Certification Examination

Study Guide

Laboratory Analyst Grade I

CALIFORNIA WATER ENVIRONMENT ASSOCIATION

Grade I Laboratory Analyst Study Guide

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California Water Environment Association

Grade I
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 encourage you to identify and utilize the other resources in preparing for your next test.

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Section 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 (with two parallel specialties of Electrical/ Instrumentation, and Mechanical Technologist)
- Laboratory Analyst
- Collection System Maintenance
- Environmental Compliance Inspector
- Industrial Waste Treatment Plant Operator
- 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 a candidate's 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 I Laboratory 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!

Section 2

Certification Program Information and Policies

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

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

Technical Certification Program History

TCP was created to offer multilevel technical certification for individuals employed in the water quality field. Tests are written by vocational specialists and administered throughout the year in six different disciplines: Collection System Maintenance, Environmental Compliance Inspection, Laboratory Analysis, Plant Maintenance (Electrical/Instrumentation and Mechanical Technologist), 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 with specialized certificate programs for Collection System Maintenance, Plant Maintenance, 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 Operator.

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

Certification Process

To become certified, *all applicants* must complete the Application for Technical Certification, pay the application fee, have suitable experience and education, and pass the computer-based test. Application instructions and fee schedules are listed on the application. After applications are received at the CWEA office, applicant information is compiled in a database, and reviewed by CWEA staff and Subject Matter Experts for the respective vocation applied for. If approved, the applicant will receive an eligibility. 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 official test results. Those who pass the exam, are mailed certificates and wallet cards.

Test Administration

Test Dates and Sites

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

Test Site Admission

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

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

Test Security

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

Test Rescheduling and Cancellation

To reschedule your application you must submit a written request (a letter stating that you wish to postpone) to postpone to the adjacent testing window. You may only reschedule once without a fee. Additional reschedule requests will require a $40 fee. There are no exceptions to this policy.

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

Test Result Notification

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

Issue of Certificate/Wallet Card

Certificates and wallet cards are issued to all candidates who pass the test. Certificates are mailed about two to three weeks after result notifications letters 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 retest to regain certification. Renewal notices are mailed to certificate holders two months before the due date. It is the responsibility of certificate holders to ensure the certificate(s) remains valid. Continuing education will be required for renewal after 2001.

Accommodations for Physical or Learning Disabilities

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

Test Design and Format

Test Design

All certification tests are designed to test knowledge and abilities required to perform the Essential Duties listed at the end of the 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 on-site visits of over 31 water and wastewater agencies, interviews with 110 water and wastewater professionals, and analysis of more than 300 job specifications. All research was conducted under the guidance of the TCP Committee, vocational sub-committees, and CWEA staff. All test questions are designed to measure at least one area of knowledge or ability that is required to perform an essential duty.

Test Delivery Mechanism

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

Test Format

All TCP tests are in multiple choice format (see the sample test questions in this booklet 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 their 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 rate 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 willanswer 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.

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 varies, 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. Candidate feedbacks will be evaluated and appropriate adjustments will be made to the test content. Candidates submitting feedback will not be contacted in regards to the appeal.

Qualifying for the Test

There are no experience or education requirements for Grade I Lab Analyst Certification. Completing the Application for Technical Certification, paying the appropriate application fee, and passing the computer-based test are the only requirements. It is, however, ***recommended*** that Grade I candidates have at least one year of experience working as a Lab Analyst performing the *Essential Duties*.Many candidates without the recommended experience have difficulty successfully completing the written test. The Essential Duties include:

- Routine laboratory analysis; including chloride, conductivity, alkalinity, pH, temperature, total hardness, turbidity, chlorine residual (free and combined), dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, solids (total, dissolved, suspended, volatile, non-volatile), settleable solids; and microbiological analyses, in cluding sterile techniques, total and fecal coliform (MPN), confirmed test, media preparation, and total plate count.
- Maintaining routine documentation, including worksheet/log sheet entries, sample documentation, and chain-of-custody forms. Record data precisely and accurately.
- Operating and maintaining test equipment such as UV/visible spectrophotometer, dissolved oxygenmeters, pH meters and turbidimeter. Performs routine calibration.
- Collecting samples of wastewater, sludge, receiving water and industrial waste in accordance with established laboratory procedures.
- Preparing, sorting, washing, decontaminating, sterilizing and storing lab glassware.
- Preparing chemical reagents and bacteriological culture media.
- Routine quality control checks for all reagents, media and data generated specific to subject matter.

Section 3

Skill Sets

The Grade I Laboratory Analyst (Lab Analyst) has many responsibilities. In smaller laboratories, the Lab Analyst may have duties that, in addition to chemical analysis, include microbiological analysis. In larger laboratories, these two branches of analytical work are often separated into two different work groups where staff specializes in specific analysis. Some laboratories are staffed by operators who perform process control analysis for immediate plant operations, while sending NPDES-required analysis to a certified commercial laboratory. Other laboratories employ three to seven chemists and a microbiologist, while still other laboratories may have a staff exceeding one hundred employees. The Lab Analyst's responsibilities may range from sampling and shipping samples off site, to running every analytical determination the laboratory is certified for, to specializing in one branch of chemistry or even one instrument.

Regardless of the size of the laboratory, or the specific duties assigned, the Lab Analyst has the responsibility to master certain laboratory concepts. These concepts include:

- Communication
- Safety
- Sampling Techniques
- Equipment Monitoring
- Glassware Washing
- Recordkeeping
- Documentation
- Mathematics
- Chemistry
- Microbiology
- Quality Control
- Perform Analyses
- Operate and Maintain Basic Laboratory Equipment
- Methods for Analyses
- Analyze for Solids and Microorganisms

This section presents a description of the practical skills necessary to achieve and maintain a career as a Grade I Laboratory Analyst. Everyday duties, from laboratory safety to relationships with co-workers to analyses techniques, are discussed here.

Table 3-1, presented at the end of this section, cross-references each skill set with a specific chapter, section, or page of applicable references to assist the candidate better understand 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 referenced by EPA regulations and therefore is the basis for developing the TCP test questions.

Skill Set 1 Work Habits

It is important to maintain effective communication with customers, co-workers, and supervisors. The Lab Analyst should be able to speak and write in the English language at a comprehensive level of proficiency. Job skills also require the ability to communicate orally and to listen effectively, to give and receive instructions to and from co-workers, write daily log reports, and accomplish all other tasks requiring communication skills. Successful communication requires being courteous, providing answers to questions when sure of the response, and having the ability to adeptly refer a person to a supervisor if unsure of the proper answer.

Skill Set 2 Safety

Safety is always a concern for Lab Analysts, both in the laboratory and in the field. Lab Analysts are required to perform essential duties in a safe manner. Field sampling requires awareness of hazards in the outdoor environment. Safety within the laboratory encompasses numerous aspects. Knowledge of laboratory hazards and proper safety precautions and procedures, including personal protective equipment and chemical hygiene, is critical. Also of utmost importance is the ability to follow established safe working practices.

Lab Analysts should be aware of common laboratory hazards, which include physical, chemical and biological dangers; the use and maintenance of personal protective equipment; and the use of laboratory equipment such as hoods and fire extinguishers. Other important things to be mindful of include a knowledge of basic laboratory safety techniques such as correct use of gas cylinders, cleaning up acid spills, handling acids and bases and safe storage of chemicals. Conscientious Lab Analysts will also be familiar with OSHA's Lab Right-to-Know Standard, which includes the Chemical Hygiene Plan, Material Safety Data Sheet (MSDS) format, and chemical laboratory information. Knowledge of basic first aid is also helpful.

Safety in the microbiological laboratory shifts from chemical hazards to health hazards. To prevent contamination of analytical work, as well as to safeguard the health of Lab Analysts, the laboratory working area is frequently disinfected. Physical hazards, such as high temperature steam release from an autoclave, require cautious work habits.

Skill Set 3 Sampling

Sampling is an important task often assigned to Lab Analysts. Lab Analysts will collect samples of wastewater, sludge, receiving water and industrial waste in accordance with established laboratory procedures. Standard physical, chemical and biological tests are performed on treated and polluted water, potable water, industrial and domestic wastewater, and related materials. Such tests are conducted using proper sampling and preservation techniques.

Proper sample protocol requires attention to detail that starts before leaving the laboratory. The correct type of container must be properly washed, rinsed or sterilized for the analyte of interest. Preservatives or dechlorinating chemicals may be required. Representative sampling techniques are required, regardless if the sample is a grab or a composite sample. Lab Analysts may be required to combine individual samples to create a composite based on sample flow. Lab Analysts are responsible for maintaining routine documentation, including worksheet/log sheet entries, sample documentation, and chain-of-custody forms. Data must be recorded precisely and exactly so that accurate and complete laboratory records can be maintained.

Sampling for microbiological analysis is similar to sampling for chemical analyses with two distinct differences. First, sampling equipment must be sterilized prior to use and sterile sampling technique must be used. Second, the analytical method may require that the sample be dechlorinated to protect the bacteria population from exposure to chlorine. A series of questions Lab Analysts should ask to assure familiarity with sampling protocol are:

- What type of container is used (glass, plastic, autoclavable plastic, or vial)?
- How should the container be washed and rinsed (soap and water, Freon, acid)?
- Does the sample require preservatives? Chemical or temperature?
- How should the sample be stored in transit and in the laboratory?
- What is the holding time of the sample?
- How should the sample be labeled?
- How should the chain-of-custody be filled out?

For microbiological samples:

- How should the container be sterilized (time, temperature and temperature ranges, pressure)?
- Will the sample require dechlorination?
- What is the declorination agent?

- What sampling technique is appropriate for microbiological samples (such as representative stream flows with sterile technique)?

Safety is an imperative part of sampling. Safety rules and regulations are critical for all Lab Analysts to learn and follow.

Skill Set 4 Recordkeeping and Lab Maintenance

Lab Analysts are frequently assigned the task of routine equipment monitoring and laboratory maintenance. This task includes monitoring laboratory water for contamination, refreshing desiccant in the desiccators, and checking safety equipment, such as fume hood flow, and eye wash stations or showers.

Temperature logs are required for ovens, incubators, water baths, autoclaves, and refrigerators. Thermometers used to monitor equipment must be calibrated against National Institute of Standards and Testing (NIST) standards. Balances, pH meters, and conductivity meters should be calibrated daily before use. Media logs track date of media purchase, storage conditions, and so forth. Lab Analysts have knowledge of safe chemical storage, and each reagent container in the laboratory should be labeled appropriately. Lab Analysts also complete routine documentation, including worksheet/log sheet entries, sample documentation, and chain-of-custody forms.

Lab Analysts may also be responsible for washing, sterilizing, and acid-or-solvent rinsing glassware, sample containers and other laboratory ware. The ability to monitor and operate laboratory equipment and maintain the laboratory in an orderly fashion is part of this task.

Skill Set 5 Mathematics and Chemisrty

Chemistry requires a foundation of mathematical ability. Mathematics required in day-to-day laboratory operations is simple, yet still needs to be mastered. A knowledge of basic wastewater mathematical calculations related to laboratory analysis, including significant figures, is necessary.

Unit factor mathematics are used to determine weights or volumes required to prepare specified normality or molarity solutions. The preparation of solutions also requires knowledge of atomic weights, gram molecular weights, and chemical symbols for elements and compounds. Lab Analysts must also understand chemical principles of acids and bases, precipitation, and other basic chemistry concepts.

Lab Analysts will be required to use specific formulas given in the analytical method to determine results from analytical data, such as alkalinity, residual chlorine, hardness, and BOD results. Other examples of the use of mathematical formulas may include solids calculations, solution densities, percents, flow proportional compositing, and temperature conversions.

In reporting data, it is important that Lab Analysts possess the ability to correctly analyze and interpret standard laboratory test results. Results are expressed in terms of units (e.g. mg/L, ppb, percent, NTU or pH units), constituent measured (e.g. volatile acids are reported as mg/L of acetic acid, alkalinity is reported as mg/L of calcium carbonate), and the correct number significant figures.

Skill Set 6 Reagents and Media Preparation

The mathematics required of Lab Analysts are most often employed in the preparation of laboratory solutions. These solutions require knowledge regarding molarity and normality, molecular and formula mass, and dilutions. Lab Analysts must possess the ability to read, understand and follow proper procedures in preparing reagents and media.

Standardization is often required of a freshly prepared reagent. This involves the preparation of a primary standard solution from dry reagent and titration of the solution in question by the primary standard. Standardized reagents are appropriately labeled, including reagent name, date prepared, analyst initials, and concentration in normality, molarity, or ppm. A log/work book is maintained for all standardized solutions prepared in the laboratory.

Lab Analysts are required to know the methods for analyzing various bacteria. Each method specifies the media used and its preparation. Questions Lab Analysts may ask to assure familiarity with media preparation are:

- What media is used?

- ❑ What is the name of the media?
- ❑ What organisms are the media being used for?
- ❑ How is the dry media stored (conditions and time)?
- ❑ How is the prepared media stored (conditions and time)?
- ❑ How is the media prepared (cooking temperature and range, time, pressure)?
- ❑ What type of labware is used (pour plates, tubes)?
- ❑ What are the quality control checks performed on the media?

Skill Set 7 Chemical Analysis Techniques

Lab Analysts must be able to utilize proper laboratory technique to perform work in an accurate manner. Many basic laboratory skills depend on understanding the importance of gravimetric determination, filtration techniques, and titrations. Solids analysis requires gravimetric techniques and calculations based on the weight of the sample as it is processed through different stages of filtration and drying. The sample drying temperature is specified in the test method. Titrations involve the use of standardized titrants, accurate measurement of volumes, knowledge of chemical reactions, indicators (color change or potentiometric), and calculations from accurately recorded laboratory data.

Skill Set 8 Laboratory Instrumentation

Lab Analysts use a variety of laboratory instruments and equipment. These may include ultraviolet (UV)/visible light spectrophotometer, dissolved oxygen meters, pH meters, turbidimeters, and conductivity meters. Routine calibration of these instruments is also the duty of Lab Analysts. Questions Lab Analysts may ask to assure familiarity with the instrument and its use are:

- ❑ What is the name of the instrument?
- ❑ What are the components of the instrument and its accessories (e.g. probes)?
- ❑ What is the theory behind the instrument?
- ❑ What is the theory behind the accessories (e.g. probe)?
- ❑ How is the instrument calibrated?
- ❑ If any standards are required, how are the standards prepared and used?
- ❑ How are the results detected and then interpreted?
- ❑ How are the instrument and its accessories maintained?

Skill Set 9 Analytical Chemistry Methods

Standard Methods for the Examination of Water and Wastewater (*Standard Methods*) is a compilation of many methods, most of which are approved for wastewater analysis by the EPA. EPA approved methods must be followed in detail, unless the laboratory has submitted a request for modification. Test methods for the following determinations are found in *Standard Methods*:

- ❑ Turbidity
- ❑ Alkalinity
- ❑ Total hardness
- ❑ Conductivity
- ❑ Solids
- ❑ Temperature
- ❑ Residual chlorine
- ❑ Chloride
- ❑ pH
- ❑ DO
- ❑ BOD
- ❑ COD

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

- ❑ What is the name of the method?
- ❑ What type of test is it (colormetric, titrimetric, gravimetric, instrumental)?
- ❑ What is the basic summary of the method?
- ❑ What is the basic sequence of the method?
- ❑ What is being measured and what is being reported? (e.g., In the BOD test, dissolved oxygen is being measured, but the calculated BOD is reported. In the hardness test, calcium and magnesium are measured, but the calculated hardness is reported.)

- What are the reagents and what are their functions (e.g. Standards, titrants, color-reacting reagents)?
- What is the chemical theory behind how the chemicals are reacting?
- Are there special chemical or other safety hazards?
- What is the sample protocol (preservation, containers, holding time)?
- Is any sample pretreatment required?
- Are there any interferences that affect the method? How are they treated?
- Are there sources and treatments of erroneous test results?
- What are the limits of the method (e.g. concentration, linear range)?
- Are there restrictions on the test? (e.g. BOD must deplete greater then 2 with greater than 1 remaining mg/L DO.)
- How are the results calculated from laboratory data?
- How are the laboratory results interpreted?

Regarding titrations:

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

Regarding standard curves:

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

Skill Set 10 Microbiological Analysis

Common microbiological analysis performed by Lab Analysts include MPN including Presumptive Test, Confirmed Test, and Completed Test; total and fecal coliform using the membrane filter (MF) technique; and total plate count or heterotrophic plate count. Questions that Lab Analysts may ask to assure familiarity with microbiological analysis are:

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

Skill Set 11 Quality Assurance

Lab Analysts must maintain routine documentation, including worksheet/log sheet entries, sample documentation, and chain-of-custody forms. Data must be recorded precisely and accurately. Lab Analysts need to be familiar with many terms that are used in statistics. These include terms such as accuracy, precision, standard deviations, mean, median, and range.

The accuracy and precision of laboratory analysis is confirmed through the practice of quality control. Quality control includes the use of blanks, duplicates, and spikes.

Lab Analysts are also responsible for assuring the proper number of significant figures and proper mathematical calculations are used.

Table 3-1 Grade I Laboratory Analyst					
Primary References[a]					
No.	Skill Set	Standard Methods 18th Edition	Operation of Watsewater Treatment Plants	Water and Wastewater Laboratory Techniques	Handbook for Analytical Quality Control in Water and wastewater laboratories
1	Work Habits				
		Chapter 6			
2	Safety				
		1090 CA-J (especially A, B, C)	Chapter 14 All except 14.2, 14.5 and 14.6 Chapter 16.2		Chapter 14 Pages 14-1 to 14-17
3	Sampling				
		1060: A, B, C Table 1060:I	Chapter 16.3		Chapter 10 Page 10-1
4	Recordkeeping and Lab Maintenance				
		1080, Table 1080:I	Chapter 16.0, 16.1	Chapter 1 especially pages 13-16	Chapter 2
5	Mathematics and Chemistry				
		1050	Chapter 16.11	Chapter 9 Pages 169-175	
6	Reagents and Media Preparation				
		Older Editions Part 102 Sections 1, 3, 4, 5		Chapter 6 and 7 Appendix A and B Pages 100-108 Pages 109-111 Pages 191-195 Pages 197-201	Chapter 5
7	Chemical Analysis Techniques				
				Chapter 8 Pages 137-165	Chapter 3

[a] **Complete reference information given in Section 6**

Table 3-1 Grade I Laboratory Analyst (continued)					
Primary References[a]					
No.	Skill Set	Standard Methods 18th Edition	Operation of Watsewater Treatment Plants	Microbiological Methods for Monitoring the Environment	Water and Wastewater Laboratory Techniques
8	Laboratory Instrumentation				
8.1	**Turbidimeter**	2130, A, B			Chapter 8 Page 160
8.2	**UV/VIS Spectrophotometer**		Chapter 16.17		Chapter 8 Pages 155-160
8.3	**pH and Ion Selective Electrodes**	4500-H+			Chapter 8 Pages 165-167
8.4	**Dissolved Oxygen Meter**	4500-O, A , C, G, G.1 a, b, c			
8.5	**Conductivity**	2510 A, B	Chapter 16.5-14		
9	Analytical Chemistry Methods				
9.1	**Turbidity**	2130 A, B	Chapter 16.5-19		
9.2	**Alkalinity**	2320 A, B	Chapter 16.5-2		
9.3	**Total Hardness**	2340 A, C			
9.4	**Solids (TS, TDS, TSS, Settleable**	2540 A, B, C, D, E, F	Chapter 16.42, 16.43, 16.44, 16.5-13		
9.5	**Temperature**	2550 A, B	Chapter 16.5-17		Chapter 5 Pages 91-100
9.6	**Residual Chlorine (Free, Combined)**	4500-CL A, B, D	Chapter 16.5-5		
9.7	**Chloride**	4500-Cl-A, B, C, D (especially B)	Chapter 16.5-4		
9.8	**pH**	4500-H+ A, B	Chapter 16.5-8		
9.9	**Dissolved Oxygen**	4500-O A, C	Chapter 16.5-7		
9.10	**BOD**	5210 A, B	Chapter 16.5-3		

[a] **Complete reference information given in Section 6**

Table 3-1 Grade I Laboratory Analyst (continued)						
		Primary References[a]				
No.	Skill Set	Standard Methods 18th Edition	Operation of Watsewater Treatment Plants	Microbiological Methods for Monitoring the Environment	Water and Wastewater Laboratory Techniques	Handbook for Analytical Quality Control in Water and wastewater laboratories
10	Microbiological Analysis					
10.1	**Safety**	1090, A, B, C 1060, A.2	Chapter 16.2	Part V, C		
10.2	**Sampling**	9030, B.18 9060, A, B		Part II, A.1 Part II A.6		
10.3	**Documentation**	1060 B 9030 B		Part II, A.3, A.4, B.1		
10.4	**Glassware and Laboratory Maintenance**	9040, 9030, 9020		Part II, B.1, B.2, B.3 Part V, C.4.3		
10.5	**Laboratory Equipment**	9020 A, B.2		Part II, B 1.3, 3.2, 3.1		
10.6	**Media Preparation**	9050 A, C 9215 A.6 9221 B 1, 2, 3 9221 E.1		Part II, B.4 (all) Part II, B.5 (5.3.1, 5.3.2, 5.3.3, 5.3.4) Part II B.5, 1.5		
10.7	**MPN**	9221 A, B, C	Chapter 16.5-6	Part III, B, B.1, B.4		
10.8	**Fecal Coliform**	9221 E	Chapter 16.4-6	Part III, C C.1, C.2, C.5		
10.9	**Heterotrophic (or Standard) Plate Count**	9215 A, B, C		Part III, A		
11	Quality Assurance					
11.1	**Chemistry**	1010 (especially C) 1020 (B.2, 4, 6)			Chapter 10 Pages 177-188	Pages 177-188
11.2	**Microbiology**	9020 Table 9020:I		Part II, B.6 Table IV-A-3 Part IV, A.7		
[a] Complete reference information given in Section 6						

Section 4

Test Preparation

This section provides tips on how candidates should prepare for the test, information on questions that will be on the test, and solutions to math problems. Information included on the test, as well as a table of units and sample math problems are attached.

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 examination 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 subject areas of the examination that are not being performed on a day-to-day basis.

While using this study guide, be sure to understand the answers to all the questions. Discuss test questions with others. Not only is this a good study technique, it is also an excellent way to learn.

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 examination. Refer to Section 3, Skill Set for a list of topics that will be covered on the test.

It is not necessary to memorize all formulas and conversion factors. A sheet is provided with the examination to assist in this area (see Table 4-1).

Candidates should obtain the primary reference and training material listed in Section 6, References. Any material not available at their workplace can be obtained from the sources listed in Section 6.

Multiple Choice Questions

The test is written entirely in the objective (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 given. 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

4. Never make a choice based on the frequency of the previous answer. 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.

Table 4-1 Laboratory Analyst General Information

Element Symbols and Atomic Weights*

Element	Symbol	Atomic Weight
Aluminum	Al	27
Arsenic	As	75
Calcium	Ca	40
Carbon	C	12
Chlorine	Cl	35.5
Chromium	Cr	52
Copper	Cu	63.5
Hydrogen	H	1
Iodine	I	126.9
Magnesium	Mg	24
Nickel	Ni	59
Nitrogen	N	14
Oxygen	O	16
Phosphorus	P	31
Potassium	K	39
Silver	Ag	108
Sodium	Na	23
Sulfur	S	32

*Source: *Standard Methods*, 18th Edition

Conversion Factors

1 gal. = 834 lbs
1 cu. ft. = 7.48 gal.
1 lb. = 454 grams

Abbreviations

AA: Atomic Absorption
AE: Atomic Emission
mL: Mililiter
mg: Miligram
L: Liter
g: Gram
GC: Gas Chromatography
F: Formal
M: Molar
N: Normal
MGD: Million Gallons per Day

MPN Index (10 mL, 1.0 mL, 0.1 mL)
5 - 3 - 0 80
5 - 5 - 3 900
5 - 5 - 5 >1600

5. Reject answers that are obviously not right and choose from remaining answers.

   Example

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

   a. diameter
   b. circumference
   c. chord
   d. radius

   It is possible to reason out the answer by having some knowledge of geometry, 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.

6. 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 gives a clue to the right answer. 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 "c" 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.

7. Skip over questions that are troublesome. Mark these questions for later review.

8. 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.

9. 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

10. Keep a steady pace. Check the time periodically.

11. 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 languages of this chosen profession.

Math Problems

Math problems on the certification tests are meant to reflect the type of work encountered in Plant Maintenance Mechanical Technology. Although there is no specific math section on the test, many questions will require some calculations such as area, volume, ratios, and conversion of units. By far, the greatest number of applicants that fail the certification examinations 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 (i.e. square root) are not necessary, but may be helpful in some situations. The most important factor in effectively using a calculator is the candidates' 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 worksheets in this section as well as the sample problems at the various grade levels will improve proficiency. Additional use will also help. For example, calculate the gas mileage when filling a vehicle's tank each time. 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 are not accidentally punched. Be certain there are new batteries in the calculator, or use a solar powered calculator with battery back up.

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
This is where the equation or equations that will be used to generate the answers are listed.

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, reducing chances of making an error.

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 solution that is different, but arrives at the correct answer is found, then that solution can be used.

Equivalents/Formulas

A sample of the equivalents and formulas sheet from the examination is included in Table 4-1. Familiarity with each of the equivalents (conversion factors) and each of the formulas 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.
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 = $50 \frac{gal}{min}$

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:

$$50 \frac{\cancel{gal}}{\cancel{min}} \times 60 \frac{\cancel{min}}{\cancel{hr}} \times 24 \frac{\cancel{hr}}{\cancel{day}} \times 365 \frac{\cancel{days}}{yr} \times 1 \frac{MG}{1{,}000{,}000 \cancel{gal}} = 26.28 \text{ MGY}$$

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.

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

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

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

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

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

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

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

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

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

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

   =19gpd

6. 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?

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

Math Skills

Successful Grade I Lab Analyst candidates must be skilled in arithmetic, beginning statistics, and algebra. Candidates must be able to apply these skills to make calculations for work-related tasks in general chemistry, preparing standard solutions, reporting laboratory data, assisting plant operations, and any other job related math skill that may fall within the Skill Sets listed in Section 3. General chemistry problems will require Lab Analysts to understand how to determine:

- Mass given concentration in mg/L (or ppm), flow converted to mgd and memorizing the formula

  mg/L X mgd X 8.34 = lbs/day

- Mean, median, mode, and range given a set of numbers
- Correct number of significant digits
- Conversion of temperatures from Fahrenheit to Celsius and vice versa
- Gram molecular weight given a chemical formula and molecular weights of the elements
- Concentration of a diluted solution in mg/L or ppm given the initial percent concentra tion, the volumes used to dilute, and the volume of the final solution
- Normality of an acid or base given the three of the factors in the formula $N_1V_1 = N_2V_2$ (the formula must be memorized)
- Weight of dry reagent required to prepare a standard solution given the molecular formula of the reagent, molecular weights of the elements, and the final volume desired.

Problems using laboratory data will require Lab Analysts to memorize the formulas in *Standard Methods* for the analytical methods covered by a Grade I exam. These types of problems will require Lab Analysts to determine:

- Suspended solids, volatile solids, total solids, and dissolved solids given weights of the tared filter or dish and final weights of the filter with residue.

- 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 calculation differences when the sample is seeded or not seeded.
- Estimated sample volume required for the BOD test given the bottle volume, expected BOD results, and 50 percent depletion.
- Chloride, residual chlorine, hardness, COD and alkalinity from the formulas given in *Standard Methods*.

Plant operations type problems require the Lab Analyst to understand how to determine:

- Influent or effluent suspended solids concentration given the effluent or influent suspended solids and suspended solids removal percentage.
- Volume required from one discrete sample to make a flow proportional sample given the times and flows.
- Grams of a dry reagent in a specified volume of solution given solution density and percent reagent in the solution.

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

Arithmetic

Candidates should be able to perform and understand 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 knowledge and application of basic arithmetic and the ability to convert units.

Example

How many grams of silver nitrate ($AgNO_3$) are needed to prepare one liter of 1,000 mg/L Ag standard (Ag=108, N=14, O=16)?

First, determine the molecular weight of silver nitrate in g/gmole.

(108+14+3X16) = 170 g/gmole

Determine the unit weight (g) of silver nitrate per weight (g) of silver

$$= \frac{\text{gmole Ag}}{108\ \text{g}} \times \frac{1\ \text{mole Ag NO}_3}{1\ \text{gmole AG}} \times \frac{170\ \text{g AG NO}_3}{1\ \text{gmole AG}}$$

$$= 1.574\ \text{g}\ \frac{\text{Ag NO}_3}{\text{g Ag}}$$

Multiply the unit-weight factor by the desired concentration to determine the weight of silver nitrate including the conversion factor of grams to milligrams

$$\frac{1{,}000\ \text{mg}}{1\text{L std}} \times \frac{\text{g}}{1{,}000\ \text{mg}} \times \frac{1.574\ \text{g Ag NO}_3}{\text{gAg}}$$

= 1.574 g Ag NO_3

Statistics

Candidates should be able to perform and understand the basic statistical calculations such as determining the mean, median, mode and range of numbers either manually or with a calculator.

Example

Find the mean, median, and range of the following numbers.

6, 7, 8, 6, 9, 8, 8, 9, 8

Use the definitions of each term to determine the value.

Mean or average is the sum of all the values divided by the number of values.

$$\text{mean} = \frac{\text{Sum of All Value}}{\text{Number of All Values}}$$

$$= \frac{6 + 7 + 8 + 6 + 9 + 8 + 8 + 9 + 8}{9} = 7.7$$

Median is the midpoint of the range of values, where one-half of the values are higher and one-half of the values are lower. Arrange the values from highest to lowest.

6, 6, 7, 8, 8, 8, 8, 9, 9

Median value = 8.

There are four values higher than this number and four values lower. If the total number of values is an even number, the two values closest to the mid-point are averaged to obtain the midpoint, or median value.

Range is simply the difference between the highest value and the lowest value.

Range = $V_H - V_L$ $\quad 9 - 6 = 3$

Algebra

Candidates should be able to perform basic applied algebra for solving calculations such as solving for one unknown in one equation. Remember that when solving for the unknown that there are two basic rules that apply:

- The unknown must be in the numerator (on the top of the fraction, if one exists).
- The unknown must be by itself on one side of the equation with all knowns on the other side.

These two basic steps should be performed in the order that they appear above.

Example

A treatment plant removes 85% of the suspended solids in the secondary clarifier. If the effluent suspended solids are 22 mg/L, the secondary influent suspended solids are ____mg/L.

Solution

This problem can be done using ratios:

$$\frac{\%\text{ SS effluent}}{\%\text{ SS influent}} = \frac{\text{mg/L SS effluent}}{\text{mg/L SS influent}}$$

Given that influent represent 100 percent of the suspended solids and removal in the secondary clarifier is 85 percent, primary effluent percent suspended solids is calculated as follows:

% SS effluent = (100% - 85%) = 15%

$$\frac{15\%}{100\%} = \frac{22\text{ mg/L}}{\text{SS influent}}$$

Solving for the unknown multiply both sides by SS influent.

$$\text{SS influent} \times \frac{15\%}{100\%} = \frac{22\text{ mg/L}}{\cancel{\text{SS influent}}} \times \cancel{\text{SS influent}}$$

Multiplying by inverse percentages

$$\text{SS influent} \times \frac{\cancel{15\%}}{\cancel{100\%}} \times \frac{\cancel{100\%}}{\cancel{15\%}} = 22\text{ mg/L} \times \frac{100\%}{15\%}$$

$$\text{SS inflent} = \frac{22\text{ mg}}{\text{L}} \times \frac{100\%}{15\%} = 147\text{ mg/L}$$

Section 5

Diagnostic Test

Introduction

This section provides a diagnostic test for individuals studying for a Grade I Laboratory Analyst (Lab Analyst) Certification to help determine their current knowledge level of wastewater chemistry and microbiology.

This diagnostic test can also be used to help create more detailed questions. For example, if a question asks, "What is the titrant used to determine alkalinity?" Lab Analysts may expand on the question by asking, "What are the titrants used in the hardness, chloride, residual chlorine, and the Winkler dissolved oxygen titrations?" A question that asks how a constituent is reported may be a reminder to look for unusual reporting units as found in alkalinity, conductivity, turbidity, and volatile acids. A question about instrument theory or instrument components should lead to learning the components for several types of instruments.

These questions represent the type of knowledge that may be required to successfully pass the test. They are generally based on the information contained in the references (See Section 6 for a list of references) and arranged according to the skill sets presented in Section 3.

Passing the example questions does not, however, guarantee passing the test. Test answers, the applicable skill set, and selected solutions are presented at the end of the section. 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 subject.

Skill Set 1 Work Habits

1. Sexual harassment is not a workplace issue when the:
   a. harasser is a female.
   b. behavior occurs off the work site.
   c. behavior is welcome.
   d. subordinate is harassing a supervisor.

2. If you have been given written instructions that you do not understand:
   a. do what you think is best.
   b. ask a co-worker.
   c. ask your supervisor.
   d. ask the author.

Skill Set 2 Safety

1. The mercuric nitrate titration technique for measuring chloride is falling into disuse in the laboratory because the:
   a. results are not as reliable as those achieved by the silver nitrate titration technique.
   b. endpoint is difficult to determine.
   c. technique is lengthy and requires highly skilled instrument technicians to accurately analyze the samples.
   d. mercury creates a hazardous waste disposal problem.

2. Standard phenylarsine oxide solution (PAO):
   a. requires only routine lab safety considerations.
   b. should be handled with caution because it is highly corrosive.
   c. should be handled with caution because it is highly acidic.
   d. should be handled with caution because it is a severe poison.

Skill Set 3 Sampling

1. Sampling protocol for chloride includes:
   a. glass or plastic container preserved with sodium thiosulfate.
   b. plastic container preserved with sulfuric acid.
   c. glass or plastic container with no preservative.
   d. glass or plastic container preserved at 4°C.

2. You have been directed to collect a 12-hour flow proportional sample. Using the following data, select the volume of sample to be collected at 12:00 p.m. if a total sample volume of one liter is required.

Time	Flow, MGD
6:00 a.m.	5.8
7:00 a.m.	6.4
8:00 a.m.	6.8
9:00 a.m.	7.2
10:00 a.m.	6.8
11:00 a.m.	7.2
12:00 p.m.	9.0
1:00 p.m.	9.6
2:00 p.m.	8.8
3:00 p.m.	8.2
4:00 p.m.	7.6
5:00 p.m.	6.8

   a. 90 mL
   b. 90.2 mL
   c. 100 mL
   d. 180 mL

Skill Set 4 Recordkeeping and Lab Maintenance

1. The incubator for the BOD determination should be monitored and recorded daily. The incubator temperature should be:
   a. 20° +/- 0.5° C.
   b. 20° +/- 1° C.
   c. 20° +/- 2° C.
   d. 20° +/- 5° C.

2. Laboratory data mistakes may be corrected by:
   a. covering the mistake with white correction fluid, writing over the fluid after it has dried with analyst's initials and date.
   b. erasing the mistake and writing the correct answer again in pencil.
   c. lining out the mistake with pen and writing the correct answer to the side of the first.
   d. lining out the mistake with pen and writing the correct answer to the side of the first, with analyst's initials and date.

3. The Sample Receiving Log must record time and date sampled:

   a. time and date received at the laboratory, sample collector, nature of sample and sample recipient.

   b. sample collector, nature of sample, analyses to be performed, preservatives, condition of sample and sample recipient.

   c. time and date received at the laboratory, sample collector, nature of sample, analyses to be performed, preservatives.

   d. time and date received at the laboratory, sample collector, nature of sample, weather conditions during sampling, analyses to be performed, preservatives, condition of sample and sample recipient.

4. Hood flow should be monitored and documented at:

   a. 100 milligrams per liter.

   b. 100 parts per million.

   c. 100 linear feet per minute.

   d. 100 cubic feet per minute.

Skill Set 5 Mathematics and Chemisrty

1. An analyst filters 50 mL of raw domestic wastewater through a tared glass fiber filter, dries the filter at 103 degrees to 105 degrees C and weighs it again. Given the following weights, what is the total suspended solids of the sample in mg/L?

   Tare weight: 0.4158 g

   Dry weight: 0.4285 g

   a. 0.25 mg/L

   b. 0.64 mg/L

   c. 250 mg/L

   d. 640 mg/L

2. Given the following data, calculate the COD for the sample.

   mL of FAS to titrate 10 mL of 0.25 N dichromate = 10.7

   mL of FAS to titrate reagent blank = 10.6

   mL of FAS to titrate sample = 7.5

   sample size = 20 mL

   a. 32 mg/L COD

   b. 230 mg/L COD

   c. 290 mg/L COD

   d. 975 mg/L COD

3. Given the following, find the percent solids and the percent volatile solids of the sample:

   Dish tare weight = 1.38 g

   Dish and wet sample weight = 32.40

   Dish and dry sample weight = 1.86 g

   Dish and ashed weight = 1.56 g

   a. 0.96 percent solids and 62.5 percent volatile solids

   b. 0.96 percent solids and 83.9 percent volatile solids

   c. 1.55 percent solids and 62.5 percent volatile solids

   d. 1.55 percent solids and 83.9 percent volatile solids

4. A treatment plant removes 41% of the suspended solids in the primary clarifiers. If the primary effluent suspended solids are 112 mg/L, the primary influent suspended solids are :

   a. 52.7 mg/L influent SS.

   b. 66.1 mg/L influent SS.

   c. 190 mg/L influent SS.

   d. 273 mg/L influent SS.

Skill Set 6 Reagents and Media Preparation

1. What is the normality of a sodium hydroxide solution if 25 mL of a 0.01 N sulfuric acid solution neutralizes 100 mL of the NaOH solution?
   a. 0.0025 N
   b. 0.064 N
   c. 0.25 N
   d. 6.4 N

2. A sample of ferrous chloride contained 30% ferrous chloride and had a density of 1.33 g/mL. Calculate the total ferrous chloride in one liter of the solution.
   a. 39.9 grams per liter
   b. 226 grams per liter
   c. 399 grams per liter
   d. 4,430 grams per liter

3. Given the following data, calculate the BOD for the sample if the initial DO is 8.5 mg/L.

Sample size, mL	DO Final, mg/L
Blank	8.5
3.0	7.0
5.0	5.8
7.0	4.8
9.0	3.4
11	2.7
15	0.5

   a. 159 mg/L
   b. 159.7 mg/L
   c. 160 mg/L
   d. 162.2 mg/L

4. A standard solution is prepared from a 0.100% stock solution of a pure metal. Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. The concentration of the standard solution is:
   a. 0.2 mg/L.
   b. 0.5 mg/L.
   c. 1.0 mg/L.
   d. 2.0 mg/L.

5. How many grams of chromium trioxide (CrO_3) are needed to prepare one liter of 1,000 mg/L Cr standard (Cr=52, O=16)?
   a. 0.520 g CrO_3
   b. 0.765 g CrO_3
   c. 1.308 g CrO_3
   d. 1.923 g CrO_3

6. Lauryl Sulfate Broth is sterilized before use for:
   a. 15 minutes at 121°C (15 lbs. pressure).
   b. 15 minutes at 118°C (12 lbs. pressure).
   c. 20 minutes at 115°C (10 lbs. pressure).
   d. 20 minutes at 121°C (15 lbs. pressure).

7. Agar medium is used for:
   a. escherichia coliform.
   b. fecal coliform.
   c. heterotrophic plate count.
   d. all bacterial analysis.

Skill Set 7 Chemical Analysis Techniques

1. During an acid-base titration, the titrant is added to the sample with a:
   a. graduated cylinder.
   b. seriological pipet.
   c. class A pipet.
   d. buret.
2. Separatory funnels are designed to facilitate liquid-liquid extractions. Liquid-liquid extraction can be used to separate:
   a. organic analytes from the water by partitioning them into an organic solvent.
   b. salt compounds (TSS) from the water by filtering the sample to remove suspended solids and allowing the remaining sample to evaporate to dryness.
   c. nitrogen compounds from the water by distilling the sample, collecting the distillate in boric acid solution.
   d. inorganic salts from acids.

Skill Set 8 Laboratory Instrumentation

1. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by:
   a. conductivity.
   b. pH or hydrogen ion activity.
   c. specific ion probe analysis.
   d. alkalinity.
2. A solution with a pH of 5 has a concentration of hydrogen ions that is how many times higher than a solution with a pH of 7?
   a. 2 times higher
   b. 10^{-5} times higher
   c. 10^{-2} times higher
   d. 100 times higher
3. A pH measurement requires the following:
   a. a voltmeter, glass pH electrode, reference electrode, and a temperature compensating device.
   b. a voltmeter, glass pH electrode, combination electrode, and a temperature compensating device.
   c. a voltmeter, combination electrode, reference electrode and a temperature compensating device.
   d. a voltmeter, glass pH electrode, reference electrode, and a combination electrode.
4. Conductance measurements are temperature compensated to:
   a. 20.0°C.
   b. 25.0°C.
   c. 30.0°C.
   d. 20.0° to 25.0° C.
5. The conductivity meter is calibrated with:
   a. 0.0100 N potassium chloride standard.
   b. 0.0100 N silver chloride standard.
   c. 0.0100 N sodium chloride standard.
   d. 0.1000 N sodium chloride standard.

Skill Set 9 Analytical Chemistry Methods

1. Alkalinity is reported as:
   a. alkalinity, mg/L phenolphthalein.
   b. alkalinity, mg $CaCO_3$/L.
   c. alkalinity, mg/L.
   d. alkalinity, mg/L acetic acid.

2. The hardness determination by EDTA titration measures:
   a. calcium and magnesium.
   b. calcium carbonate.
   c. alkalinity, corrosivity and carbonates.
   d. calmagite.

3. The indicator for the hardness determination is:
   a. ethylenediaminetetracetic acid.
   b. eriochrome Black T.
   c. ethylenediaminetriacetic acid.
   d. bromcresol green.

4. EPA acceptable primary standards for the turbidity determination include:
   a. formazine and synthetic styrene-divinylbenzene.
   b. formazine only.
   c. synthetic styrene-divinylbenzene only.
   d. formazine, and manufactured gel-filled vials.

5. The Biochemical Oxygen Demand (BOD) determination is an empirical test in which standardized laboratory procedures are used to:
   a. determine the relative dissolved oxygen in wastewaters, effluents and polluted waters.
   b. determine the relative oxygen requirements of wastewaters, effluents and polluted waters.
   c. determine the relative chemical oxidizers in wastewaters, effluents and polluted waters.
   d. determine the relative organic compounds of wastewaters, effluents and polluted waters.

6. Sample pretreatment for the BOD determination includes:
   a. assuring that the samples are neutralized to a pH range between 6.5 and 7.5, and that any residual chlorine has been dechlorinated.
   b. assuring that the samples are neutralized to a pH range between 5.5 and 8.5, and that any residual chlorine has been dechlorinated.
   c. assuring that any residual chlorine has been dechlorinated.
   d. assuring that the samples are neutralized to a pH range between 6.5 and 7.5.

Skill Set 10 Microbiological Analysis

1. The process designed to kill most microorganisms in wastewater, including essentially all pathogenic bacteria is called:
   a. sterilization.
   b. disinfection.
   c. biodegredation.
   d. chlorine demand.

2. Fecal coliform bacteria:
   a. are pathogenic bacteria found in the intestinal tract of warm-blooded animals.
   b. are the cause of cholera, a water-borne disease in humans.
   c. are the cause of dysentery, a water-borne disease in humans.
   d. are bacteria found in the feces of warm-blooded animals.

3. The definition for the total coliform group is:
   a. all of the aerobic and facultative anaerobic, gram-negative, nonspore -forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C.
   b. all of the aerobic and facultative anaerobic, gram-negative, spore-forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C.
   c. all of the aerobic and facultative anaerobic, gram-positive, nonspore-forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C.
   d. all of the aerobic and facultative anaerobic, gram-negative, nonspore -forming, rod-shaped bacteria that ferment alcohol in 24-48 hours at 35°C.

Skill Set 11 Quality Assurance

1. Laboratory test results for an individual environmental sample within an analytical batch may be rejected when:
   a. extremely high or low concentrations of the analyte are achieved.
   b. the recovery of the laboratory control standard falls outside of the control limits.
   c. the relative standard deviation between the duplicates falls outside the control limits.
   d. a known error has occurred.
2. Precision is measured by:
   a. analyzing replicate samples.
   b. analyzing matrix spiked samples.
   c. calculating standard error.
   d. calculating percent recovery.

Match the definitions in questions 3 through 6 with one of the four phrases listed below:

   a. Accuracy
   b. Bias
   c. Precision
   d. Random error

3. Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

4. The deviation in any step in an analytical procedure that can be treated by standard statistical techniques.

5. The combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.

6. Measure the degree of agreement among replicate analyses of a sample, usually expressed as the standard deviation.

7. Select the correct mean, median, mode and range from the following list.

6.7, 8.6, 9.0, 8.9, 8.9, 9.0, 8.5, 8.4, 8.7, 6.6, 8.8, 7.2, 8.5, 9.3, 8.9

a. Mean = 8.4, median = 8.7, mode = 8.9, range = 2.6
b. Mean = 8.4, median = 8.7, mode = 8.9, range = 2.7
c. Mean = 8.4, median = 8.8, mode = 8.9, range = 2.7
d. Mean = 8.5, median = 8.6, mode = 8.4, range = 2.4

Test Answer Key

The following tables show the correct answers for the test questions included in this study guide. The tables show what section the answers are for, the correct answer, and the subsection the question refers to. If you marked a wrong answer to any of the diagnostic test questions, refer to the skill set listed and you will be able to find the reference material to study to help you correctly answer the question.

Skill Set 1 Work Habits

No.	Answer
1	c
2	d

Skill Set 2 Safety

No.	Answer
1	d
2	d

Skill Set 3 Sampling

No.	Answer
1	c
2	c

Skill Set 4 Record Keeping and Lab Maintenance

No.	Answer
1	b
2	d
3	b
4	c

Skill Set 5 Mathematics and Chemisrty

No.	Answer
1	c
2	c
3	c
4	c

Skill Set 6 Reagents and Media Preparation

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

Skill Set 7 Chemical Analysis and Techniques

No.	Answer
1	d
2	a

Skill Set 8 Laboratory Instrumentation

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

Skill Set 9 Analytical Chemistry Methods

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

Skill Set 10 Microbiological Analysis

No.	Answer
1	b
2	d
3	a

Skill Set 11 Quality Assurance

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

Selected Solutions

Skill Set 3 Sampling

2. You have been directed to collect a 12-hour flow proportional sample. Using the following data, select the volume of sample to be collected at 12:00 p.m. if a total sample volume of one liter is required.

Time	Flow, MGD
6:00 a.m.	5.8
7:00 a.m.	6.4
8:00 a.m.	6.8
9:00 a.m.	7.2
10:00 a.m.	6.8
11:00 a.m.	7.2
12:00 p.m.	9.0
1:00 p.m.	9.6
2:00 p.m.	8.8
3:00 p.m.	8.2
4:00 p.m.	7.6
5:00 p.m.	6.8

Solution

$$\frac{\text{mL, 12:00 p.m. sample}}{\text{mL, total sample}} = \frac{\text{mgd, flow at 12:00 p.m.}}{\text{mdg, total flow}}$$

$$\frac{\text{mL, 12:00 p.m. sample}}{\text{mgd, total flow}} = \text{mgd, flow at 12:00 p.m.}$$

$$\frac{9 \text{ mgd} \times 1{,}000 \text{ mL}}{90.2 \text{ mgd}} = 100 \text{ mL}$$

Skill Set 5 Mathematics and Chemisrty

1. An analyst filters 50 mL of raw domestic wastewater through a tared glass fiber filter, dries the filter at 103 degrees to 105 degrees C and weighs it again. Given the following weights, what is the total suspended solids of the sample in mg/L?

   Tare weight: 0.4158 g

   Dry weight: 0.4285 g

Solution

0.4285g - 0.4158g = 0.0127g suspended solids per 50 mL wastewater

$$\frac{0.0127 \text{ g}}{50 \text{ mL}} \times \frac{1{,}000 \text{ mL}}{1 \text{ L}} \times \frac{1{,}000 \text{ mg}}{1 \text{ g}} = \frac{254 \text{ mg}}{1 \text{L}}$$

= 250 mg/L

2. Given the following data, calculate the COD for the sample.

   mL of FAS to titrate 10 mL of 0.25 N dichromate = 10.7

   mL of FAS to titrate reagent blank = 10.6

   mL of FAS to titrate sample = 7.5

   sample size = 20 mL

Solution

1. Determine the normality of FAS ($N_1V_1=N_2V_2$)

2. Determine the COD, mg/L

$$N_{FAS} = \frac{\text{N dichromate} \times \text{mLs dichromate}}{\text{mLs FAS}}$$

$$= \frac{0.25 \text{ N} \times 10 \text{ mL}}{10.25 \text{ mL}} = 0.23 \text{ N}$$

$\text{mL FAS}_{blank} = A$ $\text{mL FAS}_{Sample} = B$

$$\text{COD} = \frac{(A - B) \times 8{,}000 \times N_{FAS}}{\text{mL}}$$

$$\text{COD mg/L} = \frac{(10.6 \text{ mL} - 7.5 \text{ mL}) \times 0.23 \text{ N}}{20 \text{ mL}}$$

= 290 mg/L COD

3. Given the following, find the percent solids and the percent volatile solids of the sample:

   Dish tare weight = 1.38 g

   Dish and wet sample weight = 32.40

   Dish and dry sample weight = 1.86 g

   Dish and ashed weight = 1.56 g

   a. 0.96 percent solids and 62.5 percent volatile solids

   b. 0.96 percent solids and 83.9 percent volatile solids

   c. 1.55 percent solids and 62.5 percent volatile solids

   d. 1.55 percent solids and 83.9 percent volatile solids

Solution

Wet sample weight = 32.40 g - 1.38 g = 31.02 g

Dry sample weight = 1.86 g - 1.38 g = 0.48 g

Ash sample weight = 1.56 g - 1.38 g = 0.18 g

$$\text{\% solids} = \frac{\text{dry sample weight} \times 100}{\text{wet sample weight}}$$

$$= \frac{0.48\text{ g} \times 100}{31.02\text{ g}} = 1.55\%\text{ solids}$$

$$\%\text{ volatile solids} = \frac{(\text{dry wt.} - \text{ash wt.}) \times 100}{\text{dry wt.}}$$

$$= \frac{(0.48\text{ g} - 0.18\text{ g}) \times 100}{0.48\text{ g}} = 62.5\%\text{ volatile}$$

4. A treatment plant removes 41% of the suspended solids in the primary clarifiers. If the primary effluent suspended solids are 112 mg/L, the primary influent suspended solids are :

Solution

The problem can be done using ratios:

$$\frac{\%\text{ SS effluent}}{\%\text{ SS influent}} = \frac{\text{mg/L SS effluent}}{\text{mg/L SS influent}}$$

Given that influent represent 100 percent of the suspended solids and removal in the primary clarifier is 41 percent, primary effluent percent suspended solids is calculated as follows:

$$\frac{59\%}{100\%} = \frac{112\text{ mg/L}}{?}$$

Solving for the unknown:

$$112\text{ mg/L} \times \frac{100\%}{59\%} = 190\text{ mg/L influent SS}$$

Skill Set 6 Reagents and Media Preparation

1. What is the normality of a sodium hydroxide solution if 25 mL of a 0.01 N sulfuric acid solution neutralizes 100 mL of the NaOH solution?

Solution

$$N_1V_1 = N_2V_2 \quad \frac{25\text{ mL} \times 0.01\text{ N}}{100\text{mL}} = 0.0025\text{ N NaOH}$$

2. A sample of ferrous chloride contained 30% ferrous chloride and had a density of 1.33 g/mL. Calculate the total ferrous chloride in one liter of the solution.

Solution

$$\frac{1{,}000\text{ mL sample}}{1\text{ L sample}} \times \frac{1.33\text{ g sample}}{1\text{mL sample}} \times \frac{30\text{ g ferrous chloride}}{100\text{ g sample}} = 399\text{ grams/L } FeCl_3$$

3. Given the following data, calculate the BOD for the sample if the initial DO is 8.5 mg/L.

Sample size, mL	DO Final, mg/L
Blank	8.5
3.0	7.0
5.0	5.8
7.0	4.8
9.0	3.4
11	2.7
15	0.5

Solution

Calculate the BOD for each sample, average the valid sample results, and round the results to proper significant digits.

$$\text{BOD} = \frac{(DO_{initial}\text{ mg/L} - DO_{final}\text{ mg/L}) \times 300\text{ mL}}{\text{sample size mL}}$$

Average of 5, 7, 9 and 11 mL sample size is 162 mg/L. Round to 160 mg/L.

4. A standard solution is prepared from a 0.100% stock solution of a pure metal. Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. The concentration of the standard solution is:

Solution:

This is a serial dilution problem. First convert the standard solution to concentration and then multiply by the dilutions.

$$\frac{1{,}000{,}000\ mg/L}{100\%} \times 0.100\% = 1{,}000\ mg/L$$

$$\frac{1{,}000\ mg\ \text{“X”}}{1{,}000\ mL\ \text{“A”}} \times \frac{10\ mL\ \text{“A”}}{1{,}000\ mL\ \text{“B”}} \times \frac{5\ mL\ \text{“B”}}{100\ mL\ \text{“C”}}$$

$$\times \frac{1{,}000\ mL\ \text{“C”}}{1L\ \text{“C”}} = \frac{0.5\ mg\ \text{“X”}}{L\ \text{“C”}} = 0.5\ mg/L$$

5. How many grams of chromium trioxide (CrO_3) are needed to prepare one liter of 1,000 mg/L Cr standard (Cr=52, O=16)?

Solution:

Molecular weight of CrO_3

= (1 x 52 g/gmole) + 3 x 16 g/gmole)

= 100 g/gmole

$$\frac{1{,}000\ mg\ Cr}{L\ standard} \times \frac{1\ g\ Cr}{1{,}000\ mg\ Cr}$$

$$\times \frac{1\ mole\ Cr}{52\ g\ Cr} \times \frac{1\ mole\ CrO_3}{1\ mole\ Cr}$$

$$\times \frac{100\ g\ CrO3}{1\ mole\ CrO3} = 1.923\ g\ Cr0_3$$

Skill Set 11 Quality Assurance

7. Select the correct mean, median, mode and range from the following list.

6.7, 8.6, 9.0, 8.9, 8.9, 9.0, 8.5, 8.4, 8.7, 6.6, 8.8, 7.2, 8.5, 9.3, 8.9

Solution:

To do this problem, the candidate must know the definitions and formulas of the requested statistical parameters.

Mean = sum of numbers divided by the number of values (same as average)

Median = central number when listed in numerical order

Mode = most frequently occurring number, it may not be unique

Range = absolute difference between high and low

Mean: 126/15 = 8.4

Median: 6.6, 6.7, 7.2, 8.4, 8.5, 8.5, 8.6, 8.7, 8.8, 8.9, 8.9, 9.0, 9.0, 9.3

15/2 = 7.5, therefore the eighth value or 8.7

Mode: 8.5, 8.9, 9.0

Range: 9.3 – 6.6 = 2.7

Mean = 8.4, median = 8.7, mode = 8.9, range = 2.7

Section 6

References

This section includes the titles and information of primary and secondary references for the Environmental Compliance Inspector. Because these references contain the majority of the information needed for the CWEA certification test, it is recommended that these references be obtained for personal use. They may also be obtained at a university library or possibly an employer's library.

For the latest information on how to get the following references visit the TCP Resources web page at www.cwea.org/tcp/resources. Many publications are are available for free download.

Primary References

Operation of Wastewater Treatment Plants, A Field Study Training Program Fourth Edition, Volume I and II.
Office of Water Programs
California State University Sacramento
6000 J Street
Sacramento, CA 95819-6025
916/ 278-6142
Fax 916/ 278-5959
www.owp.csus.edu

Go to **www.cwea.org/certification/How to Become Certified/Preparing for the Test/Resources** for free download of these publications:

Microbiological Methods for Monitoring the Environment: Water and Wastes
EPA 600/8-78-019; NTIS: PB-290329
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
800/553-NTIS www.ntis.gov

Handbook for Analytical Quality Control in Water and Wastewater Laboratories
EPA: 600/4-79-019; NTIS: PB-297451
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
800/553-NTIS www.ntis.gov

Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, and WEF
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206 or 703/684-2452
Fax 703/686-2492
www.wef.org

Water and Wastewater Laboratory Techniques
Author: Smith, R. K.
NTIS: P15124WW
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206 or 703/684-2452
Fax 703/686-2492
www.wef.org

Secondary References

The information contained in the Primary Reference section above provides a solid base of knowledge for the Grade I Lab Analyst. Additional references that enhance the material provided in these references may be found at a university library, or in the case of chemistry textbooks, at a thrift store, often for less than one dollar. Many of these references can also be found on Amazon.com or other electronic book retailers. Visit www.cwea.org/tcp/resources for the latest information about how to get these books.

Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants. (Reprinted from Operation Wastewater Treatment Plants Volume II.)
CWEA
7677 Oakport St. Suite 525
Oakland, CA 94621
510-382-7800
www.cwea.org/tcp/resources

Laboratory Analyst Certification Candidate Handbook CWEA 510-382-7800
www.cwea.org/certification/How to Become Certified/Handbooks

Lectures on Wastewater Analysis and Interpretation
Genium Publishing Corporation
Dept. EAM99A
One Genium Plaza
Schenectady, NY 12304-4690
800/ 243-6486.
Fax 518/ 377-1891
genium@genium.com
www.cwea.org/tcp/resources

Laboratory Safety Pocket Handbook
Genium Publishing Corporation
Dept. EAM99A
1171 Riverfront Center
Amsterdam, NY 12010
800/ 243-6486.
Fax 518/ 842-1843
genium@genium.com
www.cwea.org/Certification/How to Become Certified/Preparing for the Test/Resources

Basic Science Concepts and Applications, Principles and Practices of Water Supply Operations
American Water Works Association
6666 W. Quincy Ave.
Denver, CO 80235
303/ 794-7711
www.awwa.org

Microbiological Skills for Water and Wastewater Analysis
Author: Douglas W. Clark, 1985
Report No. M16
New Mexico Water Resources Research Institute
New Mexico State University
Box 30001, MSC 3167
Las Cruces, NM 88003-8001
505/646-4337 (Order by Phone)
505/646-6418 fax
www.wrri.nmsu.edu

Appendix A

You and Wastewater Math

by Cheryl Ooten, Mathematics Professor, Santa Ana College, ooten-cheryl@rsccd.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.

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-Taking Strategies" 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 Northern and Southern Regional Training Conferences
- CWEA Study Manuals

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 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 Waste Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819
- Price, Joanne Kirkpatrick. *Basic Math Concepts for Water and Wastewater Plant Operators.* Lancaster, Pennsylvania: Technomic, 1991.
- 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: Rutger University Press, 1994.

Practice Problem Solving Strategies

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

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

Units and Arithmetic

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

the units in the problems as you write down your strategies, and then using a calculator to do the needed arithmetic.

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

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

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

For example,

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

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

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

$= 74.8$ 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.

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

$= 1.34$ 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:

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

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

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

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

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

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

Example 4

Find the number of gallons of an 11% polymer needed to produce 100 gal 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 gal 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 gal.

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

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

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

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.

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

$$= 4.42 \text{ hr}$$

Example 6

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

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

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

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

to convert cubic feet into gallons.

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

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

Example 7

A cylindrical tank is full to 3 feet below the top at 10 a.m. and empty at 4 p.m. If the tank is 50 ft tall with a diameter of 70 ft, find the volume (in gal) of the liquid at 10 a.m. and the rate of flow from the tank in gal 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 gal 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 gal at 10 a.m., use the formula for volume of a cylindrical tank which is V=(area of the base) times (height).

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

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

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

Volume = (area of the base)(height)
= (3846.5 ft^2)(47 ft) = 180,785.5 ft^3

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

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

to convert.

$$\text{Volume in gallons} = 180{,}785.5 \text{ } \cancel{ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ } \cancel{ft}^3}$$

= 1,352,275.54 gal

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 min = 1 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:

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

Rate of flow in gal per minute =

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

Take Charge of Your Success

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

Recommendations

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

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

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

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

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

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

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

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

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

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

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

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

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

Test-Taking Strategies

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

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

Before the Exam

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

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

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

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

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

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

At the Exam

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

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

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

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

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

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

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

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

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

Negative Thinking About Exams

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

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

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

Preparation by practicing problems, asking questions, and reviewing gives you confidence and skills that you need. Taking a dress rehearsal test and trying to panic can help you practice dealing with out-of-control feelings. Learning some relaxation techniques to use before and during the exam calms you and aids clear thinking. The more you prepare yourself ahead, the more you are in charge and feel relaxed.

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

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

- 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.

"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 ft^3 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.

Appendix B

Glossary

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 samples 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 blank is a sample (usually deionized water) that is taken through all the steps of analysis to monitor for contamination in the process.

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 sets for the authority for U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to POTWs.

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.

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.

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 sets for the authority for U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to POTWs.

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

Degrees 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.

Density: The relationship between weight and volume, e.g. grams per centimeter, or pounds per gallon. DMV is a useful acronym for the formula density equal mass divided by volume.

Desiccator: An airtight cabinet filled with desiccant to provide a low-humidity environment in which sample may cool without absorbing atmospheric water.

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

Dilution: The process of reducing the concentration of a solution by use of pipets and volumetric flasks.

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

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.

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

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

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

Material Safety Data Sheets: Provide 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 includes: bacteria, fungi, protozoa, microscopic algae and 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.

NPDES Permit: National Pollutant Discharge Elimination System permit is the regulatory agency document issued by either a federal or state agency which is designed to control all discharges of pollutants from point sources into U.S. waterways. 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.

National Pollutant Discharge Elimination System (NPDES): Federal permitting program for discharging effluent to surface water; required under CWA.

Normality: Equivalents per liter. A measure of concentration.

Pathogen: A disease-causing organism.

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).

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 streak plate method allows 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, called a Nephelometer, provides results in NTU's (Nephelometric Turbidity Units).

Appendix C

Common Acronyms and Abbreviations

AA	atomic absorption
AC Power	alternating current
AC	acre
AF	acre-feet
AF	acre-foot (feet)
AFY	acre-foot per year
AMSA	Association of Metropolitan Sewerage Agencies
ANSI	American National Standard Institute
APHA	American Public Health Association
AS	activated sludge
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWT	advanced wastewater treatment
AWWA	American Water Works Association
BECP	Business Emergency and Contingency Plan
BNR	biological nutrient removal
BOD5	biochemical oxygen demand after 5 days
BTU	British thermal unit
C	Celsius
Cal OSHA	California Occupational Safety and Health Act
CalEPA	California Environmental Protection Administration
CBOD	carbonaceous biochemical oxygen demand
CCE	carbon chloroform extract
CCR	California Code of Regulations
cf	cubic feet (foot)
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH4	methane
CIU	Categorical Industrial User
CM	common mode
CMOM	Capacity Management, Operations, and Maintenance
COD	chemical oxygen demand
CPU	central processing
CRWA	California Rural Water Association
CSP	confined-space permit
CT	current transformer
CWA	Clean Water Act
CWEA	California Water Environment Association
DAF	dissolved air flotation
DO	dissolved oxygen
DOHS	California Department of Health Services
DV/DT	($\Delta V/\Delta T$) The change in voltage per change in time.
DWF	dry weather flow
DWR	Department of Water Resources
EIS	Environmental Impact Statement
EMF	electromotive force or voltage
EPA	U.S. Environmental Protection Agency
F	Fahrenheit
F/M	food to microorganism ratio
ft	feet (foot)
ft^2	square foot
ft^3	cubic feet
FTU	formazin turbidity unit
GAC	granular activated carbon

gal	gallon
GFI	ground fault interrupter
GPD	gallons per day
GPM	gallons per minute
GTAW	gas tungsten arc welding
H_2S	hydrogen sulfide
HCP&ERP	Hazard Communications Program and Emergency Response Plan
hp	horsepower
HPLC	high-performance liquid chromatography
Hz	Hertz
IC	ion chromatograph
ICP	inductively coupled plasma
IEEE	Institute of Electrical and Electronics Engineers
IIPP	Injury and Illness Prevention Plan
IML	Interface Management Language
JTU	Jackson Turbidity Unit
K	kilo, a prefix meaning 1000
KVA	kilovolt amperes
kw	kilowatt
kwh	kilowatt hour
L	liter
lb	pound
M	Mega, a metric prefix meaning 1,000,000
m	meter
M	mole or molar
MA	millamps
MBAS	methylene blue active substance
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCRT	mean cell residence time
MDL	method detection limit
MG	million gallons
mg	milligram
mg/L	milligrams per liter
mgd	million gallons per day
min	minute
MIS	Manufacturing Information System
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MMI	Man Machine Interface
MOP	Manual of Practice
MPN	most probably number
MS	mass spectrometer
MSDS	Material Safety Data Sheets
N	normal
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NM	Normal Mode
NOCA	National Organization for Competency Assurance
NOD	nitrogenous oxygen demand
NPDES	National Pollutant Discharge Elimination System
NPSH	net positive suction head
NTU	nephelometric turbidity unit(s)
O&M	operation and maintenance
OCT	Operator Certification Test (State of California)
OMR	operations, maintenance, and replacement
OOC	Office of Operator Certification (SWRCB)
OSHA	Occupational Safety and Health Administration/Act
OTE	oxygen transfer efficiency
P	pico, a metric prefix meaning one millionth of a millionth, or one trillionth (10^{-12})
PC	personal computer
PCB	polychlorinated biphenyls
pH	potential of hydrogen

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