pink endpoint with 22 mLs sodium hydroxide. What is the normality of the sodium hydroxide?

Molecular weights: K=39, H=1, C=12, O=16, Na=23

Molecular weight of KHC₈H₄O₄ =

$$(39) + (1) + (12 \times 8) + (1 \times 4) + (16 \times 4) = 204 \text{ g}$$

$$\text{eq/L KHP} = \frac{0.8000 \text{ g KHP}}{50 \text{ mL}} \times \frac{1,000 \text{ mL}}{1 \text{ L}} \times$$

$$\frac{1 \text{ mole KHP}}{204 \text{ g}} \times \frac{1 \text{ eq H}^+}{1 \text{ mole KHP}} = 0.078 \text{ eq/L}$$

Using the formula $C_1V_1 = C_2V_2$

$$0.078 \text{ eq/L} \times 50 \text{ mL} = N \text{ NaOH} \times 45.5 \text{ mL}$$

$$N \text{ NaOH} = 0.078 \text{ eq/L} \times \frac{50 \text{ mL}}{45.5 \text{ mL}} = 0.086 \text{ eq/L}$$

Skill Set 8 Process Control

1. The average flow in a treatment plant is 3.1 MGD. A chlorine residual of 4.0 mg/L is maintained and the effluent must be dechlorinated before discharging. If an excess of 0.5 mg/L of sulfur dioxide is required after dechlorination, how many lbs/day of sulfur dioxide must be added?

Molecular weights: O=16, S=32, Cl=35.5

$$1 \text{ gal} = 8.34 \text{ lbs}$$

First, convert the residual chlorine to be equivalent with sulfur dioxide.

$$\frac{64 \text{ mg SO}_2}{1 \text{ mmole SO}_2} \times \frac{1 \text{ mmole SO}_2}{1 \text{ mmole Cl}_2} \times \frac{1 \text{ mmole Cl}_2}{71 \text{ mg Cl}_2} \times$$

$$\frac{4.0 \text{ mg Cl}_2}{\text{L}} = 3.6 \text{ mg SO}_2/\text{L}$$

$$3.1 \text{ MGD} \times (3.6 \text{ mg SO}_2/\text{L} + 0.5 \text{ mg SO}_2/\text{L}) \times 8.34 \text{ lbs/gal} = 106 \text{ lbs SO}_2/\text{day}$$

2. A plant serving a city of 50,000 population has an influent settleable solids of 10 mL/L. If per capita contribution to the plant flow is 100 gallons/day, how much sludge is produced in the plant in cubic feet?

$$7.48 \text{ gal} = 1 \text{ cubic foot}$$

Calculate the flow in cubic feet (cu ft)/day using the population and the flow “per capita” or per person.

$$\frac{100 \text{ gal}}{\text{capita/day}} \times 50,000 \text{ capita} \times \frac{1 \text{ cu ft}}{7.48 \text{ gal}}$$

$$= 668,449 \text{ cu ft/day}$$

The settleable unit mL/L is the same as parts/1,000 parts (p per k-p). Calculate the daily volume of sludge as follows:

$$\frac{10 \text{ p}}{\text{k-p}} \times 668,449 \text{ cu ft} \times \frac{\text{k-p}}{1,000 \text{ p}} = 6,684 \text{ cu ft}$$



Section 5: Diagnostic Test

Skill Set	10	Supervision
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3. You are asked to determine the cost per test of the COD analysis. Use the following information:

The base salary of an analyst is \$30,000; employer paid benefits add 35% to the base salary; administrative overhead adds another 45% to the base salary; there are 10 paid holidays, 15 days paid vacation leave, and 12 days paid sick leave per year; the hourly salary is determined by dividing the monthly salary by 174. Each COD test requires an average of 20 minutes of labor from sample preparation to cleanup. Costs for chemicals, glassware, and equipment use average \$1.00 per test. Disposal costs average \$2000/year for reagents from 1,000 tests.

What is the total cost per test?

Determine the total cost of the analyst's time:

$$\frac{\$30,000 + (\$30,000 \times 0.35) + (\$30,000 \times 0.45)}{1 \text{ year}} = \$54,000/\text{year}$$

$$\frac{\$54,000}{\text{year}} \times \frac{1 \text{ year}}{12 \text{ mos}} \times \frac{1 \text{ month}}{174 \text{ hrs}} = \$25.86/\text{hr}$$

At 20 minutes analyst time per test:

$$\frac{\$25.86}{\text{hr}} \times \frac{1 \text{ hour}}{60 \text{ mins}} \times \frac{20 \text{ mins}}{\text{test}} = \$8.62/\text{test}$$

(analytical labor cost)

Disposal costs:

$$\frac{\$2,000}{1,000 \text{ tests}} = \$2.00/\text{test}$$

Reagent costs = \$1.00/test

Total costs per COD test:

$$\$8.62 + \$2.00 + \$1.00 = \$11.62$$



S e c t i o n 6

References

This section provides titles and information on primary and secondary references found useful in obtaining Grade III 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.

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

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

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
<http://owp.csus.edu>

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 (Order by Phone)
www.ntis.gov
Online version available at
www.epa.gov/clhtml/pubtitle.html

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 (Order by Phone)
www.ntis.gov



Section 6: References

40 CFR (CFR Title 40: Protection of the Environment)

Available online at:

www.epa.gov/epahome/cfr40.htm

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

Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, 4th Edition, August 1993

U.S. Environmental Protection Agency

EPA-600/4-90-027F

NTIS Order No: PB94114733

National Technical Information Service (NTIS)

5285 Port Royal Road

Springfield, VA 22161

800/553-6847 (order by phone)

www.ntis.gov

Online version available at

www.epa.gov/OST/WET/disk2/

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods

EPA Publication SW-846

Available online at

www.epa.gov/epaoswer/hazwaste/test/sw846.htm

OSHA Regulations (Standards – 29 CFR)

Available on-line at:

www.osha-slc.gov/pls/oshaweb

Available in print or on CD from:

Government Institutes, Inc.

4 Research Place, Suite 200

Rockville, MD 20850

301/921-2300

ELAP Program Statutes and Regulations

California Department of Health Services

Environmental Laboratory Accreditation Program

(ELAP)

Available online at

www.dhs.ca.gov/ps/ls/elap/elapindex.htm

Supervision: Concepts and Practices of Management, 8th Edition

Raymond L. Hilgert and Edwin C. Leonard, Jr.

ISBN 0-324-01389-2

Pub Date: 2001

South-Western College Publishing

5101 Madison Road

Cincinnati, OH 45227-1490

800/543-0487

www.swcollege.com

Supervisory Management in the Water/Wastewater Field

Self-Study Course

Michigan State University

3535 Forest Rd.

Lansing, MI 48910

800/356-5705

www.vu.msu.edu

This self-study course uses *Supervision: Concepts and Practices of Management* (listed above) as a supportive textbook.



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.

Analytical Chemistry: An Introduction
Douglas A. Skoog, F. James Holler,
Donald M. West and Stanley R. Crouch
ISBN 0030202930
Pub. Date: April 1999
Saunders College Publishing
Purchase through on-line booksellers
amazon.com or barnesandnoble.com

Principles of Instrumental Analysis, 5th Edition
Douglas A. Skoog, F. James Holler, and
Timothy A. Nieman
ISBN 0030020786
Pub. Date: September 1997
Saunders College Publishing
Purchase through on-line booksellers
amazon.com or barnesandnoble.com

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

Chemistry
John McMurry and Robert C. Fay
ISBN 0-13-057677-8
Pub Date: December 2000
Prentice-Hall
Pearson Education Company
One Lake Street
Upper Saddle River, NJ 07458-1813
www.pearsonptg.com

Microbiology, An Introduction
Gerard Tortora, Berdell Funke,
and Christine Case
ISBN 0-8053-7597-X
Benjamin Cummings (publisher)
Pearson Education Company
One Lake Street
Upper Saddle River, NJ 07458-1813
201/236-7000
www.pearsonptg.com

Brock's Biology of Microorganisms
Michael T. Madigan, John M. Martinko,
and Jack Parker
ISBN 0-13-081922-0
Prentice-Hall
Pearson Education Company
One Lake Street
Upper Saddle River, NJ 07458-1813
www.pearsonptg.com

The Chemical Analysis of Water
ISBN 0-85186-797-9
Springer-Verlag New York Inc.
175 Fifth Avenue
New York, NY 10010
800-777-4643
www.springer-ny.com

*Water Supply Operations (WSO) series Part V:
Basic Science Concepts and Applications,
Textbook*
ISBN 0-89867-796-3
Catalog No: 1959
American Water Works Association (AWWA)
6666 W. Quincy Avenue
Denver, CO 80235
303-794-7711
www.awwa.org

*Chemical Technicians' Ready
Reference Handbook*
Gershon Shugar and Jack Ballinger
ISBN 0070571864
Pub Date: June 1, 1996
McGraw-Hill Professional Publishing Group
P.O. Box 548



Section 6: References

Blacklick, OH 43004-0548
800-722-4729
www.books.mcgraw-hill.com

*California Environmental Law Handbook,
11th Edition*
ISBN 0-86587-677-3
John C. Mueller, Patrick Dennis (Editors)
Available online through various booksellers

*Effective Supervisory Practices: Better Results
Through Teamwork*
ISBN: 0-87326-176-3
ICM International
City/Council Management Association
800-745-8780
www.icma.org

*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



A p p e n d i x A

You and Wastewater Math

by Cheryl Ooten, Mathematics Professor, Santa Ana College, Ooten_Cheryl@rscsd.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:

- Your math skills
- Your attitudes toward math
- 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.



Appendix A: You and Wastewater Math

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:

- Math Placement Testing
- Math Courses
- Water Utility Science Courses
- Math Anxiety Reduction Courses
- 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:

- Technical Certification Training Classes and Annual Conferences
- 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:

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



Appendix A: You and Wastewater Math

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. $\text{Volume} = (200 \text{ ft})(50 \text{ ft})(12 \text{ ft}) = 120,000$ 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.

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

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



Appendix A: You and Wastewater Math

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.

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

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

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

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.)



Appendix A: You and Wastewater Math

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:

- bodily/kinesthetic
- verbal/linguistic
- naturalist
- logical/mathematical
- visual/spatial
- interpersonal
- intrapersonal
- 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).



Glossary of Management and Supervision Terms

Acknowledgement/Credit: Many of the terms and definitions found in this glossary have been taken from the 6th Edition of *What Every Supervisor Should Know*, by L. Bittle and J. Newstrom. These definitions are reproduced, in part or in whole, with permission of The McGraw-Hill Companies. Most of the remaining terms and definitions have been taken from the 1st Edition of *Utility Management: A Field Study Training Program*, prepared by L. Lindsay for the California State University Sacramento Foundation. These definitions are copyrighted and reproduced by permission of the Office of Water Programs, CSUS.

Ability: The quality of being able to perform; a natural or acquired skill or talent.

Accident: Unplanned or uncontrolled event in which action or reaction of an object, material, or person results in personal injury.

Accountability: Non-assigned liability for the manner in which an organizational obligation held by a supervisor is discharged, either personally or by subordinates.

Active listening: Conscious process of securing information through full attention, intent listening, and alert observation.

Affirmative Action: In-company program designed to remedy current and future employment inequities.

Americans with Disabilities Act (ADA): Prohibits employment discrimination based on a person's mental or physical disability.

Appraisal interview: Meeting held between a supervisor and an employee to review performance rating and, using the evaluation as a basis, to discuss overall quality of work performed, and methods of improvement, if necessary.

Arbitration: Labor dispute or employee grievance settlement by an impartial umpire selected through mutual agreement by organization and worker's union.

Attrition: Gradual reduction in a work force due to natural events and causes, (e.g., retirement, death, resignation), as opposed to planned reductions (e.g., discharges, layoffs, early retirement).

Authority: The power needed to do a specific job, or to carry out one's responsibilities, usually handed down from immediate bosses or superior.

Body language: Nonverbal body movements, facial expressions and/or gestures that project or reveal underlying attitudes and sentiments.

Budget: Plan, or forecast, especially of allowable expenses in operation of a department.

Budgetary control: Planning and reporting system incorporating standards for operating conditions and results, as well as costs and expenses, within a single document.

Certification Exam: An examination administered by a state or professional association that candidates take to indicate a level of professional competence.

Chain-of-Command: Formal channels in an organization that distributes authority from top down.

Code of Federal Regulations (CFR): A publication of the United States Government that contains all of the proposed and finalized federal regulations, including environmental.

Collective bargaining: Process of give-and-take engaged in by management and collective employees representatives to reach formal, written agreement about wages, hours, and working conditions.

Communication process: Giving and receiving information and understanding, such as between a supervisor and an employee, leading to a desired action or attitude.



Appendix C: Glossary of Management and Supervision Terms

Computerized Maintenance Management System (CMMS): A computerized system to assist with the effective and efficient management of maintenance activities through application of computerized elements including: work orders, routine standard jobs, bills of materials, application parts, and lists of numerous other features.

Competition: Relatively healthy struggle among individuals or organizational groups to excel in striving to meet mutually beneficial goals.

Conflict: Disruptive clash of interests, objectives, or personalities, between individuals or groups within an organization.

Control: To exercise authoritative influence over; the authority or ability to manage and/or direct.

Cost-benefit analysis: Technique for weighing pros and cons of alternative actions, in which both intangible benefits as well as costs are assigned dollar values.

Cost variance report: Listing of allowable expenses compared with actual expenses incurred.

Decision-making: Part of the problem-solving process that entails evaluation of alternative solutions and a choice of an effective action.

Delegation: The act in which power is given to another person in the organization to accomplish a specific job.

Differential treatment: The act of treating a minority or protected group member differently from other applicants or employees.

Discipline: Imposition by management—in such a manner as to encourage more constructive behavior—of a penalty on an employee for infraction of a rule, regulation, or standard.

Discrimination: Managerial action or decision based on favoring or disfavoring one person or group member over another on the basis of race, color, ethnic or national origin, sex, age, handicap, Vietnam era war service, or union membership.

Division of work: Principle that performance is more efficient when a large job is broken down into smaller, specialized tasks.

Due process: Employee's legal entitlement to a fair hearing, usually before an impartial party and with appropriate representation, before discipline can be metered out.

Employee turnover: Measure of how many people come to work for an organization and do not remain employed by that organization, for whatever reason.

Ergonomics: Study of how workers react to their physical environment; used in design of more comfortable and productive workstations.

Equal Employment Opportunity (EEO): System of organizational justice, stipulated by law, that applies to all aspects of employment; intended to provide equal opportunity for all members of the labor force.

Feedback: Process of relaying measurement of actual performance back to an individual or unit, so that action can be taken to correct, or narrow, the variance.

Gantt Chart: Chart that enables a planner to schedule tasks in the most productive sequence, and that also provides a visual means for observing and controlling progress.

Geographical Information System (GIS): An integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, images, and other resource data that are geographically referenced.

Grievance: Job-related complaint stemming from an injury or injustice, real or imaginary, suffered by an employee, for which relief or redress from management is sought.

Grievance procedure: Formalized, systematic channel for employees to follow in bringing complaints to the attention of management.

Hazard: Potentially dangerous object, material, condition, or practice present in the workplace, to which employees must be alert and from which they must be protected.

Hostile Work Environment: Conditions such as harassment, offensive speech, or unwelcomed conduct, that are severe or persuasive enough to create an abusive, antagonistic, or inhospitable work place.

Information Management System (IMS): System comprised of data processing devices, programs, and people, that collects, analyzes, exchanges, and delivers information to an organization in such a manner as to aid managers in making the best possible decisions.



Appendix C: Glossary of Management and Supervision Terms

Information: Dates, past or present facts, observations, or conclusions, collected in numbers and words that have been selected, arranged, and analyzed (processed) to make them useful for a specific human (managerial) activity.

Injury Illness Prevention Plan: Plan required by California Senate Bill (SB) 198 to establish, implement, and maintain an effective program helping assure employee safety while on the job. It includes eight elements: management assignments and responsibilities, safety communications system with the employees, system assuring employee compliance with safe working practices, scheduled inspections and compliance system, accident investigation, health and safety training and instruction, and record-keeping and documentation.

Job breakdown analysis: Segmentation of a job into key elements, or steps, which require an employee to perform, induce, or supervise an action that advances work toward completion.

Job evaluation: Systematic technique for determining job worth, compared with other jobs in an organization.

Just cause: Reason for a disciplinary action that is accurate, appropriate, well founded, deserved and meets the test of prior notification of unacceptable behavior and its penalty.

Knowledge: Information that can be learned from reading, listening to an expert, or keenly observing a situation; often a prerequisite to skill development.

Management: Process of obtaining, deploying, and utilizing a variety of essential resources in support of an organization's objectives.

Management by objectives (MBO): Planning and control technique where supervisors and their immediate superiors agree on goals to be attained and/or standards to be maintained.

Management development: Systematic program for improving the knowledge, attitudes, and skills of supervisors and managers.

Management principles: Set of guidelines established for carrying out the management process.

Management process: General sequence of five unique functions—planning, organizing, staffing, directing or activating, and controlling—provided by managers for any organization.

Manager: An individual who plans, organizes, directs, and controls work of others in an organization.

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

Mentor: Knowledgeable, often influential, individual who takes an interest in, and advises, another person concerning that person's career.

Morale: Measure of the extent of voluntary cooperation—as well as the intensity of desire—to meet common work goals, as demonstrated by an individual or work group.

Motivation: Process that impels someone to behave in a certain manner in order to satisfy highly individual needs.

Networking: Informal process of getting to know, and create confidence among others who—through mutual exchange—help advance one's career.

Non-managerial employees: Workers who receive direction from managers, who perform specific, designated tasks, and who are responsible only for their own performance.

Organizing: Deciding who does what work and delegating authority to the appropriate person.

Organization: Structure derived from systematically grouping tasks to be performed, and from prescribing formal relationships that strengthen the ability of people to work together more effectively.

Performance appraisal: Formal and systematic evaluation of how well a person performs work and fills an appropriate role in the organization.

Penalty: Punishment or forfeiture imposed as discipline by management on an employee.

Personality: An individual's unique way of behaving and of interpreting events and the actions of others.

PERT Chart: Graphic technique for planning a project in which a large number of tasks must be coordinated, by showing the relationship between tasks and critical bottlenecks that may delay progress towards completion.



Appendix C: Glossary of Management and Supervision Terms

Policies: Broad guidelines, philosophy, or principles which management establishes and follows in support of organizational goals.

Procedures: Methods, prescribed by management, for the proper and consistent forms, sequences, and channels to be followed by individuals and units of an organization.

Productivity: Measure of efficiency that compares operational output value with cost of resources used.

Progressive Discipline: Providing increasingly harsh penalties for substandard performance or broken rules, as the condition continues or the infraction is repeated.

Quid pro quo: An equal exchange or substitution; e.g., as applied to sexual harassment, when a supervisor threatens to fire or not promote an employee if they do not provide sexual favors in return.

Regulations: Special rules, orders, and controls set forth by management, restricting the conduct of units and or individuals within an organization.

Reprimand: Severe expression of disapproval or censure by management of an employee, usually written as well as oral, and retained in an employee's personal file.

Responsibilities: Those duties one is held accountable for.

Responsibility: Duty or obligation to perform a prescribed task or service or attain an objective.

Reverse discrimination: Notion that implementation of affirmative action deprives qualified members of non-protected groups of their rightful opportunities.

Satisfaction: State that exists when motivating factors—such as interesting and challenging work, full use of one's capabilities, or recognition for achievement—are provided.

Schedules: Detailed assignments dictating how facilities, equipment, and/or individuals are used, according to times and dates, in accomplishment of organizational objectives.

Sexual Harassment: Unwanted sexual advances, requests for sexual favors, or other visual, verbal, or physical conduct of a sexual nature, which is conditioned upon an employment benefit, unreasonably interferes with an individual's work performance, or creates an offensive work environment.

Skill: The capacity to perform a job related action by blending relevant knowledge and physical or perceptual ability.

Specification: Collection of standardized dimensions and characteristics pertaining to a product, process, or service.

Stereotype: Characterization of an individual on the basis of a standardized, oversimplified view of characteristics believed to be held in common by a group to which the individual is assumed to belong.

Supervisor: Manager who is in charge of, and coordinates, activities of a group of employees engaged in related activities within a department, section, or unit of an organization.

Suspension: Temporary removal by management of an employee privilege (such as the right to report to work and receive pay for it) until proper actions have been determined and imposed.

Time budget: Charting technique for planning the systematic distribution of a supervisor's time.

Theory X: Negative approach to human relations in which a supervisor presumes most people don't like to work and thus need to be pushed or threatened.

Theory Y: Positive approach to human relations whereby a supervisor presumes that, given meaningful work, most people will try hard to achieve, especially when there is an opportunity to improve their self-regard.

Tolerance: Permissible deviation, or variance, from a standard.

Type A individual: Person characterized by high standards of achievement and an urgency to attain them, who is especially susceptible to stress.

Unfair labor practices: Practices engaged in by management or labor unions that are judged by federal labor law to be improper, especially when they interfere with the right to organize or when they discriminate against labor union activities.



Appendix C: Glossary of Management and Supervision Terms

Unity of Command: Principle that each individual should report to only one boss.

Unity of Direction: Principle that there should be a single set of goals and objectives that unites the activities of everyone in an organization.

Variance: Gap, or deviation, between actual performance, condition, or result and a standard of expected performance, condition, or result.

Warning: A reprimand so worded as to give formal notice to an employee that repetition of a particular form of unacceptable behavior will draw a penalty.

Worker's compensation: Financial reparations or awards granted by an employer to an employee who has suffered an on-the-job injury or illness that is judged to have permanently restricted the employee's earning capacity.



A p p e n d i x D

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	DWF	dry weather flow
BTU	British thermal unit	DWR	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 D: 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	OOC	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 D: 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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