Laboratory Analyst Candidate Handbook

Version 10.12.2020

Congratulations on pursuing certification. Certification is a great way to demonstrate competency, show commitment to the profession, and help with job advancement.

This handbook contains information about California Water Environment Association’s Technical Certification Program for certification candidates. Please read this entire handbook to become familiar with CWEA’s certification policies and procedures. Certification candidates are responsible for knowing the contents of this handbook. Please contact the CWEA office at (510) 382-7800 with any questions.

All policies are subject to change. The most recent edition of this handbook can be downloaded for free on Cert.CWEA.org. Candidates should ensure that they have the most current version as indicated by the date in the title above and at the bottom of each page.

Cert.CWEA.org
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INTRODUCTION TO THE TECHNICAL CERTIFICATION PROGRAM

CWEA’s Technical Certification Program (TCP) develops and administers competency-based certification exams for wastewater professionals in a number of different vocations. The certification program was founded in 1937. The first certification offered was the Wastewater Treatment Plant Operator certification, which was later adopted by the State Water Board. The exams are developed and revised by CWEA Subject Matter Experts under the guidance of exam development professionals. The certifications continue to grow and be refined in accordance with water sector and certification professional practices. Exams are offered throughout the year and are experience based, ranging from entry level to upper management.

CWEA currently certifies over 7,000 individuals. Certification is a great way to demonstrate competency, show commitment to the water profession, and help with job advancement.

TECHNICAL CERTIFICATION PROGRAM

Executive Committee

The Technical Certification Program Executive Committee is the governing body of CWEA’s certification program. It was created to develop and implement a multilevel technical certification program for individuals employed in the wastewater field. They are responsible for the development and administration of the Technical Certification Program, including the application, examination development, examination administration, and certification renewal process. They develop the guidelines, criteria, and testing procedures that are responsive to the needs of the water quality industry and allow participants to demonstrate technical competence. They are also responsible for maintaining the quality of the examinations through continuous upgrading and review.

For current Committee members, contact the CWEA office.
Overview of the Certification Process

To become certified all applicants must complete the following requirements:

1. Submit an application
2. Pay the application fee
3. Meet the minimum qualifications regarding professional experience
4. Pass the exam

Once an applicant successfully completes the requirements, they will be mailed their certificate. In order to maintain the certification once earned, certified individuals must continue to meet the following recertification requirements:

1. Submit 12 contact hours of continuing education every two years
2. Pay the annual renewal fee

Certifications Offered by CWEA

- Collection Systems Maintenance, Grades 1-4
- Mechanical Technologist, Grades 1-4
- Electrical/Instrumentation, Grades 1-4
- Laboratory Analyst, Grades 1-4
- Environmental Compliance Inspector, Grades 1-4
- Advanced Water Treatment Operator, Grades 3-5
  - Offered in partnership with California-Nevada Section of the American Water Works Association. For more information visit [www.AWTOperator.org](http://www.AWTOperator.org).

Please note that the Wastewater Treatment Plant Operator Certification and Drinking Water Treatment Plant Operator Certification are administered by the State of California. To work on a drinking water treatment system, distribution system or in a wastewater treatment plant, an individual must have a valid operator certificate or an operator-in-training certificate from the State Water Board. For information about these programs, please contact the State Water Board Office of Operator Certification.
APPLICATION PROCESS

Submitting an Application

Candidates must submit an application and be approved before they can schedule an exam. Applications can be faxed, emailed or mailed to the CWEA office at any time throughout the year. Applications are reviewed by CWEA TCP Staff and/or Subject Matter Experts. Once the application is processed, candidates are notified of their approval status via email. Please follow all instructions on the application carefully. Incomplete applications may delay approval. The application is available on the Cert.CWEA.org website.

Application Deadlines and Exam Windows

The year is divided into four exam windows, each with an application deadline. Applications are valid for one year from the first date of the applicant’s original exam window. Applicants may transfer exam windows throughout the year, for details see Transferring Exam Windows (p. 14).

<table>
<thead>
<tr>
<th>Exam Windows</th>
<th>Exam Dates</th>
<th>Application Deadlines</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALL</td>
<td>October 1&lt;sup&gt;st&lt;/sup&gt; – December 31&lt;sup&gt;st&lt;/sup&gt;</td>
<td>August 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>WINTER</td>
<td>January 1&lt;sup&gt;st&lt;/sup&gt; – March 31&lt;sup&gt;st&lt;/sup&gt;</td>
<td>November 30&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>SPRING</td>
<td>April 1&lt;sup&gt;st&lt;/sup&gt; – June 30&lt;sup&gt;th&lt;/sup&gt;</td>
<td>February 28&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>SUMMER</td>
<td>July 1&lt;sup&gt;st&lt;/sup&gt; – September 30&lt;sup&gt;th&lt;/sup&gt;</td>
<td>May 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

CWEA Application Fees

Current fees are listed on the application. Valid CWEA members qualify for a discounted member rate. The non-member rate includes a one-year CWEA membership. If an applicant does not wish to take advantage of the membership, they must note it on the application.
Minimum Qualifications: Qualifying Education and Experience

Applicants must meet the minimum qualifications for the exam at the time the application is submitted. The table below gives the combinations of education and/or experience that will satisfy the requirements. There is no education or experience requirement to take any Grade 1 exam, however, the Grade 1 exams test at the level of one year of experience in the field. Education and experience should be relevant to the vocation and reflect the job knowledge for that grade level. Relevancy is at the sole discretion of CWEA. Applicant’s experience must be indicated on the application under “Job Duties”. Applicants should provide sufficient detail to demonstrate they possess the relevant experience. The best way to provide this information is to include the official job description for the position. Applicants consent to a thorough investigation of employment records and other qualifications in related activities for the purpose of verification of qualifications. CWEA may verify job history by contacting employers.

LAB Certification Minimum Qualifications Chart

<table>
<thead>
<tr>
<th>GRADE 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION/CERTIFICATIONS</td>
<td>EXPERIENCE</td>
<td></td>
</tr>
<tr>
<td>None required to take test</td>
<td>None required to take test</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRADE 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION/CERTIFICATIONS</td>
<td>EXPERIENCE</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>4 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>Hold Grade 1 certificate in vocation for year</td>
<td>2 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>Associate’s, or higher degree in related field</td>
<td>2 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s, or higher degree in related field</td>
<td>1 full-time years in vocation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GRADE 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION/CERTIFICATIONS</td>
<td>EXPERIENCE</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>6 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>Hold Grade 2 certificate in vocation for 2 years</td>
<td>4 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>Associate’s, or higher degree in related field</td>
<td>4 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s, or higher degree in related field</td>
<td>3 full-time years in vocation</td>
<td></td>
</tr>
<tr>
<td>EDUCATION/CERTIFICATIONS</td>
<td>EXPERIENCE</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>8 full-time years in vocation with 1 year supervising others</td>
<td></td>
</tr>
<tr>
<td>Hold Grade 3 certificate in vocation for 2 years</td>
<td>6 full-time years in vocation with 1 year supervising others</td>
<td></td>
</tr>
<tr>
<td>Associate’s, or higher degree in related field</td>
<td>6 full-time years in vocation with 1 year supervising others</td>
<td></td>
</tr>
<tr>
<td>Bachelor’s, or higher degree in related field</td>
<td>5 full-time years in vocation with 1 year supervising others</td>
<td></td>
</tr>
</tbody>
</table>

**Application Approval**

Once an application has been approved, the applicant will receive a Certification Application Approval Notification via email. It is very important that applicants use a current email address when filling out the application. CWEA will only contact applicants in regard to their application status via email. The Certification Application Approval Notification will contain the certification exam the applicant has been approved for, the exam window and CWEA ID number. This ID number is needed when contacting Pearson VUE to schedule an exam appointment.

**Rejected Application**

Applications will be rejected if applicants do not meet all requirements at the time they apply. CWEA will refund the application fee minus a $40 admin fee. Refunds are automatically issued within two weeks of rejection to the original form of payment. Candidates may request that their rejected application be reviewed by the Technical Certification Program Executive Committee by submitting a request in writing to tcpcommittee@cwea.org.

**Code of Ethics**

All CWEA certification holders and applicants are expected to meet the following standards of professional conduct and ethics:
1. To protect public health, themselves, their co-workers, property, and the environment by performing the essential duties of the CWEA certified vocation safely and effectively, and complying with all applicable federal, state and local regulations.
2. To represent themselves truthfully and honestly throughout the entire certification process.
3. To adhere to all test site rules and make no attempt to complete the test dishonestly or to assist any other person in doing so.
4. To refrain from activities that may jeopardize the integrity of the Technical Certification Program.

The CWEA Code of Ethics establishes basic values and standards of conduct for certification applicants and certification holders. Any action of a certification holder or applicant that compromises the reliability of the certification process may be subject to the process described by the Ethics Procedures.

The Ethics Procedures provide a fair process for dealing with ethics complaints. The procedures define the participants in an ethics case and how each case will be handled. Individuals going through the process will be given opportunities to defend themselves and appeal any decisions made. The Ethics Officer handles all official ethics complaints and determines if there is enough merit in each case to follow through with the procedures. If appropriate, the Ethics Officer may suggest mediation to resolve ethics disputes without the formality of going through the entire procedural process. This information is paraphrased for clarity from the 05-01 CWEA Code of Ethics and Ethics Procedures.

A full copy of the policy can be requested by contacting the TCP department.

Some examples of violations would be:

- Providing false work history on an application
- Using prohibited reference materials during a test
- Taking test materials from a test site
- Falsifying documentation of continuing education contact hours

Any action that might undermine CWEA’s process of certifying basic minimal competency will be investigated.

**Non-Discrimination Policy**

CWEA does not discriminate among applicants on the basis of age, gender, race, religion, national origin, disability, sexual orientation or marital status.
Accommodations

In compliance with the Americans with Disabilities Act, reasonable 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 the individual's ability to successfully complete the certification examination. Written requests for reasonable accommodations must be submitted with the application.

Language barriers and lack of familiarity with computers are not covered under ADA laws.

Privacy

CWEA is committed to protecting privacy. Exam results and any other information regarding an application are confidential and will only be released to the applicant. Basic certification information is available on our Certification Registry. Employers can use the registry to verify an individual's certification status.

Out-of-State Programs

Anyone anywhere in the United States can apply for CWEA certification. Our certifications are specific to the state of California.

CWEA partners with the following water environment associations to administer certification exams for their members:

- Hawaii Water Environment Association
- Michigan Water Environment Association

Candidates wishing to earn certification through one of those associations should be sure to use the correct application that is specific to that association.

Reciprocity

CWEA does not grant certification by reciprocity. For other certification programs that do offer reciprocity, CWEA will provide any information necessary for verification upon request.
SCHEDULING AN EXAM

Scheduling an Exam Appointment

Once an applicant receives the approval notification email, they will be eligible to schedule an exam appointment. Applicants can schedule an exam appointment through Pearson VUE’s website by creating an account or by logging into an existing account. The applicant’s CWEA ID number is needed when creating an account. The CWEA ID number can be found in the approval notification email. To schedule an appointment over the phone, call Pearson VUE at 888-749-3881. Test centers are conveniently located throughout the U.S. Locations can be found on Pearson VUE’s Test Center Search.

Online Proctored Exams

Online proctoring is available for CWEA exams. If available, candidates will be notified in their approval email of the option to schedule their exam online versus at an in-person test center. Candidates should examine both options before making the choice that is best for them. Candidates will make their selection at the time when they schedule their exam.

Online proctored exams are a convenient way to take an exam at home or at work. Candidates will complete a check in process and are monitored online by a live proctor. An onscreen calculator and white board are provided, no physical calculators or scratch paper are allowed.

For more information about the online proctored experience, please see: https://home.pearsonvue.com/cwea/onvue. Please review the system requirements and Pearson Vue policies and procedures for online proctored exams before you schedule your appointment. You will be required to accept and comply with these policies.

To take an online proctored exam, candidates must meet the system requirements. If a candidate is testing at work, they should check with their Network Administrator or IT Professional that their system meets the requirements.

It is the candidate’s responsibility to ensure they meet the system requirements prior to their appointment time. If a candidate does not meet the system requirements, they will not be able to complete their exam and will need to reschedule.
Canceling an Existing Appointment

To cancel an appointment, applicants must notify Pearson VUE 24 hours before their scheduled appointment time. Failure to notify Pearson VUE at least 24 hours before the existing appointment will result in an $80 No Show fee. Pearson VUE will send applicants a Cancellation Confirmation to the email on file in their Pearson VUE account.

The following are considered No Shows and will result in an $80 No Show fee:

- Failing to appear at a scheduled test appointment
- Failing to check-in for an online appointment
- Arriving at the test center without a current, government-issued photo ID
- Arriving at the test center 15 minutes or later to a scheduled test appointment

Applicants must pay the No Show fee to schedule a new test appointment. Applicants should contact the CWEA office to reschedule.

Rescheduling an Exam Appointment

To reschedule an existing appointment within the same exam window, applicants must call Pearson VUE directly at least 24 hours before their existing exam appointment, for details see Canceling an Existing Appointment (p. 14).

Applicants must contact the CWEA office to reschedule (transfer) an existing exam appointment to a different exam window. Before contacting CWEA, the applicant must cancel their existing appointment.

Transferring Exam Windows

Applications are valid for one year from the first date of the applicant’s original test window. Applicants may transfer exam windows throughout the year. The first transfer is complimentary, subsequent transfers are $40.

Applicants can request a transfer at any time. If an applicant does not test by the last date of their original exam window, CWEA will automatically initiate a transfer and the applicant will be notified via email.
## Laboratory Analyst Certification Scope

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description of the Grade Level in relation to the job family.</td>
<td>Entry and basic working level.</td>
<td>Skilled or journey level.</td>
<td>Lead/advanced technical level.</td>
<td>Program manager level.</td>
</tr>
<tr>
<td>Level of knowledge, skill and ability within the job family, in relation to job tasks, including the taxonomic level of knowledge applied on the job.</td>
<td>Basic knowledge and ability, as needed to safely and effectively perform basic tasks. This includes: recall and recognition, comprehension, and application.</td>
<td>Knowledge and ability to safely and effectively accomplish most technical tasks in the job family. This includes: comprehension, application, and analysis.</td>
<td>Knowledge, skill and ability to safely and effectively accomplish and coordinate complex tasks. This includes: application, analysis and synthesis.</td>
<td>Knowledge, skill and ability to administer, coordinate and manage complex programs across vocations. This includes: analysis, synthesis, and evaluation.</td>
</tr>
<tr>
<td>Level of supervision received.</td>
<td>Receives direct supervision.</td>
<td>Receives limited supervision.</td>
<td>Receives general direction.</td>
<td>May receive broad direction.</td>
</tr>
<tr>
<td>Level of supervision exercised.</td>
<td>None.</td>
<td>May provide technical direction over other staff.</td>
<td>Will oversee and direct complex tasks performed by others.</td>
<td>Will coordinate program activities within or across vocations.</td>
</tr>
<tr>
<td>Level of training provided to other personnel.</td>
<td>None.</td>
<td>May train lower level personnel.</td>
<td>May oversee a training program.</td>
<td>Designs and administers training programs within the job family.</td>
</tr>
<tr>
<td>Use of tools.</td>
<td>Will recognize the basic tools of the job family.</td>
<td>Will be able to apply most of the tools used by those in the job family.</td>
<td>Will select tools for individuals and teams in relation to specific problems.</td>
<td>Manages and evaluates systems and facilities.</td>
</tr>
</tbody>
</table>

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Cert.CWEA.org
<table>
<thead>
<tr>
<th>Specifications</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem solving and troubleshooting</td>
<td>Follows directions.</td>
<td>Troubleshoots and solves common problems.</td>
<td>Troubleshoots and solves complex problems.</td>
<td>Evaluates program effectiveness and takes corrective actions as needed.</td>
</tr>
<tr>
<td>responsibilities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actions in relation to standard operating</td>
<td>Has the ability to follow S.O.P.s.</td>
<td>Has the ability to understand and apply S.O.P.s, laws and regulations.</td>
<td>Formulates new S.O.P.s, in compliance with laws and regulations.</td>
<td>Assures program compliance with laws and regulations.</td>
</tr>
<tr>
<td>procedures (S.O.P.s), laws and regulations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actions in relation to documentation of</td>
<td>Completes minimal work process</td>
<td>Completes routine work process</td>
<td>Responsible for detailed technical report writing and review.</td>
<td>Responsible for quality assurance of program documentation.</td>
</tr>
<tr>
<td>work activities.</td>
<td>documentation.</td>
<td>documentation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Exam Content

CWEA’s Technical Certification Program Laboratory Analyst exams are based on exam blueprints that outline the exam content and are periodically reviewed by CWEA Subject Matter Experts. An exam blueprint is based on a job task analysis that includes research of the essential duties of a Laboratory Analyst worker at a representative cross-section of systems and facilities in California. The Laboratory Analyst Certifications were last reviewed by Subject Matter Experts in 2015.

The exam content outlines that follows presents content covered on the Laboratory Analyst exams and shows the amount of the exam devoted to each KSA in the column labeled % on the exam.
LAB GRADE 1 EXAM CONTENT OUTLINE

Knowledge, Skills and Abilities (KSAs)

Each KSA describes the competencies required of an individual to successfully perform the essential duties of the job at grade level. Although the KSAs do not correspond precisely to every individual job description, they do reflect the core competencies and essential duties required of any Laboratory Analyst. The KSAs are developed from a job analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California and other participating states.

Each KSA includes descriptions of the general competencies, math competencies, and suggested reading for that KSA. Candidates are expected to understand the competencies described in this section and seek further educational opportunities to address those KSAs that have not been mastered.

KSA Weight is the approximate percent of the test content covered by a KSA. For example, a KSA with a weighting of 7% will have about 7% of all questions (or points) dedicated to that KSA, or 7% of the test is about that KSA. The KSA weight is approximate and shows the relative importance of a KSA compared to the other KSAs. The KSA weight on the actual certification test may vary slightly.

Each KSA includes an expanded description of the competencies, tasks, and duties expected of certificate holders. Math Competencies describe the math, analytical, or calculation knowledge and skills that are expected of certificate holders. There are no specific “math” questions on the test, but questions in some KSAs require computational skills to complete. Like all other questions on the test, questions requiring math or computational skills are randomly distributed throughout the test.

The Suggested Reading lists some materials that are representative of each KSA. Each reference includes chapters, sections, or pages that are representative of the KSA. This is not an exhaustive list of sources relevant to the KSA and candidates are strongly encouraged to seek additional material that covers each KSA especially in those KSAs where the candidate is not adequately prepared.
KSA 101

Understands the basic physical properties of water and wastewater and analytical methods to determine:

- Color
- Turbidity
- Odor
- Alkalinity
- Hardness
- Conductivity
- Solids
- Temperature
- pH

KSA 101 General Competencies

A Grade I Laboratory Analyst is expected to understand and competently perform relevant basic wet bench chemistry methods such as:

- Colorimetry using colorimetric comparators.
- Turbidimetry and Nephelometry using ion selective electrode equipment.
- Titrimetric tests.

These concepts are usually gained through a basic water chemistry class, entry level training or vocational school.

KSA 101 Math Competencies

- Grade I analysts must be able to calculate alkalinity, hardness, and solids based on analytical testing results.
- Analysts should be able to perform unit conversions utilizing dimensional analysis.

KSA 101 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 2120 A, B; 2130 A, B; 2150 A, B; 2320 A, B; 2340 A, B; 2510 A, B; 2550 A, B; 2540 A, B, C, D, E, F

Operation of Wastewater Treatment Plants: Chapter 16
KSA 102  

Understands the basic chemical properties of water and wastewater and analytical methods to determine:

- Dissolved oxygen
- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- Chlorine residual (Total and Free)
- Sulfide

KSA 102 General Competencies

- A Grade I Laboratory Analyst needs to demonstrate an understanding of the chemical properties and analytical methods in this KSA and how they relate to wastewater/water treatment.
- Determine dissolved oxygen using the Winkler method and a dissolved oxygen probe to determine biochemical oxygen demand.
- Determine chlorine residual using a colorimeter and titration.
- This knowledge is usually obtained through on the job training, vocational school, suggested reading, and basic water quality chemistry courses.

KSA 102 Math Competencies

- The Grade I lab analyst is expected to be able to calculate the results in this KSA from analytical results in using laboratory methods.
- Calculate results from above analytical methods.
- The analyst should be prepared to use dimensional analysis and unit conversions for calculations.
- The analyst should have basic algebraic skills to solve for an unknown.

KSA 102 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 4500-O A, C; 5210 A,B; 4500-CL A, B, D; 5220A, C,D; 4500-S2

Operation of Wastewater Treatment Plants: Chapter16

Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants: Lesson 4, Section 16.41, 16.410, 16.411
KSA 103 Weight: 8%

Understands the microbiological properties and methods for analysis of water and wastewater such as:

- Coliform by Multiple Tube Fermentation
- Coliform by Enzyme Substrate Test
- Heterotrophic Plate Count (HPC)

KSA 103 General Competencies

- A Grade I laboratory analyst should understand the general bacteriological concepts (sterilization, media preparation and different types of bacteria).
- This knowledge is usually obtained through hands on experience, suggested reading, microbiology college course work, and vocational school.

KSA 103 Math Competencies

- Laboratory analysts should be comfortable calculating concentrations from a dilution series.
- This requires familiarity with scientific notation, dimensional analysis, unit conversions and solving for an unknown using algebra.

KSA 103 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 9050 A, C; 9215 A, B, C; 9221 A, B, C, E; 9223 A, B

Microbiological Methods for Monitoring the Environment: Part II: A.1, 3, 6, B. 1,2,3,4, 5, 6; Part III: A, B, C; Part IV: A; Part V: C

Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants: Chapter 16, Lesson 7
KSA 104

Collection of samples of wastewater, sludge, receiving water and industrial waste in accordance with established lab procedures.

- Chain of custody
- Sample type (grab and composite)
- Container type and preparation
- Preservation
- Hold time
- Sampling techniques
- Proper labeling
- Storage condition

KSA 104 General Competencies

- Accurate and clear documentation and legal/regulatory requirements for record keeping.
- Understanding of 24-hour sampling and operation of an autosampler.
- Knowledge of preservation and use of glass and plastic containers.

KSA 104 Math Competencies

- No known math competencies needed for this KSA.

KSA 104 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Section 1060: A, B, C, Table 1060:I; 1080, Table 1080:I; 9030, B. 18, 9060 A, B

Operation of Wastewater Plants: Chapter 14, 16

Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants: Chapter 16.3
KSA 105

Utilizes techniques and equipment used in laboratory analysis. Gravimetric (balance weighing)

- Titrimetric/volumetric (burette, pipette, graduated cylinder)
- Sterilization (autoclave, Bunsen burner, oven)
- Colorimetric (visual observation, spectrophotometer/colorimeter)
- Electrometric (meters, probes/electrodes)
- Turbidimetric (Nephelometer)
- Thermometers (ranges and max temp)

KSA 105 General Competencies

- A Grade I Laboratory Experience with calibration and use of the above instruments and equipment.
- Ability to use these techniques and instruments to analyze physical properties listed in KSA 101 such as alkalinity, turbidity, color, etc.
- This knowledge is obtained through hands on experience, college level chemistry coursework, suggested reading, and vocational school.

KSA 105 Math Competencies

- Analyst should know how to complete unit conversions such as converting from PPM to mg/L, temperatures in Celsius and Fahrenheit.
- Ability to convert units using dimensional analysis.

KSA 105 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 1050; 2130 A, B; 4500-H+; 9040,9030,9020

Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants: Chapter 16.1-16.2
KSA 106

Operates, maintains and routinely calibrates basic test equipment such as:

- Turbidimeters
- Dissolved oxygen meters
- pH meters
- Balances (analytical and top-loading)
- Conductivity meters

KSA 106 General Competencies

- Experience calibrating and using the above equipment in the field and laboratory.
- Understand how to make a dilution series.
- Calibration of equipment based on direction from lead analyst.
- Experience is usually gained through on the job training, college level chemistry lab work, vocational school, and suggested reading.

KSA 106 Math Competencies

- Unit analysis
- Dimensional analysis
- Utilizing concepts such as molarity and normality.

KSA 106 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 2130 A, B; 2510 A, B; 4500-H+; 4500-O A, C, G
KSA 107

Recognizes laboratory hazards and follows proper safety procedures with an understanding of:

- Chemical handling, storage, disposal, and spill response
- Personal Protective Equipment (PPE)
- Biological and chemical hygiene
- Engineering controls (fume hoods, etc.)
- Safety Data Sheet (SDS)
- Physical hazards (burns, sharps, compressed gas, electrical safety, fire, etc.)
- Good housekeeping

KSA 107 General Competencies

- Knowledge of safety regarding handling and disposal of acids and bases, solvents.
- Safety regarding inhalation hazards.
- Familiarity with the purpose and use of Personal Protective Equipment (PPE) such as face shields, gloves, emergency showers.
- Understanding of each section of Safety Data Sheets and their relation to lab safety and the laboratory right-to-know law.
- Skills in this KSA are typically gained through hands on experience, suggested reading, college level chemistry lab coursework, and/or vocational school coursework.
- OSHA courses or safety training courses are useful in expanding knowledge in this KSA.

KSA 107 Math Competencies

- No specific math competencies needed for this KSA.

KSA 107 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 1090 A-J
Operation of Wastewater Treatment Plants: Chapter 14
Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants: Chapter 16, Section 16.2-16.23
KSA 108  
Prepares solutions and essential laboratory supplies  
- Dilution of concentrated solutions  
- Preparation of filters and dishes for residue testing  
- Preparation of bacteriological culture media  

KSA 108 General Competencies  
- Knowledge of the safety concerns regarding the preparation of solutions and different types of measurement instruments/glassware.  
- Glass fiber filters, crucibles.  
- Sterilization.  
- Buffering solutions.  
- This knowledge and skills in this KSA are typically obtained through hands on experience, vocational training, water quality chemistry coursework and the suggested reading.  

KSA 108 Math Competencies  
- Ability to calculate concentrations from a dilution series.  
- Familiarity with scientific notation, dimensional analysis, unit conversions and solving for an unknown using algebra.  

KSA 108 Suggested Reading  
Standard Methods for Examination of Water and Wastewater, Sections: 2540 A, B, C, D, E, F; 9050 A, C; 9215 A, 6; 9221 B.1, 2, 3; 9221 E.1
KSA 109  
Performs accurate calculations

- Significant figures, proper rounding
- Unit conversion
- Basic algebraic and statistical calculations
- Solution preparation (dilution factors, normality, molarity)
- Sample dilution
- Scientific notation

KSA 109 General Competencies

- The ability to apply these math skills in the performance of other relevant KSAs.
- These skills through coursework in algebra and chemistry through a vocational school or the suggested reading.
- While an analyst can learn some on the job, an entry level analyst should already have a firm grasp on these concepts.

KSA 109 Math Competencies

- It is important for calculating wastewater and water parameters to know: multiplication, division, algebraic concepts, dimensional analysis, and unit conversions.

KSA 109 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 1010; 1020 A, B; 1030 A, B, C; 1050 A, B
KSA 110          Weight: 4%

Understands and practices proper laboratory ethics.

KSA 110 General Competencies

- Reporting ethics violations such as improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards.
- Direct chain of command
- Consequences of violations.
- Typically, knowledge in this KSA is gained on the job through data integrity/ethics program training courses, a vocational or college level chemistry course.

KSA 110 Math Competencies

- None for this KSA.

KSA 110 Suggested Reading

NELAC Standard (2003) Section 5.5.2.7
KSA 111

Documents and maintains accurate and complete laboratory records.

- Routine documentation, including worksheet/log sheet entries
- Sample documentation
- Chain-of-custody
- Record data accurately
- Report non-conforming data
- Awareness of LIMS (Laboratory Information Management Systems)
- Data integrity and legal defensibility

KSA 111 General Competencies

- Baseline knowledge in order to analyze samples and keep legal documentation of samples from receiving to reporting.
- These skills can be obtained through on the job training, vocational school, college level chemistry course or suggested reading.

KSA 111 Math Competencies

- Understanding of standard deviations, mean, median, and mode.

KSA 111 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 1050; 1080; Table 1080:

Operation of Wastewater Treatment Plants: Chapter 16.0, 16.1
KSA 112 

Understands basic concepts of Quality Assurance/Quality Control

- Control charts
- Data quality
- Standard and reagent quality
- Reagent water quality
- DOC (Demonstration of Competency)

KSA 112 General Competencies

- These skills can be obtained through on the job training, vocational school, water quality laboratory methods course or suggested reading.

KSA 112 Math Competencies

- Understand and apply standard deviations, mean, median, and mode.

KSA 112 Suggested Reading

Standard Methods for Examination of Water and Wastewater, Sections: 1010; 1020 A, B; 1030 A, B, C; 1050 A, B
Study Materials

The following section includes the titles and information of primary and secondary references. 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.

Primary Study Materials


- Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants (Reprinted from Operation Wastewater Treatment Plants Volume II.)

- Lectures on Wastewater Analysis and Interpretation Genium Publishing Corporation Dept.


- Microbiological Skills for Water and Wastewater Analysis Author: Douglas W. Clark 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 505/646-6418 fax www.wrri.nmsu.edu
Practice Test

This section provides a practice certification test to help certificate candidates become familiar with the test format and subject matter.

Select the best answer for each item below.

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.

3. 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.

4. 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.
5. 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.

6. 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.

<table>
<thead>
<tr>
<th>Time</th>
<th>Flow, MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00 a.m.</td>
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</tr>
<tr>
<td>7:00 a.m.</td>
<td>6.4</td>
</tr>
<tr>
<td>8:00 a.m.</td>
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</tr>
<tr>
<td>9:00 a.m.</td>
<td>7.2</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>6.8</td>
</tr>
<tr>
<td>11:00 a.m.</td>
<td>7.2</td>
</tr>
<tr>
<td>12:00 p.m.</td>
<td>9.0</td>
</tr>
<tr>
<td>1:00 p.m.</td>
<td>9.6</td>
</tr>
<tr>
<td>2:00 p.m.</td>
<td>8.8</td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td>8.2</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>7.6</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>6.8</td>
</tr>
</tbody>
</table>

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

7. 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.
8. 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.

9. 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.

10. 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.
11. 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

12. 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
- 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

13. 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
14. 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.

15. 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

16. 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
17. Given the following data, calculate the BOD for the sample if the initial DO is 8.5 mg/L.

<table>
<thead>
<tr>
<th>Sample size, mL</th>
<th>DO Final, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>8.5</td>
</tr>
<tr>
<td>3.0</td>
<td>7.0</td>
</tr>
<tr>
<td>5.0</td>
<td>5.8</td>
</tr>
<tr>
<td>7.0</td>
<td>4.8</td>
</tr>
<tr>
<td>9.0</td>
<td>3.4</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
</tr>
<tr>
<td>15</td>
<td>0.5</td>
</tr>
</tbody>
</table>

a. 159 mg/L  

b. 159.7 mg/L  

c. 160 mg/L  

d. 162.2 mg/L

18. 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

19. How many grams of chromium trioxide (CrO₃) are needed to prepare one liter of 1,000 mg/L Cr standard (Cr=52, O=16)?

a. 0.520 g CrO₃  

b. 0.765 g CrO₃  

c. 1.308 g CrO₃  

d. 1.923 g CrO₃

20. 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).
21. Agar medium is used for:
   a. escherichia coliform.
   b. fecal coliform.
   c. heterotrophic plate count.
   d. all bacterial analysis.

22. During an acid-base titration, the titrant is added to the sample with a:
   a. graduated cylinder.
   b. serological pipet.
   c. class A pipet.
   d. burette.

23. When preparing diluted calibration standards from a stock standard, use a combination of the following to get the most precise standard:
   a. graduated cylinder and class A volumetric pipet
   b. graduated cylinder and burette
   c. class A volumetric flask and class A volumetric pipet
   d. class A volumetric flask and burette

24. 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.

25. 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
26. 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.

27. Conductance measurements are temperature compensated to:
   a. 20.0°C.
   b. 25.0°C.
   c. 30.0°C.
   d. 20.0°C to 25.0°C.

28. 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.

29. Alkalinity is reported as:
   a. alkalinity, mg/L phenolphthalein.
   b. alkalinity, mg CaCO3/L.
   c. alkalinity, mg/L.
   d. alkalinity, mg/L acetic acid.

30. The hardness determination by EDTA titration measures:
   a. calcium and magnesium.
   b. calcium carbonate.
   c. alkalinity, corrosivity and carbonates.
   d. calmagite.
31. The indicator for the hardness determination is:
   a. ethylenediaminetetraacetic acid.
   b. eriochrome Black T.
   c. ethylenediaminetriacetic acid.
   d. brom cresol green.

32. 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.

33. 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.

34. 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.
35. The process designed to kill most microorganisms in wastewater, including essentially all pathogenic bacteria is called:
   a. sterilization.
   b. disinfection.
   c. biodegradation.
   d. chlorine demand.

36. 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.

37. 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.

38. 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.
39. Precision is measured by:
   a. analyzing replicate samples.
   b. analyzing matrix spiked samples.
   c. calculating standard error.
   d. calculating percent recovery.

40. Match the term with one of the four definitions listed below:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Accuracy</td>
<td>1. Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.</td>
</tr>
<tr>
<td>b. Bias</td>
<td>2. The deviation in any step in an analytical procedure that can be treated by standard statistical techniques.</td>
</tr>
<tr>
<td>c. Precision</td>
<td>3. The combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.</td>
</tr>
<tr>
<td>d. Random Error</td>
<td>4. Measures the degree of agreement among replicate analyses of a sample, usually expressed as the standard deviation.</td>
</tr>
</tbody>
</table>

41. 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
## Answer Key

<table>
<thead>
<tr>
<th>No.</th>
<th>Answer</th>
<th>KSAs</th>
<th>No.</th>
<th>Answer</th>
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<td>12</td>
<td>C</td>
<td>101, 102, 109</td>
<td>33</td>
<td>B</td>
<td>101, 102</td>
</tr>
<tr>
<td>13</td>
<td>C</td>
<td>101, 102, 109</td>
<td>34</td>
<td>A</td>
<td>101, 102</td>
</tr>
<tr>
<td>14</td>
<td>C</td>
<td>101, 102, 109</td>
<td>35</td>
<td>B</td>
<td>103, 108</td>
</tr>
<tr>
<td>15</td>
<td>A</td>
<td>102, 103, 108, 109</td>
<td>36</td>
<td>D</td>
<td>103, 108</td>
</tr>
<tr>
<td>16</td>
<td>C</td>
<td>102, 103, 108, 109</td>
<td>37</td>
<td>A</td>
<td>103, 108</td>
</tr>
<tr>
<td>17</td>
<td>C</td>
<td>102, 103, 108, 109</td>
<td>38</td>
<td>D</td>
<td>112</td>
</tr>
<tr>
<td>18</td>
<td>B</td>
<td>102, 103, 108, 109</td>
<td>39</td>
<td>A</td>
<td>112</td>
</tr>
<tr>
<td>19</td>
<td>D</td>
<td>102, 103, 108, 109</td>
<td>40</td>
<td>A, 3 B, 1 C, 4 D, 2</td>
<td>112</td>
</tr>
<tr>
<td>20</td>
<td>A</td>
<td>102, 103, 108, 109</td>
<td>41</td>
<td>B</td>
<td>112</td>
</tr>
<tr>
<td>21</td>
<td>C</td>
<td>102, 103, 108, 109</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Selected Problem Solutions

6. 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.

<table>
<thead>
<tr>
<th>Time</th>
<th>Flow, MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00 a.m.</td>
<td>5.8</td>
</tr>
<tr>
<td>7:00 a.m.</td>
<td>6.4</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>6.8</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>7.2</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>6.8</td>
</tr>
<tr>
<td>11:00 a.m.</td>
<td>7.2</td>
</tr>
<tr>
<td>12:00 p.m.</td>
<td>9.0</td>
</tr>
<tr>
<td>1:00 p.m.</td>
<td>9.6</td>
</tr>
<tr>
<td>2:00 p.m.</td>
<td>8.8</td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td>8.2</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>7.6</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Solution:

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

\[
9 \text{ mgd} \times 1,000 \text{ mL} = 100 \text{ mL} \\
90.2 \text{ mgd}
\]
11. 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
0.0127 g x 1,000 mL x 1,000 mg = 254 mg
50 mL 1 L 1 g 1L
= 250 mg/L

12. 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:
Determine the normality of FAS (N\(_1\)V\(_1\)=N\(_2\)V\(_2\))
Determine the COD, mg/L

\[ N_{\text{FAS}} = \frac{N_{\text{dichromate}} \times \text{mLs dichromate}}{\text{mLs FAS}} \]
\[ = \frac{0.25 \text{ N} \times 10 \text{ mL}}{10.7 \text{ mL}} = 0.23 \text{ N} \]

mL FAS\(_{\text{blank}}\) = A mL FAS\(_{\text{sample}}\) = B

\[ \text{COD} = \left( A - B \right) \times 8,000 \times N_{\text{FAS}} \]
\[ \text{mL} \]
COD mg/L = \((10.6 \, \text{mL} - 7.5 \, \text{mL}) \times 0.23 \, \text{N}\)

\[
\frac{20 \, \text{mL}}{20 \, \text{mL}} = 290 \, \text{mg/L COD}
\]

13. 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 g
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

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

\[
= \frac{0.48 \, \text{g} \times 100}{31.02 \, \text{g}} = 1.55\% \, \text{solids}
\]

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

\[
= \frac{(0.48 \, \text{g} - 0.18 \, \text{g}) \times 100}{0.48 \, \text{g}} = 62.5\% \, \text{volatile}
\]
14. 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:

\[
\begin{align*}
\% \text{ SS effluent} &= \frac{\text{mg/L SS effluent}}{\% \text{ SS influent}} \\
\% \text{ SS influent} &= \frac{\text{mg/L SS influent}}{59%} = 112 \text{ mg/L} \\
100% &= \text{?}\end{align*}
\]

Solving for the unknown:

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

15. 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:

\[
N_1V_1 = N_2V_2 \quad 25 \text{ mL} \times 0.01 \text{ N} = 0.0025 \text{ N NaOH} \quad \frac{100 \text{ mL}}{1 \text{ mL}}
\]

16. 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:

\[
1,000 \text{ mL sample} \times \frac{1.33 \text{ g sample}}{1 \text{ L sample}} \times \frac{30 \text{ g ferrous chloride}}{100 \text{ g sample}} = 399 \text{ grams/L FeCl}_3
\]
17. Given the following data, calculate the BOD for the sample if the initial DO is 8.5 mg/L.

<table>
<thead>
<tr>
<th>Sample size, mL</th>
<th>DO Final, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>8.5</td>
</tr>
<tr>
<td>3.0</td>
<td>7.0</td>
</tr>
<tr>
<td>5.0</td>
<td>5.8</td>
</tr>
<tr>
<td>7.0</td>
<td>4.8</td>
</tr>
<tr>
<td>9.0</td>
<td>3.4</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
</tr>
<tr>
<td>15</td>
<td>0.5</td>
</tr>
</tbody>
</table>

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

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

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

The problem can be done using ratios:

\% \ SS_{effluent} = \frac{mg/L \ SS_{effluent}}{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:

\[\frac{59}{100} = \frac{112 \ mg/L}{?} \]

Solving for the unknown:

\[112 \ mg/L \times \frac{100}{59} = 190 \ mg/L \ \text{influent SS} \]
18. 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.

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

$$\frac{1,000 \text{ mg} \times 10 \text{ mL} \times A \times 5 \text{ mL} \times B}{1,000 \text{ mL} \times A \times 1,000 \text{ mL} \times B \times 100 \text{ mL} \times C \times 1,000 \text{ mL} \times C} = \frac{0.5 \text{ mg} \times X}{1 \text{ L} \times C} = 0.5 \text{ mg/L}$$

19. 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$_3$

$$= (1 \times 52 \text{ g/gmole}) + 3 \times 16 \text{ g/gmole)$$

$$= 100 \text{ g/gmole}$$

$$\frac{1,000 \text{ mg} \times \text{Cr}}{1 \text{ L} \times 1,000 \text{ mg} \times \text{Cr}} \times \frac{1 \text{ g} \times \text{Cr}}{1 \text{ mole} \times \text{Cr}} \times \frac{1 \text{ mole} \times \text{CrO}_3}{52 \text{ g} \times \text{Cr}} \times \frac{100 \text{ g} \times \text{CrO}_3}{1 \text{ mole} \times \text{CrO}_3} = 1.923 \text{ g CrO}_3$$
41. 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: \( \frac{126}{15} = 8.4 \)  
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  
\( \frac{15}{2} = 7.5 \), 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
LAB GRADE 2 EXAM CONTENT OUTLINE

Knowledge, Skills and Abilities (KSAs)

Each KSA describes the competencies required of an individual to successfully perform the essential duties of the job at grade level. Although the KSAs do not correspond precisely to every individual job description, they do reflect the core competencies and essential duties required of any Laboratory Analyst. The KSAs are developed from a job analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California and other participating states.

Each KSA includes descriptions of the general competencies, math competencies, and suggested reading for that KSA. Candidates are expected to understand the competencies described in this section and seek further educational opportunities to address those KSAs that have not been mastered.

KSA Weight is the approximate percent of the test content covered by a KSA. For example, a KSA with a weighting of 7% will have about 7% of all questions (or points) dedicated to that KSA, or 7% of the test is about that KSA. The KSA weight is approximate and shows the relative importance of a KSA compared to the other KSAs. The KSA weight on the actual certification test may vary slightly.

Each KSA includes an expanded description of the competencies, tasks, and duties expected of certificate holders. Math Competencies describe the math, analytical, or calculation knowledge and skills that are expected of certificate holders. There are no specific “math” questions on the test, but questions in some KSAs require computational skills to complete. Like all other questions on the test, questions requiring math or computational skills are randomly distributed throughout the test.

The Suggested Reading lists some materials that are representative of each KSA. Each reference includes chapters, sections, or pages that are representative of the KSA. This is not an exhaustive list of sources relevant to the KSA and candidates are strongly encouraged to seek additional material that covers each KSA especially in those KSAs where the candidate is not adequately prepared.
KSA 201  
Demonstrates proficient knowledge of the physical properties, methods and interferences for the analysis of water and wastewater.

- Color
- Turbidity
- Odor
- Alkalinity
- Hardness
- Conductivity
- Solids
- Temperature
- pH
- Acidity
- Salinity
- Oil and grease

KSA 201 General Competencies
A journey level laboratory analyst is expected to have a comprehensive knowledge of topics in KSA201. This is typically gained through

- Graduate school
- Entry-level in-house training

KSA 201 Math Competencies
Ability to do temperature conversions between different temperature scales. Ability to calculate alkalinity, hardness or acidity using formula

KSA 201 Suggested Reading
Standard Methods for the Examination of Water and Wastewater, Section 2010, 2020, 2110, 2120, 2130, 2150, 2310, 2320, 2340, 2510, 2520, 2540, 5520.

Lectures on Wastewater Analysis and Interpretation, Lecture 7, 14, 15.
KSA 202

Demonstrates proficient knowledge of the chemical properties, methods and interferences for the analysis of water and wastewater

- Dissolved oxygen
- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- Chlorine residual (Total and Free)
- Sulfide
- Phosphorus methods (orthophosphate, total phosphorus)
- Nitrogen methods (ammonia, nitrate, nitrite, Total Kjeldahl Nitrogen)
- Major cations (Sodium, Calcium, Magnesium, Potassium)
- Major anions (Sulfate, Chloride, Fluoride, Nitrite, Nitrate, Bicarbonate)

KSA 202 General Competencies

A journey level Laboratory analyst is expected to have in depth knowledge and complete understanding of all the topics in KSA 202. This includes the how the tests are done, the chemistry behind the analyte tested for and test method used, interferences affecting the test and how it is eliminated.

KSA 202 Math Competencies

Ability to calculate BOD and determine waste water treatment efficiency. Using corresponding formula to determine the analyte of interest for all tests.

KSA 202 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 4010, 4020, 4500-Cl, 4500-CI\(^-\), 4500-F\(^-\), 4500-N, 4500-NH\(_3\), 4500-NO2\(^-\), 4500-NO3\(^-\), 4500-Norg, 4500-O, 4500-P, 4500-S2\(^-\), 5020, 5210,
5220

Lectures on Wastewater Analysis and Interpretation, Lecture 6, 8, 9, 10, 11, 12.
KSA 203

Demonstrates proficient knowledge of the microbiological properties, methods and Interferences for the analysis of water and wastewater

- Coliform by Multiple Tube Fermentation
- Coliform by Enzyme Substrate Test
- Coliform by Membrane filtration
- Heterotrophic Plate Count (HPC)

KSA 203 General Competencies

A journey level Laboratory analyst is expected to have a complete understanding of all the topics of micro testing used in wastewater treatment facility. This includes how the tests mentioned in KSA 203 are done, results reported and validated. Choice of indicator organism, their temperature requirements and incubation period. This knowledge is typically gained through

- Graduate school
- Experience working in the wastewater treatment facility

KSA 203 Math Competencies

Ability to calculate results using serial dilution.

KSA 203 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section: 9010, 9020, 9030, 9040, 9050,
9060, 9215, 9221, 9222.

Lectures on Wastewater Analysis and Interpretation, Lecture 17.

Cert.CWEA.org
KSA 204

Demonstrates functional knowledge of acute toxicity methods.

KSA 204 General Competencies

For this KSA the analyst is required to have a functional understanding of WET testing techniques and all new terms and jargon that are unique to the procedure.

KSA 204 Math Competencies

N/A

KSA 204 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 8010, 8910. The Whole Effluent Toxicity methods listed in 40 CFR 136.3

Lectures on Wastewater Analysis and Interpretation, Lecture 18
KSA 205          Weight: 6%

Demonstrates basic understanding of the wastewater treatment process control analyses

- Process control topics (MLSS/SVI, MCRT, F/M, chlorination, dechlorination, volatile acids/alkalinity ratio)
- Microorganism speciation and counting
- Digester sludge analysis

KSA 205 General Competencies

A journey level laboratory analyst is required to understand waste water treatment processes including effluent discharge and efficiency, activated sludge monitoring and treatment chemical dosages.

KSA 205 Math Competencies

Conversion of laboratory results in mg/L to plant operating units of pounds and gallons

KSA 205 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 2540, 2530, 2710, 2720, 4500-Cl 5020, 5560.

Lectures on Wastewater Analysis and Interpretation, Lecture 17 (Microscopic examination), 20.
KSA 206

Collects samples of wastewater, sludge, receiving water and industrial waste in accordance with established lab procedures

- Chain of custody
- Sample type (grab and composite)
- Container type and preparation
- Preservation (pH adjustment)
- Hold time
- Sampling technique
- Proper labeling
- Storage condition
- Sample location
- QC (sample validation/invalidation)
- Ultra clean sampling methods
- Autosampler maintenance and programming (flow-based or time-based)

KSA 206 General Competencies

A journey level laboratory analyst is required to have detailed understanding of sampling techniques. Importance of COC and sample lineage.

KSA 206 Math Competencies

N/A

KSA 206 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 1060, individual method sections for preservation and storage.

Lectures on Wastewater Analysis and Interpretation, Appendix B
KSA 207

Utilizes techniques and maintains/troubleshoots equipment used in laboratory analysis

- Gravimetric (balance weighing)
- Titrimetric/volumetric (burette, pipette, graduated cylinder, titrator)
- Sterilization (autoclave, Bunsen burner, oven)
- Colorimetric (visual observation, spectrophotometer/colorimeter)
- Electrometric (meters, probes/electrodes, LDO, ISE)
- Turbidimetric (Nephelometer)
- Thermometers (ranges and maximum temperature)
- Ion chromatographs
- Sample preparation (digestion, extraction, filtration, distillation)

KSA 207 General Competencies

A journey level analyst acquires skills mentioned in KSA 207 typically through experience working in a wastewater treatment plant laboratory. The analyst also needs to be aware of the instrument principle, working and troubleshooting techniques used for:

- Analysis the instrument is used for
- Instrument operation and working principle
- Instrument maintenance and troubleshooting techniques

KSA 207 Math Competencies

N/A

KSA 207 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 2130, 9030, 2550, 3030.
KSA 208

Operates, maintains and performs routine calibration on test equipment.

- Turbidimeters
- Dissolved oxygen meters
- pH meters
- Balances (analytical and top-loading)
- Ion chromatographs
- Conductivity meters
- Microscopes
- Autoclaves
- Ovens
- Incubators
- Refrigerators
- Water baths
- Titrators
- Spectrophotometers

KSA 208 General Competencies

A journey level analyst acquires skills mentioned in KSA 208 typically through experience, working in a wastewater treatment plant laboratory.

KSA 208 Math Competencies

N/A

KSA 208 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 2130, 9010, 9020, 9030, 2120, 2510, 4500-NH₃, 4500-H⁺, 4500-O.
KSA 209

Recognizes and recommends corrective action for laboratory hazards and follows proper safety procedure. (*Only basic understanding required)

- Physical hazards (burns, sharps, compressed gas, electrical safety, fire, etc.)
- Chemical hazards (handling, storage, disposal, and spill response)
- Biological hazards (handling, storage, and disposal)
- Chemical hygiene plan
- Personal Protective Equipment (PPE)
- Engineering controls (fume hoods, etc.)
- Safety Data Sheet (SDS)
- Good housekeeping
- *(Confined space awareness)
- *(Manhole sampling procedure and safety)

KSA 209 General Competencies

A journey level analyst must be aware of common laboratory conditions and laboratory safety including chemistry laboratory safety.

KSA 209 Math Competencies

N/A

KSA 209 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 1090.

Occupational Safety and Health Act of 1970 (OSH Act) and other relevant laws.
KSA 210
Prepares reagents, calibration and quality control standards, and essential laboratory supplies

- Dilution of concentrated solutions
- Preparation of filters and dishes for residue testing
- Preparation of bacteriological culture media
- Clean glassware used in laboratory analysis
- Create working standards from concentrated standards
- Verify prepared reagent quality (standardization)
- Maintain chemical inventory

KSA 210 General Competencies
The journey level laboratory analyst is required to have a good understanding of preparation of intermediate and working standards from stock standards or corresponding dry chemicals. Knowledge of standard preparation log and chemical inventory is also necessary.

KSA 210 Math Competencies
Dilution calculations

KSA 210 Suggested Reading
Standard Methods for the Examination of Water and Wastewater, Section 1010, 1020, 1070, 1080, 2540.

Lectures on Wastewater Analysis and Interpretation, Lecture 7
KSA 211

Weight: 4%

Performs accurate calculations

- Significant figures
- Unit conversion
- Advanced algebraic and statistical calculations
- Solution preparation (dilution factors, normality, molarity)
- Sample dilution
- Graphing (linear regression)
- Standard curves

KSA 211 General Competencies

The journey level analyst must have a very good understanding of mathematical and statistical concepts used in chemistry.

KSA 211 Math Competencies

All topics in KSA 211 require a good understanding of Math and statistics.

KSA 211 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 1010, 1020, 1030, 1050.

Lectures on Wastewater Analysis and Interpretation, Lecture 2.
KSA 212

Understands and practices proper laboratory ethics.

KSA 212 General Competencies

Laboratory professionals are required to maintain high standards of lab practice. They grade II analyst are required to exercise sound judgment in performing laboratory testing.

KSA 212 Math Competencies

N/A

KSA 212 Suggested Reading

Lectures on Wastewater Analysis and Interpretation, Lecture 23. www.acs.org, The chemical professionals code of conduct.
KSA 213

Documents and maintains accurate and complete laboratory records and reports

- Routine documentation, including worksheet/log sheet entries
- Sample documentation
- Chain-of-custody forms
- Record data accurately
- Report non-conforming data
- Awareness of Lab Information Management Systems (LIMS)
- Assist with the preparation of technical reports
- Awareness of SCADA
- Data integrity and legal defensibility

KSA 213 General Competencies

The journey level analyst is required to have a good understanding of how data is reported, evaluated and validated.

KSA 213 Math Competencies

N/A

KSA 213 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 1010, 1020, 1030, 1040, 1050, 1060.

Lectures on Wastewater Analysis and Interpretation, Lecture 2, 21.
KSA 214

Assesses data using Quality Assurance/Quality Control

- Control charts
- Standards and reagents quality
- Reagent water quality (inhibitory residue and water suitability)
- Demonstration of Capability (DOC)
- Instrument maintenance records
- Perform MDLs
- Perform proficiency testing
- Documentation of corrective action
- Analytical and microbiological data quality

KSA 214 General Competencies

The journey level analyst must have a good knowledge and understanding of QA/QC procedures used in the wastewater treatment facility laboratory.

KSA 214 Math Competencies

Statistical methods used in chemistry

KSA 214 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 1010, 1020, 1030, 1040, 1050, 1070, 1080.

Lectures on Wastewater Analysis and Interpretation, Lecture 2, 21, 23
KSA 215

Understands and follows government regulations

- Clean Water Act
- NPDES permit compliance and regulatory authority
- OSHA (IIPP, ERP, CHP)

KSA 215 General Competencies

The journey level analyst must have a detailed knowledge and understanding of federal and state regulations. The analyst operates within a compliance monitoring network using approved methods.

KSA 215 Math Competencies

N/A

KSA215 Suggested Reading

Lectures on Wastewater Analysis and Interpretation, Lecture 1, 23, Appendix A (Code of Federal Regulations).

Clean Water Act, 40 CFR 136, Method Update Rule.
Study Materials

The following section includes the titles and information of primary and secondary references. 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.

Primary References:


- Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants (Reprinted from Operation Wastewater Treatment Plants Volume II.)

- Lectures on Wastewater Analysis and Interpretation Genium Publishing Corporation Dept.


Practice Test

This section provides a practice certification test to help certificate candidates become familiar with the test format and subject matter.

Select the best answer for each item below.

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

2. Which of the following practices is important in storing and handling flammable liquids?
   a. Flammable liquids must only be used in a low oxygen environment.
   b. All nonworking quantities of flammable liquids should be removed from the bench top and stored under the counter or in a laboratory storage cabinet.
   c. Flammable liquids need to stored separate from other flammable organic solvents.
   d. Segregate flammable liquids from other hazardous materials and minimize ignition sources whenever flammable liquids are being stored or handled.

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

4. The methods of analysis that are approved (promulgated) for use on regulated wastewater samples are found listed in:
   d. EPA/600/4-79/020 Methods for Chemical Analysis of Water and Wastes.
5. Sample protocol for residual chlorine includes:
   a. preserving the sample with sodium thiosulfate for a 7-day holding time.
   b. preserving the sample at 4°C for a 7-day holding time.
   c. preserving the sample at 4°C for a 2-hour holding time.
   d. no preservation and immediate analysis.

6. Sample containers typically are made of plastic or glass, but one material may be preferred over the other. Which of the following statements is correct?
   a. Silica and sodium may be leached from plastic but not from glass, and trace levels of metals may adsorb onto the walls of glass containers.
   b. Silica and sodium may be leached from plastic but not from glass, and trace levels of metals may adsorb onto the walls of plastic containers.
   c. Silica and sodium may be leached from glass but not from plastic, and trace levels of metals may adsorb onto the walls of glass containers.
   d. Silica and sodium may be leached from glass but not from plastic, and trace levels of metals may adsorb onto the walls of plastic containers.

7. Of the four possible outcomes of bias and precision:
   a. only the condition of low bias and high precision is accurate.
   b. only the condition of low bias and low precision is accurate.
   c. only the condition of high bias and high precision is accurate.
   d. only the condition of high bias and low precision is accurate.

8. Chain-of-custody:
   a. replaces the need for sample container labels.
   b. must include field notes regarding sampling conditions.
   c. is the ability to trace sample possession and handling from collection through analysis and final disposition.
   d. is the ability to trace sample handling techniques from preservation through extraction or digestion to analysis.
9. What is the most correct answer to the following addition problem? 10.623 + 2.16 + 200.5 + 1478 =
   a. 1691.28
   b. 1691.3
   c. 1691
   d. 1690

10. What is the weight of anhydrous KH2PO4 required to make 100 mL of solution containing 15.0 mg/L phosphorus (P)?
   a. 6.6 g
   b. 6.6 mg
   c. 3.4 g
   d. 0.34 mg

11. Oxidation refers to:
   a. a gain in electrons with a corresponding decrease in oxidation number.
   b. a loss in electrons with a corresponding decrease in oxidation number.
   c. a gain in electrons with a corresponding increase in oxidation number.
   d. a loss in electrons with a corresponding increase in oxidation number.

12. A standard solution is prepared from a 0.100% stock solution of a pure metal. Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. What is the concentration of the standard solution?
   a. 0.005 mg/L
   b. 0.050 mg/L
   c. 0.500 mg/L
   d. 5.00 mg/L

13. UV/Visible spectroscopy is based on which of the following scientific principles?
   a. Nernst Equation
   b. Bernoulli’s Law
   c. Henry’s Law
   d. Beer’s Law
14. In atomic absorption spectrophotometry, for a particular element to absorb light at its characteristic wavelength, the atoms must be:
   a. ionized.
   b. reduced to their ground-state.
   c. complexed.
   d. oxidized.

15. Turbidity analysis is an optical measurement of scattered light. Here the scattered light is measured by the detector at an angle of
   a. 45°
   b. 75°
   c. 180°
   d. 90°

16. Do not report values above the highest standard of a standard curve unless:
   a. no instrument parameters have been changed.
   b. the value is less than 1.5 times the highest standard.
   c. an initial demonstration of greater linear range has been made.
   d. all of the above criteria are met.

17. According to the Lambert’s/Beer’s Law:
   a. absorbance is proportional to concentration.
   b. transmittance is proportional to concentration.
   c. transmittance is proportional to absorbance.
   d. transmittance is independent of concentration.

18. A Conductivity meter is calibrated using
   a. 0.01M KCl
   b. 0.01N NaCl
   c. 0.01N AgCl
   d. 0.001M NaCl

19. Which of the following parameters cannot be measured using a specific-ion electrode?
   a. Nitrate
   b. Fluoride
   c. Chemical oxygen demand
   d. Ammonia
20. Preliminary treatment for acid-extractable metals would consist of:
   a. filtering the sample, acidifying the filtrate, and analyzing directly.
   b. filtering the sample, digesting the filter and residue, and performing analysis.
   c. adding 5 mL of a 50% hydrochloric acid solution to a 10 mL sample, heating 15 minutes on a steam bath, filtering, and then diluting to 100 mL.
   d. adding 5 mL of a 50% nitric acid solution to a 10 mL sample, heating until almost evaporated and nitrous oxide fumes develop, filtering, and then diluting to a 100 mL volume.

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

23. In the COD titrimetric determination, the sample is refluxed in strongly acid solution with a known excess of potassium dichromate. After the sample has cooled, the residual dichromate is titrated with:
   a. ferroin.
   b. ferrous ammonium sulfate.
   c. mercuric sulfate.
   d. sulfuric acid.

24. In Method 1664 for grease and oil, which solvent is used for extracting the oil from the water phase?
   a. Hexane
   b. Methylene chloride
   c. Pentane
   d. Ethyl alcohol

25. Total Kjeldahl nitrogen (TKN) is defined as the total sum of:
   a. Nitrate and nitrite
   b. Nitrate and ammonia
   c. Organic nitrogen and ammonia
   d. Organic nitrogen and nitrate
26. In the preliminary distillation step for ammonia nitrogen:
   a. the sample is steamed at an acidic pH to release the ammonia.
   b. the sample is steamed at a neutral pH to release the ammonia.
   c. the distilled ammonia is captured in a basic solution.
   d. the distilled ammonia is captured in an acidic solution.

27. Total phosphorus may be defined analytically as:
   a. orthophosphate, reactive, and acid-hydrolyzable phosphorus.
   b. reactive, condensed, and dissolved phosphorus.
   c. reactive, acid-hydrolyzable, and organic phosphorus.
   d. orthophosphate, condensed, and organically bound phosphates.

28. Potassium dichromate (K₂Cr₂O₇) is to be used in the COD test. How many grams
    would it take to make 0.5 liters of 0.25 N solution?
    Molecular weights: K=39, Cr=52, O=16 Hint:
    \[6\text{Fe}^{2+} + \text{Cr}_2\text{O}_7^= + 14\text{H}^+ = 6\text{Fe}^{3+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}\]
    a. 6.125 g
    b. 24.5 g
    c. 49.0 g
    d. 220.6 g

29. If the anticipated BOD (unseeded) of a wastewater sample is 120 mg/L, what is the
    sample volume giving nearest to 50% oxygen depletion in a 300 mL bottle? (initial DO
    = 8 mg/L)
    a. 1 mL
    b. 3 mL
    c. 10 mL
    d. 15 mL
30. A dechlorinated effluent sample was analyzed for BOD. Two dilutions were prepared. In the first, 30 mL of effluent was seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. In the second, 50 mL of effluent was likewise seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. A separate seed control was prepared by diluting 5 mL of seed into a 300 mL BOD bottle. The samples were incubated at 20°C for 5 days.

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<td>2.6</td>
</tr>
<tr>
<td>5 mL Seed</td>
<td>7.7</td>
<td>5.0</td>
</tr>
</tbody>
</table>

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

a. 15 mg/L  
b. 22 mg/L  
c. 25 mg/L  
d. 32 mg/L  

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

a. 0.5 mg/L residual chlorine  
b. 2.0 mg/L residual chlorine  
c. 4.0 mg/L residual chlorine  
d. 4.4 mg/L residual chlorine  

32. Potassium permanganate is a(n):

a. reducing agent.  
b. oxidizing agent.  
c. acidifying agent.  
d. neutralization agent.
33. The most oxidized form of nitrogen which may be found in waters and wastewaters is:
   a. organic nitrogen.
   b. ammonia.
   c. nitrate.
   d. nitrite.

34. 24-hour composite samples from the inlet and outlet of a primary clarifier had an influent TSS of 220 mg/L and an effluent TSS of 90 mg/L. How many pounds of solids were removed if the flow was 12.5 MGD, and what was the percent removal?
   a. 13,600 pounds removed, 41% removal
   b. 13,600 pounds removed, 59% removal
   c. 22,900 pounds removed, 41% removal
   d. 22,900 pounds removed, 59% removal

35. Given the following data, calculate percent volatile solids. weight of empty dish = 20.50g
   a. weight of dish and wet sample = 52.71g weight of dish and dry sample = 20.95g and weight of dish and fixed sample = 20.66g
   a. 35.3%
   b. 77.3%
   c. 64.4%
   e. 97.6%

36. During the nitrification process, Nitrobacter and Nitrosomonas bacteria:
   a. require free molecular oxygen.
   b. can use nitrate oxygen.
   c. do not require free molecular oxygen.
   d. oxidize inorganic nitrogen
37. In a secondary plant, a grab sample of mixed liquor was brought to the laboratory to be analyzed for total suspended solids. In the total suspended solids analysis the tare weight of the filter paper was 0.0910 g before sample filtration. After filtration of 10 mL of sample, followed by oven drying and subsequent cooling, the dry weight of the paper and dried sample residue was 0.1094 g. In a separate settleability test on the same sample, the mixed sample settled to 230 mL in a 1 L graduated cylinder. What is the SVI of the mixed liquor?
   a. 8 mL/g
   b. 125 mL/g
   c. 184 mL/g
   d. 8,000 mL/g

38. Wastewater and drinking water samples are sampled and then analyzed for microbiological examination within
   a. 8 hours for wastewater and 10 hours for drinking water
   b. 2 hours for wastewater and 20 hours for drinking water
   c. 6 hours for wastewater and 8 hours for drinking water
   d. 8 hours for wastewater and 30 hours for drinking water

39. Escherichia Coli was chosen as an indicator organism because:
   a. its presence indicates that conditions are right for harmful (pathogenic) bacteria to also be present.
   b. it can easily be identified because it produces gas bubbles in Lauryl Tryptose Broth (LTB), and does not produce gas bubbles in Brilliant Green Bile (BGB).
   c. it is a disease-causing organism normally found in the mammalian intestinal tract.
   d. it is the only member of the coliform group of bacteria that can be identified using the multiple tube fermentation technique (MPN).
40. The membrane filter (MF) technique is used because:
   a. it is highly reproducible, can be used to test relatively large sample volumes, and yields numerical results more rapidly than the multiple-tube procedure (MPN).
   b. it is superior to the multiple-tube procedure (MPN) because sample turbidity does not affect the MF technique.
   c. it is a superior technique for use on water samples that contain high levels of non-coliform bacteria.
   d. it is able to detect total coliforms that have been stressed by the presence of toxic metals, or toxic organic compounds such as phenols.

41. Methods for differentiation of the coliform group are available. Such differentiation is generally considered of limited value in assessing drinking water quality because:
   a. the presence of any coliform bacteria renders the water potentially unsatisfactory and unsafe.
   b. fecal streptococci and enterococci can be identified, but not enumerated.
   c. the results cannot yield information concerning the possible source of pollution in the water.
   d. fecal members of the coliform group may be expected to survive longer in an unfavorable environment than nonfecal members.

42. The most correct sterilizing conditions for dry glassware in closed metal containers are:
   a. autoclave at 121°C at 15 psi for 15 minutes.
   b. autoclave at 121°C at 15 psi for 30 minutes.
   c. dry heat oven at 170°C for one hour.
   d. dry heat oven at 170°C for two hours.

43. Opened bottles of dehydrated media should be stored in a desiccator and used up or discarded after:
   a. 1 month.
   b. 3 months.
   c. 6 months.
   d. 1 year.
44. Fecal coliform bacteria:
   a. are the cause of dysentery, a water-borne disease in humans.
   b. are the cause of cholera, a water-borne disease in humans.
   c. are bacteria found in the feces of warm-blooded animals.
   d. are pathogenic bacteria found in the intestinal tract of warm-blooded animals.

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

46. A bacterial culture was sampled and serially diluted prior to spread-plating onto triplicate plate count agar plates. The dilutions were as follows: one mL of the original sample was added to 99 mL of Solution B. One mL of solution B was added to 9 mL of Solution C. Five mL Solution C was added to 5 mL Solution D. This final mix was plated in triplicate at 0.1 mL per plate. The plates were incubated at 35°C for 2 days before colonies were counted. The counts obtained were 52, 64, and 43 colonies per respective plate. Calculate the original concentration of the bacterial culture in CFU/mL.
   a. $3 \times 10^6$ CFU/mL
   b. $3 \times 10^5$ CFU/mL
   c. $1 \times 10^{-1}$ CFU/mL
   d. $1 \times 10^6$ CFU/mL

47. A gram stain of a pure culture of E. Coli would show:
   a. gram-negative rods.
   b. gram-positive rods.
   c. filamentous bacteria.
   d. gram-negative cocci.
48. A test designed to enumerate all types of bacteria in a water sample is called:
   a. multiple tube fermentation test.
   b. selective media test.
   c. heterotrophic plate count.
   d. petri dish assay.

Answer Key

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Selected Problem Solutions

9. What is the most correct answer to the following addition problem? 10.623 + 2.16 + 200.5 + 1478 =

Solution:
10.623  3 decimal places
2.16    2 decimal places
200.5   1 decimal place
1478.   0 decimal places
1691.283
Round to 1691
The sum must be rounded off to 1691, no decimals, because one of the addends, 1478, has no decimal places.

10. What is the weight of anhydrous KH2PO4 required to make 100 mL of solution containing 15.0 mg/L phosphorus (P)?

Solution:
Molecular weight of KH2PO4 is
(39 x 1) + (1 x 2) + (31 x 1) + (16 x 4) = 136 g
mole

Weight of KH2PO4
= 136 g KH2PO4 x mole KH2PO4 x mole P
  mole KH2PO4 mole P 31 g P
x 1 g P  x  15 mg P x 1,000 mg x 100 ml
1,000 mg P 1,000 ml 1 g
= 6.6 mg
12. A standard solution is prepared from a 0.100% stock solution of a pure metal (“M”). Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. What is the concentration of the standard solution?

**Solution:**

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

\[
\begin{align*}
1,000 \text{ mg } \text{“M”} & \times 10 \text{ ml sol. A} \\
1,000 \text{ mL sol. A} & \times 1,000 \text{ mL sol. B} \\
x 5 \text{ mL sol. B} & \times 1,000 \text{ mL sol. C} \\
100 \text{ mL sol. C} & \times 1 \text{ L sol. C} \\
\end{align*}
\]

= 0.500 mg/L

28. Potassium dichromate (K2Cr2O7) is to be used in the COD test. How many grams would it take to make 0.5 liters of 0.25 N solution?

**Solution:**

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

Hint:

\[6\text{Fe}^{++} + \text{Cr}_{2}\text{O}_7^{-} = +14\text{H}^{+} = 6\text{Fe}^{+++} + 2\text{Cr}^{+++} + 7\text{H}_2\text{O}\]

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

Molecular weight of K2Cr2O7 is

\[(39 \times 2) + (52 \times 2) + (16 \times 7) = 294 \text{g} \]

\[294 \text{ g K2Cr2O7} \times \frac{1 \text{ mole}}{294 \text{ g}} \times \frac{1 \text{ mole}}{6 \text{ equivalent}} \times \frac{0.25 \text{ equivalent}}{1 \text{ liter}} \times 0.5 \text{ Liters} = 6.125 \text{ g K2Cr2O7}\]
30. A dechlorinated effluent sample was analyzed for BOD. Two dilutions were prepared. In the first, 30 mL of effluent was seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. In the second, 50 mL of effluent was likewise seeded with 1.5 mL of seed and diluted to volume in a 300 mL BOD bottle. A separate seed control was prepared by diluting 5 mL of seed into a 300 mL BOD bottle. The samples were incubated at 20°C for 5 days.

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

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

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<th>Final DO</th>
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<td>5 mL Seed</td>
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<td>2.7 (Bi - Bf)</td>
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</table>

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

\[
\text{BOD, mg/L} = (\text{DOi} - \text{DOf}) - (\text{Bi} - \text{Bf}) \times \left( \frac{P}{f} \right)
\]

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

Ratio of seed in diluted sample to seed in seed control = \( \frac{0.5}{300} \) / \( \frac{5}{300} \) = 0.1 For the 30 ml sample

\[
\text{BOD} = (7.8 - 4.6) - (7.7 - 5.0) \times 0.1 \\
(\frac{30}{300})
\]

\[
= (3.2) - (2.7 \times 0.1) \times 300 = 29.3 \\
30
\]

For the 50 ml sample

\[
\text{BOD} = (7.8 - 2.6) - (7.7 - 5.0) \times 0.1
\]
(50/300)
= (5.2) - (2.7 x 0.1) x 300 = 29.6
50
Average BOD, mg/L = \( \frac{29.3 + 29.6}{2} \)
= 29.4 mg/L = 29 mg/L

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

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

\[
\text{mg/L Cl}_2 = \frac{(5.0 \text{ mL } 0.00564 \text{ N PAO} - 5(0.6 \text{ mL } 0.0282 \text{ N I}_2))_{200}}{200 \text{ mL sample}}
\]

\[
= \frac{(5.0 - 5(0.6))_{200}}{200}
\]

= 2.0 mg/L total residual chlorine

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

Solution:

\[
\text{lbs/day} = 8.34 \times \text{mg/L} \times \text{flow in MGD}
\]

= 8.34 \times (220 - 90) \times 12.5

= 13,553 \text{ lbs/day removed}

Round to 13,600.
TSS_{inf} - TSS_{eff} \times 100 = \% \text{ removal} \\
TSS_{inf} \\

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

35. Given the following data, calculate percent volatile solids. 
weight of empty dish = 20.50g 
weight of dish and wet sample = 52.71g 
weight of dish and dry sample = 20.95g and 
weight of dish and fixed sample = 20.66g 

Solution: 
Percent Volatile Solids = \frac{(\text{Dry Solids Weight, g} - \text{Ash Solids weight, g}) \times 100}{\text{Dry Solids Weight, g}} 

\text{Dry Solids weight} = \text{Weight of dish and dry sample} - \text{Weight of empty dish} 
\text{Ash Solids weight} = \text{Weight of dish and fixed sample} - \text{Weight of empty dish} 
Percent Volatile Solids = \frac{(20.95g - 20.50g) - (20.66g - 20.50g)) \times 100}{(20.95g - 20.50g)} 

Percent Volatile Solids = 64.4\% 

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

Solution: 
TSS = \frac{\text{mg residue}}{1 \text{L sample}} 
= \frac{(0.1094 \text{ g} - 0.0910 \text{ g}) \times 1000 \text{ ml} \times 1000 \text{ mg}}{10 \text{ ml sample} \quad \text{L} \quad \text{g}}
46. A bacterial culture was sampled and serially diluted prior to spread-plating onto triplicate plate count agar plates. The dilutions were as follows:

one mL of the original sample was added to 99 mL of Solution B. One mL of solution B was added to 9 mL of Solution C. Five mL Solution C was added to 5 mL Solution D.

This final mix was plated in triplicate at 0.1 mL per plate. The plates were incubated at 35°C for 2 days before colonies were counted. The counts obtained were 52, 64, and 43 colonies per respective plate. Calculate the original concentration of the bacterial culture in CFU/mL.

Solution:
Calculate the dilution factor by multiplying together each serial dilution.
1 mL in 99 mL is a 1:100, or $10^{-2}$ dilution
1 mL in 9 mL is a 1:10, or $10^{-1}$ dilution
5 mL in 5 mL is a 1:1, or 0.5 dilution
mL in 1 mL is a 1:10, or $10^{-1}$ dilution
$10^{-2} \times 10^{-1} \times 0.5 \times 10^{-1} = 0.5 \times 10^{-4}$

Find average of colony counts.
$\frac{52 + 64 + 43}{3} = 53$ colonies

Divide colony counts by dilution.
$\frac{53 \text{ colonies}}{0.5 \times 10^{-4}} = 1 \times 10^{6} \text{ CFU/mL}$
LAB GRADE 3 EXAM CONTENT OUTLINE

Knowledge, Skills and Abilities (KSAs)

Each KSA describes the competencies required of an individual to successfully perform the essential duties of the job at grade level. Although the KSAs do not correspond precisely to every individual job description, they do reflect the core competencies and essential duties required of any Laboratory Analyst. The KSAs are developed from a job analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California and other participating states.

Each KSA includes descriptions of the general competencies, math competencies, and suggested reading for that KSA. Candidates are expected to understand the competencies described in this section and seek further educational opportunities to address those KSAs that have not been mastered.

KSA Weight is the approximate percent of the test content covered by a KSA. For example, a KSA with a weighting of 7% will have about 7% of all questions (or points) dedicated to that KSA, or 7% of the test is about that KSA. The KSA weight is approximate and shows the relative importance of a KSA compared to the other KSAs. The KSA weight on the actual certification test may vary slightly.

Each KSA includes an expanded description of the competencies, tasks, and duties expected of certificate holders. Math Competencies describe the math, analytical, or calculation knowledge and skills that are expected of certificate holders. There are no specific “math” questions on the test, but questions in some KSAs require computational skills to complete. Like all other questions on the test, questions requiring math or computational skills are randomly distributed throughout the test.

The Suggested Reading lists some materials that are representative of each KSA. Each reference includes chapters, sections, or pages that are representative of the KSA. This is not an exhaustive list of sources relevant to the KSA and candidates are strongly encouraged to seek additional material that covers each KSA especially in those KSAs where the candidate is not adequately prepared.
KSA 301

Applies advanced knowledge of the physical properties, methods and interferences for the analysis of water and wastewater.

- Color
- Turbidity
- Odor
- Alkalinity
- Hardness
- Conductivity
- Solids
- Temperature
- pH
- Acidity
- Salinity
- Oil and Grease

KSA 301 General Competencies

Understands the principles in the methods and how interferences will affect results. The grade 3 analyst is familiar with the relationships between different analysis (e.g., TDS/EC ratio).

KSA 301 Math Competencies

Basic math skills for calculating lab data including converting units (g/L to mg/L), computing percentages and ratios (% solids or % moisture), also familiar with rounding and significant figures.

KSA 301 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed, Section 2010, 2020, 2110, 2120, 2130, 2150, 2310, 2320, 2340, 2510, 2520, 2540, 2550, 4010, 4020, 4500-H+, EPA method 1664A,B

(Method Update Rule for current regulations)
KSA 302         Weight: 10%

Applies advanced knowledge of the chemical properties, methods and interferences for the analysis of water and wastewater. (*Only proficient knowledge required)

- Dissolved oxygen
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Chlorine residual (Total and Free)
- Sulfide
- Phosphorus methods (Orthophosphate, Total Phosphorus)
- Nitrogen methods (Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen)
- Major cations (Sodium, Calcium, Magnesium, Potassium)
- Major anions (Sulfate, Chloride, Fluoride, Nitrite, Nitrate, Bicarbonate)
- Cyanide
- *Trace metals
- *(Volatile, semi-volatile, pesticides, and organics)
- *Total Organic Carbon (TOC)
- *Surfactants (MBAS)
- *Priority pollutants

KSA 302 General Competencies

Understands the chemical principles of methods/analysis. Understands why some methods work better for certain matrices as well as how and why interferences can be controlled (chlorine residual and cyanide).

Understands how results are qualified and quantified. Knows relationships between various analytical techniques (BOD/COD/TOC, anion-cation balance).

KSA 302 Math Competencies

Basic math skills for calculating lab data including percentages and ratios, converting units and scales (centigrade to Fahrenheit). The grade III analyst is familiar with molecular weights and is able to convert results from NO3-NO2-N to NO3-N. Grade III analyst is familiar with rounding and significant figures.
KSA 302 Suggested Reading


4500-CN, Hach LDO method 10360, EPA 600 series for organics, EPA method 300.0, EPA method 200.8, EPA 200.7, 40 CFR part 123

(Method Update Rule for current rules and regulation)
KSA 303  Weight: 8%

Applies advanced knowledge of the microbiological properties, methods and interferences for the analysis of water and wastewater

- Coliform by Multiple Tube Fermentation
- Coliform by Enzyme Substrate Test
- Coliform by Membrane Filtration
- Heterotrophic Plate Count (HPC)
- Enterococcus

KSA 303 General Competencies

Grade III analyst should understand the importance of sterile environments for microbiological analyses. They should understand and be familiar with media prep, water quality and identification of positive results. should understand how to perform and interpret inhibitory residue and water suitability tests to verify water quality.

KSA 303 Math Competencies

Basic math skills for calculating lab data including making dilutions and using dilution factors.

KSA 303 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed. Sections: 9010, 9020, 9030, 9040, 9050, 9060, 9215, 9221, 9222, 9223, IDEXX Enterolert

(Method Update Rule for current rules and regulation)
KSA 304  
Demonstrates functional knowledge in acute and chronic toxicity methods.

KSA 304 General Competencies
Knows advantages and disadvantages between flow through, static and renewal techniques. Is also familiar with reference toxicity study and how and when to set them up. The grade III analyst understands the limits on loading and how to measure whether a system is overloaded with test organisms.

KSA 304 Math Competencies
Basic math skills for calculating lab data including percentages and ratios, how to make serial dilutions. The use of statistics to extrapolate data for a concentration-response relationship.

KSA 304 Suggested Reading
EPA Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, Fifth Ed.
(Method Update Rule for current rules and regulation)
KSA 305          Weight: 6%

Demonstrates proficiency in wastewater treatment process control analyses.

- Process control topics (MLSS/SVI, MCRT, F/M, chlorination, dechlorination, volatile acids/alkalinity ratio)
- Microorganism speciation, counting and interpretation of results
- Digester sludge analysis
- Phases of the treatment process

KSA 305 General Competencies

Knows which pollutants can be removed at each stage of treatment and which pollutants will remain in the final effluent. The grade III analyst knows how lab results are used to optimize plant processes. Is familiar with chlorination procedures, chlorine residual calculations, types of chlorine (free and total) as well how to calculate dosages used in the plant.

KSA 305 Math Competencies

Basic math skills for calculating plant data including conversions from metric to standard weights (g/L to pounds/day).

KSA 305 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed. Sections: 2010, 2020, 2710, 5010, 5020, 5560,

Biology of Wastewater Treatment (Gray, N.F.)
KSA 306

Coordinates collection of wastewater, sludge, receiving water and industrial waste samples in accordance with established lab procedures.

- Chain of custody
- Sample type (grab and composite)
- Container type and preparation
- Preservation (pH adjustment)
- Hold time
- Sampling technique
- Proper labeling
- Storage condition
- Sampling location
- QC (sample validation/invalidation)
- Ultra clean sampling methods
- Autosampler maintenance and programming (flow-based or time-based)

KSA 306 General Competencies

Understands legal defensibility and the importance of a paper trail. Knows what constitutes non-conformance and out of control. Knows how and when to fill out Corrective Action forms. Understands why SOPs are important and when they need to be revised.

KSA 306 Math Competencies

Basic math skills required to calculate lab data

KSA 306 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed. Sections: 1010, 1020, 1030, 1060, EPA Handbook for Sampling and Sample Preservation of Water and Wastewater (EPA-600/4-82-029), 40CFR part 136, Table II, EPA method 1669 sampling for trace metals

(Method Update Rule for current rules and regulation)
KSA 307

Implements and evaluates techniques and equipment used in laboratory analysis. (*Only functional understanding required)

- Gravimetric (balance weighing)
- Titrimetric/volumetric ( burette, pipettes, graduated cylinder, titrators)
- Sterilization ( autoclave, Bunsen burner, oven)
- Colorimetric ( visual observation, spectrophotometer/colorimeter)
- Electrometric ( meters, probes/electrodes, LDO, ISE)
- Turbidimetric ( Nephelometer)
- Thermometers ( ranges and maximum temperature)
- Sample preparation ( digestion, extraction, filtration, distillation)
- *Ion chromatographs
- *(GC, GC/MS, ICP-OES/MS, cold vapor AAS, HPLC)

KSA 307 General Competencies

Is familiar with regulatory requirements for calibration and/or service requirements. Is able to calculate MDLs and know when they need to be updated.

KSA 307 Math Competencies

Basic math skills for calculating lab data including statistics and using standard deviations and student’s T- statistics.

KSA 307 Suggested Reading

Instrument Manuals, Lab SOPs, California Environmental Laboratory Accreditation Program EPA 608, 624, 625, 610, 200.8, 1631

(Method Update Rule for current rules and regulation)
KSA 308

Coordinates operation and maintenance of test equipment. (*Only functional understanding required)

- Turbidimeters
- Dissolved oxygen meters
- pH meters
- Balances (analytical and top-loading)
- Spectrophotometers
- Conductivity meters
- Microscopes
- Autoclaves
- Ovens
- Incubators
- Refrigerators
- Water baths
- Titrators
- *(GC, GC/MS, ICP-OES/MS, cold vapor AAS, HPLC)
- *Ion chromatographs

KSA 308 General Competencies

Is familiar with required preventive maintenance schedules and regulatory requirements for calibration and or service.

KSA 308 Math Competencies

Basic math skills for calculating lab data including percentages.

KSA 308 Suggested Reading

Laboratory Equipment manuals, California Environmental Laboratory Accreditation Program.
KSA 309  

Implement corrective action for laboratory hazards and follows proper safety procedure. (*Only basic understanding required)

- Physical hazards (burns, sharps, compressed gas, electrical safety, fire, etc.)
- Chemical hazards (handling, storage, disposal, and spill response)
- Biological hazards (handling, storage, and disposal)
- Chemical hygiene plan
- Personal Protective Equipment (PPE)
- Engineering controls (fume hoods, etc.)
- Safety Data Sheet (SDS)
- Good housekeeping
- *(Confined space awareness)
- *(Manhole sampling procedure and safety)

KSA 309 General Competencies

Is very familiar with lab safety protocols and recognize potentially dangerous situations and how to deal with them safely.

KSA 309 Math Competencies

None required.

KSA 309 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed. Sections 1090, 1100, Laboratory Safety Pocket Handbook, OSHA Regulations
KSA 310 Coordinates preparation of reagents, calibration, and quality control standards and essential laboratory supplies

- Dilution of concentrated solutions
- Preparation of filters and dishes for residue testing
- Preparation of bacteriological culture media
- Create working standards from concentrated standards
- Verify prepared reagent quality (standardization)
- Maintain chemical inventory

KSA 310 General Competencies

Understand the importance of second source standards. The grade III analyst fully understands the concepts of molarity/normality and equivalents/valences. Has a knowledge of atomic weights and molecular weights. Knows how to standardize solutions using chemicals of known concentrations.

KSA 310 Math Competencies

Basic math skills for calculating lab data including serial dilutions, percent recoveries and calculating expected recoveries.

KSA 310 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed. Sections: 1010, 1040, 1050, 1080, 2540

(Method Update Rule for current rules and regulation)
KSA 311  
Performs accurate calculations

- Significant figures
- Unit conversion
- Advanced algebraic and statistical calculations
- Solution preparation (dilution factors, normality, molarity)
- Sample dilution
- Graphing (linear regression)
- Standard curves

KSA 311 General Competencies

The grade III analysts is expected to be familiar with calculations regarding lab data and be responsible for review of others work as well as their own.

KSA 311 Math Competencies

Basic math skills for calculating lab data including chemical equivalencies and determinations of linearity of calibration curves.

KSA 311 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed. Sections: 1010, 1020, 1030, 1050,
KSA 312 Weight: 3%
Understands, practices and enforces proper laboratory ethics.

KSA312 General Competencies
Knows the difference between fraud and error and why mistakes should not be punished. Knows the importance of paper trails and an ethics program - how it can protect the laboratory from a bad judgement by a single employee. Knows root causes of fraud and techniques to avoid or discourage fraud. Knows what “cherry picking” is and knows how to avoid it. Ethics are an individual choice - supervisors need to set examples and encourage ethics to protect employees and the laboratory.

KSA312 Math Competencies
None required

KSA312 Suggested Reading
KSA 313

Documents and maintains accurate and complete laboratory records and reports

- Routine documentation, including worksheet/log sheet entries
- Sample documentation
- Chain-of-custody forms
- Record data accurately
- Report non-conforming data
- Awareness of Lab Information Management Systems (LIMS)
- Prepare technical reports
- Standard Operating Procedures (SOP)
- Method development and validation
- Awareness of SCADA
- Data integrity and legal defensibility

KSA 313 General Competencies

Understands legal defensibility and the importance of a paper trail. Knows what constitutes non-conformance and out of control. Knows how and when to fill out Corrective Action forms. Understands why SOPs are important and when they need to be revised.

KSA 313 Math Competencies

Basic math skills required to calculate lab data.

KSA 313 Suggested Reading

Standard Methods for the Examination of Water and Wastewater 22nd Ed., EPA Office of Enforcement, Compliance Monitoring Procedure

Method Update Rule
KSA 314
Develops, maintains and interprets Quality Assurance/Quality Control criteria

- Control charts
- Standards and reagents quality
- Reagent water quality (inhibitory residue and water suitability)
- Instrument maintenance records
- Establish Method Detection Limits (MDLs) and Reporting Limits (RLs)
- Proficiency testing
- Documentation of corrective action
- Demonstration of Capability (DOC)
- Internal/external audits
- Concept of equivalency testing/Alternative Test Protocol (ATP)
- Correctness of analysis
- Quality assurance plan
- Equipment calibration and verification
- Analytical and microbiological data quality

KSA 314 General Competencies
The grade III analyst is familiar with and adheres to the laboratory Quality Assurance Plan and associated quality control including the use of blanks, spikes and duplicates. Is able to calculate MDLs and RLs.

Knows how an instrument is calibrated and what constitutes a good calibration. Is familiar with various method specific quality controls: internal standards, surrogate standards, LCS, etc. The grade III analyst is able to write corrective action forms for failed proficiency tests. Analysts are familiar with reagent water quality requirements and how to collect for these tests.

KSA 314 Math Competencies
Basic math skills for calculating lab data including statistical analysis, standard deviations, percent recovery and expected percent recovery

Control charts

KSA 314 Suggested Reading
Standard Methods for the Examination of Water and Wastewater
Method Update Rule
KSA 315

Understands and follows government regulations

- Clean Water Act
- NPDES permit compliance and regulatory authority
- OSHA (IIPP, ERP, HCP)
- NFPA
- Method Update Rule
- Hazardous waste program

KSA 315 General Competencies

The grade III analyst understands and complies with all government regulations pertaining to laboratory work, including discharge permits, analytical methods, hazardous waste management and lab safety. The grade III analyst should be thoroughly familiar with 40 CFR 136 for analytical procedures. Analysts should have a good understanding of the reporting requirements of the permit for the influent, effluent, solids, downstream monitoring and know the pretreatment program.

KSA 315 Math Competencies

None required

KSA 315 Suggested Reading

40CFR part 136, Clean water Act, Title 22 water, 13267 Letter, NPDES permit, DOT (HM-126F), 49CFR part 172.704
KSA 316  
Supervises, trains and evaluates the activities of staff

- Establishes maintains effective working relationships (coworkers, governmental agencies and the public)
- Communicates effectively both verbal and written
- Practices effective supervision of personnel
- Assists management with staff trainings and corrective actions

KSA 316 General Competencies
The grade III analyst is capable of supervising other analysts. The grade III analyst is able to communicate effectively, both written and verbally, to both management and lab staff. Is capable of evaluating staff and providing performance feedback and supports upper management policies. The grade III analyst is able to understand how to handle personal conflicts and is familiar with progressive discipline. Supervisors are responsible for training and for ensuring all analyses are performed correctly.

KSA 316 Math Competencies
Basic math skills for calculating lab data.

KSA 316 Suggested Reading
N/A
KSA 317

Assists with the preparation of the laboratory budget

- Monitor expenditures
- Estimate time, materials and equipment
- Suggest capital improvements

KSA 317 General Competencies

The Lab Analyst 3 should be knowledgeable about planning, scheduling and assigning work. They should be able to write reports and be familiar with the laboratory budget. They should be able to track expenditures and be able to perform a cost analysis assessment to justify additional staff or new equipment.

KSA 317 Math Competencies

Familiarity with spreadsheets and cost assessments to validate potential lab expenditures.

KSA317 Suggested Reading

N/A
Study Materials

The following section includes the titles and information of primary and secondary references. 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.

Primary References


- Federal Register, Volume 77. Number 97, Friday, May 18, 2012, Environmental Protection Agency, Rules and Regulations, 40 CFR Parts 136, etc.

- Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants (Reprinted from Operation Wastewater Treatment Plants Volume II.)

- Lectures on Wastewater Analysis and Interpretation Genium Publishing Corporation Dept.


- Microbiological Skills for Water and Wastewater Analysis Author: Douglas W. Clark
Practice Test

This section provides a practice certification test to help certificate candidates become familiar with the test format and subject matter.

Select the best answer for each item below.

1. Which of the following techniques is used to isolate anionic surfactants (as MBAS) from the sample matrix?
   a. Atomization  
   b. Chelation  
   c. Distillation  
   d. Extraction

2. In the cyanide determination, which one of the following is not an interference?
   a. Carbonates  
   b. Halogenated aromatics  
   c. Fatty acids  
   d. Sulfides

3. Which of the following is not a major interference in phenol determination?
   a. Hydroxy derivatives of benzene  
   b. Oils and tars  
   c. Oxidizing agents, such as chlorine  
   d. Sulfur compounds, such as hydrogen sulfides and sulfur dioxide

4. A freshly prepared sodium hydroxide (NaOH) solution is standardized against primary standard potassium acid phthalate (KHC8H4O4). 0.8000 grams of potassium acid phthalate was dissolved into 50 mL CO2-free water. 2-3 drops of phenolphthalein were added. The sample was titrated to a faint pink endpoint with 22 mLs sodium hydroxide. What is the normality of the sodium hydroxide?
   Molecular weights: K=39, H=1, C=12, O=16, Na=23
   a. 3.580 N  
   b. 1.156 N  
   c. 1.980 N  
   d. 0.178 N
5. What does an ICP source consist of?
   a. An electrically heated atomizer with programmable temperature ramping capability
   b. A cavity-type microwave with programmable temperature ramping capability
   c. A flowing stream of argon gas ionized by an applied radio frequency
   d. A hydride reactor cell purged with a flowing stream of argon gas

6. In gas chromatography, electron capture detectors (ECD) are used to detect which of the following compounds?
   a. Polynuclear aromatic hydrocarbons
   b. Aldehyde and ketone derived pesticides
   c. Chlorinated hydrocarbon pesticides
   d. Polynuclear phenols

7. Why is methylene chloride replaced by hexane in sample preparation for analyses detected by GC electron capture detection (ECD)?
   a. Methylene chloride is carcinogenic
   b. Chlorine compounds are detected by ECD
   c. Methylene chloride is unable to separate organic compounds from water-based samples
   d. Methylene chloride is unable to migrate through capillary columns

8. Which of the following methods is used to determine pesticides?
   a. EPA Method 8082
   b. Standard Method 5230
   c. EPA Method 624
   d. EPA Method 608

9. What analysis uses the purge and trap technique?
   a. Polyaromatic hydrocarbon analysis
   b. Volatile organic compound analysis
   c. Pesticide analysis
   d. Organic acid analysis
10. The test for inhibitory residues on glassware and plastic ware determines the toxic or stimulatory effects of dishwashing detergents used for bacterial analysis. Which bacterial genera is used for this test?
   a. Escherichia
   b. Citrobacter
   c. Enterobacter
   d. Klebsiella

11. The Water Suitability Test (Test for Bacteriological Quality of Reagent Water) determines the toxic or stimulatory effects of the distilled or deionized water system. Which bacteria genera is used for this test?
   a. Escherichia
   b. Citrobacter
   c. Enterobacter
   d. Klebsiella

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

13. Basic requirements for toxicity tests do not include:
   a. adequate space and well-planned holding, culturing and testing equipment and facilities.
   b. an adequate source of health experimental organisms.
   c. documented re-use of control test organisms.
   d. an abundant supply of water of desired quality.

14. A test in which solutions and test organisms are placed in test chambers and kept there for the duration of the test is called a:
   a. flow through test.
   b. range finding test.
   c. static test.
   d. definitive test.
15. A test in which solution is replaced continuously in test chambers through the test duration is called a:
   a. flow through test.
   b. range finding test.
   c. static test.
   d. definitive test.

16. A preliminary test designed to establish approximate toxicity of a solution is called a:
   a. flow through test.
   b. range finding test.
   c. static test.
   d. definitive test.

17. A toxicity test designed to establish concentration at which a particular end point occurs is called a:
   a. flow through test.
   b. range finding test.
   c. static test.
   d. definitive test.

18. Which of the following types of control samples may be used to determine accuracy?
   a. Method blank
   b. Calibration standard
   c. Certified reference material
   d. Duplicate

19. Which of the following types of control samples may be used to determine precision?
   a. Method blank
   b. Calibration standard
   c. Certified reference material
   d. Duplicate
20. The average flow in a treatment plant is 3.1 MGD. A chlorine residual of 4.0 mg/L is maintained and the effluent must be dechlorinated before discharging. If an excess of 0.5 mg/L of sulfur dioxide is required after dechlorination, how many lbs/day of sulfur dioxide must be added?

Molecular weights: O=16, S=32, Cl=35.5 1 gal = 8.34 lbs.
   a. 96 lbs SO2/day
   b. 150 lbs SO2/day
   c. 106 lbs SO2/day
   d. 160 lbs SO2/day

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

7.48 gal = 1 cubic foot
   a. 6.68 cu ft/day
   b. 374 cu ft/day
   c. 6,684 cu ft/day
   d. 70,600 cu ft/day

22. Which of the following formulas determines chlorine demand?
   a. Chlorine dose + chlorine residual = chlorine demand
   b. Chlorine dose - chlorine residual = chlorine demand
   c. Breakpoint chlorine - chlorine dose = chlorine demand
   d. Chlorine dose - breakpoint chlorination = chlorine demand

23. What is the most important measurable parameter to judge the performance of an anaerobic sludge digester?
   a. pH
   b. Volatile solids reduction
   c. Volatile acids
   d. Alkalinity
24. What is a multicopy shipping document that accompanies hazardous waste shipments called?
   a. Small quantity generator
   b. Chain-of-custody
   c. Manifest
   d. DOT Form 200

25. The HAZWOPER Standard, 29 CFR 1910.120 addresses which of the following situations?
   a. Regulates shipments of hazardous waste
   b. Regulates the disposal of radioisotopes
   c. Characterizes toxicity and lists organic compounds, metals, and herbicides considered to be hazardous waste
   d. Requires documentation of training for the handling of major spills and acutely hazardous materials

26. A waste is considered hazardous if it has at least one of the following properties:
   a. ignitability, reactivity, toxicity, and is carcinogenic.
   b. ignitability, corrosivity, acidity, and toxicity.
   c. ignitability, corrosivity, reactivity, and toxicity.
   d. ignitability, corrosivity, reactivity, and conductivity.

27. Performance standards do not place emphasis on which of the following?
   a. Quality of product
   b. Personality characteristics
   c. Unit costs
   d. Time requirements

28. Of the following inquiries during an interview, which one is appropriate?
   a. “Do you have any physical disabilities?”
   b. “By whom were you referred for a position here?”
   c. “Are you currently employed?”
   d. “Are you a United States Citizen?”
29. You are asked to determine the cost per test of the COD analysis. Use the following information:

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

What is the total cost per test?

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

30. The lower warning limit (LWL) on an LCS control chart indicates:

   a. The recovery which is two standard deviations below the average recovery.  
   b. The standard is out of control and must be reanalyzed.  
   c. The recovery is one standard deviation (95%) below the average recovery.  
   d. The standard is one standard deviation (105%) above the average recovery.

31. When two of three successive determinations fall outside the warning limits:

   a. No action is needed, warning limits indicate the control limit may be reached at a later date.  
   b. Another determination should be made, and if it is within the warning limits no action is needed.  
   c. Another determination is made, and if it is outside of the warning limits the analysis needs to be commented.  
   d. The analysis needs to be stopped and the problem fixed.
32. Which of the below statements is not correct when collecting samples for the detection of mercury by EPA 245.1 or SM 3112B?
   a. Collect in polyethylene bottle and preserve with nitric acid and measure within 2 weeks.
   b. Collect in glass bottle and preserve with nitric acid and measure within 28 days.
   c. Collect in fluoropolymer bottle and preserve with nitric acid and measure within 28 days.
   d. All of the above are true.

33. Which of the below statements is correct when collecting samples for the detection of mercury by EPA 1631?
   a. Collect in fluoropolymer bottle and preserve with HCl within 48 hours.
   b. Collect in glass bottle and preserve with nitric acid within 24 hours.
   c. Collect in polyethylene bottle and preserve with nitric acid within 24 hours.
   d. Collect in polyethylene bottle and preserve with HCl within 24 hours.
## Answer Key

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Selected Problem Solutions

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

Molecular weights: K=39, H=1, C=12, O=16, Na=23
Molecular weight of KHC8H4O4 =
(39) + (1) + (12 x 8) + (1 x 4) + (16 x 4) = 204 g

\[ eq/L \text{ KHP} = \frac{0.8000 \text{ g KHP}}{204 \text{ g}} \times \frac{1 \text{ mole KHP}}{1 \text{ mole KHP}} \times \frac{1 \text{ eq} \text{ H}^+}{1 \text{ mole KHP}} \times \frac{1 \text{ eq} \text{ H}^+}{1 \text{ eq} \text{ KHP}} \times \frac{1 \text{ L}}{1 \text{ eq} \text{ H}^+} \times \frac{1 \text{ eq} \text{ KHP}}{1 \text{ mole KHP}} \times \frac{1 \text{ mole KHP}}{204 \text{ g}} \]

\[ 0.078 \text{ eq/L} \times 50 \text{ mL} = N \text{ NaOH} \times 22 \text{ mL} \]

\[ N \text{ NaOH} = 0.078 \text{ eq/L} \times 50 \text{ mL} = 0.086 \text{ eq/L} \]

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

Molecular weights: O=16, S=32, Cl=35.5
1 gal = 8.34 lbs

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

\[ 64 \text{ mg SO}_2 \times \frac{1 \text{ mmole SO}_2}{1 \text{ mmole Cl}_2} \times \frac{71 \text{ mg Cl}_2}{4.0 \text{ mg Cl}_2} \]

\[ 3.1 \text{ MGD} \times (3.6 \text{ mg SO}_2/L + 0.5 \text{ mg SO}_2/L) \times \frac{1 \text{ mmole SO}_2}{8.34 \text{ lbs/gal}} \times \frac{1 \text{ mmole Cl}_2}{71 \text{ mg Cl}_2} \times \frac{1 \text{ mmole Cl}_2}{1 \text{ mmole SO}_2} \]

\[ 0.8000 \text{ g KHP} \times \frac{1 \text{ mL}}{50 \text{ mL}} \times \frac{204 \text{ g}}{1 \text{ mole KHP}} \times \frac{1 \text{ eq} \text{ H}^+}{1 \text{ eq} \text{ KHP}} \times \frac{1 \text{ eq} \text{ H}^+}{1 \text{ mole KHP}} \times \frac{1 \text{ mole KHP}}{204 \text{ g}} \]

\[ 0.086 \text{ eq/L} \times 50 \text{ mL} = 22 \text{ mL} \]

\[ 204 \text{ g} \times \frac{1 \text{ mmole KHP}}{1 \text{ mole KHP}} \times \frac{1 \text{ eq} \text{ H}^+}{1 \text{ eq} \text{ KHP}} \times \frac{1 \text{ eq} \text{ H}^+}{1 \text{ mole KHP}} \times \frac{1 \text{ mole KHP}}{204 \text{ g}} \]

\[ 4.0 \text{ mg Cl}_2 \times 71 \text{ mg Cl}_2 \times \frac{1 \text{ mmole Cl}_2}{4.0 \text{ mg Cl}_2} \times \frac{1 \text{ mmole SO}_2}{8.34 \text{ lbs/gal}} \times \frac{1 \text{ mmole SO}_2}{71 \text{ mg Cl}_2} \times \frac{1 \text{ mmole Cl}_2}{1 \text{ mmole SO}_2} \]

\[ 3.1 \text{ MGD} \times (3.6 \text{ mg SO}_2/L + 0.5 \text{ mg SO}_2/L) \times \frac{1 \text{ mmole SO}_2}{8.34 \text{ lbs/gal}} \times \frac{1 \text{ mmole Cl}_2}{71 \text{ mg Cl}_2} \times \frac{1 \text{ mmole Cl}_2}{1 \text{ mmole SO}_2} \]
21. A plant serving a city of 50,000 population has an influent settleable solids of 10 mL/L. If per capita contribution to the plant flow is 100 gallons/day, how much sludge is produced in the plant in cubic feet/day?

\[
7.48 \text{ gal} = 1 \text{ cubic foot}
\]

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

\[
\frac{100 \text{ gal}}{\text{capita/day}} \times 50,000 \text{ capita} \times \frac{1 \text{ cu ft}}{7.48 \text{ gal}} = 668,449 \text{ cu ft/day}
\]

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

\[
\frac{10 \text{ p}}{1,000 \text{ p}} \times 668,449 \text{ cu ft} = 6,684 \text{ cu ft/day}
\]

29. You are asked to determine the cost per test of the COD analysis. Use the following information:

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

What is the total cost per test?

Determine the total cost of the analyst’s time:

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

\[
\frac{$54,000}{\text{year}} \times \frac{1 \text{ month}}{12 \text{ mos}} = \frac{$25.86}{\text{hr}}
\]

At 20 minutes analyst time per test:

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

Disposal costs:
$2,000 = $2.00/test
1,000 tests
Reagent costs = $1.00/test
Total costs per COD test:
$8.62 + $2.00 + $1.00 = $11.62
LAB GRADE 4 EXAM CONTENT OUTLINE

Knowledge, Skills and Abilities (KSAs)

Each KSA describes the competencies required of an individual to successfully perform the essential duties of the job at grade level. Although the KSAs do not correspond precisely to every individual job description, they do reflect the core competencies and essential duties required of any Laboratory Analyst. The KSAs are developed from a job analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California and other participating states.

Each KSA includes descriptions of the general competencies, math competencies, and suggested reading for that KSA. Candidates are expected to understand the competencies described in this section and seek further educational opportunities to address those KSAs that have not been mastered.

KSA Weight is the approximate percent of the test content covered by a KSA. For example, a KSA with a weighting of 7% will have about 7% of all questions (or points) dedicated to that KSA, or 7% of the test is about that KSA. The KSA weight is approximate and shows the relative importance of a KSA compared to the other KSAs. The KSA weight on the actual certification test may vary slightly.

Each KSA includes an expanded description of the competencies, tasks, and duties expected of certificate holders. Math Competencies describe the math, analytical, or calculation knowledge and skills that are expected of certificate holders. There are no specific “math” questions on the test, but questions in some KSAs require computational skills to complete. Like all other questions on the test, questions requiring math or computational skills are randomly distributed throughout the test.

The Suggested Reading lists some materials that are representative of each KSA. Each reference includes chapters, sections, or pages that are representative of the KSA. This is not an exhaustive list of sources relevant to the KSA and candidates are strongly encouraged to seek additional material that covers each KSA especially in those KSAs where the candidate is not adequately prepared.
KSA 401 Weight: 5%
Interprets and evaluates data related to the physical properties, methods and interferences for the analysis of water and wastewater.

- Color
- Turbidity
- Odor
- Alkalinity
- Hardness
- Conductivity
- Solids
- Temperature
- pH
- Acidity
- Salinity
- Oil and Grease

KSA 401 General Competencies
The Laboratory Analyst IV is expected to have mastered the test methods, its principle and interferences. The analyst understands the interrelationships between the different analyses and has the ability to interpret and evaluate data based on that.

KSA 401 Math Competencies
Ability to calculate and alkalinity, hardness, solids, acidity and temperature conversions.

KSA 401 Suggested Reading
Standard Methods for the Examination of Water and Wastewater Sections 2010, 2020, 2110, 2120, 2130, 2150, 2310, 2320, 2340, 2510, 2520, 2540, 5520.
Lectures on Wastewater Analysis and Interpretation, Lectures 14,15, 21
KSA 402  Weight: 11%

Interprets and evaluates data related to chemical properties, methods and interferences for the analysis of water and wastewater.

- Dissolved oxygen
- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- Chlorine residual (Total and Free)
- Sulfide
- Phosphorus methods (Orthophosphate, Total Phosphorus)
- Nitrogen methods (Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen)
- Major cations (Sodium, Calcium, Magnesium, Potassium)
- Major anions (Sulfate, Chloride, Fluoride, Nitrite, Nitrate, Bicarbonate)
- Cyanide
- Trace metals
- Volatile and semi-volatile organics, and pesticides
- TOC (Total Organic Carbon)
- Surfactants (MBAS)
- Priority pollutants

KSA 402 General Competencies

The Laboratory Analyst IV is expected to have mastered these test methods, its principle and interferences. The analyst understands the interrelationships between the different analyses (e.g. nitrogen methods, phosphorus methods, BOD-COD, etc.). The analyst has the ability to interpret and evaluate (including validation and invalidation) data. The analyst also has the ability to choose the best method for testing an analyte of interest based on sample matrix.

KSA 402 Math Competencies

Ability to calculate results for corresponding tests using formulas, dilution factors and conversions as appropriate

KSA 402 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 4010, 4020, 4500-CN, 4500-Cl,4500-F, 4500-N, 4500-NH3, 4500-NO2-, 4500-NO3-, 4500-Norg, 4500-O, 4500-P, 4500- S2-, 5010, 5020, 5210, 5220, 5310, 5540.

EPA 600 series for organics, EPA method 300.0, EPA method 200.8.

Lectures on Wastewater Analysis and Interpretation, Lectures 3-6, 8-13, 15, 21.
KSA 403

Interprets and evaluates data related to the microbiological properties, methods and interferences for

- Heterotrophic Plate Count (HPC)
- Enterococcus
- Iterative methods (drinking water, ambient water, ground water, reclaimed water)

KSA 403 General Competencies

The Laboratory Analyst IV is expected to be an expert in microbiological properties, methods and interferences for analysis of water and wastewater. The analyst also provides supervision for junior staff in using the right method based on sample (wastewater, drinking water or reclaimed water) requirements.

The analyst also develops alternative test protocol methods, as needed to meet the testing requirements of the lab, following correct protocol, which includes application for its approval. The analyst is also able to interpret and evaluate test data.

KSA 403 Math Competencies

Serial dilution calculations and use of dilution factors.

KSA 403 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections: 9010, 9020, 9030, 9040, 9050, 9060, 9215, 9221, 9222, 9223.

Lectures on Wastewater Analysis and Interpretation, Lectures 17, 21;

The Clean Water Act Alternate Test Procedure (ATP) program is described at 40 CFR 136.4 and 136.5.
KSA 404  
Interprets, evaluates and reports acute and chronic toxicity data results  
- Toxicity Reduction Evaluation (TRE)  
- Toxicity Identification Evaluation (TIE)

KSA 404 General Competencies  
The Laboratory Analyst IV is expected to be knowledgeable in all aspects of Whole Effluent Toxicity testing. This includes facilities and equipment, dilution water, effluent sampling methods, holding times, temperature, organism culturing and handling, data analysis, report preparation. The WET test results (e.g. the log dose-response curve) are statistical evaluations of a biological phenomenon. The analyst should be able to interpret it with respect to the realities of the test and suggest if and when a TRE, TIE study need to be done.

KSA 404 Math Competencies  
The statistical methods used for analyzing test data in an acute and chronic toxicity test

KSA 404 Suggested Reading  
Standard Methods for the Examination of Water and Wastewater, Sections 8010, 8020, 8711, 8712, 8910, 8921.  
The Whole Effluent Toxicity method listed in 40 CFR 136.3  
Lectures on Wastewater Analysis and Interpretation, Lectures 18,21.
KSA 405

Interprets and evaluates wastewater treatment process control data.

- Process control topics (MLSS/SVI, MCRT, F/M, chlorination, dechlorination, volatile acids/alkalinity ratio)
- Microorganism speciation, counting and interpretation of results
- Digester sludge analysis
- Phases of the treatment process
- Plant process efficiency

KSA 405 General Competencies

A Laboratory Analyst IV is required to have mastered an understanding of waste water treatment processes including effluent discharge monitoring and process efficiency, activated sludge monitoring and chemicals used in treatment. The analyst is adept at applying lab results to plant processes and interpreting plant performance.

KSA 405 Math Competencies

Conversion of laboratory results in mg/L to plant operating units of pounds and gallons.

KSA 405 Suggested Reading

Standard Methods for the Examination of Water and Wastewater. Sections 2540, 2530, 2710, 2720, 4500-Cl, 5020, 5560.

Lectures on Wastewater Analysis and Interpretation, Lectures 17(Microscopic examination), 20, 21.

Operation of Wastewater Treatment Plants-A field study training program, Chapter 21-Lessons 1, 2, 3.
KSA 406  Weight: 6%

Implements lab procedures and directs the collection of wastewater, sludge, receiving water and industrial waste samples

- Chain of custody
- Sample type (grab and composite)
- Container type and preparation
- Preservation (pH adjustment)
- Hold time
- Sampling technique
- Proper labeling
- Storage condition
- Sample location
- QC (sample validation/invalidation)
- Ultra clean sampling methods
- Autosampler maintenance and programming (flow-based or time-based)

KSA 406 General Competencies

The Laboratory Analyst IV is expected to have mastered appropriate sampling techniques for a variety of sample matrices, including wastewater, sludges, biosolids, etc. The analyst must know the preservation requirements, potential interferences and mitigating techniques, and reason preservation is necessary for all analyses run in the lab. The analyst must know the required elements of a chain of custody form. The analyst must know where to find sampling requirements, and how to keep them current.

KSA 406 Math Competencies

Ability to program a flow-based sampling schedule.

KSA 406 Suggested Reading

Code of Federal Regulations: TITLE 40, Chapter 1, Subchapter D, Part 136

Standard Methods for the Examination of Water and Wastewater, Sections 1060, individual method sections.

Lectures on Wastewater Analysis and Interpretation, Appendix B

EPA Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels
KSA 407

Implements and evaluates techniques and equipment used in laboratory analysis.

- Gravimetric (balance weighing)
- Titrmetric/volumetric (burette, pipette, graduated cylinder, titrators)
- Sterilization (autoclave, Bunsen burner)
- Colorimetric (visual observation, spectrophotometer/colorimeter)
- Electrometric (meters, probes/electrodes, LDO, ISE)
- Turbidimetric (Nephelometer)
- Thermometers (ranges and maximum temperature)
- Ion chromatographs
- Sample preparation (digestion, extraction, filtration, distillation)
- GC, GC/MS, ICP-OES/MS, cold vapor AAS, HPLC

KSA 407 General Competencies

The Laboratory Analyst IV is expected have advanced knowledge of laboratory instrumentation. This includes knowing the methods associated with an instrument, the instrument’s operational range, and the instrument’s QC and calibration requirements. The analyst must know the typical substances an instrument is used to measure, and why one type of instrument should be used versus an alternative instrument or method.

KSA 407 Math Competencies

Ability to use significant figures appropriately. Ability to read a thermometer accurately.

KSA 407 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 2130, 9010, 9020, 9030, 2120, 4500-NH3, 4500-H+, 4500-O.

EPA Methods 300.0, 1668.
KSA 408

Directs operation and maintenance of test equipment.

- Turbidimeters
- Dissolved oxygen meters
- pH meters
- Balances (analytical and top-loading)
- Ion chromatographs
- Spectrophotometers
- Conductivity meter
- Microscopes
- Autoclaves
- Ovens
- Incubators
- Refrigerators
- Water baths
- Titrators
- GC, GC/MS, ICP-OES/MS, cold vapor AAS, HPLC
- Reagent water purification system

KSA 408 General Competencies

The Laboratory Analyst IV is expected to know the maintenance requirements for all laboratory instrumentation. This includes knowing the frequency of maintenance, calibrations and standardizations must, and what must be done following maintenance to bring the instrument back into service. The analyst should be familiar with the benefits and drawbacks of service contracts.

KSA 408 Math Competencies

N/A

KSA 408 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 2130, 9010, 9020, 9030, 2120, 2510, 4500-NH3, 4500-H+, 4500-O.

EPA Methods 300.0, 1668
KSA 409

Directs implementation of corrective action for laboratory hazards and follows proper safety procedures.

- Physical hazards (burns, sharps, compressed gas, electrical safety, fire, etc.)
- Chemical hazards (handling, storage, disposal, and spill response)
- Biological hazards (handling, storage, and disposal)
- Chemical hygiene plan
- Personal Protective Equipment (PPE)
- Engineering controls (fume hoods, etc.)
- Safety Data Sheet (SDS)
- Good housekeeping
- Confined space awareness
- Manhole sampling procedure and safety

KSA 409 General Competencies

The Laboratory Analyst IV is expected to have advanced knowledge of laboratory safety requirements. This includes fire prevention and response, the elements of a Chemical Hygiene Plan, the elements of a Safety Data Sheet, proper chemical storage, proper hazardous waste disposal, and spill response measures. The analyst must know the hazards associated with confined space sampling, and the correct use of PPE.

KSA 409 Math Competencies

N/A

KSA 409 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Section 1090.
Occupational Safety and Health Act of 1970 (OSH Act) and other relevant laws.
KSA 410

Ensures the correct preparation of reagents, calibration and quality control standards and essential laboratory supplies

- Dilution of concentrated solutions
- Preparation of filters and dishes for residue testing
- Preparation of bacteriological culture media
- Create working standards from concentrated standards
- Verification of prepared reagent quality (standardization)
- Maintenance of chemical inventory

KSA 410 General Competencies

The Laboratory Analyst IV is adept at preparation of stock standards and reagents, and guides junior staff in standard preparation and standardization. The analyst also directs the use of internal, external and second source QC standards.

KSA 410 Math Competencies

Calculations involving Normality, Molarity, percentage, and serial dilution.

KSA 410 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 1010, 1020, 1040, 1050, 1070, 1080, 2540.

Lectures on Wastewater Analysis and Interpretation, Lecture 7.
KSA 411

Ensure accurate calculations.

- Significant figures
- Unit conversion
- Advanced algebraic and statistical calculations
- Solution preparation (dilution factors, normality, molarity)
- Sample dilution
- Graphing (linear regression)
- Standard curves

KSA 411 General Competencies

The Laboratory Analyst IV is an expert in mathematical and statistical concepts used in chemistry. The analyst also reviews and validates the work of junior staff.

KSA 411 Math Competencies

Statistical concepts used in environmental science, including linear regression. The analyst has mastered the ability to apply dilution factors in standards and sample calculations, prepares graphical analysis of data, and reviews results applying correct significant figures.

KSA 411 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 1010, 1020, 1030, 1050.

Lectures on Wastewater Analysis and Interpretation, Lectures 2, 21.
KSA 412          Weight: 4%

Ensures the enforcement of proper laboratory ethics.

KSA 412 General Competencies

The Laboratory Analyst IV has the responsibility of ensuring that data produced by the lab is not fraudulent. Laboratory professionals are required to maintain high standards of lab practice. They are required to exercise sound judgment in performing and evaluating laboratory testing. The analyst is required to be alert and sensitive to actions by staff that may be improper, illegal or in violation of ethics policy and practices.

KSA 412 Math Competencies

N/A

KSA 412 Suggested Reading

Lectures on Wastewater Analysis and Interpretation, Lecture 23.
American Chemical Society, Chemical professionals code of conduct.
KSA 413

Manages, maintains and archives accurate and complete laboratory records and reports.

- Routine documentation, including worksheet/log sheet entries
- Sample documentation
- Chain-of-custody forms
- Record data accurately
- Report non-conforming data
- Management of laboratory computerized database
- Technical reports (NPDES compliance)
- Standard Operating Procedures (SOP)
- Method development and validation
- Awareness of Process Operations SCADA
- Data integrity and legal defensibility

KSA 413 General Competencies

Laboratory documentation is a prima facie (first indicator) to auditors, legal authorities and others that the lab follows its procedures. The Laboratory Analyst IV oversees how the lab properly records, reports, maintains, manages and archives its data. The analyst is also an expert on standard operating procedures, new method development and its validation.

KSA 413 Math Competencies

Mathematical, statistical and graphing concepts used in data handling.

KSA 413 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 1010, 1020, 1030, 1040, 1050, 1060.

Lectures on Wastewater Analysis and Interpretation, Lecture 2, 21
KSA 414

Implements and directs Quality Assurance/Quality Control program

- Control charts
- Standards and reagents quality
- Reagent water quality (inhibitory residue and water suitability)
- Instrument maintenance records
- Establish MDLs and RLs
- Proficiency testing
- Documentation of corrective action
- DOC (Demonstration of Capability)
- Internal/external audits
- Concept of equivalency testing/Alternative Test Protocol (ATP)
- Correctness of analysis
- Quality assurance plan
- Equipment calibration and verification
- Training records
- Analytical and microbiological data quality

KSA 414 General Competencies

The Laboratory Analyst IV is responsible for managing, updating, and implementing the lab’s QA/QC program. The analyst directs lab functions to ensure that methods are applied correctly, and that testing meets expected needs. The analyst is adept at specific quality controls along with how it fits in the overall quality assurance program. The analyst also implements training of new and current staff according to the established QA plan.

KSA 414 Math Competencies

Mathematical, statistical and graphing concepts used in data handling.

KSA 414 Suggested Reading

Standard Methods for the Examination of Water and Wastewater, Sections 1010, 1020, 1030, 1040, 1050, 1070, 1080.

Lectures on Wastewater Analysis and Interpretation, Lectures 2, 21, 23
KSA 415  Weight: 7%

Ensures adherence to government regulations

- EPA regulations as applied to laboratories (Clean Water Act, 40 CFR Part 136)
- NPDES permit compliance and regulatory authority
- OSHA (IIPP, ERP, HCP)
- NFPA (chemical storage and labeling)
- Method Update Rule
- Laboratory accreditation
- Hazardous waste program

KSA 415 General Competencies

The Laboratory Analyst IV is responsible for attaining and maintaining laboratory accreditation for all laboratory methods used for regulatory compliance. The analyst also ensures that all laboratory policies are kept current to meet changing regulations.

KSA 415 Math Competencies

Not applicable.

KSA 415 Suggested Reading

California ELAP
EPA NPDES Wastewater Discharge Permit Monitoring Program
OSHA and CAL-OSHA IIPP and Chemical Hygiene Plan regulation
NFPA (need reference)
California Code of Regulations (CCR), Title 22, Laboratory and Hazardous Waste regulations
KSA 416

Plans, organizes, staffs, directs, and controls the activities of the laboratory.

- Establishes and maintains effective working relationships (coworkers, contractors, governmental agencies and the public)
- Communicates effectively both verbal and written
- Practices effective supervision of personnel
- Hires personnel and conducts performance evaluations
- Reviews and implements disciplinary/incentive actions
- Establishes goals and objectives consistent with agency goals and objectives
- Reviews and approves staff recommendations on division work organization, assignments, work schedules and training needs
- Establishes contracts or agreements with contract laboratories and vendors
- Coordinates laboratory services with other departments and agencies

KSA 416 General Competencies

The Laboratory Analyst IV must communicate effectively with both laboratory staff under supervision and with management and operations staff. The analyst must plan and organize laboratory duties to match regulatory and operational testing needs for the agency. The analyst must identify and hire competent laboratory staff to match the testing needs of the laboratory. The analyst must effectively direct and control laboratory staff to ensure testing is conducted per standard operating procedures and meets quality control requirements.

KSA 416 Math Competencies

N/A

KSA 416 Suggested Reading

Supervision: Concepts and practices of Management, University of Michigan
Lectures on Wastewater Analysis and Interpretation, Lecture 23.
Utility Management, Office of Water Programs Office of Water Programs - Sacramento State University.
KSA 417  
Administers the preparation of the laboratory budget.  

- Monitor expenditures  
- Estimate time, materials and equipment  
- Suggest capital improvements  
- Evaluate staffing needs

KSA 417 General Competencies
The Laboratory Analyst IV must monitor all laboratory expenses to ensure the laboratory operation stays within planned operating budget. The Analyst will need to know how to prepare cost justifications for the hiring of additional staff and/or purchasing new laboratory equipment or new capital improvements.

KSA 417 Math Competencies
Basic math related to budget management and cost justification.

KSA 417 Suggested Reading
Supervision: Concepts and practices of Management, University of Michigan.

Utility Management, Office of Water Programs Office of Water Programs - Sacramento State University.
Study Materials

The following section includes the titles and information of primary and secondary references. 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.

Primary References

  (Please note that the latest Code of Federal Regulations, 40 CFR Part 136, should be referenced to determine which edition of Standard Methods applies for a given method.)

- Lectures on Wastewater Analysis and Interpretation Genium Group, Inc.


- Operation of Wastewater Treatment Plants, Volumes I and II Office of Water Programs California State University, Sacramento (CSUS) 6000 J Street Sacramento, CA 95819-6025916-278-6142 http://owp.csus.edu


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


- Laboratory Safety Pocket Handbook Genium Publishing Corporation

- OSHA Regulations (Standards – 29 CFR)

- Utility Management Office of Water Programs California State University Sacramento (CSUS) 6000 J Street Sacramento, CA 95819-6025 916-278-6142 www.owp.csus.edu


- Math Text for Water and Wastewater Technology, 2nd Edition Wright’s Training P.O. Box 515 Elmira, CA 92625 707/448-3659

Practice Test

This section provides a practice certification test to help certificate candidates become familiar with the test format and subject matter.

Select the best answer for each item below.

1. In the cyanide determination, which one of the following is not an interference?
   a. Sulfides
   b. Hydrogen cyanide
   c. Fatty acids
   d. Carbonates

2. Standard addition is best if the addition increases analyte:
   a. 0.3 to 0.6 times its original concentration.
   b. 1.5 to 3 times its original concentration.
   c. 3 to 6 times its original concentration.
   d. 15 to 30 times its original concentration.

3. Advantages of ion-selective electrodes do not include:
   a. wide-range of linear response.
   b. being unaffected by color or turbidity.
   c. interferences.
   d. short response time.

4. Which gas chromatography detector(s) could be used for selective trace analysis of halogen-containing compounds?
   a. Flame ionization Detector (FID)
   b. Thermionic Selective Detector (TSD)
   c. Catalytic Combustion Detector (CCD)
   e. Electron Capture Detector
5. In atomic absorption spectrophotometry, a method not used for background correction is:
   a. beam chopping.
   b. Zeeman correction system.
   c. Doppler broadening correction system.
   d. Deuterium lamps.

6. In chromatography:
   a. the greater the ratio of partition coefficients between mobile and stationary phases, the greater the separation between two components of a mixture.
   b. the greater the ratio of partition coefficients between mobile and stationary phases, the smaller the separation between the two components of a mixture.
   c. the greater the ratio of partition coefficients between two components of a mixture, the greater the separation between the mobile and stationary phases.
   d. the smaller the ratio of partition coefficients between two components of a mixture, the greater the separation between the mobile and stationary phases.

7. A mass spectrometer is an instrument:
   a. containing a hollow graphite rod that can be heated electrically to about 2500°K to decompose and atomize a sample for analysis.
   b. which measures a sample that has been bombarded with electrons to produce charged molecular fragments that are separated according to their mass in a magnetic field.
   c. in which an electric potential exists at the junction between two different electrolyte solutions or substances.
   d. in which the analytes are immediately accelerated by a powerful radiofrequency field that oscillates about a load coil at a frequency of 27 MHz.
8. In gas chromatography:
   a. a mobile phase (a gas carrier) transports a sample through a stationary phase (column packing or capillary column coating), which is used to separate individual compounds.
   b. a sample is injected into an effluent stream and passed through a series of ion-exchanging columns.
   c. molecules are separated by size with no attractive interaction between the stationary phase and the solute.
   d. a mobile phase (a liquid carrier) transports a sample through a stationary phase (column packing or capillary column coating), which is used to separate individual compounds.

9. Inductively coupled plasma (ICP) is desirable in comparison to Atomic Absorption Spectrophotometry (AA) for the following reasons, with the exception of:
   a. the high temperature and stability in ICP eliminates much of the interferences encountered with AA.
   b. ICP is less expensive to purchase and operate.
   c. atomization in ICP is more complete.
   d. ICP can measure multiple analytes per sample injection

10. The genera that does not contain members of the coliform group is:
    a. Enterobacter.
    b. Klebsiella.
    c. Aeromonas.
    d. Citrobacter.

11. An organism associated with activated sludge treatment problems is the:
    a. Sphaerotilus.
    b. Streptococcus.
    c. Salmonella.
    d. Rotifer.
12. Particular problems associated with the detection of viruses of public health interest in the aquatic environment do not include:
   a. the small size of virus particles.
   b. the high virus concentrations in water and the variability in amounts and types that may be present.
   c. the various dissolved and suspended materials in water that interfere with virus detection.
   d. the present limitations of virus estimation and identification methods.

13. Short term toxicity tests are inappropriate for
   a. Obtaining toxicity data as rapidly and inexpensively as possible
   b. Obtaining the identification of a toxicant
   c. Screening test solution or materials for which toxicity data do not exist
   d. Determining chronic toxicity

14. Toxicity Reduction Evaluation (TRE) is a phased approach that:
   a. Identifies the species most vulnerable to the toxicant(s) of concern.
   b. Identifies the toxicant(s) of concern.
   c. Removes the toxicant from the wastewater treatment process.
   d. Stepwise process to identify the causative agents of toxicity.

15. Toxicity Identification Evaluation (TIE) achieves which function during a Toxicity Reduction Evaluation study?
   a. Identifies the species most vulnerable to the toxicant(s) of concern.
   b. Identifies the toxicant(s) of concern.
   c. Removes the toxicant from the wastewater treatment process.
   d. Stepwise process to identify the causative agents of toxicity.

16. Calculate the chlorine demand using the following data: the chlorinator is set at 250 lbs/day, the flow is 2.4 MGD, and the residual chlorine is 1.4 mg/L.
   a. 222 lbs/day
   b. 236 lbs/day
   c. 245 lbs/day
   d. 278 lbs/day
17. A sample of wastewater with an average flow of 100 gallons per capita per day contains 10 mL/L settleable solids. The city has a population of 50,000 persons. The cubic feet of solids produced per day is:
   a. 70,600 cu ft.
   b. 6.68 cu ft.
   c. 6,684 cu ft.
   d. 374,000 cu ft.

18. A treatment plant has the following characteristics of suspended solids removal: the primary clarifier removes 39% of the applied suspended solids; the biological treatment removes 85% of the applied suspended solids; the secondary clarifier removes 16% of the applied suspended solids. The plant flow is 18.2 MGD. The wastewater influent has 215 mg/L suspended solids. Assuming that results can be reported to three significant figures, what is the amount of solids, in pounds/day, removed in the process?
   a. 11.4 pounds removed per day
   b. 4,054 pounds removed per day
   c. 11,400 pounds removed per day
   d. 30,100 pounds removed per day

19. A Quality Assurance/Quality Control document is a necessary component of the Environmental Laboratory Accreditation Program. Of the following, the one area that does not need to be covered in the document is:
   a. organization and responsibility.
   b. sampling procedures.
   c. assessment of precision and accuracy.
   d. standard operating procedures for each analysis.

20. The methods of analysis that are promulgated for use on most wastewater samples are found in:
   c. 40 CFR 403.
   d. 40 CFR 503.
21. Of the following, which section of the Code of Federal Regulations determines the concentrations of toxins, heavy metals, pathogens, and other pollutants found in biosolids?
   a. 29 CFR 1910.1450
   b. 40 CFR 136
   c. 40 CFR 403
   d. 40 CFR 503

22. A toxicant concentration producing death of test organisms, usually defined as a median value of 50%, is known as:
   a. a dose response concentration.
   b. an acute toxicity concentration.
   c. an LC50 value.
   d. an EC50 value.

23. As a laboratory supervisor, you must see that someone is primarily responsible for safety supervision. The most appropriate method of assigning this duty would be:
   a. to rotate the responsibility to someone new each month so everyone will feel involved in laboratory safety issues.
   b. to assign a permanent safety officer so that the individual can provide planning continuity and follow-up attention to reported hazards.
   c. to ask for a volunteer because volunteers tend to be more conscientious and capable because they have expressed an interest in the job.
   d. as a laboratory supervisor, you are ultimately responsible for laboratory safety and are unable to delegate this important responsibility.

24. When developing an Emergency Response Plan, the first step is to:
   a. inventory all chemicals in the laboratory.
   b. identify the tasks assigned to each group responding to emergency situations.
   c. identify the line of authority in an emergency.
   d. identify the hazards and dangers faced by the plant.
25. If a laboratory reports unacceptable data in a Proficiency Testing Study:
   a. the laboratory must determine the cause of the failure, perform corrective action, and repeat another study as soon as possible.
   b. the laboratory must determine the cause of the failure, and perform corrective action prior to participation in another study in the next calendar year.
   c. the laboratory must wait for the next Proficiency Testing Study to determine the cause of the failure.
   d. the laboratory must write a letter requesting leniency prior to participation in another study.

26. An application for laboratory accreditation (ELAP or NELAP) includes:
   a. laboratory information; personnel qualifications for the lab director and the quality assurance officer; fields of testing; invoice for fees; and the submission of a quality assurance manual.
   b. laboratory information; personnel qualifications for the lab director, the emergency response team leader, and the quality assurance officer; fields of testing; and the submission of a quality assurance manual.
   c. laboratory information; personnel qualifications for the lab director and the quality assurance officer; fields of testing; and the submission of a quality assurance manual and the standard operating procedures manual.
   d. laboratory information; personnel qualifications for the lab director, the quality assurance officer, and the safety officer; fields of testing; and the submission of a standard operating procedures manual.
27. The difference between duplicate determinations on randomly-selected routine samples is used in the development of quality control charts. One approach used to calculate the control limit specifies the following formula:

\[
UCL = D4R, \text{ where } D4 = 3.27 \text{ is used for duplicates and } R = \text{ the average difference of each of the duplicate samples.}
\]

Ten duplicate determinations for a constituent is g/L are as follows:

152 and 160  163 and 158  148 and 154  142 and 151
150 and 160  160 and 154  145 and 149  162 and 155
156 and 157  159 and 151

The duplicate analyses for a wastewater sample were 180 and 167 g/L. Calculate the upper control and determine whether the analytical results for the plant sample are under control.

a. The UCL = 6.3 g/L and the wastewater sample duplicate analysis is in control.
b. The UCL = 6.3 g/L and the wastewater sample duplicate analysis is out of control.
c. The UCL = 20.9 g/L and the wastewater sample duplicate analysis is in control.
d. The UCL = 20.9 g/L and the wastewater sample duplicate analysis is out of control.
28. Calculate the method detection limit given the following information.
A standard solution was analyzed 7 times with the following results in mg/L:

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Calculated mean = 0.0362
Calculated standard deviation = 0.00125

**Level of Certainty**

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<td>1.860</td>
<td>2.896</td>
<td>3.355</td>
</tr>
</tbody>
</table>

a. 0.00393 mg/L
b. 0.00375 mg/L
c. 0.109 mg/L
d. 0.114 mg/L

29. In the management-by-exception concept:

a. objectives are non-specific.
b. tasks are closely managed.
c. all activities are reported in detail.
d. routine activities are not reported in detail.
30. When an employee has made a mistake or error, the least important of the following is:
   a. obtain all the facts.
   b. maintain calmness.
   c. have the employee admit the error.
   d. keep a record of the event.

31. The most effective way to obtain an employee’s cooperation on a plan is to:
   a. let the employee know you will assume full responsibility.
   b. let the employee know that he or she will be held personally responsible for the plan.
   c. let the employee know your availability in the implementation of the plan.
   d. let the employee know his or her role in the implementation of the plan.

32. An organization chart for a utility can be helpful for several reasons. Which of the following is the least valid objective of an organization chart?
   a. To establish proper chain-of-command authority
   b. To help in making up project schedules
   c. To help in scheduling emergencies
   d. To help develop a budget

33. Successful communication requires mutual:
   a. understanding.
   b. confusion.
   c. transmission.
   d. agreement.

34. When a great deal of authority is delegated on many levels, an organization may be described as:
   a. authoritarian.
   b. centralized.
   c. decentralized.
   d. unstructured.
35. Recognition and job security are indications of:
   a. a good organization.
   b. a good supervisor.
   c. external morale factors.
   d. internal morale factors.

36. Generally, as an individual is promoted upward into a management position, reliance on personal technical skill:
   a. changes to the more complex.
   b. decreases.
   c. increases.
   d. remains the same.

37. How can the supervisor be certain that scheduled maintenance is completed?
   a. Ask the workers
   b. Hire someone to inspect completed work
   c. Use a form that compares work assigned with work completed
   d. Wait and see if there are any failures

38. Word has just come down from the upper management that operating funds are being cut. How should this be handled?
   a. Cut the supplies and repairs in order to balance the budget
   b. Fire some of the less productive old employees
   c. Keep it quiet and do what you have to do—the less said the better
   d. Let the other personnel know what the situation is and ask for their help

39. One job opening has become available which would be an advancement to any one of three qualified employees. How should this situation be handled?
   a. Hire an outsider to fill the position
   b. Pick one and notify all personnel of the change
   c. Split the work between the three and leave the position open
   d. Talk to the three as a group, explain the situation and make your selection, and then notify all personnel of the change
40. One of the employees in your crew complains about having to do a hard job. The proper thing to do is:
   a. explain that all employees must do their fair share of the hard work as well as the easier tasks.
   b. ignore the complaint.
   c. promise that the next assignments will be easier ones.
   d. tell the employee to shut up and work or quit and go home.

41. Occasionally some of the people on a work crew will indulge in active horseplay. This should be:
   a. discouraged because some of the workers might not like it.
   b. encouraged because it promotes good fellowship.
   c. permitted as it is a form of relaxation.
   d. stopped immediately because it is likely to cause an accident.

42. The managerial function which involves devising an appropriate system of pay is:
   a. controlling.
   b. organizing.
   c. planning.
   d. staffing.

43. The span of supervision is the:
   a. average length of time required to be in the organization before making supervisor.
   b. number of levels between the lowest employee and the boss.
   c. number of subordinates for each manager.
   d. number of supervisors in an organization.

44. If an organization’s departments are organized by jobs to be done, this is known as departmentation by:
   a. customer.
   b. function.
   c. product.
   d. territory.
45. Decentralized authority describes the process of:
   a. changing an organization from centralized to decentralized.
   b. delegating authority to one’s superiors instead of one’s subordinates.
   c. delegating power for decisions to lower levels.
   d. retracting authority that has been previously delegated and probably changing functions and duties.

46. What term means that the employee reports to one specific supervisor, and that the delegation of authority comes from one particular supervisor to the employee?
   a. Formal organization
   b. Span of supervision
   c. Organizational chart
   d. Unity of command

47. The term “control” in management practices is:
   a. backward-looking.
   b. concentrating on the present.
   c. forward-looking.
   d. not connected to the other managerial functions.

48. If you are supervisor of two lead workers, one whose work is exceptionally good and a second whose work is substandard, what should you do?
   a. Demote the substandard lead worker and bring up a replacement from the ranks
   b. Discuss the performance problem with the substandard lead worker and offer to help before any other action is taken
   c. Find a replacement and then fire the substandard foreman
   d. Wait to see if the substandard foreman does better

49. Recruiting of new employees falls within which category?
   a. Directing
   b. Organizing
   c. Planning
   d. Staffing
50. The managerial function, which includes the guiding, teaching, motivating and supervising of Laboratory Analysts is:
   a. staffing.
   b. planning.
   c. organizing.
   d. directing.

51. “Essence of control” is:
   a. written records.
   b. testing.
   c. evaluation.
   d. action.

52. In the evaluation of an applicant for employment, which of the following may enter into your decision?
   a. Age
   b. Education level
   c. Minority classification
   d. All of the above

53. Why are good records important?
   a. To demonstrate a pattern of lawful behavior over time
   b. To demonstrate your good report-writing skills
   c. To provide a journal record all uncritical events
   d. To prepare for facility audits

54. What is the meaning of the term job applicant “paper screening”?
   a. Additional analysis of qualified applicants
   b. Elimination of applicants not qualified for the job
   c. Filing of unsuccessful applicants’ paperwork for future job openings
   d. Review of research papers submitted by a job applicant

55. Which one of the following questions is an acceptable interview question?
   a. What is your religious affiliation?
   b. What is the nationality of your parents or spouse?
   c. What is your age?
   d. What is your technical background?
56. What is the best approach to solving a discipline problem?
   a. Accept the employee’s solution to the problem
   b. Form a committee of peers to make a recommendation
   c. Ignore the problem and it will go away
   d. State the problem and then ask employee to suggest a solution

57. What is the best way to prevent sexual harassment?
   a. Ignore any accusations
   b. Require victims to prepare a written document
   c. Set an example by your own behavior
   d. Tell people sexual harassment is wrong

58. Why is written communication more demanding than oral communication?
   a. Ideas must be expressed clearly in full detail
   b. Important information may be missed
   c. It requires the use of highly technical terms
   d. There is no chance to clarify and explain ideas in response to an audience

59. What kinds of behavior are considered sexual harassment?
   a. Humiliating
   b. Annoying
   c. Invited
   d. Uninvited

60. When an employee breaks the rules and requires discipline, who is responsible for administering it?
   a. Fellow employees
   b. The personnel office
   c. The Supervisor
   d. Upper management
61. You are asked to determine the cost per test of the COD analysis. Use the following information:

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

What is the total cost per test?

a. $11.62/test  
b. $8.62/test  
c. $20.24/test  
d. $13.04/test

62. You must select one of two approved methods for performing an analysis. Method A requires 30 minutes of analyst time per test and uses no special instruments. Method B requires 10 minutes of analyst time per test and uses an instrument costing $30,000.

The base salary for the analyst is $2,600 per month, employer paid benefits add 35% to the base salary, and administrative overhead adds another 45%. Assume there are 2,080 working hours per year. The instrument has a one-year full warranty; maintenance and repair costs for subsequent years are estimated to be $1,000 per year. The instrument has an eight-year service life. The test is now run on one sample at each of three locations, five days per week. Regulatory requirements may add one or two more sampling locations to the present requirements. The justification for expenditure for an instrument must show at least a 20% cost saving. (Assume there is no inflation in the salary for this example.) The recommendation you make is to:

a. remain with Method A.  
b. purchase the equipment with the present requirements.  
c. purchase the equipment if one more sample location is added.  
d. purchase the equipment if two more sample locations are added.
### Answer Key

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<th>No.</th>
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<td>31</td>
<td>D</td>
<td>416</td>
<td>62</td>
<td>D</td>
<td>417</td>
</tr>
</tbody>
</table>
Selected Problem Solutions

16. Calculate the chlorine demand using the following data: the chlorinator is set at 250 lbs/day, the flow is 2.4 MGD, and the residual chlorine is 1.4 mg/L.

   First convert the residual chlorine concentration to mass, and then subtract it from the mass output of the chlorinator.

\[
2.4 \text{ MGD} \times 8.34 \text{ lbs} \times 1.4 \text{ parts} = 28 \text{ lbs/day}
\]

\[
250 \text{ lbs/day} - 28 \text{ lbs/day} = 222 \text{ lbs/day}
\]

17. A sample of wastewater from a city of 50,000 population with an average flow of 100 gallons per capita per day contains 10 mL/L settleable solids. The cubic feet of solids produced per day is:

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

\[
100 \text{ gal} \times 50,000 \text{ capita} \times 1 \text{ cu ft capita/day} = 668,449 \text{ cu ft/day}
\]

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

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

18. A treatment plant has the following characteristics of suspended solids removal: the primary clarifier removes 39% of the applied suspended solids; the biological treatment removes 85% of the applied suspended solids; the secondary clarifier removes 16% of the applied suspended solids. The plant flow is 18.2 MGD. The wastewater influent has 215 mg/L suspended solids. Assuming that results can be reported to three significant figures, what is the amount of solids, in pounds/day, removed in the process?

   Applied suspended solids refers to the influent load. Solids added by biological growth in the biological treatment are ignored. The solids remaining in the effluent of each treatment unit become the solids applied to the next treatment unit. First, use the removal efficiencies across each treatment unit to calculate the solids remaining in the secondary effluent.

\[
215 \text{ mg/L} \times (1 - 0.39) \times (1 - 0.85) \times (1 - 0.16)
\]
= 16.52 mg/L

Calculate the mass of solids removed across the plant.

\[
(215 - 16.52) \times 8.34 \text{ lbs} \times 18.2 \text{ MG/gal/day} = 30,126 \text{ lbs/day}
\]

Round answer to three significant figures:
30,100 lbs/day

27. The difference between duplicate determinations on randomly-selected routine samples is used in the development of quality control charts. One approach used to calculate the control limit specifies the following formula:

\[
\text{UCL} = D4R, \text{ where } D4 = 3.27 \text{ is used for duplicates and } R = \text{ the average difference of each of the duplicate samples.}
\]

Ten duplicate determinations for a constituent is g/L are as follows:
152 and 160  
163 and 158  
148 and 154  
142 and 151  
150 and 160  
160 and 154  
145 and 149  
162 and 155  
156 and 157  
159 and 151

The duplicate analyses for a wastewater sample were 180 and 167 g/L. Calculate the upper control and determine whether the analytical results for the plant sample are under control.

Using the formula given above, calculate the upper control limit by summing the difference between each set of duplicate analyses, divide by the number of duplicates, and multiply by D4.

\[
\frac{8 + 5 + 6 + 9 + 10 + 6 + 4 + 7 + 1 + 8}{10} \times 3.27 = 20.9 = \text{ upper control limit}
\]

The difference between the duplicates for the wastewater sample is 180 - 167 = 13. Thirteen is less than the upper control limit, therefore, the duplicate analysis on the wastewater sample is in control.
28. Calculate the method detection limit given the following information.
A standard solution was analyzed 7 times with the following results in mg/L:

0.0356 0.0380
0.0352 0.0360
0.0371 0.0374
0.0346

Calculated mean = 0.0362
Calculated standard deviation = 0.00125

T Scores

<table>
<thead>
<tr>
<th>N</th>
<th>90%</th>
<th>95%</th>
<th>99%</th>
<th>99.5%</th>
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<tr>
<td>1</td>
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<td>6.314</td>
<td>31.821</td>
<td>63.657</td>
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<tr>
<td>2</td>
<td>1.886</td>
<td>2.920</td>
<td>6.965</td>
<td>9.925</td>
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<td>3.499</td>
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<td>7</td>
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<td>1.860</td>
<td>2.896</td>
<td>3.355</td>
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<tr>
<td>8</td>
<td>1.397</td>
<td>1.860</td>
<td>2.896</td>
<td>3.355</td>
</tr>
</tbody>
</table>

Standard Methods states: Analyze seven portions of this solution and calculate the standard deviation. Compute MDL from replicate measurements one to five times the actual MDL. From a table of the one-sided t distribution, select the value of t for 7 - 1 = 6 degrees of freedom at the 99% level; this value is 3.14. The product 3.14 times the standard deviation is the desired MDL.

3.14 x 0.00125 = 0.00393

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

Determine the total cost of the analyst’s time:

$30,000 + ($30,000 x 0.35) + ($30,000 x 0.45)

1 year
= $54,000/year
$54,000 \times 1 \text{ year} \times 1 \text{ month} = \$25.86/\text{hr}

\text{year} \quad 12 \text{ mos} \quad 174 \text{ hrs}

At 20 minutes analyst time per test:
$25.86 \times 1 \text{ hour} \times 20 \text{ mins} = \$8.62/\text{test}

\text{hr} \quad 60 \text{ mins.} \quad \text{test} \quad \text{(analytical labor cost)}

Disposal costs:
\$2,000 = \$2.00/\text{test}

1,000 tests

Reagent costs = \$1.00/\text{test}

Total costs per COD test:
\$8.62 + \$2.00 + \$1.00 = \$11.62

62. You must select one of two approved methods for performing an analysis. Method A requires 30 minutes of analyst time per test and uses no special instruments. Method B requires 10 minutes of analyst time per test and uses an instrument costing $30,000. Base salary for the analyst is $2,600 per month, employer paid benefits add 35% to the base salary, and overhead adds another 45%. Assume there are 2,080 working hours per year. The instrument has a one-year full warranty; maintenance and repair costs for subsequent years are estimated to be $1,000 per year. The instrument has an eight-year service life. The test is now run on one sample at each of three locations, five days per week. Regulatory requirements may add one or two more sampling locations to the present requirements. The justification for expenditure for an instrument must show at least a 20% cost saving. (Assume there is no inflation in the salary for this example.) The recommendation you make is to:

Determine total cost of analyst’s time:

\$2,600 + (\$2,600 \times 0.35) + (\$2,600 \times 0.45)

\text{month}

= \$4,680/\text{month}

\$4,680 \times 12 \text{ months} \times 1 \text{ year} = \$27.00/\text{hr}

\text{Month} \quad 1 \text{ year} \quad 2,080 \text{ hrs}

Method A:

Cost/sample (Analyst’s time) =

\$27.00 \times 1 \text{ hr} \times 30 \text{ mins}
hr  60 mins.  sample
= $13.50/sample
Present workload = 15 samples/week
15 samples/week x $13.50/sample
= $202.50/week
With 1 additional sample point
= 20 samples/week
20 samples/week x $13.50/sample
= $270.00/week
With 2 additional sample points
= 25 samples/week
25 samples/week x $13.50/sample
= $337.50/week

Method B:
Cost/sample (Analyst’s time) =

$27.00 x 1 hr x 15 mins = $6.75/sample
hr 60 mins.  sample
Present workload = 15 samples/week
15 samples/week x $6.75/sample
= $101.25/week
With 1 additional sample point
= 20 samples/week
20 samples/week x $6.75/sample
= $135.00/week
With 2 additional sample points
= 25 samples/week
25 samples/week x $6.75/sample
= $168.75/week

Instrument costs:
$30,000 + (7 years x $1,000/year maintenance) = $37,000 over 8 years
$37,000 \times \frac{1 \text{ year}}{8 \text{ years} \times 52 \text{ weeks}} = \$88.94/\text{week}

8 years 52 weeks

Method B present workload
= $101.25 + $88.94 = $190.19/\text{week}

Method B with 1 additional sample point
= 20 samples/week = $135.00 + $88.94
= $223.94/\text{week}

Method B with 2 additional sample points
= 25 samples/week = $168.75 + $88.94
= $257.69/\text{week}

Method A / Method B relative costs:

Present workload = $190.19 = 0.94
$202.50

With 1 additional sample point = $223.94 = 0.83
$270.00

With 2 additional sample points = $257.69 = 0.76
$337.50

The addition of two sample points would justify the expenditure due to a cost savings of >20%. 
### LAB FORMULA SHEET

#### Element Name, Symbols and Standard Atomic Weights:

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Atomic Weight</th>
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</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>Al</td>
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<td>Arsenic</td>
<td>As</td>
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<td>Calcium</td>
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<td>Carbon</td>
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<td>Chlorine</td>
<td>Cl</td>
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<td>Chromium</td>
<td>Cr</td>
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<td>Copper</td>
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<td>Magnesium</td>
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<tr>
<td>Sulfur</td>
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</table>

#### Conversion Factors:

- 1 gal = 8.34 lbs
- 1 cu ft = 7.48 gal
- 1 lb = 454 grams

#### Abbreviations

- AA = atomic absorption
- AE = atomic emission
- mL = milliliter
- mg = milligram
- L = liter
- g = gram
- GC = gas chromatography
- M = molar
- N = normal
- MGD = million gallons per day

#### MPN Index (10 mL, 1.0 mL, 0.1 mL)

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<tr>
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<th>80 MPN/100mL</th>
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</thead>
<tbody>
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<td>900 MPN/100mL</td>
</tr>
<tr>
<td>5 - 5 - 4</td>
<td>1600 MPN/100mL</td>
</tr>
<tr>
<td>5 - 5 - 5</td>
<td>&gt; 1600 MPN/100mL</td>
</tr>
</tbody>
</table>

*Source: Standard Methods for the Examination of Water and Wastewater, 22nd Edition*
CREATING A STUDY PLAN

Completing a Gap Analysis

CWEA certification exams are experience based. The Gap Analysis Tool is designed to help candidates identify which grade level is best suited to their current level of experience, and where they may be lacking sufficient experience.

This free self-evaluation is available on the CWEA website for all vocations.

Candidates are encouraged to develop their own personal study plan based on individual needs, experience and knowledge. Candidates should seek as many different study materials as possible as well as attend educational events and on-the-job training. This is especially important for areas in which the candidate is not adequately prepared.

CWEA’s exams do not correspond directly to any specific textbook, educational course, or program. Instead, the exams are based on an analysis of the duties commonly performed in actual practice.

CWEA Local Section Training

It is the goal of CWEA’s Technical Certification Program to operate in line with established best practices for certification programs. As such, CWEA is careful to separate its education and training activities from its certification program to ensure that no conflict of interest exists. Any educational materials or trainings that are designed to prepare candidates for an exam are developed and conducted by individuals that do not have access to the exams.

CWEA Local Sections host education and training events throughout the year that focus on the job duties tested by our certifications. These trainings are limited based on demand and volunteer availability.

Local Section trainings can be found on the CWEA Events Website. For questions about a Local Section training, please contact the Local Section directly. Contact information for individual Local Sections can be found in our Directory.
TEST SITE INFORMATION

Test Site Admission

Applicants are required to show at least one current, valid, government-issued photo identification, such as a state driver’s license or ID, or passport. A temporary license is acceptable if there is an expiration date, or if it is accompanied by paperwork explaining an expiration date.

Calculators Allowed

An onscreen calculator with basic and scientific capability is available on all CWEA exams. Applicants may bring a handheld calculator to a test center as long as it is from the CWEA approved calculator list:

<table>
<thead>
<tr>
<th>Calculator Brand</th>
<th>Models Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casio</td>
<td>All FX-115 models (any Casio calculator with FX-115 in its name)</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>All TI-30x and TI-36x models</td>
</tr>
<tr>
<td>Sharp</td>
<td>EL models except EL-W516B and EL-W535B</td>
</tr>
</tbody>
</table>

Pearson VUE’s Candidate Rules Agreement

Pearson VUE maintains its own rules regarding professional examinations. All applicants are required to sign the Candidate Rules Agreement at the test center prior to sitting the exam. Applicants are responsible for knowing and complying with these rules. CWEA recommends all applicants familiarize themselves with this agreement prior to testing.
AFTER THE EXAM

Exam Result Notification

Applicants will see their result on the screen immediately after the exam is submitted. An Official Score Report will be printed out and given to the applicant before they leave the test center. Additional copies can be obtained by logging into the Pearson VUE user account. All results are confidential and will only be released to the applicant. No results will be given over the phone, by fax or email.

Exam Appeal Policy

All appeals must be submitted within two weeks of the exam date. Appeals will be reviewed by CWEA staff and/or Subject Matter Experts. Candidates will be updated on the status of their appeal within 4-6 weeks, and they will be notified in writing when a decision has been made. Once an appeal has been processed, candidates cannot submit a new appeal for the same exam.

Candidates cannot submit an appeal simply because they did not pass the exam.

Candidates can appeal under the following justifications:

Exam Delivery Appeal

Candidates may appeal testing conditions severe enough to have caused a major disruption of the examination process. CWEA staff will review the appeal and consult our exam administrator, Pearson VUE, to investigate the appeal if necessary. Please note, under Pearson VUE’s candidate agreement, candidates must notify the proctor immediately during the exam of any issues to open a claim documenting the incident. If candidates did not notify the proctor during the exam, an appeal may still be submitted but may be dismissed if CWEA cannot verify the validity of the complaint.

Exam Question Appeal

If the candidate wishes to comment on specific exam questions, they may flag the question during the exam using the Flag to Enter a Comment function. Candidates are allowed to add comments about any question as long as there is time remaining. All comments will be reviewed and considered by the Technical Certification Program as part of the ongoing exam.
review and development process. Candidates that wish to submit an appeal of their exam results, must complete the form below within two weeks of their exam date. Candidates that wish to have specific comments considered in support of their appeal should indicate so on the appeal form.

Non-substantive appeals or appeals without just cause will be automatically rejected. If candidates are not satisfied with the outcome of their appeal, they may submit a request for review by the Technical Certification Program Executive Committee at tcpcommittee@cwea.org. The committee’s decision will be final.

All communication related to certification decisions and appeal results with the Technical Certification Program Executive Committee must be sent in writing to tcpcommittee@cwea.org. We ask that candidates do not contact committee members directly.

The appeal form can be accessed here: CWEA Exam Appeal Form.

Retest Application

If the candidate does not pass the exam the first time, they can submit a retest application along with the appropriate fees. The candidate will be required to skip at least one exam window before they are eligible to retest. If the candidate tested within the first 15 days of a window, they are not required to skip an exam window. Under no circumstances are candidates allowed to sit for the same exam twice in the same window. There are no exceptions to this policy.

To be eligible to use the retest application form, candidates must submit the application within one year of their original exam date. Candidates must meet the minimum qualifications of the exam for which they are applying. CWEA may require candidates to fill out a full application with job history to verify candidates meet the minimum requirements. Use of a retest application does not guarantee approval for any exam.

Receiving the Certificate and Blue Card

Certificates and Blue Cards will be issued to all candidates who pass their exam. The certificate contains the certification number and expiration date. The Blue Card contains the expiration date, contact hour due date and contact hour period. These documents are mailed along with
the Score Report within 4 weeks to the address on file with CWEA. Candidates are responsible for making sure this address is current.

**MAINTAINING CERTIFICATION**

**How to Renew**

All certifications must be renewed annually. Certifications expire one year from the last day of the month in which the certification was earned. Renewal notices are mailed to certification holders three months before the expiration date. Certification holders can pay their renewal online by logging into their mycwea.org account or by mailing their renewal notice with a check or credit card information to the CWEA office.

Certification holders are required to meet Continuing Education (CE) requirements. This requirement is met by completing 12 contact hours (1.2 CEUs) of vocation-related education or training every two years. For more information about earning contact hours, for details see *Earning Contact Hours* (p. 168).

Not meeting these requirements by the expiration date will cause the certification to expire. Certifications that have been expired for more than three months are subject to a $25 late fee. If a certification holder does not meet the renewal requirements within two years of their expiration date their certification will permanently expire. To become certified once again, the individual must re-apply for certification and pass the exam. It is the certification holder’s responsibility to ensure that his or her certification remains valid. There are no exceptions to these policies.

**Renewal Fees**

Current fees are listed on the [CWEA website](https://www.cwea.org). Valid CWEA members qualify for a discounted member rate. The non-member rate includes a one-year CWEA membership. If an applicant does not wish to take advantage of the membership, please inform CWEA.

**Continuing Education (CE) Requirement**

Certification holders are required to meet Continuing Education (CE) requirements. This requirement is met by completing 12 contact hours (1.2 CEUs) of vocation-related education or training every two years.
training every two years. Certification holders may submit up to 50% (6 contact hours) of the required contact hours in safety related training. One contact hour is defined as 50 minutes of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction.

Contact hours must be earned within the contact hour period. Hours are earned on the date of completion of the educational or training program. The program may begin before, but must be completed during the contact hour period. If a certification holder will not earn the required hours within their contact hour period, they must notify CWEA before the period ends if they wish to remain certified, for details see *Temporary Deactivation* (p. 169).

Individuals holding more than one CWEA certification can apply the same contact hours to each certification as long as the training is relevant to each vocation. Training is acceptable as long as it is related to the vocations in which certification is held. CWEA may send contact hour certificates to Subject Matter Experts to determine relevancy.

In-house training can be used to meet this requirement as long as standard Safety Tailgate meetings do not exceed 50% (6 contact hours). In-house training includes any training that is conducted by an employer, or a trainer contracted by an employer.

**Earning Contact Hours**

Contact hours may be earned by any of the following activities:

- Attendance at educational/training programs, including in-house training
- Teaching, instructing or presenting educational/training material (1 hour per 25 min)
- Developing and reviewing CWEA certification exam content as a Subject Matter Expert (1 hour per 25 minutes)
- Authorship of published books or articles (2 hours per book or article)
- Retesting and passing the relevant CWEA certification exam (12 hours)
- Membership in professional membership organizations (.5 hours per year, per membership, with a maximum of 6 hours per contact hour period)

CWEA may require and request additional documentation to assess the authenticity and/or relevance of these activities.

This information is paraphrased for clarity from the 02-03 TCP Re-Certification Policy; a full copy of the policy can be requested by contacting the TCP department.
Contact Hour Documentation

Proof of contact hour completion for an educational/training program must meet these following guidelines:

- The name of the training organization
- The training title
- The name of the attendee who completed the program
- The number of contact hours earned
- The date of completion
- An official signature or stamp from the training organization, instructor’s signature is acceptable

For other continuing education activities, CWEA may request additional information. Any documentation that does not meet these guidelines will not be accepted. It is the certification holder’s responsibility to retain verification of records documenting earned contact hours and submit proof to CWEA.

Contact Hour Audit

Audits are conducted on a regular basis by CWEA to ensure that certification holders are complying with the continuing education requirement and that the documentation meets the guidelines. Certification holders are randomly selected for an audit of contact hours. The audit reviews the relevancy of the trainings to the vocation, and the dates in which the contact hours were earned to ensure that they fall within the appropriate contact hour period.

Selected participants will be notified via email that they have either successfully passed the audit, or that CWEA requires further information.

Temporary Deactivation

The Temporary Deactivation program is for certification holders that will not meet the continuing education requirement for recertification by their expiration date. Under this program, certification holders can request that CWEA temporarily deactivate their certification for up to two years from their expiration date. This grants the individual extra time to earn the required contact hours. During the time of temporary deactivation, the CWEA certification is invalid and may not be used. Certification holders can apply for reactivation once they fulfill all
requirements. Certification must be in good standing to qualify for this program. For more information including current fees, or to request an application for temporary deactivation, contact the CWEA office.

The application must be submitted before the certification expiration date. There is no exception to this policy.

Reinstating Certification

If a certification expires, it is invalid until all recertification requirements are met. There is a three-month grace period before a certification is considered lapsed. Once a certification becomes lapsed, the certification holder will need to pay a $25 late fee in addition to meeting the renewal requirements. Certification will remain lapsed for up to two years from the expiration date. If a lapsed certification is not renewed within the two-year period, the certification becomes permanently expired.

Expired Certification

Certificates expired for two years, or longer, cannot be reinstated under any circumstances. To become certified once again, the individual must re-apply for certification and pass the exam. It is the certification holder's responsibility to ensure that his or her certification remains valid. There are no exceptions to these policies.

Retiring Certification

Certification holders can request that CWEA retire their certification at the time it expires if they no longer wish to hold it. Once a certification has been retired, the certification will no longer be valid and CWEA will cease all communications regarding the certification. A retired certification can be reactivated only if the certification holder has met all renewal requirements within the appropriate timeframe and the certification has not permanently expired.
EXAM DESIGN AND FORMAT

Exam Design

All certification exams are designed to test knowledge required to perform the essential duties of a job at a given grade level with minimum acceptable competence. Exams are created by Subject Matter Experts under the guidance of exam development professionals.

Exam content is developed from a job task analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California. All exam items are written by subject matter experts based on the content outline established by the job task analysis. These items are used to create the exam forms. The pass point for each exam is based on difficulty, using the Modified Angoff Method, for details see Pass Point and How Pass Points are Set (p. 172).

Exam Delivery Mechanism

All exams are computer-based format and are available in the English language only. Exams are delivered at Pearson VUE testing centers or via Pearson VUE’s online testing platform On Vue.

Exam Format

All certification exams are in multiple-choice format. Multiple-choice is considered the most effective format for use in standardized tests as it allows for 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.

Weighting

The percentage of the exam that covers a particular content area is referred to as its weighting. Weightings are established through a Job Task Analysis and are based on the frequency and criticality of the task. A weighting is approximate and shows the relative importance of a particular area compared to the other portions of the exam. Weightings are
indicated on the content outline for each exam and can be found in the preparation materials. Each weighting on the actual certification exam may vary slightly.

Pass Points

An exam pass point is the minimum score required to pass a certification exam. The pass point is also known as a cut score or passing score. Candidates should try to score as high as possible on their exam. Pass points for CWEA certification exam vary with each exam form. The pass point for each vocation, grade level and exam form is set independently.

How Pass Points are Set

A modified Angoff Method is used to determine the pass point for each version of each exam. The modified Angoff Method uses expert judgments to determine the difficulty level of the exam. The easier the exam, the higher the pass point. Likewise, the more difficult the exam, the lower the pass point.

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

1. A group of Subject Matter Experts (SMEs) independently rate each exam question within a given exam. The ratings are defined as the probability, or likelihood, that a minimally competent person with the requisite education and experience will answer the question correctly. A minimally competent person is defined as someone who adequately performs all job functions safely and requires no further training to do so.

2. The SMEs review each exam question as a group. A consensus is reached for the rating of each exam question. During this time the SMEs review comments submitted in writing by exam-takers. Any exam 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 exam. These exam questions are then revised for future use, re-classified, or deleted from the exam item bank.

3. After the data are refined, the final step is to calculate the mean, or average, of all the exam question ratings. This becomes the overall pass point estimation.
Why Use Modified Angoff?

Each version of a given certification exam pulls questions from an exam item bank. Each of these questions varies in difficulty. Because a different mix of questions is used in each exam form, 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 exam to ensure that results are reliable. Exam reliability is concerned with the reproducibility of results for each version of a given exam. In other words, for an exam to be reliable it must yield the same result (pass or fail) for the same individual under very similar circumstances. For example, imagine a candidate takes an exam at a certain grade level and passes it. Immediately after completing the exam, the candidate takes the same grade level exam, but a different version. If the exam is reliable they will achieve the same result: pass. If they do not, it is likely that the exam is not a reliable measure of minimal competency.

By taking into consideration the difficulty level of an exam, the modified Angoff Method significantly increases the reliability of the exams. Also, since each exam is adjusted for difficulty level, each exam version has the same standard for passing. Thus, exam-takers are treated equitably and fairly, even if they take different versions of the exam.

There are other methods for setting pass points. However, for the type of exams administered by CWEA, the modified Angoff Method is the best.

Exam Scoring

All exams are electronically scored by Pearson VUE. Most exam items are valued at one point unless otherwise stated on the exam. After exams are scored, total points are compiled, and an overall score is calculated as the sum of all points earned on the exam. If the overall score is equal to, or greater than the established pass point, the candidate has passed the exam. Each question is worth 1 point. Total points possible for each exam are as follows:

- Grade 1 - 100 points
- Grade 2 - 100 points
- Grade 3 - 100 points
- Grade 4 - 100 points
Summary of Certification Activities

A summary of certification activities for each vocation is available upon request. The summary includes the number of candidates examined, pass/fail statistics, and the number of individuals currently certified. To request this information, please contact the CWEA office.