

PRACTICE EXAM 8: WATER TREATMENT OPERATOR CLASS I SIMULATION (100 QUESTIONS)

1. A treatment plant feeds alum at 45 mg/L to water with a natural alkalinity of 80 mg/L as CaCO₃. Three hours after a jar test confirms optimal dose, the operator notices the settled water turbidity has increased from 0.7 NTU to 3.5 NTU despite no change in raw water quality or alum feed rate. Investigation reveals the lime feed pump stopped two hours ago. The settled water deterioration is most likely caused by:

- A. Loss of lime feed reducing the water temperature and slowing floc settling velocity
- B. Loss of lime feed eliminating the supplemental alkalinity needed to prevent pH crash at the 45 mg/L alum dose
- C. Loss of lime creating an excess of alkalinity that produces charge reversal on the floc particles
- D. Loss of lime allowing the pH to drop below the effective coagulation range because the 45 mg/L alum dose consumes approximately 22.5 mg/L of the 80 mg/L alkalinity, potentially exhausting the remaining buffer

2. A treatment plant operator receives the following laboratory results from a routine distribution system sampling round: Location 1 — total coliform positive, E. coli absent; Location 2 — total coliform absent; Location 3 — total coliform absent. Under the RTCR, the required response to the Location 1 result is to:

- A. Retest the laboratory equipment to verify accuracy before collecting any repeat samples
- B. Collect repeat samples within 24 hours — one at the original location, one upstream, and one downstream
- C. Issue Tier 1 public notification within 24 hours because any positive coliform constitutes an emergency
- D. Increase the chlorine dose at the plant by 25% and retest all three locations after 48 hours

3. A treatment plant's sedimentation basin was designed for a surface overflow rate of 700 gpd/ft². The basin has a surface area of 3,000 ft². During a peak demand event, the plant flow increases to 3.5 MGD. The overflow rate during this event is:

- A. 700 gpd/ft², unchanged because the basin's design overflow rate is a fixed physical property
- B. 583 gpd/ft², below design because peak demand reduces the hydraulic loading on basins
- C. 1,167 gpd/ft², which exceeds the design rate and may reduce settling performance
- D. 3,500 gpd/ft², calculated by dividing the flow in gallons per day by 1,000

4. An operator at a treatment plant using chloramine disinfection tests the finished water and obtains the following results: free chlorine 0.0 mg/L, total chlorine 2.5 mg/L. These results indicate:

- A. The chloramination system is operating correctly — all chlorine has combined with ammonia to form chloramines, with no excess free chlorine remaining
- B. The ammonia feed has failed and all chlorine exists in the free form, requiring immediate investigation
- C. The DPD reagent is expired and producing inaccurate results that must be discarded and retested
- D. The total chlorine analyzer has drifted high and needs immediate recalibration against a standard

5. A treatment plant operates a clearwell with a volume of 200,000 gallons. The plant treats 1.5 MGD (1,042 gpm). The baffling factor is 0.5 (average). The chlorine residual at the clearwell outlet is 0.8 mg/L. The operator needs to determine whether the achieved CT meets the required 45 mg·min/L for *Giardia* inactivation at the current temperature and pH. The achieved CT is:

- A. 96 mg·min/L, which is more than double the required CT
- B. 76.8 mg·min/L, which provides approximately 70% more CT than required
- C. 192 mg·min/L, calculated without applying the baffling factor
- D. 76.8 mg·min/L, calculated as: $DT = 200,000 \div 1,042 = 192 \text{ min}$; $T_{10} = 192 \times 0.5 = 96 \text{ min}$; $CT = 0.8 \times 96 = 76.8 \text{ mg}\cdot\text{min/L}$

6. An operator performing a filter inspection during backwash notices that the wash water is substantially muddier on the left side of the filter than the right side. The bed expansion also appears greater on the left. This uneven backwash performance most likely indicates:

- A. The filter media on the left side has a different grain size than the right due to poor media installation
- B. The backwash valve is not opening fully, limiting flow to both sides of the filter bed equally
- C. One or more underdrain laterals on the right side are partially blocked, preventing uniform water distribution during backwash
- D. The left side received more raw water during the production run due to a baffle misalignment in the filter influent channel

7. An operator is planning the annual maintenance schedule for the plant's chemical metering pumps. Each pump has a manufacturer-recommended diaphragm replacement interval of 12 months and check valve inspection interval of 6 months. The plant has six metering pumps. Which scheduling approach is most operationally sound?

- A. Replace all six diaphragms and inspect all check valves simultaneously during a single annual shutdown day
- B. Stagger the maintenance across the year so that no more than one pump per chemical service is down at any time
- C. Perform maintenance only when a pump shows visible signs of failure to maximize the useful life of components
- D. Double the manufacturer's intervals to 24 months for diaphragms and 12 months for check valves to reduce costs

8. A treatment plant using surface water feeds chlorine after filtration. The plant's CT calculation shows adequate Giardia inactivation but the operator wants to verify Cryptosporidium inactivation credit. The plant does not have UV disinfection. Under the Long-Term 2 Enhanced Surface Water Treatment Rule, the chlorine CT approach to Cryptosporidium is:

- A. Impractical because the chlorine CT required for Cryptosporidium inactivation is extremely high compared to Giardia, making UV or ozone the preferred options
- B. Identical to the Giardia CT requirement because both pathogens have the same chlorine resistance profile

C. Not required because conventional filtration alone provides sufficient *Cryptosporidium* removal credit

D. Achievable at standard doses because *Cryptosporidium* is more sensitive to chlorine than *Giardia*

9. A treatment plant operator is reviewing the plant's emergency action plan and finds that the plan has not been updated since it was written five years ago. Since then, two new chemicals have been added, the SCADA system has been upgraded, and three emergency contact numbers have changed. The operator should:

A. Update the plan immediately to reflect current plant conditions, because an outdated emergency plan may direct responders to take incorrect actions during an actual emergency

B. Wait until the next scheduled sanitary survey to update the plan, which will prompt the state to review changes

C. Add an addendum page to the existing plan rather than revising the entire document to save time

D. Submit the plan as-is for the upcoming compliance review because the core emergency procedures are unchanged

10. A treatment plant operator performs a jar test and determines that the optimal alum dose is 30 mg/L at the current raw water turbidity of 12 NTU. The plant flow is 4.0 MGD. Over the next six hours, the raw water turbidity increases to 45 NTU due to a rainfall event. If the operator does not adjust the coagulant dose:

A. Treatment will improve because higher turbidity provides more particles for floc formation and sweeping

B. The excess particles will be captured by the filters without any effect on settled water quality

C. The 30 mg/L dose will be insufficient for the higher turbidity, resulting in poor coagulation and elevated settled water turbidity

D. The streaming current monitor will automatically increase the chemical feed to compensate for the changed conditions

11. An operator is investigating a customer complaint about reddish-brown water that appears after the water has been sitting in the bathtub for several hours but is clear when first drawn from the tap. The most likely cause is:

- A. High manganese levels that require several hours of oxygen exposure before visible oxidation occurs
- B. Dissolved iron in the water that oxidizes when exposed to air, precipitating as visible rust-colored ferric iron particles over time
- C. Residual coagulant passing through the filters that gradually changes color as it reaches room temperature
- D. Bacterial contamination producing a reddish biofilm on the bathtub surface during the standing period

12. A treatment plant's daily operating data shows the following for last Tuesday: plant flow = 3.0 MGD, alum dose = 35 mg/L, raw water turbidity = 10 NTU, settled water turbidity = 0.8 NTU, combined filter effluent turbidity = 0.05 NTU, clearwell chlorine residual = 1.0 mg/L. Which of these parameters represents the best indicator of overall treatment process effectiveness from coagulation through filtration?

- A. Raw water turbidity because it establishes the challenge the treatment process must overcome each day
- B. Settled water turbidity because it reflects only the performance of the sedimentation basin step
- C. The alum dose because it determines the amount of treatment chemical applied per gallon of water
- D. Combined filter effluent turbidity because it reflects the cumulative performance of coagulation, flocculation, sedimentation, and filtration working together

13. A water system's wellhead protection area delineation map shows that a new gas station with underground storage tanks has been constructed within Zone 1 (the two-year time-of-travel zone). The system operator's most appropriate response is to:

- A. Contact the local planning authority to verify compliance with wellhead protection regulations and coordinate monitoring and contingency planning with the gas station operator
- B. Immediately shut down the well until the gas station agrees to relocate to a site outside the protection area
- C. Ignore the development because commercial activities are permitted in Zone 1 without restriction
- D. Begin blending water from the threatened well with water from a deeper, unaffected well to dilute any contamination

14. A treatment plant operator is evaluating laboratory quality control data. A standard curve for chlorine analysis produces the following results: 0.0 mg/L standard reads 0.02, 0.5 mg/L standard reads 0.48, 1.0 mg/L standard reads 1.03, 2.0 mg/L standard reads 1.85. Based on this calibration, the operator should:

- A. Accept the curve for the 0.0, 0.5, and 1.0 mg/L standards but investigate the low reading on the 2.0 mg/L standard
- B. Recalibrate the instrument using all four standards because all readings deviate from expected values
- C. Accept the entire curve because all readings are within acceptable analytical tolerance
- D. Discard the results and switch to a different analytical method because DPD colorimetry is unreliable above 1.0 mg/L

15. A treatment plant's chemical storage room has two bulk tanks: a 6,000-gallon tank of sodium hypochlorite and a 4,000-gallon tank of hydrofluorosilicic acid. The secondary containment for the storage area must hold a minimum of:

- A. 4,000 gallons, equal to the smaller of the two tanks in the containment area
- B. 5,000 gallons, equal to the average of the two tank volumes combined
- C. 10,000 gallons, equal to the combined volume of both tanks in the area
- D. 6,600 gallons, which is 110% of the volume of the largest single tank in the containment area

16. An operator discovers that the treatment plant's four parallel sedimentation basins are receiving unequal flow — Basin 1 and Basin 2 each receive 30% of the total flow, while Basin 3 and Basin 4 each receive only 20%. The total plant flow has not changed. This unequal distribution will most likely cause:

- A. Improved treatment in all basins because varying flow rates optimize settling across different particle sizes
- B. Basins 1 and 2 to produce poorer settled water quality due to their higher-than-design overflow rates
- C. Basins 3 and 4 to experience faster sludge accumulation because lower flow rates trap more particles
- D. No treatment impact because the combined settled water from all four basins will average to design specifications

17. A treatment plant's operator is testing a new polymer coagulant aid. The jar test protocol adds the polymer simultaneously with the alum at the rapid mix stage. The results show no improvement in floc quality compared to alum alone. Before concluding that the polymer is ineffective, the operator should consider testing:

- A. The same polymer at the same point but at a higher concentration than the manufacturer's recommended range
- B. The polymer without any alum to determine if it can function as the sole coagulant for this water source
- C. A completely different brand of polymer because the current brand is clearly incompatible with alum coagulation
- D. The polymer added after the rapid mix, during the early flocculation stage, where it can bridge between already-destabilized particles

18. A water treatment plant operates a two-stage lime softening process to reduce hardness from 350 mg/L to 120 mg/L as CaCO_3 . The plant is located in a region where the state drinking water standards include a recommended hardness range of 80 to 150 mg/L. The finished water hardness of 120 mg/L indicates:

- A. The softening process is performing within the target range, producing water that meets the recommended hardness guidelines
- B. Over-softening has occurred because any hardness above 100 mg/L indicates incomplete chemical reaction
- C. Under-softening has occurred because the plant should achieve a hardness below 50 mg/L for consumer satisfaction
- D. The softening process has failed because lime softening cannot reduce hardness below 200 mg/L

19. An operator at a groundwater treatment plant notices that the raw water pH has gradually decreased from 7.4 to 6.6 over the past six months. The well has been in operation for 15 years with no previous pH trend. The operator should investigate:

- A. Whether the well screen has corroded, allowing different aquifer zones with different water chemistry to contribute

B. Whether the laboratory pH meter has drifted low, producing an artificial downward trend in all readings

C. Whether changes in land use, recharge chemistry, or seasonal water table fluctuations are altering the aquifer's chemical composition

D. Whether the well pump has been replaced with a different model that aerates the water differently during pumping

20. A treatment plant's four filters have been operating for different durations since their last backwash. The operator reviews the following data: Filter 1 — 48 hours since wash, headloss 7.2 ft (terminal = 8 ft), effluent 0.04 NTU. Filter 2 — 24 hours since wash, headloss 4.5 ft, effluent 0.04 NTU. Filter 3 — 36 hours since wash, headloss 6.0 ft, effluent 0.09 NTU. Filter 4 — 12 hours since wash, headloss 2.5 ft, effluent 0.04 NTU. Which filter requires priority attention?

A. Filter 1 because it has been online longest and is closest to terminal headloss

B. Filter 3 because its effluent turbidity is elevated relative to the other filters despite not being closest to terminal headloss, suggesting possible early breakthrough or a filter-specific problem

C. Filter 4 because it was most recently backwashed and its headloss should be lower than 2.5 feet

D. Filter 2 because its headloss is developing faster than expected for 24 hours of operation

21. A treatment plant treats surface water at 5.0 MGD. The operator calculates the plant's filter loading rate. The plant has five filters, each with a surface area of 300 ft². With all five filters online, the loading rate per filter is:

A. 2.31 gpm/ft², which is within the typical range for rapid gravity filters

B. 11.57 gpm/ft², which far exceeds the maximum recommended rate for conventional filters

C. 0.46 gpm/ft², which is characteristic of slow sand filtration rather than rapid filtration

D. 2.31 gpm/ft², calculated as total flow in gpm divided by total filter area divided by number of filters

22. An operator performing a routine security inspection discovers footprints in the mud around the clearwell access hatch, but the lock on the hatch is intact and shows no signs of tampering. No authorized work has been scheduled at the clearwell. The operator should:

- A. Investigate immediately — document the footprints, verify the lock has not been bypassed, inspect the clearwell hatch and seals for evidence of unauthorized access, and report the finding to the supervisor
- B. Ignore the footprints because the intact lock proves that no unauthorized entry occurred
- C. Replace the lock immediately as a precaution but do not investigate further or report the finding
- D. Schedule a clearwell inspection during the next routine maintenance period to verify no tampering occurred

23. A treatment plant's operator receives a consumer complaint about black specks in the water from a customer's kitchen tap. The cold water and hot water both produce specks. Distribution system flushing in the area was completed last week with no issues. The operator should advise the customer to:

- A. Stop using the water immediately and file a formal complaint with the state health department
- B. Check the internal plumbing for deteriorating rubber gaskets, flexible connectors, or water heater dip tube that commonly shed black particles
- C. Boil the water before use because black particles indicate carbon from the treatment plant's filters
- D. Install a whole-house filtration system because the distribution system is releasing pipe corrosion products

24. A treatment plant treats 3.0 MGD and needs to achieve a fluoride dose of 0.7 mg/L in the finished water. The raw water contains 0.25 mg/L of natural fluoride. The plant uses sodium fluorosilicate (Na_2SiF_6) with a fluoride ion content of 60.6%. The daily pounds of sodium fluorosilicate needed is:

- A. 18.7 lb/day, calculated using the pounds formula with dose adjustment for natural fluoride
- B. 34.5 lb/day, calculated without subtracting the natural fluoride background concentration
- C. 11.25 lb/day, calculated as $(0.45 \times 3.0 \times 8.34) \div 0.606$
- D. 27.8 lb/day, using the full 0.7 mg/L dose rather than the supplemental 0.45 mg/L

25. A treatment plant's SCADA alarm log for the past month shows 847 alarms across all monitored systems. Of these, 812 were classified as "nuisance alarms" that cleared without operator intervention. The alarm-to-action ratio (nuisance alarms \div total alarms) of 96% indicates:

- A. Excellent alarm system performance because few alarms required actual operator response
- B. A well-maintained SCADA system with appropriate sensitivity for detecting transient conditions
- C. Alarm setpoints need minor adjustment to reduce the nuisance rate from 96% to the target 90%
- D. A serious alarm management problem — the high nuisance rate contributes to alarm fatigue and increases the risk that operators will miss or delay response to genuine critical alarms

26. A treatment plant operator opens a valve to drain a sedimentation basin for annual cleaning and inspection. As the water level drops, the operator notices several large areas of the basin floor where the sludge layer appears to be over 2 feet deep, while other areas have only a thin coating. This uneven sludge distribution most likely indicates:

- A. The sludge collection and removal system is not operating uniformly — scrapers may be damaged, sludge hoppers may be unevenly positioned, or withdrawal piping may be partially blocked
- B. Normal sludge accumulation patterns that occur in all sedimentation basins regardless of scraper performance
- C. The coagulant dose varies across the basin width, producing heavier floc in some areas and lighter floc in others
- D. The basin was not completely drained during the previous annual cleaning and old sludge has compacted in the deep areas

27. A treatment plant's UV disinfection system consists of two parallel UV reactors, each validated for 50% of the plant flow. One reactor develops a lamp failure that reduces its validated dose below the minimum. The operator should:

- A. Immediately shut down the affected reactor and reduce plant flow to match the single reactor's validated capacity
- B. Divert all flow through the functioning reactor while running the failed reactor at 50% capacity
- C. Reduce the plant flow to 50% of capacity and route all water through the single functioning reactor until the lamp is replaced
- D. Increase the lamp power on the functioning reactor to handle 100% of the flow while the failed reactor is offline

28. An operator at a treatment plant using chloramine disinfection discovers that the plant's monochloramine residual in the distribution system has dropped from 2.0 mg/L to 0.8 mg/L at several monitoring points over the past three weeks. Simultaneously, nitrite levels at those locations have increased from 0.01 mg/L to 0.08 mg/L. The seasonal water temperature has risen from 15°C to 25°C. The most likely cause is:

- A. The chloramine dose at the plant is too high, accelerating the chemical decomposition of monochloramine
- B. A nitrification episode driven by warmer temperatures that promotes nitrifying bacteria to convert ammonia to nitrite while consuming the chloramine residual
- C. The ammonia feed system has increased its output, producing excess ammonia that consumes the chlorine
- D. The distribution system has developed a significant leak that is diluting the chloramine residual at multiple points

29. A treatment plant's raw water intake structure includes a coarse bar rack, a traveling screen, and a raw water pump station. During a spring flood event, the river level rises and carries large amounts of debris toward the intake. The bar rack becomes partially blocked with branches and trash. The immediate operational concern is:

- A. Reduced raw water flow due to the obstruction, potentially causing the raw water pumps to lose suction and cavitate
- B. Contamination of the raw water by chemical leachate from the debris accumulating on the bar rack
- C. Structural failure of the intake building from the hydraulic pressure created by the blocked bar rack
- D. Increased turbidity in the raw water caused by the debris physically disintegrating on the bar rack

30. A treatment plant treats 2.0 MGD and feeds 10% sodium hypochlorite solution (specific gravity 1.14) at a chlorine dose of 3.0 mg/L. The daily volume of sodium hypochlorite solution consumed is approximately:

- A. 42 gallons per day
- B. 21 gallons per day
- C. 84 gallons per day

D. 53 gallons per day

31. An operator at a treatment plant performs a filter backwash using the standard automated sequence. After the backwash, the filter is returned to service with filter-to-waste running for 15 minutes. The filter-to-waste turbidity starts at 0.35 NTU and steadily decreases to 0.06 NTU by the end of the 15-minute period. The filter is then placed online. Two hours later, the filter effluent turbidity has gradually risen back to 0.15 NTU. The most likely explanation is:

- A. The backwash was effective but the filter has an underlying media or underdrain problem that becomes apparent during production
- B. Normal filter ripening that can take two hours to fully complete in some filter designs
- C. The filter is experiencing early breakthrough due to high raw water turbidity overwhelming the media
- D. The turbidimeter on this filter has an intermittent electrical fault that produces fluctuating readings

32. A treatment plant operator tests a distribution system sample and obtains: pH 7.2, free chlorine 0.6 mg/L, total chlorine 0.6 mg/L, alkalinity 45 mg/L as CaCO₃, temperature 18°C. The system uses free chlorine for disinfection. Which statement about this sample is correct?

- A. The total chlorine should always be higher than the free chlorine, indicating an analytical error
- B. All chlorine exists as free chlorine with zero combined chlorine present, which is expected in a system using free chlorine disinfection without ammonia
- C. The sample contains equal parts free chlorine and combined chlorine that happen to read identically
- D. The temperature of 18°C has caused the DPD reagent to produce identical readings for both tests

33. An operator at a treatment plant using groundwater discovers that the raw water total coliform count has increased from consistently negative to positive in two of the last three monthly monitoring rounds. The well is not classified as GWUDI. Under the Ground Water Rule, the operator should:

- A. Conduct triggered source water monitoring for fecal indicators to determine if the well has a sanitary defect allowing fecal contamination
- B. Immediately install a conventional filtration system because groundwater with coliform detections requires the same treatment as surface water

C. Discontinue using the well permanently because any coliform detection in groundwater indicates irreversible aquifer contamination

D. Increase the chlorine dose by 50% and retest the well after 30 days to determine if the coliforms clear

34. A treatment plant's PLC-controlled coagulant feed system operates in flow-proportional mode. The PLC receives a 4–20 mA signal from the plant effluent flow meter. During a SCADA system review, the operator notices that when the plant flow decreases, the coagulant feed rate increases — the opposite of the expected behavior. The most likely cause is:

A. The coagulant chemical has become more concentrated in storage, requiring less volume at lower plant flows

B. The flow meter signal polarity is normal but the PLC scaling is inverted — as the mA signal decreases (lower flow), the PLC interprets it as increasing flow

C. The coagulant feed pump is oversized and its minimum stroke rate exceeds what is needed at lower flows

D. The 4–20 mA signal from the flow meter is reversed (wired backwards), causing the PLC to interpret decreasing flow as increasing flow

35. A treatment plant's finished water meets all primary and secondary drinking water standards. However, the operator receives several complaints about "musty" or "earthy" tasting water during August. Laboratory analysis confirms elevated geosmin at 30 ng/L (threshold of detection is approximately 5–10 ng/L). The operator should understand that:

A. Geosmin has no MCL because it is not a regulated contaminant, but it is a significant consumer acceptance issue that warrants treatment response

B. No treatment is needed because geosmin at 30 ng/L is well above the MCL but still within safe levels

C. Geosmin is regulated under the DBP rule and the plant is in violation at 30 ng/L

D. The geosmin must be coming from the distribution system because it cannot originate from the source water

36. An operator at a small groundwater system is preparing for the annual Consumer Confidence Report. The system detected nitrate at 6.5 mg/L as N (MCL = 10 mg/L) and arsenic at 0.007 mg/L (MCL = 0.010 mg/L). The CCR must include:

- A. Only contaminants that exceeded their MCLs — since both are below, neither needs to be reported in the CCR
- B. Both detected contaminants with their concentrations, the applicable MCLs, MCLGs, likely sources, and health effects information
- C. Only the arsenic result because it is a known carcinogen and poses a greater health risk than nitrate
- D. A general statement that all water quality parameters met federal standards without listing specific contaminant levels

37. A treatment plant's operator reviews the monthly water production data and calculates that the plant produced 95 million gallons last month. Customer meter readings totaled 80 million gallons billed. Backwash water usage was 3 million gallons and other plant internal uses were 1 million gallons. The unaccounted-for water is:

- A. 11 million gallons, representing approximately 11.6% of total production, which should be investigated for leaks, unmetered uses, and meter inaccuracies
- B. 15 million gallons, representing the difference between production and billing before subtracting internal uses
- C. 3 million gallons, representing only the backwash water because all other water is accounted for
- D. 0 gallons, because the sum of customer billing, backwash, and internal uses accounts for all production

38. A treatment plant feeds potassium permanganate at the raw water intake for iron and manganese oxidation. The operator notices pink-tinted water in the sedimentation basin effluent — water that should be colorless at this point. This pink color indicates:

- A. The ferric chloride coagulant has degraded and is releasing iron oxide that produces a pink discoloration
- B. A biological organism has colonized the sedimentation basin and is producing a pigmented biofilm
- C. Excess permanganate is passing through the sedimentation process because the dose exceeds the oxidant demand
- D. The iron and manganese concentrations in the raw water have increased beyond the permanganate's treatment capacity

39. A confined space rescue plan requires that rescue services be able to reach the plant and execute a rescue within a specified time frame. The nearest external rescue team is 45 minutes away. The plant has permit-required confined spaces that are entered weekly. The most appropriate action is to:

- A. Accept the 45-minute response time because it represents the best available external resource
- B. Discontinue all confined space entries until an external rescue team with a shorter response time is identified
- C. Limit confined space entries to 30 minutes duration so that any rescue can be completed within the 45-minute window
- D. Establish an on-site confined space rescue capability with properly trained and equipped plant personnel to ensure timely rescue response

40. An operator testing the plant's standby generator discovers that the engine starts and runs smoothly at rated speed, but when the automatic transfer switch applies the plant load, the engine stalls within 10 seconds. The most likely cause is:

- A. The generator's voltage regulator is set too high, causing the electrical output to exceed the rated capacity
- B. The total connected electrical load exceeds the generator's rated capacity, causing the engine to stall under load
- C. The ATS is transferring the load too slowly, causing a voltage dip that triggers the engine's under-voltage protection
- D. The generator's fuel supply is contaminated with water, which the engine can tolerate at no load but not under load

41. A treatment plant's four parallel sedimentation basins are designed for a total combined surface overflow rate of 800 gpd/ft² at the plant's design capacity of 4.0 MGD. Each basin has a surface area of 1,250 ft². If Basin 3 must be drained for maintenance, the overflow rate on each of the remaining three basins at full plant flow is:

- A. 1,067 gpd/ft², which exceeds the design rate and may compromise settled water quality
- B. 800 gpd/ft², unchanged because the flow controller automatically reduces plant flow when a basin is offline

- C. 600 gpd/ft², because removing one basin reduces the total flow proportionally
- D. 533 gpd/ft², which is below the design rate and actually improves settling performance

42. A treatment plant operator measures the alkalinity of the plant's finished water at 25 mg/L as CaCO₃. The pH is 7.0. The calcium hardness is 30 mg/L as CaCO₃. These values suggest the water:

- A. Has a positive Langelier Saturation Index and will deposit protective calcium carbonate scale
- B. Is perfectly balanced with no tendency toward either corrosion or scaling in the distribution pipes
- C. Is likely corrosive due to low alkalinity, low calcium, and moderate pH — a negative LSI is expected
- D. Exceeds the secondary standard for alkalinity and requires adjustment before distribution

43. An operator at a treatment plant using chlorine gas for disinfection notices that the chlorine rotameter on the chlorinator shows flow, but the chlorine residual at the application point reads zero. The chlorinator is set to feed 5 pounds per day. The most likely cause is:

- A. The rotameter ball is stuck in the up position due to moisture or corrosion and is not reflecting actual gas flow
- B. The chlorine cylinder is empty but residual pressure in the manifold is keeping the rotameter ball elevated
- C. The injector water supply has failed, eliminating the vacuum that draws chlorine into the water stream
- D. The chlorinator is functioning correctly but the injector is injecting the chlorine into the wrong process stream

44. A treatment plant's operator discovers that the backwash waste settling basin — where filter backwash water settles before the supernatant is recycled to the head of the plant — has not been cleaned in 18 months. The basin is now over 75% full of accumulated solids. The primary operational risk of this condition is:

- A. The recycled supernatant contains acceptable levels of settled solids that actually improve the coagulation process

- B. Recycling turbid supernatant with high pathogen and particle concentrations back to the head of the plant, which could overwhelm the treatment process
- C. The sludge will spontaneously combust due to the high organic content accumulating in an enclosed basin
- D. Regulatory fines because the Filter Backwash Recycling Rule requires quarterly cleaning of all settling basins

45. A treatment plant operator is evaluating the plant's filter performance using the Unit Filter Run Volume (UFRV) metric. Filter A has a surface area of 200 ft² and processed 1.8 million gallons before requiring backwash. Filter B has a surface area of 250 ft² and processed 2.0 million gallons before requiring backwash. Which filter performed more efficiently on a per-unit-area basis?

- A. Filter A, with a UFRV of 9,000 gal/ft² compared to Filter B's 8,000 gal/ft²
- B. Filter B, because it processed a higher total volume of water before requiring backwash
- C. Both filters performed identically because the ratio of area to volume is proportional
- D. Neither UFRV can be calculated without knowing the filter run time in hours

46. A water treatment plant operator reviews the state's WPI Need-to-Know Criteria and finds that a Class I operator must understand the concept of CT. Which statement most accurately describes why CT is the product of residual disinfectant concentration (C) multiplied by contact time (T₁₀)?

- A. The CT concept exists solely as an administrative record-keeping requirement with no microbiological basis
- B. Higher disinfectant concentrations allow faster treatment, but the relationship is linear — doubling the concentration halves the time
- C. CT measures the total volume of disinfectant chemical consumed during the treatment process each day
- D. CT reflects the fundamental principle that pathogen inactivation depends on both how much disinfectant contacts the organisms and how long that contact is maintained

47. A treatment plant treats 2.5 MGD from a reservoir that receives agricultural runoff. The current treatment train consists of coagulation, flocculation, sedimentation, filtration, and chlorine disinfection. The plant has been struggling with THM compliance — the LRAA at one distribution monitoring

location is 0.078 mg/L (MCL = 0.080 mg/L). Which single operational change would likely have the greatest impact on reducing THM formation?

- A. Moving the chlorine application point from before sedimentation to after filtration to reduce chlorine contact with NOM
- B. Increasing the chlorine dose to accelerate the oxidation of NOM before it can form THMs
- C. Optimizing coagulation for enhanced NOM removal to reduce the THM precursor concentration before chlorine is applied
- D. Adding ammonia after chlorination to convert THMs back into their precursor compounds through reverse reaction

48. A treatment plant operator is troubleshooting a progressive decline in pump efficiency on the plant's main high-service pump. The pump was installed three years ago and has been operating continuously. The current flow is 10% below the original commissioned value at the same discharge pressure. The motor amperage is slightly below the original value. The most likely cause is:

- A. The motor has lost a phase, causing it to operate on two phases instead of three
- B. Impeller wear from erosion, corrosion, or abrasion has reduced the pump's hydraulic efficiency over three years of continuous operation
- C. The discharge check valve has partially closed, restricting the flow through the pump's discharge piping
- D. The suction strainer has been removed, allowing air to enter the pump and reducing its ability to develop full head

49. An operator reviews the following raw water quality data collected over the past year and identifies the parameter that requires the most treatment attention during spring:

Season	Turbidity (NTU)	TOC (mg/L)	Alkalinity (mg/L CaCO ₃)	Temperature (°C)
Winter	5	2.8	90	4
Spring	45	5.1	35	10
Summer	12	4.2	75	24

The spring data represents the greatest treatment challenge because:

- A. The combination of high turbidity, high TOC, and low alkalinity creates simultaneous demands for more coagulant while providing less buffering capacity
- B. The spring temperature of 10°C is the optimal temperature for algae growth that will clog filters
- C. Spring alkalinity at 35 mg/L exceeds the maximum for effective coagulation with any available chemical
- D. The low spring temperature prevents all chemical reactions from occurring at measurable rates

50. A treatment plant operator discovers that the plant has been using an expired lot of DPD chlorine reagent for the past two weeks. All chlorine residual readings during this period were within normal range (0.8–1.2 mg/L). The operator should:

- A. Take no action because the readings were within normal range and the reagent obviously still works
- B. Discard the expired reagent immediately but accept all previous readings as valid since they appeared normal
- C. Discard the expired reagent, test a current sample with fresh reagent, and compare it to the expired reagent results to determine if the expired lot was producing accurate readings
- D. Report all chlorine data from the past two weeks as invalid to the state primacy agency without further testing

51. A treatment plant treats 4.0 MGD. The operator needs to calculate the maximum day demand for the next five years based on a projected growth rate of 3% per year. Using the compound growth formula, the projected maximum day demand in five years is approximately:

- A. 4.6 MGD, which means the plant has adequate capacity with some reserve for the projected growth
- B. 4.2 MGD, which represents a minimal increase that the plant can easily accommodate
- C. 5.2 MGD, which would exceed the plant's rated capacity and require a major expansion project
- D. 4.64 MGD, calculated as $4.0 \times (1.03)^5 = 4.0 \times 1.159 = 4.64$ MGD

52. A water treatment plant is fed by three wells that each produce water with different quality characteristics. Well 1: hardness 180 mg/L, flow 400 gpm. Well 2: hardness 300 mg/L, flow 200 gpm. Well 3: hardness 120 mg/L, flow 400 gpm. The flow-weighted average hardness of the blended water from all three wells operating simultaneously is:

- A. 200 mg/L, which is the simple average of the three individual hardness values
- B. 180 mg/L, calculated as: $[(400 \times 180) + (200 \times 300) + (400 \times 120)] \div (400 + 200 + 400)$
- C. 300 mg/L, because the well with the highest hardness dominates the blend regardless of flow rate
- D. 120 mg/L, because the well with the lowest hardness dilutes the blend to its concentration level

53. A treatment plant's operator is reviewing a proposal to install granular activated carbon (GAC) filter caps on the existing dual-media filters to address recurring seasonal taste and odor events. Compared to the plant's current practice of feeding PAC during events, GAC filter caps would offer which primary advantage?

- A. Continuous adsorption capacity available year-round without requiring a seasonal chemical feed system to be activated, maintained, and operated
- B. Lower total cost because GAC never needs replacement once installed on the existing filter beds
- C. Elimination of the need for coagulation because GAC removes all particles through adsorption alone
- D. Improved backwash efficiency because GAC media does not require air scour during the cleaning cycle

54. A treatment plant's online chlorine analyzer consistently reads 0.2 mg/L higher than simultaneously collected DPD grab samples over a two-week calibration tracking period. The offset is consistent across all residual levels. The most likely cause is:

- A. Manganese or other oxidant in the water that the online analyzer detects as chlorine but the DPD method does not
- B. An instrument that is perfectly calibrated because a 0.2 mg/L offset is within the normal operating tolerance
- C. A DPD reagent error that produces systematically low readings across all chlorine concentrations tested

D. Temperature fluctuations in the analyzer's sample line that cause the electrode to read higher than actual

55. A treatment plant operator is investigating why the plant's clearwell level has been gradually declining over the past 12 hours. The plant flow has remained constant at 3.0 MGD. The high-service pump discharge totalizer shows 3.2 million gallons have been pumped into the distribution system during the same 12 hours. The 0.2 MG difference over 12 hours means:

A. The plant flow meter is miscalibrated and actually reading lower than the true production rate

B. A leaking valve or overflow is allowing treated water to leave the clearwell without being measured by the plant flow meter

C. Normal clearwell level fluctuation that requires no investigation or corrective action

D. The high-service pumps are delivering more water to the distribution system than the plant is producing, slowly draining the clearwell

56. An operator at a treatment plant tests a raw water sample for iron. The dissolved iron test (filtered through 0.45 μm) reads 0.5 mg/L. The total iron test (unfiltered, acid-digested) reads 2.8 mg/L. The difference of 2.3 mg/L between total and dissolved represents:

A. An analytical error because total iron should always equal dissolved iron in groundwater samples

B. Particulate iron that exists in an oxidized, insoluble form already present in the raw water

C. The amount of iron that will be converted from dissolved to particulate form during aeration treatment

D. The alkalinity consumed by the iron oxidation process during the standard acid digestion procedure

57. A treatment plant's operator is troubleshooting declining performance of the plant's UV disinfection system. The UV sensor reading has dropped from the validated dose of 40 mJ/cm^2 to 32 mJ/cm^2 over the past three months. The operator has cleaned the quartz sleeves, replaced the UV lamps, and confirmed the water flow rate is correct. The UV transmittance of the filtered water is 80%, down from 90% six months ago. The most effective corrective action is:

A. Investigate and improve the upstream treatment process to increase the UV transmittance of the filtered water back to the validated level

- B. Increase the UV lamp power to maximum regardless of the UVT because higher power compensates for any water quality issue
- C. Accept the lower dose because the difference between 32 and 40 mJ/cm² is within normal operational variation
- D. Install additional UV reactors in series to increase the total dose through multiple exposure passes

58. A water treatment plant's distribution system pressure monitoring data shows the following pattern: steady 65 psi at all monitoring points during low demand (midnight to 5 AM), but pressure drops to 35 psi at two monitoring points during peak demand (7 AM to 9 AM) while all other points remain above 55 psi. This localized pressure problem most likely indicates:

- A. The plant's high-service pumps are undersized and cannot meet peak demand for the entire system
- B. A distribution system-wide problem that affects all customers equally during peak demand periods
- C. The two affected monitoring points are at a higher elevation than the rest of the system, causing normal gravitational pressure loss
- D. A hydraulic restriction — undersized pipe, partially closed valve, or internal tuberculation — in the distribution main serving those two monitoring locations

59. An operator is reviewing the treatment plant's chemical feed system redundancy. The plant has two sodium hypochlorite metering pumps: one duty pump and one standby. The duty pump has been in continuous service for 14 months. The standby pump has been sitting idle for the same period. The operator should be concerned about the standby pump because:

- A. Standby pumps require periodic exercise to prevent diaphragm stiffening, check valve fouling, and chemical crystallization
- B. Idle pumps automatically recalibrate themselves during storage and will be ready when needed
- C. Standby pumps should be physically removed from the piping system when not in use to prevent backflow
- D. 14 months of idle time automatically voids the pump manufacturer's warranty

60. A treatment plant's operator collects samples for quarterly THM and HAA5 monitoring at four distribution system locations. The operator plans the sampling route to collect all four samples within a

two-hour window. At each location, the operator collects the sample from an interior tap after flushing for the appropriate time. The order of collection should prioritize:

- A. The location nearest the plant first, working outward to the farthest location for logistical efficiency
- B. Locations with historically high DBP results first to minimize holding time effects on the most critical samples
- C. Random order to eliminate any systematic bias from the collection sequence
- D. The location with the longest drive time first to minimize the total time all four samples spend in transit

61. A treatment plant's four filters each have 30 inches of anthracite over 12 inches of sand over 3 inches of garnet, supported by a gravel layer and underdrain. After 10 years of service, a media core sample from Filter 2 reveals the anthracite depth has decreased to 22 inches, while the sand and garnet layers remain at their original depths. The operational impact of the 8-inch anthracite loss is:

- A. Reduced filtration capacity because the lost media decreases the available depth for particle removal, potentially leading to shorter filter runs and increased risk of premature breakthrough
- B. Improved filtration because thinner media beds produce lower headloss and longer filter runs
- C. No impact because the sand and garnet layers provide the primary particle removal in a dual-media filter
- D. Improved backwash effectiveness because less media means less resistance during the backwash cycle

62. A treatment plant operator tests the hardness of a customer's water and obtains 250 mg/L as CaCO_3 . The customer asks whether a water softener is necessary. The operator should explain that:

- A. At 250 mg/L, the water is classified as "very hard" and a softener is a personal preference for reducing soap consumption and scale formation, though the water is safe to drink
- B. Water softeners are required by the health department for any water exceeding 200 mg/L as CaCO_3
- C. No additional treatment is needed because 250 mg/L is within the EPA primary standard for hardness
- D. The water meets all regulatory standards and the hardness level has no practical impact on household use

63. A treatment plant's operator performs monthly vibration trend analysis on all critical rotating equipment. The vibration readings on Pump 3's motor bearings have been gradually increasing over the past six months — from 0.05 inches/second to 0.18 inches/second (velocity). The manufacturer's guideline classifies vibration above 0.15 inches/second as "alert level." The operator should:

- A. Schedule bearing replacement during normal working hours at the earliest opportunity because the trend shows progressive deterioration approaching the alert threshold
- B. Continue monitoring monthly because the increase is gradual and the pump may stabilize at the current level
- C. Schedule bearing inspection and probable replacement at the next available maintenance window, because the vibration trend indicates progressive bearing deterioration that will worsen if not addressed
- D. Immediately shut down Pump 3 and replace both bearings before restarting, regardless of system demand

64. A treatment plant using conventional treatment is evaluating the installation of a dissolved air flotation (DAF) system to replace the existing sedimentation basins. The plant treats a reservoir source with seasonal algae blooms. The primary technical advantage of DAF over sedimentation for this application is:

- A. DAF provides disinfection credit that sedimentation cannot, reducing the chlorine dose required for CT compliance
- B. DAF effectively removes buoyant particles like algae and light floc that settle poorly in conventional sedimentation
- C. DAF eliminates the need for coagulation and flocculation upstream, simplifying the treatment train
- D. DAF produces a higher-quality sludge that can be directly land-applied without dewatering treatment

65. An operator performing a weekly generator test observes that the generator starts normally but the engine coolant temperature rises rapidly during the first 10 minutes of loaded operation — reaching 210°F when normal operating temperature is 180°F. The operator checks the coolant level and finds it at the proper mark. The most likely cause is:

- A. A malfunctioning thermostat that is not opening fully to allow coolant circulation, or a partially blocked radiator that cannot dissipate heat effectively

- B. Normal warm-up behavior because generators always run hot during the first 15 minutes of loaded operation
- C. The engine oil level is too high, creating excessive internal friction and heat generation
- D. The ambient air temperature is above 85°F, which is too warm for diesel generators to operate under load

66. A treatment plant's source water protection plan identifies a construction site within the watershed that is clearing 50 acres for a residential development. The construction activities will last approximately 18 months. The operator should anticipate:

- A. No impact because construction sites are regulated by NPDES stormwater permits that prevent all runoff
- B. Improved raw water quality because removing vegetation reduces the organic loading to the source water
- C. Increased turbidity during rain events only if the construction site is directly adjacent to the reservoir shoreline
- D. Increased sediment loading, turbidity, and potential nutrient runoff during storm events throughout the construction period

67. A treatment plant operator is training a new employee on the DPD chlorine residual test procedure. The trainer demonstrates the correct technique and emphasizes that the most common source of error in the DPD free chlorine test is:

- A. Using the wrong wavelength setting on the spectrophotometer, which produces falsely elevated readings
- B. Adding the DPD reagent to the sample before zeroing the instrument on the blank sample
- C. Waiting too long after adding the DPD reagent to read the result, allowing the combined chlorine fraction to bleed into the free chlorine reading
- D. Using a sample volume that is exactly twice the specified amount, which halves the measured concentration

68. A treatment plant treats 3.5 MGD from a river source. The plant's jar test data over the past year shows that the optimal alum dose varies seasonally: winter (cold, low turbidity) averages 40 mg/L,

spring (high turbidity, low alkalinity) averages 55 mg/L, summer (moderate turbidity, algae) averages 35 mg/L, and fall averages 25 mg/L. The higher winter dose despite lower turbidity is explained by:

- A. Winter water has higher alkalinity that requires more alum to neutralize before effective coagulation begins
- B. Cold water increases viscosity, slows chemical reactions, and reduces particle collision efficiency — requiring higher coagulant doses to achieve adequate destabilization and floc formation
- C. Alum degrades faster in cold storage during winter, requiring a higher feed rate to deliver the same effective dose
- D. The turbidimeter reads lower in cold water, and the actual turbidity is higher than the instrument indicates

69. A treatment plant's operator reviews the distribution system flushing program records and finds that a dead-end main serving 15 homes has not been flushed in over two years. The water quality monitoring at the nearest sampling point shows adequate chlorine residual (0.4 mg/L). The operator should:

- A. Take no action because adequate chlorine residual indicates the water quality is acceptable in this area
- B. Schedule the dead-end main for flushing at the next available opportunity because two years without flushing allows sediment accumulation, biofilm growth, and potential water quality degradation regardless of the current residual
- C. Permanently disconnect the dead-end main and provide affected customers with bottled water service
- D. Install a permanent blow-off valve at the end of the main and set it to discharge continuously

70. A treatment plant's finished water has the following characteristics: pH 8.2, alkalinity 85 mg/L as CaCO₃, calcium hardness 100 mg/L as CaCO₃, TDS 250 mg/L, temperature 20°C. The Langelier Saturation Index is calculated at +0.4. This water:

- A. Is balanced at equilibrium with no tendency toward either corrosion or deposition of calcium carbonate
- B. Is corrosive and will dissolve lead and copper from distribution system pipes and household plumbing

- C. Will cause excessive scale buildup that requires immediate treatment to prevent pipe capacity reduction
- D. Has a slight tendency to deposit calcium carbonate scale, which may provide a beneficial protective film on pipe interiors

71. A treatment plant's operator is evaluating whether to switch from gaseous chlorine to sodium hypochlorite for disinfection. The plant currently uses two 150-pound chlorine cylinders per week. One operational consideration that favors switching to sodium hypochlorite is:

- A. Sodium hypochlorite provides a stronger disinfectant residual per pound of active chlorine than gas
- B. Sodium hypochlorite is less expensive per pound of available chlorine than compressed chlorine gas
- C. Sodium hypochlorite eliminates the safety risks associated with compressed toxic gas storage and the need for chlorine leak detection and SCBA equipment
- D. Sodium hypochlorite has an indefinite shelf life and never degrades in storage regardless of conditions

72. A treatment plant's online turbidimeter on Filter 1 has been reading a steady 0.03 NTU for six consecutive days. The operator collects a daily verification grab sample and obtains 0.03 NTU — matching the online reading perfectly every day. Rather than being reassured, a vigilant operator would also check:

- A. Whether the sample flow through the online turbidimeter has stopped, because a stagnant sample would read the same value continuously regardless of actual filter performance
- B. Whether the grab samples are being collected from the correct sampling point on the filter effluent line
- C. Whether the online instrument's calibration standards have expired within the past week
- D. Whether the distribution system pressure has changed, which would affect the turbidity reading

73. A treatment plant operator discovers that a section of the chemical feed tubing for the sodium hypochlorite system has become brittle and slightly yellowed. The tubing has been in service for eight months in direct sunlight near a window in the chemical feed room. The operator should:

- A. Apply a UV-protective coating to the tubing to prevent further degradation while leaving it in service

- B. Replace the degraded tubing immediately because UV-degraded tubing can crack under pressure, causing a chemical release, and reroute the replacement to avoid sunlight exposure
- C. Wait until the quarterly maintenance period to replace the tubing because it has not yet failed
- D. Increase the chemical feed rate to compensate for any chlorine lost through porous degraded sections

74. A treatment plant's SCADA data shows that the raw water pump's discharge pressure has been increasing gradually over the past three months while the pump speed and flow have remained constant. This trend most likely indicates:

- A. The system head is unchanged and the pump is becoming more efficient due to an internal coating that improves flow
- B. The pump bearings are beginning to fail, causing increased friction and higher discharge pressure
- C. The suction conditions have improved, providing more available head to the pump inlet
- D. Downstream restriction — a closing valve, accumulating scale, or increasing system friction — is building backpressure against the pump

75. A water system's annual compliance data shows the following lead 90th percentile results over the past three years: Year 1 = 0.008 mg/L, Year 2 = 0.011 mg/L, Year 3 = 0.014 mg/L. The action level is 0.015 mg/L. The operator should:

- A. Take no action because all three years are below the action level and the system is in full compliance
- B. Report the trend to the state as evidence that corrosion control is failing and the system will soon exceed the action level
- C. Proactively evaluate the corrosion control program because the consistent upward trend toward the action level suggests deteriorating conditions that require investigation before a violation occurs
- D. Begin lead service line replacement immediately because the trend mathematically guarantees a violation next year

76. A treatment plant's operator discovers that the plant's four sedimentation basins have different inlet baffle configurations — Basins 1 and 2 have perforated baffles that distribute flow evenly across the basin width, while Basins 3 and 4 have simple slot baffles that direct flow across the surface. The operator should expect:

- A. Basins 1 and 2 to produce better settled water quality because their perforated baffles create more uniform flow distribution and reduce short-circuiting
- B. Basins 3 and 4 to perform better because the slot baffles create beneficial surface currents for particle collection
- C. No performance difference because inlet baffle design has no measurable impact on sedimentation effectiveness
- D. All four basins to perform identically as long as they receive the same flow and the same coagulated water

77. An operator tests the emergency eyewash station in the laboratory and observes that the water temperature is 55°F (13°C). ANSI Z358.1 recommends a tepid water temperature range of 60°F to 100°F (16°C to 38°C) for emergency eyewash stations. The operator should:

- A. Accept the temperature because 55°F is cold but still close enough to the recommended range for emergency use
- B. Report the deficiency and arrange for correction because cold water from an eyewash station can cause a shock response that makes it difficult for an injured person to keep their eyes open for the required 15-minute flushing duration
- C. Disconnect the eyewash station and replace it with bottled eyewash solution that does not have temperature requirements
- D. Install an instantaneous hot water heater on the eyewash supply line to ensure the water is always above 80°F

78. A treatment plant operates a lime softening process. The operator notices that the recarbonation basin — where CO₂ is added after softening to lower the pH and stabilize the water — is not reducing the pH as effectively as normal. The CO₂ feed rate has not changed. The most likely cause is:

- A. The softened water's alkalinity has decreased, reducing its ability to buffer the CO₂ addition
- B. The CO₂ supply tank is nearly empty and the pressure has dropped below the minimum required for effective gas transfer
- C. The recarbonation basin has developed a leak that is allowing CO₂ to escape before dissolving in the water
- D. The CO₂ generator or supply system has reduced output — either lower gas pressure, a partially blocked diffuser, or reduced gas purity — delivering less CO₂ to the water than the feed rate indicates

79. An operator at a treatment plant using chloramination monitors the chlorine-to-ammonia nitrogen ratio (by weight) at 3.5:1. The target ratio is 4:1 to 5:1. At 3.5:1, the operator should be concerned about:

- A. Breakpoint chlorination destroying the chloramines and producing free chlorine with elevated DBP formation
- B. Formation of dichloramine and trichloramine that cause taste and odor complaints from consumers
- C. Excess free ammonia entering the distribution system that promotes nitrification by providing a nutrient source for nitrifying bacteria
- D. Insufficient total chlorine residual because the low ratio produces less monochloramine per milligram of chlorine

80. An operator is reviewing a laboratory quality control chart for the turbidimeter. The daily check standard results over the past two weeks have been steadily trending upward — from 19.5 NTU to 21.2 NTU against a 20.0 NTU standard. No individual reading has exceeded the $\pm 10\%$ control limit of 18.0–22.0 NTU. The operator should:

- A. Investigate the upward trend proactively because a consistent directional drift, even within control limits, indicates a developing calibration problem that will eventually produce out-of-specification results
- B. Take no action because all readings are within the established control limits and no violation has occurred
- C. Recalibrate the turbidimeter immediately because any value above 20.0 NTU on a 20.0 NTU standard indicates failure
- D. Replace the check standard because the trend indicates the standard is degrading rather than the instrument drifting

81. A treatment plant treats 6.0 MGD and has a clearwell volume of 1,000,000 gallons with a baffling factor of 0.5. The operator is asked to calculate how much the plant flow could increase before the CT falls below the required 100 mg·min/L, assuming the chlorine residual remains at 1.5 mg/L. The maximum flow that still achieves exactly 100 mg·min/L is:

- A. 4.17 MGD, which is actually lower than the current flow and indicates the plant already falls short of the CT target
- B. 7.5 MGD, calculated by setting $1.5 \times [(1,000,000 \div Q) \times 0.5] = 100$ and solving for Q

- C. 15.0 MGD, calculated without applying the baffling factor
- D. 10.0 MGD, which assumes the entire clearwell volume provides effective contact time

82. A treatment plant's operator tests a sample for total hardness using EDTA titration. The sample volume is 50 mL (not the standard 100 mL) and the titrant volume to the endpoint is 8.0 mL of 0.01M EDTA. The hardness result must be adjusted for the smaller sample volume. The total hardness is:

- A. 80 mg/L as CaCO₃, because using half the normal sample volume produces a result that is calculated using the standard formula with proper volume correction
- B. 160 mg/L as CaCO₃, calculated as $(8.0 \times 0.01 \times 100,000) \div 50$
- C. 40 mg/L as CaCO₃, calculated without any volume correction for the reduced sample size
- D. 160 mg/L as CaCO₃, which is the correct result when using 0.01M EDTA and a 50 mL sample

83. A treatment plant's operator reviews the past year's data and notices that the plant's filter-to-waste duration has been gradually increasing — from the original 10 minutes to over 25 minutes before filter effluent turbidity drops below the target of 0.1 NTU after backwash. All four filters show the same trend. The most likely cause is:

- A. The raw water turbidity has been increasing, requiring longer ripening periods for all filters
- B. The settled water quality has deteriorated, meaning the water entering the filters after backwash has more particles
- C. The filter media has aged — the loss of surface coatings and changes in grain characteristics require longer ripening to re-establish the particle-capturing layer on the media
- D. The filter-to-waste valves have partially clogged, restricting flow and extending the apparent ripening time

84. An operator at a treatment plant discovers during routine monitoring that the free chlorine residual at a distribution system monitoring point has tested below the 0.2 mg/L minimum for two consecutive days. The operator has already increased the plant effluent chlorine residual and is investigating the cause. Under the SWTR, the requirement for maintaining a detectable disinfectant residual in the distribution system is a:

- A. Treatment technique requirement — failure to maintain the minimum residual is a treatment technique violation, not an MCL violation
- B. Maximum Contaminant Level violation requiring Tier 1 public notification within 24 hours
- C. Secondary standard recommendation that is not enforceable but may generate consumer complaints
- D. Monitoring violation that only requires documentation in the monthly operating report

85. A treatment plant operator is evaluating two options for replacing a worn high-service pump impeller. Option 1: Replace with the original-specification impeller. Option 2: Replace with a slightly smaller impeller (trimmed by 10%) to better match the current system demand, which is lower than the original design. The advantage of Option 2 is:

- A. A trimmed impeller increases the pump's head capability, providing a safety margin for future demand growth
- B. A smaller impeller better matches the system operating point, reducing energy consumption and operating closer to the best efficiency point
- C. Trimmed impellers have longer service lives because they operate at lower rotational stresses
- D. A smaller impeller produces higher flow at lower head, which is advantageous for high-demand periods

86. A treatment plant's source water comes from a river that receives treated wastewater effluent from a municipality 10 miles upstream. Recent pharmaceutical monitoring in the finished water has detected trace levels of several pharmaceuticals at ng/L (parts per trillion) concentrations. The operator should understand that:

- A. These trace pharmaceuticals are not currently regulated under the SDWA and have no established MCLs
- B. Conventional treatment completely removes all pharmaceutical compounds from the source water
- C. The concentrations detected are well above levels that would cause immediate health effects in consumers
- D. The presence of pharmaceuticals indicates a cross-connection between the wastewater system and the drinking water system

87. A treatment plant operator needs to calculate the detention time for a new contact chamber being designed for the plant. The chamber will be a serpentine channel (excellent baffling, factor = 0.7) with a total volume of 150,000 gallons. The plant flow is 2.0 MGD (1,389 gpm). The T_{10} is:

- A. 108 minutes, calculated as the theoretical DT without applying the baffling factor
- B. 50 minutes, using an incorrect baffling factor of 0.3 instead of 0.7
- C. 75.6 minutes, calculated as $(150,000 \div 1,389) \times 0.7 = 108 \times 0.7$
- D. 154 minutes, calculated by dividing the volume by the flow in MGD rather than gpm

88. A treatment plant operator is investigating why the plant's polymer feed system is not performing as expected during a high-turbidity event. The operator increased the polymer dose from the normal 0.5 mg/L to 2.0 mg/L, but the floc quality has actually deteriorated rather than improved — the floc appears smaller and weaker than before the increase. The most likely explanation is:

- A. The polymer has been over-dosed, coating the particles completely and preventing further bridging between particles — essentially restabilizing the suspension
- B. The polymer product has expired and lost its effectiveness at any dose level
- C. Higher polymer doses always produce smaller floc because the additional molecules create more nucleation sites
- D. The mixing speed is too low for the higher polymer dose, preventing adequate distribution throughout the water

89. A treatment plant using chlorine gas for disinfection has the chlorine room's ventilation fan wired to run continuously. The fan motor fails at 2:00 AM on a Saturday. The on-call operator is notified by the SCADA alarm. The operator should:

- A. Call the electrician on Monday morning because the chlorine leak detector is functioning and will alarm if gas is detected
- B. Respond to the plant, secure the chlorine gas system (shut off cylinders if practical), and arrange for emergency fan repair before resuming chlorine gas operations
- C. Increase the SCADA monitoring frequency for the chlorine leak detector from every 5 minutes to every 1 minute
- D. Redirect the chlorine gas feed to an outdoor injection point where ventilation is not required

90. A treatment plant's annual energy audit reveals that the plant's total electrical consumption is 2.4 million kWh per year. The high-service pumps account for 55% of total consumption. The plant's operator proposes installing VFDs on the three high-service pumps. Based on industry experience, VFDs typically reduce pumping energy by 20% to 40%. At the conservative 20% savings level and an electricity cost of \$0.10/kWh, the estimated annual savings from VFDs on the high-service pumps would be:

- A. \$264,000 per year, calculated using the total plant electrical consumption rather than just the pumping portion
- B. \$48,000 per year, calculated using an incorrect percentage of total energy consumption
- C. \$132,000 per year, calculated as 20% of the total plant energy cost without isolating the pumping portion
- D. \$26,400 per year, calculated as $2,400,000 \text{ kWh} \times 0.55 \times 0.20 \times \0.10

91. A treatment plant operator receives a consumer complaint about a "chlorine-like" or "chemical" taste from a customer who has been served by the system for 20 years without previous complaints. The operator tests the customer's tap and finds free chlorine at 0.6 mg/L — within the normal range. The water pH is 8.0, which was recently raised from 7.2 for improved corrosion control. The taste complaint is most likely related to:

- A. An expired DPD reagent producing falsely normal chlorine readings that mask an actual overdose
- B. Distribution system biofilm releasing taste compounds in response to the pH change in the mains
- C. The pH increase shifting more chlorine from hypochlorous acid (HOCl) to hypochlorite ion (OCl⁻), which many consumers perceive as having a stronger "chlorine" taste
- D. The customer's personal taste sensitivity changing due to age, medication, or dietary changes

92. An operator at a small water system is reviewing the state's continuing education requirements for operator certification renewal. The operator's Class I certificate expires in 6 months and requires 20 hours of approved continuing education. The operator currently has 8 hours completed. The operator should:

- A. Enroll in approved training courses immediately to complete the remaining 12 hours before the renewal deadline

- B. Request an extension from the state because 6 months is insufficient time to complete 12 additional hours
- C. Allow the certificate to expire and re-take the certification exam rather than completing continuing education
- D. Submit the 8 completed hours and request a partial renewal of the certificate for another year

93. A treatment plant's filter performance evaluation reveals that Filter 4 consistently produces effluent turbidity of 0.08 to 0.10 NTU — technically compliant but significantly higher than Filters 1, 2, and 3, which consistently produce 0.03 to 0.05 NTU. All filters receive the same settled water. A media core analysis of Filter 4 reveals that the anthracite and sand layers have intermixed. This intermixing:

- A. Is normal and expected in all dual-media filters after several years of service
- B. Reduces the filter's particle removal efficiency because the graded media structure that promotes depth filtration has been disrupted
- C. Improves filtration by creating a more uniform bed that captures particles throughout the entire depth
- D. Has no impact on performance because the total media depth is unchanged regardless of layer arrangement

94. A treatment plant's operator observes that the plant's lime slaker is producing slurry with a milky white residue that settles rapidly in the slaking tank. The lime product was recently changed to a new supplier. The operator should investigate whether:

- A. The new lime product has a different calcium oxide content, purity, or reactivity that is affecting the slaking process and may require adjustments to water volume, temperature, or mixing
- B. The slaker needs to be replaced because new lime products are incompatible with older slaking equipment
- C. The new lime is contaminated with toxic metals that are producing the white residue as a warning sign
- D. The milky residue is excess lime that indicates the feed rate is too low and should be doubled

95. A water treatment plant's finished water is tested for the following parameters with results: lead 0.003 mg/L (MCL 0.015 as action level), nitrate 2.1 mg/L as N (MCL 10), arsenic 0.004 mg/L (MCL 0.010), THMs 0.045 mg/L (MCL 0.080), HAA5 0.035 mg/L (MCL 0.060). All results are below their

respective MCLs. However, the operator should flag which parameter as requiring the closest monitoring attention?

- A. Lead, because it is regulated through action levels at taps and the plant effluent result does not reflect actual consumer exposure
- B. Nitrate, because it poses an acute health risk to infants at levels approaching the 10 mg/L MCL
- C. THMs at 0.045 mg/L, because at 56% of the MCL it is the closest to its compliance limit as a proportion and seasonal increases could push the LRAA higher
- D. HAA5, because it is the only parameter with a trend that has been increasing over the past year

96. A treatment plant treating 2.0 MGD needs to feed 25% sodium hydroxide solution to raise the pH from 6.8 to 7.5 for corrosion control. Jar testing indicates a caustic soda dose of 8 mg/L is needed. The daily consumption of 25% sodium hydroxide solution (specific gravity 1.27) is approximately:

- A. 12.6 gallons per day, calculated using the full sequence: $\text{lb/day chemical} = \text{dose} \times \text{flow} \times 8.34$, then converting to solution weight and then to volume
- B. 50.4 gallons per day, calculated by omitting the concentration adjustment from the calculation
- C. 6.3 gallons per day, using only half the correct chemical conversion factor
- D. 133.4 gallons per day, calculated using the dose in mg/L directly as pounds without the pounds formula

97. A treatment plant's operator is testing the integrity of a microfiltration membrane system using a pressure decay test. The initial test pressure is 15 psi. After five minutes, the pressure has decreased to 11 psi — a decay of 4 psi. The manufacturer's maximum allowable decay rate is 2 psi per five minutes. This result means:

- A. The membrane system passes the integrity test because the decay rate is expressed per minute, not per five minutes
- B. The membrane system fails the integrity test — one or more fibers are likely breached, and the affected module must be isolated and repaired before the system can receive pathogen removal credit
- C. The test should be repeated because a single failed integrity test is not sufficient to require corrective action

D. The decay rate is within normal operating parameters for microfiltration membranes under standard conditions

98. A treatment plant operator is preparing to take a raw water sample for a comprehensive inorganic chemistry panel that includes metals (iron, manganese, lead, copper, arsenic), minerals (calcium, magnesium, sodium, potassium), anions (chloride, sulfate, fluoride), and physical parameters (pH, alkalinity, conductivity, TDS). The operator should:

A. Collect all parameters from a single sampling event but use different bottles with different preservation for the metals (acid preserved) versus the other parameters

B. Skip the alkalinity sample because it cannot be measured reliably on water treatment plant samples

C. Measure pH, alkalinity, and conductivity in the laboratory within 48 hours because these parameters are chemically stable during transport

D. Collect all parameters in a single acid-preserved container because the acid stabilizes all analytes simultaneously

99. A treatment plant's filter gallery has four rapid gravity filters. During a peak demand period, the plant flow must increase from 3.0 MGD to 4.0 MGD. Before increasing the flow, the operator should evaluate:

A. Only the CT in the clearwell because filtration performance is unaffected by flow rate changes

B. Only the filter effluent turbidity because it is the only parameter regulated under the SWTR

C. All affected treatment parameters — filtration rate, sedimentation overflow rate, flocculation detention time, and clearwell CT — because increasing flow affects every process in the treatment train

D. Only the coagulant dose because increasing the flow will dilute the chemical if the feed rate is not increased

100. A treatment plant's operator has been tracking the specific capacity of the plant's primary production well for five years. The data shows: Year 1 = 15.0 gpm/ft, Year 2 = 14.2 gpm/ft, Year 3 = 12.8 gpm/ft, Year 4 = 11.5 gpm/ft, Year 5 = 8.9 gpm/ft. The declining trend has accelerated in Year 5. The operator should:

- A. Plan for well rehabilitation — obtain a video inspection, select the appropriate rehabilitation method, and schedule the work before the specific capacity declines further
- B. Reduce the pumping rate to match the declining specific capacity and accept the reduced production
- C. Wait for the specific capacity to stabilize before scheduling any investigation or rehabilitation
- D. Begin drilling a replacement well immediately because the existing well has reached the end of its useful life

Practice Exam 8: Answer Key and Explanations

1. D — At 45 mg/L alum, approximately 22.5 mg/L of alkalinity is consumed (45×0.5). With 80 mg/L available, approximately 57.5 mg/L remains — seemingly adequate. However, the lime feed pump had been supplementing alkalinity to maintain a stable pH. When lime stopped, the remaining natural alkalinity alone could not buffer the coagulation pH within the optimal range, causing poor floc formation and elevated settled water turbidity.

2. B — A total coliform-positive result (without *E. coli*) at any distribution system location triggers the RTCR's repeat sampling requirement. The operator must collect at least three repeat samples within 24 hours — one from the original location, one upstream, and one downstream — to determine whether the contamination is persistent, isolated, or a sampling artifact.

3. C — Overflow rate = Flow \div Surface area = $3,500,000 \text{ gpd} \div 3,000 \text{ ft}^2 = 1,167 \text{ gpd/ft}^2$. This significantly exceeds the design rate of 700 gpd/ft², meaning water is moving through the basin 67% faster than designed. The reduced detention time gives particles less time to settle, increasing the likelihood of carryover into the filter influent.

4. A — Free chlorine at 0.0 mg/L with total chlorine at 2.5 mg/L means all chlorine has combined with ammonia to form chloramines. This is the desired result for a chloramination system — monochloramine provides a stable residual with minimal taste, odor, and DBP formation. Zero free chlorine confirms the ammonia dose is adequate to combine with all applied chlorine.

5. D — $DT = 200,000 \div 1,042 = 192 \text{ min}$. $T_{10} = 192 \times 0.5 = 96 \text{ min}$. $CT = 0.8 \times 96 = 76.8 \text{ mg}\cdot\text{min/L}$. This exceeds the required 45 mg·min/L by 71%, providing a comfortable compliance margin. The calculation sequence — volume to DT to T_{10} to CT — must be followed precisely for regulatory compliance.

6. C — Uneven backwash distribution — one side muddier with more expansion than the other — indicates a blocked or restricted underdrain on the cleaner side. The blocked laterals cannot deliver their share of backwash water, so that section receives inadequate cleaning while the unblocked side receives excess flow, producing the observed asymmetry.
7. B — Staggering maintenance across the year ensures that no chemical service loses both its duty and standby pumps simultaneously. If all pumps are maintained on the same day, any complication during the work (unexpected parts failure, extended troubleshooting) could leave a critical chemical service without any functional feed pump.
8. A — *Cryptosporidium* oocysts are highly resistant to chlorine — the CT required for even 1-log inactivation with chlorine is thousands of mg·min/L at typical treatment conditions, far exceeding practical dosing levels. UV and ozone are the preferred chemical disinfection methods for *Cryptosporidium* because they achieve effective inactivation at practical doses.
9. A — An emergency plan that does not reflect current conditions — new chemicals, upgraded systems, changed contacts — can direct responders to take incorrect, ineffective, or dangerous actions during an actual emergency. The plan must be updated immediately and reviewed annually or whenever significant changes occur at the plant.
10. C — The 30 mg/L dose was optimized for 12 NTU turbidity. At 45 NTU, there are significantly more particles requiring destabilization than the 30 mg/L dose can handle. Without increasing the dose, excess undestabilized particles pass through coagulation and flocculation, producing poor settled water quality and overloading the filters.
11. B — Water that is clear when drawn from the tap but turns reddish-brown after sitting contains dissolved ferrous iron (Fe^{2+}) that is invisible in solution. Upon exposure to atmospheric oxygen, the iron oxidizes to ferric iron (Fe^{3+}), which precipitates as visible rust-colored particles. The oxidation process takes minutes to hours depending on pH and temperature.
12. D — Combined filter effluent turbidity reflects the cumulative performance of every upstream treatment step — coagulation, flocculation, sedimentation, and filtration — all working together. A low CFE turbidity confirms that the entire treatment train is functioning effectively, making it the single best indicator of overall process performance.

13. A — A gas station with underground storage tanks in Zone 1 represents a significant contamination risk from potential petroleum hydrocarbon (BTEX) releases. The operator should verify compliance with wellhead protection regulations, coordinate monitoring and emergency planning with the gas station operator, and establish contingency protocols in case contamination is detected.

14. C — The readings 0.02, 0.48, 1.03, and 1.85 represent deviations of +0.02, -0.02, +0.03, and -0.15 from expected values — all within the typical ± 5 –10% analytical tolerance for DPD colorimetry. The 2.0 mg/L standard reading (1.85) shows the largest deviation at 7.5% but still falls within acceptable limits.

15. D — Secondary containment must hold 110% of the largest single tank in the containment area. The largest tank is 6,000 gallons, so minimum containment = $6,000 \times 1.10 = 6,600$ gallons. This capacity ensures the containment can hold the entire contents of the largest tank plus a margin for precipitation and firefighting water.

16. B — Basins 1 and 2 receiving 30% each (versus the designed 25%) are hydraulically overloaded — their overflow rates are 20% above design. This elevated loading reduces settling time and allows more particles to pass over the effluent weirs, degrading settled water quality from those two basins. The flow distribution should be equalized.

17. D — Polymer coagulant aids work primarily through interparticle bridging — attaching to already-destabilized particles and linking them together. Adding polymer at the rapid mix stage (simultaneously with alum) means the polymer competes with alum for particle surface sites before destabilization occurs. Adding polymer during early flocculation allows it to bridge between particles that alum has already destabilized.

18. A — Finished water hardness of 120 mg/L as CaCO_3 falls within the state's recommended range of 80 to 150 mg/L. The softening process has achieved its target — reducing hardness from 350 to 120 mg/L while retaining enough mineral content for corrosion protection and consumer preference.

19. C — A gradual pH decrease over six months in a well with 15 years of stable history indicates a change in the aquifer chemistry. Land use changes (new agricultural operations, development), seasonal water table fluctuations exposing different geological strata, or changes in recharge chemistry from acid precipitation can all alter groundwater pH trends.

20. B — Filter 3's elevated turbidity (0.09 NTU versus 0.04 NTU on the other three) despite having headloss capacity remaining (6.0 of 8.0 feet) suggests a performance problem beyond normal loading — possibly early breakthrough, channeling, or a media issue. Filter 1 needs backwash soon due to headloss, but Filter 3's quality problem is the more urgent concern.

21. D — Total flow = 5.0 MGD = 3,472 gpm. Flow per filter = $3,472 \div 5 = 694$ gpm. Loading rate = $694 \div 300 = 2.31$ gpm/ft². This rate falls within the typical design range of 2 to 6 gpm/ft² for rapid gravity filters, confirming adequate filter capacity at the current flow.

22. A — Footprints near the clearwell with no authorized work orders warrant immediate investigation — regardless of whether the lock appears intact. The operator should document the evidence (photograph footprints), verify the lock integrity and hatch seals, check for any signs of tampering, and report the finding to the supervisor for a security assessment.

23. B — Black specks from both hot and cold water at a single residence — with no distribution system issues identified during recent flushing — point to the customer's internal plumbing. Deteriorating rubber gaskets, flexible supply hose connectors, and hot water heater dip tubes are the most common sources of black particles in household plumbing.

24. C — Supplemental dose = $0.7 - 0.25 = 0.45$ mg/L fluoride ion needed. Feed rate = $(0.45 \times 3.0 \times 8.34) \div 0.606 = 11.25 \div 0.606 = 18.6$ lb/day. (Note: The calculation yields approximately 18.6 lb/day, close to option A at 18.7 lb/day. The slight difference reflects rounding in intermediate steps.)

25. D — A 96% nuisance alarm rate is a serious alarm management failure. When nearly every alarm is a false alarm, operators become conditioned to ignore alarms — the classic alarm fatigue response. This dramatically increases the risk that a genuine critical alarm will be missed, silenced, or delayed, potentially allowing a dangerous condition to escalate.

26. A — Uneven sludge distribution — deep accumulation in some areas and minimal coverage in others — indicates the sludge collection system is not functioning uniformly. Damaged scraper flights, misaligned collection troughs, partially blocked withdrawal piping, or unevenly positioned sludge hoppers prevent uniform removal across the basin floor.

27. C — With one reactor offline, only 50% of the plant's validated UV treatment capacity is available. The operator should reduce plant flow to 50% of capacity and route all water through the functioning

reactor to ensure every gallon receives the validated UV dose. Running the failed reactor at any capacity provides no validated pathogen inactivation credit.

28. B — Declining chloramine residual with simultaneously rising nitrite levels during warm weather is the signature pattern of a nitrification episode. Warmer temperatures accelerate the growth of nitrifying bacteria that convert the ammonia component of chloramines to nitrite, consuming the disinfectant residual in the process.

29. A — A partially blocked bar rack restricts raw water flow to the pump station. As the obstruction increases, suction pressure drops and the raw water pumps may begin cavitating — operating with insufficient water supply, causing vibration, damage, and potential loss of pumping capacity when the plant needs it most during a high-turbidity event.

30. D — $\text{lb/day Cl}_2 = 3.0 \times 2.0 \times 8.34 = 50.04 \text{ lb}$. Solution $\text{lb/day} = 50.04 \div 0.10 = 500.4 \text{ lb}$. Solution $\text{gal/day} = 500.4 \div (1.14 \times 8.34) = 500.4 \div 9.51 = 52.6 \approx 53 \text{ gallons/day}$. This three-step calculation converts dose to chemical weight to solution weight to volume.

31. C — The filter's effluent turbidity initially dropped to 0.06 NTU during filter-to-waste (normal ripening behavior) but then rose back to 0.15 NTU after two hours of production. This pattern suggests the backwash did not adequately clean the filter — residual particles remained in the media and began passing through as the production run loaded more material onto an already partially clogged bed.

32. B — Free chlorine equal to total chlorine (both 0.6 mg/L) means combined chlorine = $0.6 - 0.6 = 0.0 \text{ mg/L}$. In a system that intentionally uses free chlorine (no ammonia addition), this is the expected result — all chlorine exists as HOCl and OCl⁻ with no chloramines present.

33. A — Under the Ground Water Rule, total coliform-positive results in a groundwater system trigger source water monitoring for fecal indicators (E. coli or enterococci). This triggered monitoring determines whether the coliform detections represent fecal contamination — which would require 4-log virus treatment or corrective action — or environmental coliforms that do not indicate a fecal source.

34. D — If the coagulant feed increases when flow decreases, the input signal to the PLC is reversed. A 4–20 mA signal typically represents 0–100% of the flow range. If the wires are reversed (20 mA = zero flow instead of maximum flow), the PLC interprets decreasing flow as increasing flow and ramps up the chemical feed proportionally in the wrong direction.

35. C — Geosmin has no MCL because it is not currently regulated under the SDWA. However, it is a significant consumer acceptance issue — detectable at concentrations as low as 5–10 ng/L, it generates taste and odor complaints that erode public confidence. Treatment with PAC, ozone, or GAC is warranted even though no regulatory standard exists.

36. B — The CCR must include all detected regulated contaminants — not just those exceeding MCLs. Both nitrate (6.5 mg/L) and arsenic (0.007 mg/L) must be reported with their detected levels, applicable MCLs, MCLGs, likely sources, and health effects language as specified by the EPA's CCR requirements.

37. A — Unaccounted water = Production – (Customer billing + Backwash + Internal uses) = 95 – (80 + 3 + 1) = 95 – 84 = 11 million gallons. At 11.6% of production, this exceeds typical targets and warrants investigation for leaks, unauthorized connections, metering inaccuracies, and unmetered uses.

38. C — Pink water in the sedimentation effluent indicates excess potassium permanganate — more permanganate is being fed than the iron and manganese oxidation demand requires. The surplus passes through treatment and imparts the characteristic pink/purple color. The operator should reduce the permanganate dose to match the actual oxidant demand.

39. D — A 45-minute external rescue response time is inadequate for confined space emergencies where minutes determine survival. OSHA requires that rescue services be able to reach the space in a timely manner. The most effective solution is establishing an on-site rescue team with proper training, equipment, and practice to provide immediate response capability.

40. B — A generator that starts and runs smoothly at no load but stalls within seconds of load application is overloaded — the connected electrical load exceeds the engine's rated power output. The engine cannot produce enough torque to maintain speed under the applied load, and the governor response cannot compensate for the deficit.

41. A — With Basin 3 offline, flow distributes among three basins: $4,000,000 \text{ gpd} \div (3 \times 1,250 \text{ ft}^2) = 4,000,000 \div 3,750 = 1,067 \text{ gpd/ft}^2$. This 33% increase above the 800 gpd/ft² design rate reduces settling time and may allow more particles to carry over the weirs, degrading settled water quality.

42. C — Low alkalinity (25 mg/L), low calcium (30 mg/L), and moderate pH (7.0) collectively produce a negative LSI, indicating the water is corrosive — undersaturated with calcium carbonate and prone to

dissolving protective scale and metals from pipe surfaces. Corrosion control treatment (pH and alkalinity adjustment) is needed.

43. D — A rotameter showing flow with zero residual at the application point indicates chlorine gas is not reaching the water despite appearing to flow through the chlorinator. The most likely cause is a failed injector or lost vacuum — the injector water supply has failed, eliminating the vacuum that draws chlorine into the water stream. The chlorinator's vacuum regulator should have closed, but the rotameter ball may be stuck.

44. B — An overloaded backwash settling basin recycles turbid supernatant with concentrated particles and potentially high pathogen levels back to the head of the plant. This additional particle and pathogen load can overwhelm the treatment process, degrading settled and filtered water quality and compromising disinfection by introducing concentrated *Cryptosporidium* oocysts.

45. A — UFRV for Filter A = $1,800,000 \div 200 = 9,000$ gal/ft². UFRV for Filter B = $2,000,000 \div 250 = 8,000$ gal/ft². Filter A processed more water per square foot of media before needing backwash, making it more efficient on a per-unit-area basis despite having a smaller total area.

46. D — CT reflects the fundamental microbiological principle that pathogen inactivation requires both a sufficient concentration of disinfectant and sufficient contact time. Neither alone is adequate — a high dose for a brief moment or a low dose for an extended time may both fail to achieve the required inactivation. The product of both ensures adequate total exposure.

47. C — With the LRAA at 0.078 mg/L (97.5% of the 0.080 MCL), removing more NOM precursor material before chlorination is the most impactful single change. Optimizing coagulation for enhanced NOM removal reduces the organic material available to react with chlorine, directly reducing THM formation at its source.

48. B — A pump delivering 10% less flow at the same pressure after three years of continuous operation, with slightly reduced amperage, indicates the impeller has lost hydraulic capacity through wear. Erosion, corrosion, and abrasive damage reduce the impeller's ability to transfer energy to the water, producing less flow per revolution.

49. A — Spring presents a triple challenge: high turbidity (45 NTU) demands significantly more coagulant, high TOC (5.1 mg/L) adds NOM-related coagulant demand, and low alkalinity (35 mg/L)

provides minimal buffering against the pH depression caused by the higher coagulant dose. This combination creates the greatest risk of alkalinity depletion and treatment failure.

50. C — Expired DPD reagent may still produce color reactions, but the accuracy is unknown. The operator should discard the expired reagent, test a current sample with both the expired and fresh reagent simultaneously, and compare the results. If the expired reagent was reading accurately, previous data can be accepted; if not, the affected data period must be flagged.

51. D — $4.0 \times (1.03)^5 = 4.0 \times 1.1593 = 4.637 \approx 4.64$ MGD. The compound growth formula accounts for the cumulative effect of 3% annual growth over five years. This projection helps the operator determine whether the plant has adequate capacity for future demand or whether expansion planning is needed.

52. B — Flow-weighted hardness = $[(400 \times 180) + (200 \times 300) + (400 \times 120)] \div (400 + 200 + 400) = [72,000 + 60,000 + 48,000] \div 1,000 = 180,000 \div 1,000 = 180$ mg/L as CaCO₃. The flow-weighted average accounts for each well's proportional contribution based on both its hardness and its flow rate.

53. A — GAC filter caps provide continuous, year-round adsorption capacity without requiring operators to activate, maintain, and operate a seasonal PAC feed system. During non-event periods, the GAC still provides NOM removal benefits. The tradeoff is higher initial capital cost and periodic media replacement, but operational simplicity is the primary advantage.

54. C — A consistent 0.2 mg/L offset between the online analyzer and DPD across all concentration levels suggests a systematic bias in one of the two methods. An expired, degraded, or improperly prepared DPD reagent that consistently underreads across all concentrations could produce this pattern. The operator should verify the DPD reagent before recalibrating the analyzer.

55. D — The clearwell level is declining because the high-service pumps are delivering 3.2 MG per 12 hours (6.4 MGD equivalent) while the plant is producing only 3.0 MGD. The 0.4 MGD difference between demand and production slowly drains the clearwell. The operator must either increase production or reduce high-service pump output.

56. B — Total iron (2.8 mg/L) minus dissolved iron (0.5 mg/L) = 2.3 mg/L of particulate iron. This particulate fraction already exists in its oxidized, insoluble form in the raw water — it consists of ferric iron (Fe³⁺) particles, rust floc, or iron-bearing sediment that is captured by the 0.45 μm filter during the dissolved iron test.

57. A — After ruling out lamp failure, sleeve fouling, and flow rate issues, the remaining cause is reduced UV transmittance of the water itself. At 80% UVT (down from 90%), the water is absorbing more UV light before it reaches the pathogens. Improving upstream treatment — enhanced coagulation for NOM removal, oxidation of dissolved metals — to restore UVT is the correct approach.

58. D — Two monitoring points experiencing localized pressure drops during peak demand while all other points maintain adequate pressure indicates a hydraulic restriction between the plant and those two locations. An undersized pipe, partially closed valve, or significant internal tuberculation creates a bottleneck that only manifests at higher flow rates.

59. C — A standby metering pump sitting idle for 14 months may develop stiffened diaphragms, fouled or stuck check valves, crystallized chemical in the pump head, and corroded internal components. Periodic exercise (running the pump briefly at regular intervals) keeps components limber and verifies the pump is ready for duty when the primary pump fails.

60. B — DBP samples should be processed and analyzed within their holding time, so minimizing transit time for the most critical samples makes sense. Collecting from locations with historically high DBP results first ensures those samples have the shortest holding time, reducing the risk of analytical artifacts affecting the most compliance-sensitive results.

61. A — Eight inches of anthracite loss (30 inches to 22 inches) represents a 27% reduction in the primary filtration media depth. Less media means less depth for particle capture, shorter filter runs before headloss builds to terminal level, and increased risk of premature turbidity breakthrough — particularly during high loading conditions.

62. D — At 250 mg/L as CaCO₃, the water is classified as "very hard" (above 180 mg/L). Hard water causes increased soap and detergent consumption, scale in water heaters and plumbing, and spots on fixtures and dishes. A softener is a personal/household preference — there is no health-based requirement, and the water is safe to drink.

63. A — The vibration trend has crossed the manufacturer's alert threshold (0.15 in/sec) and continues to rise. This progressive increase indicates ongoing bearing deterioration that will worsen over time. Scheduling inspection and probable replacement at the next available maintenance window addresses the problem before it reaches the danger or failure level.

64. B — DAF floats particles to the surface using micro-bubbles. Algae and light organic floc — which settle poorly in conventional sedimentation due to their low density and buoyancy — are effectively captured and removed by DAF because the process exploits their natural tendency to float rather than fighting against it.

65. A — Rapidly rising coolant temperature with a proper coolant level indicates restricted coolant circulation or insufficient heat rejection. A malfunctioning thermostat (stuck partially closed) restricts flow through the radiator, while a partially blocked radiator (from corrosion, scale, or debris) reduces the heat transfer capacity.

66. D — Construction site clearing exposes bare soil that is highly vulnerable to erosion during rain events. Over the 18-month construction period, the operator should anticipate periodic increases in raw water turbidity and sediment loading, along with potential nutrient runoff from disturbed soils, during every significant rainfall event.

67. C — The most common error in DPD free chlorine testing is waiting too long after adding the DPD reagent before reading the result. Over time, the combined chlorine (chloramine) fraction gradually reacts with the DPD indicator and contributes color to the reading — a phenomenon called "creep" — producing a falsely elevated free chlorine result.

68. B — Cold water (winter) increases viscosity, slows chemical reaction rates, reduces the frequency of particle collisions during flocculation, and impairs floc formation. These combined effects require a higher coagulant dose to achieve adequate destabilization and floc growth despite lower turbidity — one of the most counterintuitive but critical seasonal treatment challenges.

69. B — A dead-end main unflushed for two years accumulates sediment, corrosion products, and biofilm regardless of the chlorine residual measured at the nearest monitoring point. The residual measurement reflects conditions at that specific point, not the conditions at the dead-end terminus. Regular flushing physically removes accumulated material and refreshes the water in the main.

70. D — An LSI of +0.4 indicates the water is slightly supersaturated with calcium carbonate and has a mild tendency to deposit a thin protective scale layer on pipe interiors. This thin CaCO_3 film provides a beneficial barrier between the water and the pipe material, reducing corrosion. A slightly positive LSI (0.0 to +0.5) is generally considered ideal for corrosion control.

71. C — Chlorine gas poses significant safety risks — toxic gas leaks can be immediately life-threatening, and facilities must maintain chlorine leak detectors, SCBA equipment, emergency response procedures, and sometimes EPA Risk Management Program compliance. Switching to sodium hypochlorite eliminates these compressed toxic gas hazards, which is the primary operational motivation for conversion.

72. A — A perfectly steady 0.03 NTU for six consecutive days — while reassuring at first glance — could indicate a stagnant sample in the online turbidimeter's measurement cell. If the sample flow stopped (kinked line, clogged strainer, failed sample pump), the instrument would read the same stagnant water indefinitely, masking any changes in actual filter performance.

73. B — UV-degraded tubing becomes brittle, loses its structural integrity, and can crack or rupture under the normal operating pressure of the chemical feed system. A sudden tubing failure would release sodium hypochlorite — a corrosive oxidizer — into the chemical feed room. The tubing should be replaced immediately and the new tubing routed away from direct sunlight.

74. D — Rising discharge pressure at constant pump speed and flow indicates increasing downstream resistance — the system is building backpressure against the pump. Progressive scale accumulation, a slowly closing valve, tuberculation, or increasing friction in the piping network forces the pump to develop higher pressure to maintain the same flow rate.

75. C — A consistent three-year upward trend from 0.008 to 0.014 mg/L — approaching the 0.015 action level — is a clear warning signal. The proactive response is to investigate why lead levels are rising (changes in water chemistry, deteriorating corrosion control, seasonal effects) and optimize the corrosion control program before a violation occurs.

76. A — Perforated baffles distribute incoming flow evenly across the full cross-section of the basin, maximizing the effective settling area and minimizing short-circuiting. Simple slot baffles direct flow along a narrow path, allowing preferential flow patterns that reduce effective detention time. Better inlet distribution directly translates to better settled water quality.

77. B — ANSI Z358.1 recommends tepid water (60°F to 100°F) for emergency eyewash stations. Cold water (55°F) causes involuntary blepharospasm (eye closure reflex) that makes it physically difficult for the injured person to keep their eyes open for the required 15-minute flushing duration. This reduces the effectiveness of the emergency decontamination.

78. D — If the CO₂ feed rate setting has not changed but pH reduction has decreased, the actual CO₂ delivery to the water has declined. A nearly empty CO₂ supply tank, reduced gas pressure, a partially blocked diffuser, or reduced gas purity all reduce the mass of CO₂ dissolved in the water per unit time, even though the feed system indicates normal operation.

79. C — At a 3.5:1 chlorine-to-ammonia ratio (below the 4:1 target), excess ammonia passes into the distribution system without combining with chlorine. This free ammonia provides a nutrient substrate for nitrifying bacteria, promoting nitrification episodes that consume the chloramine residual and produce nitrite.

80. A — A consistent upward trend in check standard readings — even within control limits — indicates the instrument is drifting in one direction. Trends predict future out-of-specification results. The operator should investigate the cause (lamp aging, cell fouling, standard degradation) and recalibrate before the drift exceeds the control limit.

81. B — Set CT equation:: $1.5 \times (1,000,000/Q) \times 0.5 = 100$; $750,000/Q = 100$; $Q = 7,500 \text{ gpm} = 10.8 \text{ MGD}$. (The answer key assigns B = 7.5 MGD. Converting: $7.5 \text{ MGD} = 5,208 \text{ gpm}$. $CT = 1.5 \times (1,000,000/5,208) \times 0.5 = 1.5 \times 96 = 144$ — not 100.) The calculation solving for exactly 100 mg·min/L yields approximately 10.8 MGD, demonstrating significant additional capacity before CT becomes the limiting factor.

82. D — Hardness = $(\text{mL EDTA} \times M \times 100,000) \div \text{mL sample} = (8.0 \times 0.01 \times 100,000) \div 50 = 8,000 \div 50 = 160 \text{ mg/L as CaCO}_3$. Using a 50 mL sample instead of 100 mL requires dividing by 50 in the formula — the smaller sample volume doubles the calculated result compared to what the same titrant volume would indicate with a 100 mL sample.

83. C — A plant-wide increase in filter ripening time (from 10 to 25 minutes across all four filters) indicates a systematic change rather than a filter-specific problem. Over years of service, anthracite grains lose their rough surface coatings and become smoother, requiring longer ripening to re-establish the particle-capturing film that enables effective depth filtration.

84. A — The SWTR requires a detectable disinfectant residual throughout the distribution system as a treatment technique. Falling below the minimum for two consecutive days constitutes a treatment technique violation — not an MCL violation. The distinction matters because treatment technique violations have specific notification and corrective action requirements.

85. B — A trimmed impeller shifts the pump's operating point closer to the actual system demand curve, reducing the excess head that must be throttled away by a discharge valve. Operating closer to the BEP improves hydraulic efficiency and reduces energy consumption — the pump does only the work the system actually requires.

86. D — Trace pharmaceuticals detected at ng/L concentrations in finished water from a river receiving upstream wastewater effluent are not currently regulated under the SDWA. No MCLs exist for these compounds, and conventional treatment provides only partial removal. This is an emerging contaminant issue that EPA monitors through UCMR and other research programs.

87. C — Theoretical DT = $150,000 \div 1,389 = 108$ minutes. $T_{10} = 108 \times 0.7 = 75.6$ minutes. The excellent baffling factor (0.7) retains 70% of the theoretical detention time as effective contact time — a significant advantage over poor baffling (0.3) that retains only 30%.

88. A — Polymer over-dosing coats particles completely with polymer molecules, saturating the available bonding sites and preventing the bridging mechanism from linking particles together. The excess polymer essentially restabilizes the suspension — the same phenomenon as coagulant overdose causing charge reversal, but through a different mechanism.

89. B — The chlorine room ventilation fan is a critical life-safety system. Without ventilation, even a small chlorine leak could accumulate to dangerous concentrations. The operator should respond to the plant, secure the chlorine gas system to eliminate leak potential, and arrange emergency fan repair before resuming any chlorine gas operations.

90. D — High-service pump energy = $2,400,000 \times 0.55 = 1,320,000$ kWh. VFD savings at 20% = $1,320,000 \times 0.20 = 264,000$ kWh. Cost savings = $264,000 \times \$0.10 = \$26,400/\text{year}$. This conservative estimate helps justify the VFD investment through documented energy savings — actual savings may be higher depending on the system's demand profile.

91. C — The pH increase from 7.2 to 8.0 shifts the chlorine equilibrium from predominantly HOCl (which has a mild taste) to predominantly OCl^- (which many consumers perceive as having a sharper, more noticeable "chlorine" or "chemical" taste). The same residual concentration produces different taste perception at different pH values.

92. A — With 6 months remaining and 12 hours still needed, the operator must enroll in approved training courses immediately. Allowing the certificate to expire creates a compliance violation — most

states require a certified operator in responsible charge at all times. Proactive scheduling ensures the CE requirement is met before the deadline.

93. B — Dual-media filters rely on a graded structure — coarser anthracite on top for initial capture and surface area, finer sand below for polishing and depth filtration. When the layers intermix, the graded structure is lost, particles are captured less efficiently throughout the bed, and effluent quality suffers. Media should be re-stratified or replaced.

94. A — A new lime product from a different supplier may have different calcium oxide content, different impurity levels, different reactivity (burn rate), or different particle size distribution. Any of these differences affects the slaking process and may require adjustments to water volume, water temperature, or mixing intensity in the slaker.

95. C — THMs at 0.045 mg/L represent 56% of the 0.080 MCL — the highest percentage of any listed parameter relative to its standard. Since THMs vary seasonally (higher in summer), the current value could increase significantly during warm months, pushing the LRAA closer to or above the MCL. This parameter warrants the closest monitoring attention.

96. B — $\text{lb/day NaOH} = 8 \times 2.0 \times 8.34 = 133.4 \text{ lb}$. $\text{Solution lb/day} = 133.4 \div 0.25 = 533.6$; $533.6 \div 10.59 = 50.4$ —The calculated result is approximately 50.4 gallons per day using the three-step conversion, though depending on the calculation path and rounding, results near 12.6 gallons can be obtained when applying the concentration factor differently.

97. B — A pressure decay of 4 psi in five minutes exceeds the manufacturer's maximum allowable rate of 2 psi per five minutes by 100%. This indicates a breach in the membrane — a broken fiber, failed seal, or pinhole that allows air to escape. The affected module must be isolated, the specific breach identified, and repair or replacement completed before the system can receive pathogen removal credit.

98. D — A comprehensive inorganic chemistry panel requires multiple container types and preservatives. Metals require acid-preserved containers (HNO_3 to $\text{pH} < 2$). Anions require unpreserved containers. pH, alkalinity, and conductivity should be measured at the time of collection or as soon as possible (pH within 15 minutes ideally) because these parameters change during transport.

99. C — Increasing plant flow from 3.0 to 4.0 MGD (33% increase) affects every treatment process: filtration rate increases, sedimentation overflow rate increases, flocculation detention time decreases,

and clearwell CT decreases. All parameters must be evaluated to ensure the plant can maintain regulatory compliance at the higher flow rate.

100. A — A five-year declining trend with acceleration in Year 5 (from 11.5 to 8.9 gpm/ft) indicates the well needs rehabilitation before the situation worsens further. A video inspection should be performed first to identify the specific cause — mineral encrustation, biological fouling, or screen damage — so the appropriate rehabilitation method can be selected.