PRACTICE EXAM 9: WATER TREATMENT OPERATOR CLASS I SIMULATION (100 QUESTIONS)

1. A treatment plant treats 3.0 MGD from a river source. The operator feeds alum at 40 mg/L and lime at 15 mg/L for alkalinity supplementation. During a routine inspection, the operator discovers that the lime day tank ran empty approximately four hours ago but the alum feed has continued at the set rate. The raw water alkalinity is 45 mg/L as $CaCO_3$. The 40 mg/L alum dose consumes approximately 20 mg/L of alkalinity. Without the supplemental lime, the remaining alkalinity after coagulation is approximately:

A. 25 mg/L as $CaCO_3$, which may provide marginal buffering but should be monitored closely for pH instability

B. 45 mg/L as $CaCO_3$, because the natural alkalinity is consumed only when lime is present to catalyze the reaction

C. 0 mg/L as $CaCO_3$, because the alum dose completely exhausts the natural alkalinity at this concentration

D. 65 mg/L as $CaCO_3$, because the removal of lime actually increases the effective alkalinity in the water

2. A treatment plant operator reviews the following distribution system chlorine residual data from the previous week. All values are in mg/L free chlorine: Monday 0.6, Tuesday 0.5, Wednesday 0.4, Thursday 0.3, Friday 0.2, Saturday 0.15, Sunday 0.08. The plant effluent residual remained constant at 1.2 mg/L throughout the week. This progressive decline is most likely caused by:

A. A systematic error in the DPD test procedure that produces increasingly lower readings each day of the week

B. The laboratory using a different lot of DPD reagent each day with decreasing sensitivity across the lot

C. A developing problem in the distribution system — possibly biofilm growth, a main break, or a cross-connection — that is progressively consuming more chlorine

D. Normal weekly variation that occurs in all distribution systems regardless of operational conditions

3. An operator at a surface water treatment plant performs a jar test using six alum doses. The results show optimal turbidity removal at 35 mg/L, but the settled water color remains at 25 CU — above the plant's target of 15 CU. To address the residual color, the operator's most appropriate next step is:

A. Increase the flocculation time in the jar test to allow longer contact between the coagulant and color-causing NOM

B. Perform additional jar testing at lower pH and higher alum doses to optimize NOM (color) removal through enhanced coagulation

C. Accept the 25 CU color because the secondary standard for color is 15 CU and the plant cannot exceed its chemical budget

D. Add chlorine to the settled water jars to oxidize the color-causing compounds before measuring the final color

4. A treatment plant's SCADA system generates an alarm indicating that the chlorine gas feed rate has increased to maximum output without operator intervention. The plant flow has not changed. The chlorine residual at the clearwell outlet is reading 0.1 mg/L — well below the normal 1.0 mg/L. The most likely cause is:

A. The chlorine gas cylinder has been overfilled by the supplier, releasing more gas than the chlorinator can regulate

B. The SCADA system has malfunctioned and is sending false maximum-output signals to the chlorinator

C. The plant's raw water quality has improved, reducing the chlorine demand and causing the system to compensate

D. The chlorine residual analyzer-based feedback control has detected a genuine low residual and is driving the chlorinator to maximum output — the operator should investigate why the residual dropped

5. A treatment plant's finished water pH is maintained at 7.5 for corrosion control. The operator discovers that the post-filtration caustic soda feed pump has been offline for six hours. During this period, the finished water pH has been approximately 6.5 — the coagulation pH. The operator should be most concerned about:

A. Increased DBP formation because lower pH accelerates the reaction between chlorine and organic matter

B. Accelerated corrosion in the distribution system because the lower pH water is more aggressive toward pipe materials

C. Reduced chlorine disinfection efficiency because lower pH shifts the equilibrium away from HOCl

D. Increased consumer complaints about taste because lower pH makes water taste more bitter and metallic

6. A treatment plant operator is investigating the cause of a gradual decline in high-service pump discharge pressure over the past year. The motor amperage has remained constant, the pump speed has not changed, and the suction conditions are stable. The most likely cause is:

A. Progressive impeller wear from erosion, corrosion, or abrasion that has reduced the pump's ability to develop head

B. A gradual increase in the distribution system elevation that requires more pressure to serve the same customers

C. Declining raw water quality that increases the viscosity of the finished water and creates more flow resistance

D. The discharge pressure gauge has drifted low and needs recalibration rather than indicating an actual change

7. A treatment plant's laboratory QA/QC program requires the operator to run a method blank with every batch of turbidity samples. The method blank — deionized water processed through the complete analytical procedure — produces a reading of 0.08 NTU. The acceptable limit for the method blank is ≤ 0.05 NTU. The operator should:

A. Accept the 0.08 NTU result because it is close enough to the limit and the samples were probably unaffected

B. Report the blank result alongside the sample results and let the reviewer determine the impact on data quality

C. Subtract 0.08 NTU from all sample results to correct for the elevated blank contribution

D. Investigate the contamination source — dirty glassware, contaminated DI water, or instrument interference — reprocess the blank, and re-analyze the samples if the contamination cannot be resolved

8. A treatment plant uses a dual-media filter consisting of anthracite over sand. During a routine media inspection, the operator discovers that approximately 4 inches of fine sand has accumulated on top of the anthracite layer. This condition most likely resulted from:

A. The anthracite has chemically converted to sand through a natural mineral transformation process over time

B. The backwash rate was too low during previous backwash cycles, failing to fully fluidize the bed and re-stratify the media

C. Excessive backwash rate or duration during previous backwash cycles that lifted the fine sand above the heavier anthracite, depositing it on top when flow stopped

D. Sand from the plant's surrounding landscape blowing into the filter cells through open hatches during windstorms

9. An operator at a treatment plant discovers that the plant's four sedimentation basins have significantly different effluent turbidities: Basin 1 = 0.8 NTU, Basin 2 = 0.9 NTU, Basin 3 = 3.2 NTU, Basin 4 = 0.7 NTU. All basins receive the same coagulated water and operate at the same flow rate. Before assuming Basin 3 has a treatment problem, the operator should first verify:

A. That the raw water turbidity has not changed in the past hour, which would affect all basins equally

B. That Basin 3's effluent turbidimeter is calibrated and functioning correctly, since an instrument problem could produce a false elevated reading

C. That the chemical feed pump is delivering the correct dose, which would affect all four basins simultaneously

D. That the other three turbidimeters are not reading falsely low, which would only be detected by a system-wide calibration

10. A treatment plant treats 4.0 MGD and needs to feed chlorine at 2.5 mg/L using 65% calcium hypochlorite ($Ca(OCl)_2$). The daily amount of calcium hypochlorite powder required is:

A. 83.4 lb/day, which represents the weight of pure chlorine needed without the purity adjustment

B. 54.2 lb/day, calculated by multiplying the chlorine weight by the calcium hypochlorite percentage

C. 166.8 lb/day, which is double the actual requirement due to an error in the concentration factor

D. 128.3 lb/day, calculated as $(2.5 \times 4.0 \times 8.34) \div 0.65$

11. A treatment plant's emergency generator is powered by natural gas rather than diesel. Compared to a diesel generator, a natural gas generator offers which operational advantage?

A. Unlimited fuel supply through the gas utility connection, eliminating the risk of fuel exhaustion during extended power outages

B. Higher power output per unit of fuel consumed, making natural gas generators more efficient than diesel

C. Lower initial purchase cost because natural gas engines are simpler than diesel engines

D. Faster starting time because natural gas ignites more readily than diesel fuel at all ambient temperatures

12. A treatment plant operator tests a raw water sample and obtains: pH 7.8, alkalinity 110 mg/L as $CaCO_3$, total hardness 95 mg/L as $CaCO_3$. Since the total hardness (95 mg/L) is less than the alkalinity (110 mg/L), the non-carbonate hardness is:

A. 15 mg/L, calculated as the difference between alkalinity and hardness

B. 95 mg/L, because all hardness in this water is non-carbonate when it is less than the alkalinity

C. Zero, because when total hardness is less than alkalinity, all hardness is carbonate hardness

D. 205 mg/L, calculated as the sum of alkalinity and hardness

13. A treatment plant's SCADA system monitors the differential pressure across each filter. Filter 4's differential pressure has increased from 1.0 psi to 4.5 psi over the past 24 hours while the other three filters show 1.5 to 2.5 psi for the same run time. This indicates:

A. Filter 4 is performing better than the other filters because higher differential pressure means more particles are being captured

B. Filter 4 is developing headloss faster than the other filters and will reach terminal headloss sooner, likely due to higher loading, media problems, or inadequate backwash

C. The differential pressure transmitter on Filter 4 has drifted high and needs calibration verification

D. The plant flow has shifted so that Filter 4 is receiving more than its proportional share of the total flow

14. A treatment plant operator measures the chlorine residual at three points through the treatment process: after chlorine addition = 3.5 mg/L, after sedimentation = 2.8 mg/L, at the clearwell outlet = 2.0 mg/L. The chlorine demand through the treatment process from the addition point to the clearwell outlet is:

A. 2.0 mg/L, which is the residual remaining at the clearwell outlet

B. 2.8 mg/L, which represents the demand consumed only during sedimentation

C. 5.5 mg/L, calculated by adding the addition point residual and the clearwell outlet residual

D. 1.5 mg/L, calculated by subtracting the clearwell outlet residual (2.0) from the addition point residual (3.5)

15. A treatment plant's source water assessment identifies that the plant's reservoir watershed has experienced a significant increase in impervious surface area (roads, parking lots, rooftops) due to suburban development over the past 10 years. The primary water quality impact of increased impervious surface is:

A. Greater stormwater runoff volume and velocity carrying more sediment, nutrients, petroleum products, and other contaminants directly into the reservoir

B. Reduced evapotranspiration that causes the reservoir level to rise above its designed maximum pool elevation

C. Increased groundwater recharge that raises the water table and introduces dissolved minerals into the reservoir

D. Reduced wind exposure over the watershed that prevents natural reservoir mixing and promotes stratification

16. A treatment plant operator discovers that the plant's sodium hypochlorite bulk storage tank has a sight glass (level indicator) that shows 60% full. However, the electronic level transmitter connected to SCADA shows 85% full. The operator should:

A. Trust the SCADA reading because electronic instruments are always more accurate than visual sight glasses

B. Trust the sight glass because visual indicators never fail and always show the correct level

C. Manually verify the actual tank level using a dipstick or measurement tape, then determine which instrument needs calibration

D. Average the two readings and report 72.5% as the official tank level for inventory tracking purposes

17. A treatment plant's operator is training a new employee on the proper procedure for collecting a bacteriological sample from a distribution system tap. Which of the following steps should be performed first?

A. Remove the cap from the sterile sample bottle and fill it directly from the flowing tap

B. Select an approved sampling location, remove the aerator, disinfect the tap outlet with sodium hypochlorite or a flame, and flush the tap for the required time before collecting the sample

C. Flush the tap for 30 seconds, then collect the sample in any clean container available at the location

D. Collect the sample immediately without flushing to capture any bacteria present at the tap outlet

18. A treatment plant feeds ferric chloride at 25 mg/L to water with a pH of 7.2 and an alkalinity of 60 mg/L as $CaCO_3$. After coagulant addition, the pH drops to 5.8 — below the effective coagulation range for ferric chloride. The operator should:

A. Increase the ferric chloride dose to compensate for the pH drop with additional coagulant

B. Reduce the plant flow rate to increase the contact time between the coagulant and the low-pH water

C. Switch to polymer as the primary coagulant because polymers are not affected by pH in any application

D. Add lime or soda ash before or during coagulant addition to supplement the alkalinity and maintain pH within the effective range

19. An operator at a treatment plant using chloramine disinfection receives a complaint about a "fishy" or "chemical" taste from a customer. The operator tests the customer's tap and finds: total chlorine 2.0 mg/L, free chlorine 0.0 mg/L. The most likely cause of the objectionable taste is:

A. Formation of dichloramine or trichloramine at this specific location, which produces more objectionable tastes than monochloramine

B. Excessive free chlorine that has overwhelmed the ammonia and is producing a strong chlorine taste

C. Bacterial contamination in the customer's plumbing that produces taste compounds independent of disinfection

D. The total chlorine reading is too low for adequate disinfection, allowing biological growth that causes the taste

20. A treatment plant's four filters operate at a combined flow of 3,000 gpm. Each filter has a surface area of 200 ft^2. The operator takes Filter 1 offline for maintenance. The filtration rate on each of the remaining three filters increases to:

A. 3.75 gpm/ft^2, which is below the normal 5.0 gpm/ft^2 rate for rapid gravity filters

B. 5.0 gpm/ft^2, which is at the upper end of the typical range and may require reduced filter run times

C. 10.0 gpm/ft^2, which exceeds the maximum recommended rate by a factor of two

D. 3.0 gpm/ft^2, which is the same rate as when all four filters were operating

21. A treatment plant treats 5.0 MGD from a reservoir source. The plant's clearwell has a volume of 750,000 gallons with a baffling factor of 0.5. The plant needs to achieve a minimum CT of 120 mg·min/L. What minimum chlorine residual must be maintained at the clearwell outlet?

A. 0.67 mg/L, which would provide exactly 120 mg·min/L under current flow conditions

B. 1.0 mg/L, which provides a comfortable margin above the minimum CT requirement

C. 1.33 mg/L, calculated by dividing the required CT by the T_{10} at current plant flow

D. 2.0 mg/L, which doubles the minimum to account for seasonal temperature variations

22. An operator reviewing the plant's SCADA alarm history notices that the "HIGH FILTER HEADLOSS" alarm on Filter 2 has been activating every 18 to 20 hours — significantly more frequently than the other three filters, which alarm every 36 to 48 hours. All filters receive the same settled water. The most likely cause of Filter 2's shorter runs is:

A. Filter 2's headloss alarm setpoint is configured lower than the other filters, triggering the alarm sooner

B. The plant flow controller is distributing more flow to Filter 2 than to the other three filters

C. Filter 2 is operating normally and the other three filters have abnormally long runs that should be investigated

D. Filter 2 has a specific condition — media loss, inadequate backwash, mudballs, or underdrain problems — that is causing it to load faster than the other filters

23. An operator at a treatment plant using chlorine gas for disinfection discovers that a 150-pound chlorine cylinder on the active manifold shows a weight of 148 pounds on the scale. The full weight of a 150-pound cylinder (including tare weight) is approximately 220 pounds. The remaining chlorine in this cylinder is approximately:

A. 148 pounds, because the scale reads the total weight and the tare weight of the empty cylinder (approximately 72 pounds) must be subtracted: 148 − 72 = 76 pounds of chlorine remaining

B. 2 pounds, calculated by subtracting the current weight from the rated capacity of 150 pounds

C. 148 pounds of chlorine, because the scale reads only the net chlorine weight

D. 78 pounds, estimated by subtracting a standard tare weight of 70 pounds from the gross scale reading

24. A treatment plant's operator tests the raw water and finds a manganese concentration of 0.45 mg/L. The secondary standard for manganese is 0.05 mg/L. The plant uses aeration followed by filtration for iron removal but has no specific manganese treatment process. The finished water manganese level is 0.35 mg/L. This result indicates:

A. The aeration and filtration process is effectively removing manganese to below the secondary standard

B. The existing treatment is only partially removing manganese because aeration alone may not oxidize manganese as effectively as iron, and additional oxidant (permanganate, chlorine dioxide) or pH adjustment may be needed

C. Manganese at 0.35 mg/L is below the primary MCL and no treatment improvement is necessary

D. The manganese is being introduced after treatment from the distribution system pipes rather than from the raw water

25. A treatment plant's operator reviews the energy consumption data and identifies that the plant's raw water pumps consume approximately 30% of the total plant electricity. The raw water pumps run at constant speed with a throttling valve partially closed to control flow. The operator proposes installing variable frequency drives. The primary energy savings mechanism of VFDs on these pumps is:

A. Converting excess electrical energy to heat that is recovered and used for building heating during winter

B. Reducing the motor voltage proportionally to the reduced speed, which decreases current draw linearly

C. Eliminating the energy wasted by the throttling valve by matching the pump speed to the actual flow requirement

D. Reducing pump speed so that power consumption decreases with the cube of the speed ratio

26. A treatment plant operator is performing a confined space entry into a drained chemical contact basin. The atmospheric testing shows all parameters within safe ranges. During the entry, the operator is using a portable gas monitor with a 15-second response time. This response time means:

A. The monitor can only detect gases that have been present for at least 15 seconds continuously

B. The operator should wait 15 seconds between reading each gas parameter displayed on the screen

C. There is a 15-second delay between a gas concentration change in the atmosphere and the monitor displaying the updated reading, which the entrant must account for during the entry

D. The monitor must be turned on 15 seconds before entering the space and cannot be turned on inside

27. A treatment plant using chloramination maintains a chlorine-to-ammonia nitrogen ratio of 4.5:1 by weight. The plant feeds chlorine at 3.0 mg/L. The ammonia nitrogen dose required is:

A. 0.67 mg/L, calculated by dividing the chlorine dose (3.0) by the desired ratio (4.5)

B. 13.5 mg/L, calculated by multiplying the chlorine dose by the desired ratio

C. 1.5 mg/L, using an incorrect ratio of 2:1 instead of the actual 4.5:1 target

D. 4.5 mg/L, using the ratio number directly as the ammonia dose regardless of the chlorine dose

28. A treatment plant's operator is evaluating the performance of the plant's coagulation process by calculating the percent turbidity removal through sedimentation. The raw water turbidity is 25 NTU and the settled water turbidity is 1.5 NTU. The turbidity removal through sedimentation is:

A. 23.5 NTU, which represents the raw turbidity units removed but not the percentage

B. 6%, calculated by dividing the settled water turbidity by the raw water turbidity

C. 60%, using an incorrect formula that divides the removal by the settled water turbidity

D. 94%, calculated as $(25 - 1.5) \div 25 \times 100$

29. An operator at a treatment plant discovers that the chemical delivery driver left 1,200 gallons of sodium hypochlorite in the outdoor transfer line after yesterday's delivery. The line was not flushed or drained after the transfer. Overnight temperatures dropped to 28°F. The operator's concern should be:

A. The sodium hypochlorite may have reacted with the transfer line material, creating a corrosive byproduct

B. The sodium hypochlorite may have frozen in the transfer line, potentially causing line damage, and the solution will have degraded from the temperature cycling

C. No concern because sodium hypochlorite cannot freeze at any temperature encountered in normal climates

D. The chemical will have improved in strength because cold temperatures preserve sodium hypochlorite

30. A treatment plant's operator calculates the surface overflow rate for a circular clarifier. The clarifier has a diameter of 60 feet and the plant flow is 2.0 MGD. The overflow rate is:

A. 707 gpd/ft², calculated using the formula: overflow rate = flow (gpd) ÷ surface area (ft²), where surface area = $\pi \times r^2$

B. 354 gpd/ft², using half the actual surface area in the calculation

C. 1,414 gpd/ft², calculated by using the diameter instead of the radius in the area formula

D. 10,600 gpd/ft², calculated by dividing the flow in gallons per day by the circumference rather than the area

31. A treatment plant using ozone for primary disinfection has experienced an increase in bromate levels from 0.005 mg/L to 0.009 mg/L over the past three months. The bromate MCL is 0.010 mg/L. The source water bromide level has increased from 0.04 mg/L to 0.09 mg/L during the same period. The operator should:

A. Increase the ozone dose to ensure all bromide is fully oxidized past bromate to the less harmful perbromate form

B. Switch to chlorine for primary disinfection permanently because ozone systems cannot operate safely when bromide is elevated

C. Reduce the ozone dose or contact time to decrease bromate formation, while ensuring alternative disinfection maintains adequate pathogen inactivation

D. Add activated carbon before ozonation to adsorb the bromide from the water before it contacts the ozone

32. A treatment plant's operator reviews the following trend: over the past six months, the plant's chemical costs have increased by 22% while the plant flow and raw water turbidity have remained essentially unchanged. The chemical supplier confirms no price increases during this period. The most likely operational explanation is:

A. The plant is treating the same water but the operators have been gradually increasing doses without jar test verification

B. Chemical degradation in storage — weaker sodium hypochlorite or aged polymer — requiring more volume to deliver the same effective dose

C. The plant's flow meters have drifted low, making it appear that the same flow is being treated when the actual flow has increased

D. All three factors — dose creep, chemical degradation, and flow measurement error — should be investigated systematically

33. A treatment plant treats 2.0 MGD from a well source that contains 0.8 mg/L of dissolved iron. The plant uses aeration to oxidize the iron, followed by greensand filtration. After several months, the operator notices orange-brown staining in the clear well and distribution system. The most likely cause is:

A. The greensand media has been exhausted and requires regeneration with potassium permanganate

B. Incomplete iron oxidation during aeration, allowing dissolved iron to pass through the greensand filter and oxidize later in the clearwell and distribution system

C. The distribution system pipes are corroding and contributing iron to the water after treatment

D. The iron concentration in the raw water has decreased, causing the treatment process to over-oxidize the remaining iron

34. An operator tests a distribution system sample and obtains: pH 8.0, free chlorine 0.5 mg/L, total chlorine 0.5 mg/L. The system uses free chlorine for disinfection. The operator calculates the HOCl percentage at pH 8.0 using the equilibrium chart and finds approximately 22% HOCl and 78% OCl^-. Compared to pH 7.0 where approximately 75% is HOCl, the disinfection effectiveness at pH 8.0 is:

A. Significantly reduced because OCl^- is 80 to 100 times less effective as a disinfectant than HOCl

B. Unchanged because the total chlorine residual is the same regardless of the $HOCl/OCl^-$ ratio

C. Improved because OCl^- is more stable and provides longer-lasting protection in the distribution system

D. Irrelevant because the pH has no influence on chlorine chemistry or disinfection capability

35. A treatment plant's operator is reviewing the results of the annual well inspection for the plant's primary production well. The video inspection reveals a buildup of reddish-brown material on the well screen slots, reducing the open area by approximately 40%. The most likely composition of this material is:

A. Calcium carbonate scale from the precipitation of dissolved minerals on the screen surface

B. Biological growth (iron-oxidizing bacteria) that has colonized the screen surface

C. Iron oxide encrustation from the oxidation and precipitation of dissolved iron on the screen

D. Sediment from the aquifer that has been pulled through the screen and deposited on the surface

36. A treatment plant treats 4.0 MGD. The plant's daily operating report shows the following chemical usage: alum 850 lb/day, lime 200 lb/day, chlorine 120 lb/day, polymer 15 lb/day. The operator wants to verify the alum dose. Using the pounds formula in reverse: dose (mg/L) = lb/day ÷ (flow MGD × 8.34), the alum dose is:

A. 25.5 mg/L, which is lower than the expected dose and suggests the operator is under-dosing

B. 25.5 mg/L, calculated as 850 ÷ (4.0 × 8.34) = 850 ÷ 33.36 = 25.5 mg/L

C. 51.0 mg/L, calculated by multiplying rather than dividing in the formula

D. 212.5 mg/L, calculated by dividing only by the flow without the 8.34 conversion factor

37. A treatment plant's operator is troubleshooting a problem with the plant's lime slurry feed system. The operator observes that the lime slurry concentration varies significantly throughout the day — sometimes thick and white, sometimes thin and watery. The slaker appears to be operating normally. The most likely cause is:

A. The lime hopper above the slaker is bridging intermittently, delivering inconsistent amounts of dry lime to the slaker

B. The water supply to the slaker has temperature fluctuations that affect the lime's dissolution rate

C. The slaker's water supply pressure is cycling, causing variable water addition to the slaking chamber

D. Intermittent lime hopper bridging that periodically stops and starts the dry chemical flow into the slaker, producing inconsistent slurry

38. A confined space entry team is preparing to enter a wet well at a raw water pump station. The wet well is 15 feet deep and normally contains 6 feet of water. The well has been pumped down for the entry. Before entry, the operator should be aware that this type of space presents the highest risk for:

A. Toxic and asphyxiating atmospheres — wet wells commonly contain hydrogen sulfide from biological decomposition and may be oxygen-deficient from microbial activity in the stagnant water

B. High-voltage electrical hazards from the submersible pump motor connections inside the wet well

C. Structural collapse because wet wells are designed to contain water and may not support human weight when empty

D. UV radiation exposure from the sunlight reflecting off the wet well walls during daytime entries

39. A treatment plant's operator tests the finished water and obtains: pH 7.5, alkalinity 45 mg/L as $CaCO_3$, total hardness 55 mg/L as $CaCO_3$, calcium hardness 40 mg/L as $CaCO_3$. The magnesium hardness is:

A. 55 mg/L, which is the total hardness value representing both calcium and magnesium

B. 40 mg/L, which represents only the calcium fraction already separated in the testing

C. 15 mg/L, calculated by subtracting the calcium hardness (40) from the total hardness (55)

D. 95 mg/L, calculated by adding the total hardness and calcium hardness together

40. A treatment plant operator reviews the weekly generator test log and notices that the generator's engine oil pressure has been gradually declining from 65 psi to 48 psi over the past three months. The manufacturer's minimum acceptable oil pressure at operating speed is 45 psi. The operator should:

A. Take no action because the oil pressure is still above the manufacturer's minimum specification

B. Schedule an oil pressure investigation and service before the pressure drops below the minimum — check oil level, filter condition, oil viscosity, and potential bearing wear

C. Replace the oil pressure gauge because gradual decline always indicates gauge failure rather than actual pressure change

D. Increase the engine RPM during testing to maintain higher oil pressure through faster oil pump speed

41. A treatment plant using surface water feeds chlorine at 3.0 mg/L. The chlorine demand of the raw water is 2.2 mg/L measured at 30-minute contact time. The expected free chlorine residual after 30 minutes of contact is:

A. 3.0 mg/L because the full dose remains as residual after the demand is satisfied

B. 0.8 mg/L, calculated by subtracting the chlorine demand (2.2) from the applied dose (3.0)

C. 2.2 mg/L because the demand represents the amount of chlorine that remains available as residual

D. 5.2 mg/L, calculated by adding the dose and the demand together as the total chlorine in the water

42. A treatment plant's operator discovers that the automatic backwash initiation on Filter 3 has been triggered by the headloss alarm, but the backwash did not start because the backwash supply valve failed to open. The filter's headloss is now at 9.0 feet — 1.0 foot above the terminal headloss of 8.0 feet. The operator should:

A. Wait for the valve to open automatically on the next backwash attempt, which the PLC will retry in 15 minutes

B. Continue operating Filter 3 at the elevated headloss because exceeding terminal headloss by 1 foot is within tolerance

C. Increase the plant flow rate to force more water through Filter 3 and hydraulically push the accumulated particles through

D. Manually initiate the backwash sequence, verify the backwash valve opens, and investigate the valve failure before returning to automatic control

43. An operator at a groundwater treatment plant reviews the state's wellhead protection area map and discovers that a new cemetery has been established within Zone 2 (the five-year time-of-travel zone) of the plant's production well. The potential contamination concern from a cemetery within a wellhead protection area is:

A. Decomposition products, embalming chemicals, and pathogens from burial sites that may leach into the groundwater over time

B. Increased foot and vehicle traffic from visitors that compacts the soil and reduces groundwater recharge

C. Ornamental plantings that consume excessive groundwater through evapotranspiration and lower the water table

D. Noise from funeral services that may interfere with the well pump's electronic monitoring equipment

44. A treatment plant's operator measures the chlorine residual at the clearwell outlet and obtains: free chlorine 0.8 mg/L, total chlorine 1.2 mg/L. The plant uses free chlorine only — no ammonia is added. The 0.4 mg/L difference between total and free chlorine indicates:

A. The plant's chlorine gas cylinders are contaminated with ammonia from the supplier

B. An analytical error because free and total chlorine must always be equal when no ammonia is added

C. Combined chlorine has formed from naturally occurring ammonia or organic nitrogen compounds in the source water reacting with the applied chlorine

D. The total chlorine analyzer needs recalibration because total chlorine cannot exceed free chlorine

45. A treatment plant's filter performance data shows that Filter 1's effluent turbidity spikes to 0.30 NTU every time the filter returns to service after backwash, then drops to 0.04 NTU after approximately 20 minutes. The other three filters show post-backwash spikes of only 0.10 NTU that clear within 5 minutes. Filter 1's prolonged ripening most likely indicates:

A. The backwash rate for Filter 1 is too low, leaving residual particles that produce an extended turbidity spike

B. The backwash rate or duration for Filter 1 is too aggressive, stripping the protective coagulant coating from the media and requiring longer ripening to rebuild it

C. Filter 1 receives more flow than the other filters during the initial return-to-service period

D. The online turbidimeter on Filter 1 has a slower response time than the instruments on the other filters

46. A treatment plant is located in an area prone to flooding. The plant's emergency plan includes provisions for operating during a flood event. The most critical action item in the flood response plan is:

A. Increasing the chlorine dose to compensate for the flood-related increase in raw water contamination

B. Stockpiling additional filter media in case the existing media is damaged during the flood event

C. Ensuring adequate fuel supply for the emergency generator, since electrical power is commonly lost during floods

D. Protecting the plant's chemical storage, electrical systems, and SCADA equipment from floodwater inundation to maintain treatment capability

47. A treatment plant's operator receives a consumer complaint about water that "leaves white spots on dishes and glassware after they dry." The operator tests the customer's tap and finds hardness at 220 mg/L as $CaCO_3$ and TDS at 350 mg/L. The white spots are caused by:

A. Dissolved minerals (calcium, magnesium, and other salts) in the hard water that remain on surfaces as the water evaporates

B. Excess chlorine residual crystallizing on the glass surface during the drying process

C. Fluoride compounds precipitating from the water when exposed to the warm air inside the dishwasher

D. Silica dissolved in the water that polymerizes and hardens on surfaces during the evaporation process

48. A treatment plant treats 3.0 MGD from a lake source. The operator needs to calculate the daily sludge production if the plant removes 30 mg/L of suspended solids and 20 mg/L of alum floc (as

aluminum hydroxide) through coagulation and sedimentation. The total solids removed is 50 mg/L. The daily dry sludge production is:

A. 375 lb/day, calculated using only the suspended solids portion of the total removal

B. 250 lb/day, using an incorrect conversion factor of 4.17 instead of 8.34

C. 1,251 lb/day, calculated as 50 × 3.0 × 8.34

D. 750 lb/day, calculated using an incorrect factor of 5.0 instead of 8.34

49. An operator at a treatment plant using chloramine disinfection performs a distribution system survey and discovers that chloramine residuals at the farthest points in the system average 0.3 mg/L — below the plant's internal target of 0.5 mg/L but above the regulatory minimum. Nitrite levels at these locations are 0.02 mg/L — elevated above the normal 0.005 mg/L. These findings suggest:

A. The chloramine dose at the plant is too high, causing the monochloramine to break down into free chlorine

B. Early-stage nitrification is developing at the far reaches of the distribution system and warrants preventive action before the residual drops further

C. The DPD reagent at these monitoring locations has expired, producing falsely low chloramine readings

D. These readings are normal for the far end of a chloraminated distribution system and require no action

50. A treatment plant's operator is calibrating a pH meter. The operator immerses the electrode in pH 7.00 buffer and the meter reads 7.00. The operator then moves to pH 4.00 buffer and the meter reads 4.15. The operator should:

A. Accept the calibration because the deviation at pH 4.00 is within the ±0.5 unit tolerance for routine monitoring

B. Check the electrode condition (clean, properly stored, not expired) because a reading of 4.15 on a 4.00 buffer indicates the electrode slope has drifted

C. Adjust the meter to read 4.00 and proceed without investigating because this is a normal two-point calibration process

D. Verify the pH 4.00 buffer is fresh and not expired, then adjust the slope calibration — if the electrode cannot hold calibration after adjustment, it needs replacement

51. A treatment plant's operator is reviewing laboratory duplicate results for a hardness analysis. The first analysis reads 145 mg/L as $CaCO_3$ and the duplicate reads 152 mg/L as $CaCO_3$. The relative percent difference (RPD) between these duplicates is approximately:

A. 7 mg/L, which is the absolute difference but not the RPD percentage

B. 4.7%, which is within the typical ±10% acceptable RPD for hardness duplicates

C. 4.7%, calculated as $|145 - 152| \div [(145 + 152) \div 2] \times 100 = 7 \div 148.5 \times 100$

D. 9.4%, calculated by doubling the absolute difference and dividing by the average

52. A treatment plant treats 2.5 MGD from a surface water source. The raw water contains 4.5 mg/L TOC and 90 mg/L alkalinity as $CaCO_3$. The enhanced coagulation matrix requires 35% TOC removal for this TOC and alkalinity combination. The plant's current treatment removes 28% of the TOC. To reach 35% removal, the operator should:

A. Increase the coagulant dose and lower the coagulation pH to drive more aggressive NOM removal

B. Increase the chlorine dose to oxidize the remaining TOC in the finished water

C. Reduce the plant flow rate by 7% to proportionally increase the TOC removal percentage

D. Apply for an alternative compliance criterion because the plant cannot physically achieve higher removal

53. A treatment plant operator discovers that the plant's four sedimentation basins have been operating with the sludge withdrawal valves on Basin 2 completely closed for the past two weeks. The sludge has been accumulating without removal. The most likely consequence that has already developed or is imminent is:

A. Increased sludge compaction on the basin floor that will make the sludge easier to remove when the valves are finally opened

B. Reduced settled water turbidity because the thick sludge blanket acts as an additional filtration layer

C. The sludge blanket is at normal depth because sludge naturally compresses and does not accumulate beyond 2 feet

D. A rising sludge blanket that may reach the effluent weirs, causing sludge carryover into the filter influent and potentially septic conditions producing gas and floating sludge

54. An operator at a treatment plant using sodium hypochlorite discovers that the chemical feed pump's suction line has been drawing air intermittently — the day tank is low and the suction line entrance is periodically exposed. This air entrainment in the feed line will cause:

A. The pump to operate more efficiently because the air reduces the density of the fluid being pumped

B. Inconsistent chemical delivery — the pump alternates between pumping chemical and pumping air, producing erratic and unpredictable dosing

C. The chemical to become more concentrated because the air removes water through evaporation in the feed line

D. No operational impact because chemical metering pumps are designed to handle air without any change in performance

55. A treatment plant's operator reviews the plant's monthly turbidity compliance data and finds that 96.5% of the 15-minute CFE turbidity readings for the month were ≤ 0.3 NTU. The maximum single reading was 0.85 NTU. The compliance status is:

A. In compliance because 96.5% exceeds the 95% threshold and no reading exceeded 1.0 NTU

B. In violation because 96.5% is too close to the 95% threshold and the maximum reading of 0.85 NTU is concerning

C. In violation because the maximum reading of 0.85 NTU exceeds the absolute limit of 0.5 NTU

D. Unable to be determined without knowing the total number of readings collected during the month

56. A treatment plant's operator is evaluating the plant's water loss. The plant produced 120 million gallons during the past month. Total metered customer consumption was 100 million gallons. Backwash water usage was 5 million gallons. Other internal plant uses were 2 million gallons. The non-revenue water percentage is:

A. 10.8%, calculated as $(120 - 100 - 5 - 2) \div 120 \times 100 = 13 \div 120 \times 100 = 10.8\%$

B. 15%, calculated by subtracting only customer consumption from production

C. 10.8%, representing unaccounted-for water after all known uses are subtracted from total production

D. 16.7%, calculated by dividing the metered consumption by the total production

57. A treatment plant's operator notices that the plant's polymer feed system is producing visible "fish eyes" — small, undissolved polymer gel balls — in the polymer solution being fed to the rapid mix. This condition reduces the polymer's effectiveness because:

A. The gel balls are toxic and must not be introduced into the treatment process under any circumstances

B. Fish eyes indicate the polymer has chemically degraded and should be replaced with a fresh product

C. The undissolved gel balls pass through treatment without contributing to floc formation, wasting chemical

D. Undissolved polymer is not available for bridging and flocculation — the gel balls represent wasted chemical that does not contact particles effectively

58. An operator at a treatment plant receiving raw water from a well discovers that the well pump is cycling on and off every 45 seconds. The pressure tank bladder is suspected. Rapid cycling is harmful to the pump motor primarily because:

A. Each start cycle draws 5 to 7 times the normal running amperage, generating excessive heat in the motor windings — frequent cycling prevents adequate cooling between starts

B. The well pump cannot develop adequate discharge pressure during such short run times

C. The cycling creates water hammer in the discharge piping that damages the pump's internal components

D. Each start cycle reverses the motor's magnetic field polarity, which demagnetizes the stator over time

59. A treatment plant's source water assessment identifies a wastewater treatment plant that discharges treated effluent into the river 5 miles upstream of the drinking water intake. The finished effluent meets all NPDES discharge permit limits. However, the drinking water plant operator should monitor for which emerging concern related to this upstream discharge?

A. Elevated nitrate from the nutrient content of treated wastewater effluent entering the source water

B. Residual disinfection byproducts from the wastewater plant's chlorination process

C. Trace pharmaceuticals, personal care products, and endocrine-disrupting compounds that conventional wastewater treatment may not fully remove

D. Elevated turbidity from the suspended solids in the wastewater effluent increasing the drinking water plant's treatment burden

60. A treatment plant's operator is reviewing the annual water quality monitoring results for the Consumer Confidence Report. The report must include results for all detected regulated contaminants. A contaminant was detected at a level below the analytical method's reporting limit but above the detection limit. The operator should:

A. Report the contaminant as "not detected" because the result is below the reporting limit

B. Report the contaminant as detected at the estimated concentration between the detection limit and the reporting limit, following the state primacy agency's guidance on reporting detected-but-below-reporting-limit results

C. Report the contaminant at the detection limit value as the official concentration

D. Omit the contaminant from the CCR because results below the reporting limit are not considered valid

61. A treatment plant's SCADA system monitors the temperature of the main electrical transformer serving the plant. The SCADA trend shows the transformer temperature has increased from its normal 140°F to 175°F over the past week, despite no increase in the plant's electrical load. The operator should:

A. Reduce the plant's electrical load by shutting down non-critical equipment to lower the transformer temperature

B. Increase the cooling fan speed on the transformer to compensate for the elevated temperature

C. Take no action because transformer temperatures fluctuate with ambient air temperature and seasonal changes

D. Report the abnormal temperature rise for investigation — possible causes include failing cooling fans, blocked ventilation, internal winding insulation breakdown, or loose connections that generate heat

62. A treatment plant operator calculates that a rectangular sedimentation basin has a theoretical detention time of 4 hours. The basin's baffling factor has been determined through tracer testing at 0.3 (poor baffling). The T_{10} for the basin is:

A. 4 hours, because the baffling factor is only used for clearwell CT calculations, not for sedimentation basins

B. 1.2 hours (72 minutes), calculated by multiplying the theoretical detention time by the baffling factor

C. 2.0 hours, using a default baffling factor of 0.5 that applies to all treatment basins

D. 13.3 hours, calculated by dividing the theoretical detention time by the baffling factor

63. A treatment plant operator is troubleshooting high combined filter effluent turbidity (0.25 NTU) when all individual filter effluents read 0.04 to 0.06 NTU. The operator investigates and finds that the CFE turbidimeter's sample line draws from a point downstream of the filter effluent valves where a drain valve has been left partially open. This drain valve is:

A. Contributing filtered water to the wrong process stream, causing a flow imbalance between filters

B. Having no effect on the CFE turbidity reading because drain valves only discharge water, never admit it

C. Allowing unfiltered or partially treated water to enter the combined effluent line through the open drain, elevating the CFE turbidity above the individual filter readings

D. Reducing the CFE turbidity by diluting the combined effluent with clean water from the drain system

64. A treatment plant's operator is reviewing the results of the annual calibration of the plant's effluent flow meter. The calibration report shows the meter reads 3% higher than the reference standard at 50% of rated flow and 5% higher at 100% of rated flow. This systematic over-reading means:

A. All flow-dependent calculations — chemical dosing, detention time, CT, overflow rate, and filtration rate — have been based on slightly inflated flow values

B. The meter is within acceptable accuracy and no corrective action is needed

C. Only the CT calculation is affected because flow does not factor into chemical dosing or filtration rate

D. The plant has been under-producing water because the meter indicates more flow than actually occurs

65. A treatment plant's operator observes that the plant's four parallel flocculation basins produce different floc quality — Basin 1 and 2 produce large, dense floc while Basin 3 and 4 produce smaller, lighter floc. All four basins receive the same coagulated water from a common rapid mix. The operator checks the mixer speeds and finds: Basin 1 = 18 RPM, Basin 2 = 17 RPM, Basin 3 = 30 RPM, Basin 4 = 28 RPM. The difference in floc quality is caused by:

A. The rapid mix distributing coagulant unevenly between the four flocculation basins

B. Temperature differences between the four basins caused by their different physical locations in the plant

C. Varying raw water quality feeding each basin from different intake points in the source water

D. Basins 3 and 4 operating at excessive mixer speed — shearing the developing floc apart instead of allowing gentle aggregation

66. An operator at a treatment plant tests the hardness of the raw water at 280 mg/L as $CaCO_3$. The calcium hardness is 180 mg/L as $CaCO_3$. The operator needs to calculate the magnesium ion concentration in mg/L (not as $CaCO_3$). The magnesium hardness is 100 mg/L as $CaCO_3$. To convert from mg/L as $CaCO_3$ to mg/L as Mg, the operator divides by the conversion factor of 4.12. The magnesium concentration is:

A. 100 mg/L as Mg, using the hardness value directly without any conversion

B. 24.3 mg/L as Mg, calculated as 100 ÷ 4.12

C. 412 mg/L as Mg, calculated by multiplying instead of dividing by the conversion factor

D. 48.6 mg/L as Mg, using an incorrect conversion factor of 2.06

67. A treatment plant using conventional filtration performs a filter assessment and determines that Filter 2's unit filter run volume (UFRV) has declined from 8,000 gal/ft^2 to 5,200 gal/ft^2 over the past year. The other three filters maintain UFRV values between 7,500 and 8,500 gal/ft^2. This decline in Filter 2 indicates:

A. Improved filter performance because a lower UFRV means the filter captures more particles per unit area

B. The filter is loading faster and reaching terminal headloss sooner, likely due to media deterioration, mudball formation, or inadequate backwashing

C. Normal filter aging that affects all filters equally over time and requires no specific investigation

D. The plant's raw water quality has deteriorated, affecting only Filter 2 due to its position in the filter gallery

68. A treatment plant operator reviews a chemical supplier's Certificate of Analysis for a delivery of 12.5% sodium hypochlorite. The certificate states the following: available chlorine = 12.5%, specific gravity = 1.18, pH = 12.5, iron = 0.2 mg/L. The operator should verify that the available chlorine matches the contract specification because:

A. If the delivered product is weaker than specified, the plant's volumetric feed calculations will under-dose chlorine, and if stronger, the calculations will over-dose

B. The available chlorine percentage has no impact on the plant's treatment process because the feed pump compensates automatically

C. The Certificate of Analysis values are guaranteed to be accurate and never need verification by the operator

D. The iron content of 0.2 mg/L is the only value that matters because iron directly affects chlorine effectiveness

69. A treatment plant's operator is evaluating two options for upgrading the plant's disinfection system. Option A: Replace chlorine gas with on-site sodium hypochlorite generation. Option B: Replace chlorine gas with bulk sodium hypochlorite delivery. The primary advantage of on-site generation (Option A) over bulk delivery (Option B) is:

A. On-site generation produces chlorine gas as an intermediate product, maintaining the same safety risks as the current system

B. On-site generation produces unlimited quantities of sodium hypochlorite at zero chemical cost after installation

C. Bulk sodium hypochlorite is always fresher and more concentrated than on-site generated product

D. On-site generation produces fresh, low-concentration sodium hypochlorite daily, avoiding the strength degradation that occurs during storage and transport of bulk product

70. A treatment plant treats 3.0 MGD. The plant's clearwell has a volume of 500,000 gallons with average baffling (factor = 0.5). The chlorine residual at the outlet is 1.2 mg/L and the water temperature is 10°C. The CT required for 0.5-log Giardia inactivation at this temperature and pH 7.0 is 32 mg·min/L. The CT achieved is:

A. 72 mg·min/L, which does not meet the requirement and the plant must increase its chlorine dose

B. 144 mg·min/L, which exceeds the requirement by a comfortable margin

C. 120 mg·min/L, calculated without applying the baffling factor to the theoretical detention time

D. 288 mg·min/L, calculated by applying the baffling factor as a multiplier rather than correctly

71. A treatment plant operator observes that the settled water turbidity from Sedimentation Basin 1 has gradually increased from 0.7 NTU to 2.0 NTU over the past week. Basins 2, 3, and 4 continue to produce settled water at 0.7 to 0.8 NTU. The operator has verified that all four basins receive the same coagulated water and operate at the same flow rate. The operator should investigate Basin 1 for:

A. Short-circuiting from a damaged baffle, excessive sludge blanket depth, or a mechanical problem with the sludge removal system that is specific to Basin 1

B. A raw water quality change that is affecting only Basin 1 through a separate intake structure

C. A coagulant feed problem that delivers less chemical to Basin 1 than to the other three basins

D. An increase in the plant flow rate that hydraulically overloads Basin 1 before affecting the other basins

72. A treatment plant operator is investigating the cause of elevated copper levels (1.1 mg/L) at consumer taps in a new housing development. The homes were built 18 months ago with copper plumbing. The plant's finished water has pH 7.0, alkalinity 25 mg/L as $CaCO_3$, and a Langelier Saturation Index of −1.5. The most effective treatment strategy to reduce copper levels is:

A. Install corrosion-resistant liner in all distribution mains serving the development

B. Add a phosphate-based corrosion inhibitor to the finished water to form a protective film on the copper pipes

C. Raise the finished water pH and alkalinity to reduce the water's aggressiveness toward copper plumbing

D. Require the developer to replace all copper plumbing with PVC or PEX piping at the developer's expense

73. A treatment plant's operator tests the emergency generator under load. The generator starts, reaches rated speed and voltage, and the ATS transfers the plant loads. After 10 minutes of loaded operation, the operator notices that the engine exhaust stack is producing a steady stream of white smoke. White exhaust smoke most commonly indicates:

A. Normal condensation from a cold exhaust system that will clear within a few more minutes of operation

B. Excess fuel reaching the exhaust without combusting, indicating a fuel injection or timing problem

C. The engine air filter is dirty and restricting airflow to the combustion chambers

D. Coolant entering the combustion chambers through a failed head gasket, cracked cylinder head, or damaged cylinder liner

74. A treatment plant using conventional treatment has the following filter performance specifications: maximum individual filter effluent turbidity = 0.3 NTU (95% of the time), never to exceed 1.0 NTU, and the plant's internal goal is ≤ 0.10 NTU. Filter 3 has been producing effluent turbidity between 0.15 and 0.22 NTU for the past two weeks — technically within regulatory limits but well above the plant's internal goal. The operator should:

A. Accept the performance because Filter 3 meets all regulatory requirements and no violation has occurred

B. Investigate Filter 3 to identify why it consistently underperforms relative to the plant's optimization goal, because elevated turbidity within regulatory limits often indicates a developing problem

C. Shut down Filter 3 immediately because any reading above 0.10 NTU indicates imminent filter failure

D. Report the elevated readings to the state primacy agency as a potential violation of the turbidity standard

75. An operator tests the alkalinity of the plant's finished water using the titration method. The sample volume is 100 mL, the titrant is 0.02N sulfuric acid, and the volume of acid to reach the pH 4.5 endpoint is 9.0 mL. The total alkalinity is:

A. 90 mg/L as $CaCO_3$, calculated using the standard formula: $(9.0 \times 0.02 \times 50{,}000) \div 100$

B. 45 mg/L as $CaCO_3$, using an incorrect normality of 0.01N in the formula

C. 180 mg/L as $CaCO_3$, calculated by doubling the result due to a sample volume error

D. 9.0 mg/L as $CaCO_3$, using only the acid volume without the normality or conversion factor

76. A treatment plant's operator discovers that the plant's automatic chemical ordering system has been calculating sodium hypochlorite orders based on a 12.5% solution strength. However, the supplier switched to a 10% solution three months ago without notifying the plant. The practical impact of this discrepancy is:

A. The plant has been receiving adequate chemical supply because the automatic system overestimates consumption

B. The chlorine dose has been 20% lower than intended for three months because the weaker solution delivers less chlorine per gallon

C. The plant has been receiving less sodium hypochlorite than needed, potentially running short before the next scheduled delivery

D. No impact because the chemical metering pump compensates automatically for solution concentration changes

77. A treatment plant's operator calculates the flow-weighted average fluoride concentration from two wells operating simultaneously. Well A produces 600 gpm with 0.3 mg/L natural fluoride. Well B produces 400 gpm with 0.8 mg/L natural fluoride. The blended natural fluoride concentration is:

A. 0.55 mg/L, which is the simple average of the two fluoride concentrations

B. 0.50 mg/L, calculated as $[(600 \times 0.3) + (400 \times 0.8)] \div (600 + 400)$

C. 1.1 mg/L, calculated by adding the two fluoride concentrations together

D. 0.50 mg/L, which is the flow-weighted average of the two well contributions

78. A treatment plant's operator reviews the distribution system flushing program and discovers that a section of 4-inch cast iron main serving 25 homes has not been flushed in three years. The main is located in an area with historically low water demand. Complaints about discolored water from customers on this main have increased over the past six months. The most appropriate response is:

A. Replace the entire section of cast iron main with PVC to permanently resolve the discoloration

B. Conduct a unidirectional flushing program on the affected main and establish a regular flushing schedule to prevent future sediment accumulation

C. Increase the chlorine dose at the plant to compensate for the water quality problems in this specific area

D. Install a permanent blow-off valve at the end of the main and set it to discharge continuously at 5 gpm

79. A treatment plant's operator tests the plant's standby generator and discovers that the battery charger is not functioning — the starting batteries show 11.2 volts (fully charged = 12.6 volts for a 12V system). The generator starts on the first attempt during the test. However, the operator should be concerned because:

A. Partially discharged batteries may not reliably start the generator during an actual power outage, especially in cold weather when the engine is harder to crank

B. The generator started successfully, proving the batteries are adequate regardless of the charger status

C. Battery voltage below 12.0 volts automatically disables the automatic transfer switch

D. The low battery voltage will cause the generator to produce reduced output voltage under load

80. A treatment plant's operator is reviewing the plant's chemical storage practices and discovers that a pallet of calcium hypochlorite (tablets) is stored directly on a wooden pallet on a concrete floor. The chemical storage room is not climate-controlled and experiences temperatures ranging from 40°F to 95°F seasonally. The operator should be concerned about:

A. Calcium hypochlorite stored on wooden pallets at ambient temperatures poses a fire risk because the chemical is a strong oxidizer that can decompose exothermally

B. The tablets will absorb moisture from the concrete floor and dissolve into a liquid within days

C. The wooden pallet will absorb chlorine gas from the tablets and become toxic to any person who handles it

D. Calcium hypochlorite is a strong oxidizer that can react with organic materials like wood, especially at elevated temperatures — creating a fire or explosion hazard

81. A treatment plant's operator tests the finished water fluoride level and obtains a result of 0.85 mg/L. The target fluoride concentration is 0.7 mg/L. The fluoride MCL is 4.0 mg/L and the secondary standard is 2.0 mg/L. The operator should:

A. Reduce the fluoride feed rate slightly to bring the concentration closer to the 0.7 mg/L target, since 0.85 mg/L is above target but well below all regulatory limits

B. Issue Tier 1 public notification because the fluoride level exceeds the target by more than 20%

C. Shut down the fluoride feed system until the concentration drops to exactly 0.7 mg/L in the distribution system

D. Increase the fluoride feed rate because the target concentration is a minimum, not a midpoint

82. A treatment plant operator is investigating why one section of the distribution system consistently has lower chlorine residuals than adjacent areas served by the same transmission main. The operator discovers that the affected section has a 6-inch looped main while the adjacent areas are served by 12-inch mains. The smaller pipe diameter most likely contributes to lower residuals because:

A. The smaller pipe has a higher ratio of pipe wall surface area to water volume, increasing the proportion of water in contact with biofilm and corrosion products that consume chlorine

B. Smaller pipes always have higher water velocity that strips chlorine from the water through turbulent mixing

C. The 6-inch main has a shorter retention time than the 12-inch main, giving chlorine less time to dissolve

D. Smaller diameter pipes are made from different materials that chemically react with chlorine more aggressively

83. A treatment plant's operator is evaluating the cost-effectiveness of the plant's backwash program. Each filter backwash uses 80,000 gallons of treated water. The plant has four filters that are each backwashed once every 36 hours on average. The total daily backwash water usage as a percentage of the plant's 3.0 MGD production is approximately:

A. 1.5%, which is well below the industry guideline of 2% to 5% of total production

B. 3.6%, which is within the industry guideline of 2% to 5% for acceptable backwash water usage

C. 7.1%, which exceeds the guideline and warrants investigation of backwash efficiency

D. 10.7%, which is critically high and indicates the filters are being backwashed far too frequently

84. A treatment plant using chlorine gas for disinfection has two 150-pound cylinders on the active manifold and four cylinders in reserve storage. The plant consumes approximately 60 pounds of chlorine per day. The operator should schedule the next cylinder delivery to arrive before the total on-hand inventory drops below:

A. Three days of supply because delivery delays of one to two days are common

B. Five days of supply to account for potential weekend and holiday delivery delays

C. One day of supply because chemical suppliers guarantee next-day delivery

D. A minimum safety stock calculated as the delivery lead time (in days) plus two days for weather, supplier, and transportation delays, multiplied by the daily consumption rate

85. A treatment plant using surface water adds powdered activated carbon (PAC) seasonally for taste and odor control. The PAC is added at the raw water intake. An operator asks why the PAC is not added after filtration, closer to the clearwell, where it would be closer to the consumer. The reason PAC is added early in the treatment process is:

A. PAC requires maximum contact time with the water for effective adsorption, and early addition before coagulation, sedimentation, and filtration provides the longest contact before the spent PAC is removed

B. PAC must be removed from the water before it reaches the distribution system, and adding it before filtration ensures the filters capture and remove it

C. PAC chemically reacts with the coagulant to form a more effective floc for turbidity removal

D. Both A and B are correct — early addition maximizes contact time and ensures the spent PAC is physically removed by the downstream treatment processes

86. A treatment plant's operator reviews the distribution system pressure monitoring data and identifies one location where the pressure drops from 65 psi during low demand to 32 psi during peak demand — below the minimum recommended pressure of 35 psi. This low-pressure condition during peak demand:

A. Meets all requirements because the minimum applies only to static (no-flow) conditions in the system

B. Indicates the system is adequately sized because pressure fluctuations are normal during demand cycles

C. Creates a risk of backflow through cross-connections because low pressure reduces the system's ability to maintain a positive pressure barrier against external contamination sources

D. Cannot be corrected without completely replacing the distribution system piping in the affected area

87. A treatment plant's operator is investigating why the plant's polymer solution seems less effective than previous batches despite using the same product from the same supplier. The operator discovers that the polymer solution was mixed using the plant's hot water supply (140°F) instead of the recommended cold water. Mixing polymer in hot water is problematic because:

A. Hot water causes the polymer to dissolve too quickly, producing a solution with no active polymer chains

B. Excessive heat can degrade the polymer's molecular structure, reducing its ability to bridge between particles and form strong floc

C. Hot water produces a polymer solution that is too viscous to pump through the metering system

D. The heat causes the polymer to react with the mixing tank material, producing a contaminated solution

88. An operator at a treatment plant using conventional treatment notices that the filter influent (settled water) turbidity has been steady at 0.8 NTU for the past week, but the individual filter effluent turbidities have gradually increased from 0.03 NTU to 0.07 NTU on all four filters simultaneously. The backwash schedule has not changed. The most likely explanation is:

A. All four turbidimeters have drifted high simultaneously due to a common power supply or calibration standard issue

B. Normal filter aging that occurs equally across all filters in a plant during every operating cycle

C. A gradual shift in the sedimentation basin effluent from 0.8 NTU to a higher actual turbidity that the plant's online turbidimeter has not detected due to its own calibration drift

D. A subtle change in floc characteristics — potentially from water temperature change, chemical aging, or minor raw water chemistry variation — producing floc that passes through filter media more readily

89. A water treatment plant's operator is responsible for maintaining the plant's records. Under federal drinking water regulations, the minimum record retention period for sanitary survey reports is:

A. 10 years from the date of the sanitary survey or until the next survey is completed, whichever is longer

B. 5 years from the date of the most recent sanitary survey

C. 3 years, matching the standard retention period for routine operational data

D. Permanently — sanitary survey records must be retained for the life of the water system

90. A treatment plant's operator is evaluating whether the plant's CT compliance would be affected if the plant flow increases from 2.0 MGD to 2.5 MGD. The clearwell volume is 300,000 gallons with a baffling factor of 0.5. The chlorine residual is 1.0 mg/L. The current CT at 2.0 MGD and the projected CT at 2.5 MGD are:

A. Current: 108 mg·min/L; Projected: 86.4 mg·min/L — both exceeding the required CT

B. Current: 216 mg·min/L; Projected: 172.8 mg·min/L — calculated without applying the baffling factor

C. Current: 108 mg·min/L; Projected: 86.4 mg·min/L — a 20% decrease in CT that must be compared against the required value at current temperature and pH

D. Current: 54 mg·min/L; Projected: 43.2 mg·min/L — calculated using a baffling factor of 0.25

91. A treatment plant operator reviews the daily SCADA data and discovers that the raw water pH has dropped from 7.2 to 6.0 overnight. The raw water turbidity and alkalinity have not changed. The plant feeds alum at the dose determined by yesterday's jar test. The operator should:

A. Continue feeding at the current dose because the pH change will not affect alum coagulation performance

B. Increase the alum dose by 20% to compensate for the lower pH that reduces coagulant effectiveness

C. Immediately stop chemical feed until the raw water pH returns to 7.2 to prevent chemical waste

D. Perform a new jar test at the current pH of 6.0 because the optimal dose may have changed with the pH shift

92. A treatment plant's operator is evaluating two polymer products for use as a coagulant aid. Product A is an anionic polymer and Product B is a cationic polymer. When used with alum (which produces positively charged aluminum hydroxide species), the more effective coagulant aid for bridging between alum-destabilized particles is typically:

A. A cationic polymer that repels the positively charged floc particles, creating space for larger aggregates

B. An anionic polymer because the negative charges on the polymer backbone attach to the positively charged alum floc particles, creating bridges between them

C. Neither polymer type is effective with alum because polymers and metal salt coagulants are chemically incompatible

D. Product selection is random because polymer charge type has no relationship to coagulation chemistry

93. A treatment plant operator calculates the volume of a cylindrical chemical mixing tank: diameter 4 feet, height 6 feet. Using $V = \pi \times r^2 \times h$ and converting to gallons ($1\ ft^3 = 7.48$ gallons), the volume is approximately:

A. 564 gallons, calculated as $\pi \times 2^2 \times 6 \times 7.48 = 3.14159 \times 4 \times 6 \times 7.48$

B. 141 gallons, using the diameter instead of the radius in the formula

C. 282 gallons, using the radius correctly but an incorrect conversion factor

D. 1,128 gallons, calculated using the diameter squared instead of the radius squared

94. A treatment plant's operator is monitoring the performance of a new UV disinfection system that was commissioned last month. The UV system has four lamps per reactor and two reactors in parallel. The UV dose sensor reads 42 mJ/cm^2 — above the validated minimum of 40 mJ/cm^2. The UVT of the filtered water is 88%. The operator should also verify:

A. That the UV lamps have been operating for at least 100 hours before trusting the sensor readings

B. That the flow rate through each reactor matches the validated flow conditions used during bioassay testing

C. That the UV system is producing a chlorine residual sufficient for distribution system protection

D. That the UVT measurement is taken from the raw water rather than the filtered water

95. A treatment plant's operator reviews the plant's historical data and identifies that the optimal alum dose has been gradually increasing by approximately 2 mg/L per month for the past six months — from 25 mg/L to 37 mg/L — despite relatively stable raw water turbidity of 8 to 12 NTU. The operator should investigate:

A. Whether the alum supplier has changed the product formulation, reducing the aluminum content per gallon

B. Whether the laboratory jar test procedure has drifted, producing increasingly higher optimal dose determinations

C. Whether the raw water's organic content, alkalinity, or other chemical characteristics have changed in ways that increase coagulant demand beyond what turbidity alone indicates

D. All of the above — product quality, testing procedure, and source water chemistry should all be investigated systematically to identify the root cause

96. A treatment plant operator discovers that the plant's emergency contact list posted in the control room lists "911" as the only emergency number. The operator should:

A. The list is adequate because 911 dispatches all necessary emergency services

B. Update the list to include direct phone numbers for the state primacy agency, poison control center, chemical emergency (CHEMTREC), plant supervisor, on-call operator, local health department, and utility management

C. Add only the plant supervisor's phone number because all other notifications are the supervisor's responsibility

D. Remove the list entirely because all emergency numbers are now programmed into the SCADA auto-dialer

97. A treatment plant operator reviews the following sequence of events: (1) the online CFE turbidimeter reads 0.04 NTU, (2) the operator collects a grab sample and reads 0.04 NTU on the laboratory turbidimeter, (3) the operator notes that the CFE turbidimeter sample flow rate indicator shows zero flow, (4) the operator restores sample flow and the online reading jumps to 0.15 NTU. This sequence indicates:

A. The online turbidimeter had been reading stagnant sample water that did not represent current filter performance — the 0.15 NTU is the actual current CFE turbidity

B. The 0.04 NTU reading was correct and the 0.15 NTU reading is an artifact caused by restarting the sample flow

C. Both readings are equally valid and should be averaged for compliance reporting purposes

D. The laboratory turbidimeter confirmed the 0.04 NTU, making the online reading of 0.15 NTU irrelevant

98. A treatment plant's operator is evaluating the plant's compliance with the Stage 2 D/DBPR. The quarterly THM results at Distribution Location #2 for the past four quarters are: Q1 = 0.058, Q2 = 0.095, Q3 = 0.102, Q4 = 0.065 mg/L. The LRAA at this location is:

A. 0.102 mg/L, using only the highest quarterly result as the compliance value

B. 0.058 mg/L, using only the lowest quarterly result for the most favorable compliance position

C. 0.080 mg/L, which exactly equals the MCL — the system is at the compliance boundary

D. 0.320 mg/L, calculated by summing all four quarterly results without dividing

99. A treatment plant's operator is preparing for the annual state sanitary survey. The survey will evaluate the plant's treatment processes, distribution system, monitoring program, management and operations, and operator compliance. To prepare effectively, the operator should:

A. Hire an outside consultant to prepare a comprehensive presentation for the survey team

B. Renovate the plant entrance, landscaping, and signage to create a positive first impression

C. Close the plant to visitors during the survey week to minimize disruptions to the inspection process

D. Ensure all operational records are organized and accessible, verify SOPs are current, confirm all required monitoring is up to date, review previous survey findings for unresolved issues, and brief all staff on the survey process

100. A treatment plant's operator reviews the plant's monthly production data and calculates the following efficiency metrics: plant availability = 99.5%, filter utilization = 87%, chemical cost per million gallons = $285, energy cost per million gallons = $420, and non-revenue water = 14%. Of these metrics, which one most directly indicates a potential area for operational improvement?

A. Plant availability at 99.5%, which exceeds the industry target but indicates 0.5% downtime that should be eliminated

B. Non-revenue water at 14%, which is at the upper end of the acceptable range and suggests the system may have significant undetected leaks, metering issues, or unaccounted water uses

C. Chemical cost at $285/MG, which cannot be evaluated without comparing to similar plants treating similar water

D. Filter utilization at 87%, which could indicate either efficient scheduling or insufficient filter capacity

Practice Exam 9: Answer Key and Explanations

1. A — Without lime supplementation, remaining alkalinity = 45 − 20 = 25 mg/L as $CaCO_3$. While 25 mg/L provides some buffering, it is marginal — the pH may be unstable and approaching the lower boundary of the effective coagulation range. The operator should monitor pH closely and refill the lime day tank immediately to restore the alkalinity supplement.

2. C — A progressive, daily decline in distribution system residual while the plant effluent remains constant indicates an increasing chlorine demand developing between the plant and the monitoring point. Biofilm growth, a slow leak introducing organic material, or a cross-connection drawing contaminated water into the main would produce this worsening pattern.

3. B — Color in water is caused by dissolved natural organic matter (NOM) that requires different coagulation conditions than turbidity removal. Lower pH and higher alum doses favor enhanced coagulation, which targets NOM removal through charge neutralization and adsorption onto aluminum hydroxide floc. Additional jar testing at varied pH values optimizes this process.

4. D — The chlorine residual control system has detected a genuine low residual (0.1 mg/L versus normal 1.0 mg/L) and is responding correctly by driving the chlorinator to maximum output. The operator must investigate why the residual dropped — possible causes include an empty gas cylinder, a failed injector, increased chlorine demand from raw water changes, or a feed system malfunction.

5. B — Finished water at pH 6.5 (instead of the target 7.5) is significantly more aggressive toward pipe materials than properly pH-adjusted water. Six hours of corrosive water entering the distribution system accelerates the dissolution of lead, copper, and iron from pipes and plumbing, potentially causing action level exceedances and consumer complaints.

6. A — Constant motor amperage, speed, and suction conditions with declining discharge pressure indicate the pump is spinning normally but transferring less energy to the water. Progressive impeller wear from erosion, corrosion, or abrasive particles is the most common cause — the worn impeller produces less head per revolution.

7. D — A method blank reading of 0.08 NTU exceeding the 0.05 NTU limit indicates contamination was introduced somewhere in the analytical process. All sample results from this batch are suspect because the contamination may have affected them equally. The operator must identify and eliminate the contamination source before reprocessing samples.

8. C — Fine sand on top of anthracite indicates the backwash was excessively aggressive — the high flow rate lifted the fine sand particles above the heavier anthracite during expansion. When the backwash stopped, the sand settled on top of the anthracite instead of beneath it, disrupting the designed dual-media stratification.

9. B — Before launching a full process investigation, the operator should verify that Basin 3's turbidimeter is calibrated and functioning correctly. A single instrument reading 3.2 NTU while three others read 0.7–0.9 NTU could be an instrument problem rather than a basin problem. Confirming the reading with a grab sample eliminates or confirms the instrument as the cause.

10. D — lb/day Cl_2 = 2.5 × 4.0 × 8.34 = 83.4 lb/day of pure chlorine. Since calcium hypochlorite is 65% available chlorine: 83.4 ÷ 0.65 = 128.3 lb/day of calcium hypochlorite product. The purity factor accounts for the fact that only 65% of each pound of product is active chlorine.

11. A — Natural gas generators connected to the utility gas supply have an effectively unlimited fuel source — as long as gas pressure is maintained, the generator can run indefinitely without refueling. Diesel generators are limited by their on-site fuel tank capacity and require refueling during extended outages.

12. C — When total hardness (95 mg/L) is less than alkalinity (110 mg/L), all of the hardness is associated with carbonate and bicarbonate ions — making it entirely carbonate hardness. Non-carbonate hardness only exists when total hardness exceeds alkalinity. The "excess" alkalinity (15 mg/L) is associated with sodium or potassium rather than calcium or magnesium.

13. B — Filter 4 developing headloss at twice the rate of the other three filters — all receiving the same water at the same rate — indicates a filter-specific condition. Possible causes include media loss,

mudball formation, inadequate previous backwash, or an underdrain problem that concentrates flow through a smaller effective area.

14. D — Chlorine demand = Applied dose − Residual = 3.5 − 2.0 = 1.5 mg/L. This 1.5 mg/L represents the chlorine consumed by reactions with organic matter, ammonia, iron, manganese, and other chlorine-demanding substances as the water travels from the addition point through sedimentation to the clearwell outlet.

15. A — Impervious surfaces prevent rainfall from infiltrating the soil (natural filtration) and instead generate rapid stormwater runoff that carries pollutants directly into receiving waters. This runoff transports sediment, petroleum products, fertilizers, pesticides, animal waste, and other contaminants at higher volumes and velocities than undeveloped land.

16. C — When two level indicators disagree, neither should be trusted until the actual level is verified independently. A manual measurement (dipstick, weighted tape, or calibrated sight tube) establishes the true level, allowing the operator to determine which instrument needs calibration and ensuring accurate inventory tracking.

17. B — Proper bacteriological sampling technique requires a specific sequence: select an approved location, remove the faucet aerator (which can harbor bacteria), disinfect the tap outlet with sodium hypochlorite or flame, flush the tap for the required duration (typically 2–3 minutes), then collect the sample in a sterile bottle. Skipping any step risks contaminating the sample.

18. D — A pH drop from 7.2 to 5.8 indicates the raw water's natural alkalinity (60 mg/L) cannot adequately buffer the acid produced by ferric chloride hydrolysis. Adding lime or soda ash before or during coagulant addition supplements the alkalinity, maintaining pH within the effective coagulation range for ferric chloride (typically 4.0–9.0, optimal near 5.5–7.0).

19. A — In a chloraminated system, "fishy" or objectionable chemical tastes at a specific location often indicate localized formation of dichloramine or trichloramine — which produce much stronger off-tastes than monochloramine. This can occur when the local chlorine-to-ammonia ratio shifts due to nitrification, varying ammonia concentrations, or breakpoint conditions at that location.

20. B — Flow per filter = 3,000 ÷ 3 = 1,000 gpm. Filtration rate = 1,000 ÷ 200 = 5.0 gpm/ft^2. This rate is at the upper end of the typical 2–6 gpm/ft^2 range for rapid gravity filters and may cause faster headloss

development, shorter filter runs, and potential effluent quality degradation compared to the normal 3.75 gpm/ft^2 with all four filters online.

21. C — DT = 750,000 ÷ 3,472 gpm (5.0 MGD) = 216 min. T_{10} = 216 × 0.5 = 108 min. Required C = CT ÷ T_{10} = 120 ÷ 108 = 1.11 mg/L. Rounding up to 1.33 mg/L provides a safety margin. (Note: The precise minimum residual is 1.11 mg/L; option C at 1.33 mg/L provides a comfortable compliance buffer.)

22. D — When one filter consistently develops headloss faster than identical filters receiving the same water at the same rate, the problem is specific to that filter. Media loss, mudballs, channeling, inadequate backwash effectiveness, or underdrain problems cause faster loading by reducing the effective filtration capacity within that specific filter.

23. A — The scale reads the total (gross) weight of the cylinder including both the chlorine and the empty cylinder (tare weight). A 150-pound chlorine cylinder has a tare weight of approximately 72 pounds. Remaining chlorine = Gross weight − Tare weight = 148 − 72 = 76 pounds of chlorine remaining. Operators must subtract tare weight to determine actual chemical inventory.

24. B — The plant removed only 0.10 mg/L of the 0.45 mg/L manganese (22% removal), leaving 0.35 mg/L in the finished water — seven times the 0.05 mg/L secondary standard. Aeration alone may not effectively oxidize manganese at the water's natural pH because manganese requires a higher pH or a stronger oxidant (permanganate, chlorine dioxide) than iron for complete oxidation.

25. D — VFDs reduce pump speed to match actual demand. The affinity law states that pump power consumption varies with the cube of the speed ratio (Power $\propto$ $Speed^3$). A pump running at 80% speed consumes only 51% of full-speed power. This cubic relationship is why even small speed reductions produce dramatic energy savings — far more effective than throttling at full speed.

26. C — A 15-second response time means there is a 15-second delay between when the atmospheric conditions change and when the monitor displays the updated reading. If the entrant moves into a pocket of toxic gas, the monitor will not alarm until 15 seconds after exposure begins. This lag must be factored into safe work practices and response procedures.

27. A — Ammonia dose = Chlorine dose ÷ Ratio = 3.0 ÷ 4.5 = 0.67 mg/L as nitrogen. This ensures the correct proportion of ammonia relative to chlorine to favor monochloramine formation while minimizing excess free ammonia that could promote nitrification in the distribution system.

28. D — Turbidity removal = (Raw − Settled) ÷ Raw × 100 = (25 − 1.5) ÷ 25 × 100 = 23.5 ÷ 25 × 100 = 94%. This excellent removal percentage indicates effective coagulation, flocculation, and sedimentation performance, reducing the particle load on the downstream filters by over 90%.

29. B — Sodium hypochlorite solutions can freeze at temperatures around 25°F to 30°F depending on concentration. Frozen chemical in a transfer line can crack or rupture the piping, and temperature cycling accelerates chemical degradation. The operator should check for line damage, drain any remaining chemical, and implement a procedure to flush and drain transfer lines after every delivery.

30. A — Surface area = $\pi \times r^2 = \pi \times 30^2 = 2{,}827\ ft^2$. Overflow rate = 2,000,000 gpd ÷ 2,827 ft^2 = 707 gpd/ft^2. This rate is within the typical design range for circular clarifiers and indicates the basin has adequate settling capacity at the current flow rate.

31. C — Rising bromate approaching the 0.010 mg/L MCL with simultaneously rising source water bromide is a direct cause-and-effect relationship. Reducing the ozone dose or contact time decreases bromate formation, but the operator must ensure alternative disinfection (UV for Cryptosporidium, chlorine for CT) compensates for the reduced ozone contribution.

32. D — A 22% cost increase with stable flow and turbidity, and no supplier price change, could have multiple causes. Chemical degradation (weaker hypochlorite requiring more volume), operator dose creep (gradually increasing doses without jar test verification), and flow meter error (under-reading, causing higher actual flow) should all be investigated systematically.

33. B — Orange-brown staining in the clearwell and distribution system despite the greensand filter indicates dissolved iron is passing through treatment without being fully oxidized and captured. The aeration system may be undersized, the contact time insufficient, or the pH too low for complete iron oxidation — allowing dissolved ferrous iron to pass through the filter and oxidize downstream.

34. A — At pH 8.0, only 22% of the free chlorine exists as HOCl (the strong disinfectant form) compared to 75% at pH 7.0. Since OCl^- is 80 to 100 times less effective than HOCl, the same 0.5 mg/L residual provides dramatically less disinfection capability at pH 8.0. The CT tables reflect this by requiring higher CT values at higher pH.

35. C — Reddish-brown encrustation on well screen slots in a groundwater system with elevated iron is most commonly iron oxide — dissolved ferrous iron in the aquifer oxidizes at the screen surface where

it contacts slightly more oxygenated conditions, precipitating as insoluble ferric oxide that progressively reduces the screen's open area and the well's specific capacity.

36. B — Dose = lb/day ÷ (Flow × 8.34) = 850 ÷ (4.0 × 8.34) = 850 ÷ 33.36 = 25.5 mg/L. This reverse calculation is useful for verifying chemical feed rates against jar test results and for confirming that the feed system is delivering the intended dose based on actual chemical consumption records.

37. D — Intermittent lime hopper bridging is the most common cause of variable slurry concentration from an otherwise normally operating slaker. The bridge forms an arch over the feeder, stopping dry lime flow. When the bridge collapses (from vibration, gravity, or the weight of lime above), a slug of lime drops into the slaker, producing alternating thick and thin slurry.

38. A — Wet wells at pump stations are among the most hazardous confined spaces in water treatment. Biological decomposition of organic matter in the stagnant water produces hydrogen sulfide (toxic at >10 ppm, immediately dangerous at >100 ppm), and microbial oxygen consumption can create oxygen-deficient atmospheres. H_2S is the leading cause of confined space fatalities in the water industry.

39. C — Magnesium hardness = Total hardness − Calcium hardness = 55 − 40 = 15 mg/L as $CaCO_3$. This simple subtraction separates the two components of total hardness, which is useful for understanding the water's chemical characteristics and for calculating the Langelier Saturation Index (which uses calcium hardness specifically).

40. B — A gradual decline from 65 to 48 psi over three months — approaching the 45 psi minimum — indicates a developing problem that will soon reach a critical threshold. The operator should investigate while the engine is still operational: check oil level, inspect the oil filter for restriction, verify oil viscosity, and evaluate bearing condition before the pressure drops below minimum.

41. B — Expected residual = Applied dose − Chlorine demand = 3.0 − 2.2 = 0.8 mg/L. The chlorine demand represents the amount consumed by reactions with substances in the water. The remaining 0.8 mg/L is the free chlorine residual available for ongoing disinfection in the clearwell and distribution system.

42. D — A filter at 9.0 feet headloss (above terminal) with a stuck backwash valve needs immediate manual intervention. The operator should manually open the backwash valve (or use the manual override), complete the backwash sequence, and then investigate the valve failure — a stuck solenoid, seized actuator, or PLC output fault — before returning to automatic control.

43. A — Cemeteries within wellhead protection areas present legitimate groundwater contamination concerns. Decomposition products, formaldehyde and other embalming chemicals, heavy metals from caskets, and potentially pathogenic organisms can leach through soil into the aquifer over time, particularly in areas with shallow water tables or permeable soils.

44. C — In a system using only free chlorine (no ammonia addition), a 0.4 mg/L difference between total and free chlorine indicates that combined chlorine (chloramines) has formed from naturally occurring ammonia or organic nitrogen in the source water reacting with the applied chlorine. This is a normal phenomenon in many surface water sources.

45. B — An aggressive backwash strips the beneficial coagulant coating from the media surface — this coating helps particles attach during filtration. Without it, the filter must rebuild the coating during the ripening period, which takes longer with a completely stripped bed than with a bed that retains some coating. The other filters, backwashed less aggressively, retain more coating and ripen faster.

46. D — During a flood, the greatest threat to continued plant operation is the inundation of critical infrastructure — chemical storage (causing spills and loss of treatment chemicals), electrical systems (causing power loss and equipment damage), and SCADA equipment (causing loss of process monitoring and control). Protecting these systems is the priority for maintaining treatment capability.

47. A — Hard water (220 mg/L) contains dissolved calcium, magnesium, and other minerals. When the water evaporates from dishes, glasses, and other surfaces, the dissolved minerals are left behind as a white, chalky residue. The higher the hardness, the more pronounced the spotting. Water softening or rinse agents are the most effective solutions for the consumer.

48. C — Total dry sludge = 50 mg/L × 3.0 MGD × 8.34 = 1,251 lb/day. This includes both the raw water suspended solids removed (30 mg/L × flow × 8.34 = 751 lb) and the alum floc generated during coagulation (20 mg/L × flow × 8.34 = 500 lb). Both contribute to the total sludge mass requiring handling and disposal.

49. B — Declining chloramine residual (0.3 vs. 0.5 target) with simultaneously elevated nitrite (0.02 vs. 0.005 normal) at the far reaches of the system is the early signature of a developing nitrification episode. Nitrifying bacteria are converting ammonia to nitrite while consuming the chloramine residual. Preventive action now — flushing, residual boosting — can arrest the process before it worsens.

50. D — A pH 7.00 buffer reading correctly but a pH 4.00 buffer reading 4.15 indicates the electrode slope has drifted. Before adjusting, the operator should verify the pH 4.00 buffer is fresh and not expired (buffers degrade over time). If the buffer is confirmed good, the slope calibration should be adjusted. If the electrode cannot hold calibration after adjustment, it needs replacement.

51. C — RPD = |145 − 152| ÷ [(145 + 152) ÷ 2] × 100 = 7 ÷ 148.5 × 100 = 4.71%, approximately 4.7%. This is well within the typical ±10% acceptable RPD for hardness duplicates, indicating good precision in the sampling and analytical process.

52. A — The plant is achieving 28% TOC removal but needs 35%. The most direct approach is to increase the coagulant dose and lower the coagulation pH to drive more aggressive NOM adsorption onto the aluminum hydroxide floc. Enhanced coagulation specifically targets NOM removal through optimized pH and dose — the regulatory mechanism designed for this exact situation.

53. D — Two weeks without sludge withdrawal from Basin 2 means the sludge blanket has been rising continuously. Depending on the plant's loading, the blanket may have already reached the effluent weirs, causing sludge carryover. Additionally, anaerobic conditions in the compacted bottom sludge produce gases (methane, H_2S) that float sludge to the surface.

54. B — Air entrainment in the suction line causes the pump to alternate between pumping chemical and pumping air — each stroke may deliver a full dose, a partial dose, or no dose depending on whether the suction line is drawing chemical or air at that moment. This erratic delivery produces unpredictable and potentially dangerous dosing fluctuations.

55. A — With 96.5% of readings ≤ 0.3 NTU (exceeding the 95% minimum) and a maximum reading of 0.85 NTU (below the 1.0 NTU never-to-exceed limit), the plant is in full compliance with both turbidity requirements. Both criteria must be met simultaneously for compliance.

56. C — Unaccounted water = 120 − 100 − 5 − 2 = 13 million gallons. Percentage = 13 ÷ 120 × 100 = 10.8%. This unaccounted-for water represents system losses, unmetered uses, and metering inaccuracies. At 10.8%, it falls at the upper end of the typical range and warrants investigation for leak detection and meter verification.

57. D — Fish eyes are undissolved polymer gel balls that form when polymer powder is added too quickly, contacts other polymer particles before hydrating, or is mixed at inadequate speed. These gel

balls do not dissolve during treatment and cannot contact or bridge between floc particles effectively — they pass through treatment as wasted chemical.

58. A — Each motor start draws 5 to 7 times the normal running amperage (inrush current). This massive current surge generates intense heat in the motor windings. With only 45 seconds between cycles, the motor cannot dissipate the heat from one start before the next start adds more. Repeated thermal stress degrades winding insulation and leads to premature motor failure.

59. C — Trace pharmaceuticals, personal care products, and endocrine-disrupting compounds are emerging contaminants that conventional wastewater treatment does not fully remove. These compounds pass through the wastewater plant and enter the receiving water at ng/L to μg/L concentrations. While not currently regulated, they represent a growing concern for drinking water treatment.

60. B — The reporting of detected-but-below-reporting-limit results varies by state and parameter. The operator should follow the state primacy agency's specific guidance, which may require reporting the estimated concentration, using a "J" qualifier flag, or noting "detected below reporting limit." The key is transparency — consumers should know the contaminant was detected.

61. D — An abnormal temperature rise in a transformer with no load increase indicates an internal or external cooling problem. Possible causes include failing cooling fans, blocked air vents, loose internal connections generating resistive heat, or developing insulation breakdown. Any of these conditions can lead to transformer failure if not investigated and corrected.

62. B — T_{10} = Theoretical DT × Baffling factor = 4 hours × 0.3 = 1.2 hours (72 minutes). The baffling factor accounts for short-circuiting — with poor baffling, much of the water passes through the basin faster than the theoretical detention time, reducing the effective contact time to only 30% of the theoretical value.

63. C — An open drain valve in the combined effluent line creates a pathway for unfiltered or partially treated water to enter the line from the drain system. This contamination raises the CFE turbidity above the individual filter effluent readings. The valve must be closed immediately, and the operator should evaluate whether the elevated CFE readings affected compliance data.

64. A — A flow meter reading 3–5% high means all flow-dependent calculations have used an inflated flow value. Chemical dosing calculated from this flow would over-feed (higher cost, more sludge).

Detention times and CT values would be underestimated (more conservative, but masking actual available contact time). Overflow rates and filtration rates would be overestimated.

65. D — Basins 3 and 4 (at 28–30 RPM) are operating at excessive mixing speed compared to Basins 1 and 2 (17–18 RPM). The higher energy input creates shear forces that break apart the floc aggregates forming during gentle mixing, producing smaller, weaker particles that settle poorly. Reducing the mixer speed in Basins 3 and 4 to match Basins 1 and 2 should resolve the issue.

66. B — Magnesium hardness = Total hardness − Calcium hardness = 280 − 180 = 100 mg/L as $CaCO_3$. Converting to mg/L as Mg: 100 ÷ 4.12 = 24.3 mg/L. The conversion factor (4.12) accounts for the difference in equivalent weights between $CaCO_3$ and magnesium.

67. C — Declining UFRV specific to one filter while others maintain their values indicates that filter is loading faster and reaching terminal headloss sooner. Media deterioration, mudball formation, reduced effective bed depth, or inadequate backwash are the most common causes of declining UFRV. The condition reduces the plant's effective production capacity and increases backwash water consumption.

68. A — If the delivered product is weaker than the contract specification (e.g., 10% instead of 12.5%), the plant's feed calculations will under-dose chlorine because they assume each gallon delivers more active chlorine than it actually contains. If stronger, the calculations over-dose. Verifying the certificate of analysis against the contract specification prevents dosing errors.

69. D — On-site sodium hypochlorite generation produces fresh, low-concentration (0.8%) solution daily from salt, water, and electricity. This fresh solution avoids the significant degradation that occurs during the manufacturing, transport, and storage of bulk 12.5% solution — which can lose 10% or more of its strength within weeks under warm storage conditions.

70. B — DT = 500,000 ÷ 2,083 gpm (3.0 MGD) = 240 min. T_{10} = 240 × 0.5 = 120 min. CT = 1.2 × 120 = 144 mg·min/L. The achieved CT of 144 mg·min/L is 4.5 times the required 32 mg·min/L for 0.5-log Giardia inactivation, providing a very comfortable compliance margin.

71. A — When one basin progressively deteriorates while the other three remain stable — all receiving the same water at the same rate — the problem is specific to Basin 1. Short-circuiting (from baffle damage), a rising sludge blanket (from a failed scraper or clogged withdrawal), or a specific mechanical problem are the most likely causes.

72. C — An LSI of −1.5 indicates highly aggressive water. The low pH (7.0), low alkalinity (25 mg/L), and resulting negative LSI are dissolving copper from the new plumbing. Raising pH and alkalinity reduces the water's aggressiveness and promotes the formation of protective mineral films inside the copper pipes.

73. D — White exhaust smoke (actually steam) after 10 minutes of loaded operation — well past the normal warm-up condensation period — indicates engine coolant is entering the combustion chambers. The most common cause is a failed head gasket, cracked cylinder head, or damaged cylinder liner that allows coolant to leak into the cylinders where it vaporizes during combustion.

74. B — Filter 3's consistent 0.15–0.22 NTU is technically compliant but represents performance 3 to 5 times worse than the plant's achievable 0.04–0.06 NTU. Operating within regulatory limits while significantly above achievable performance often indicates a developing problem — media loss, mudballs, or backwash issues — that will eventually escalate if not investigated.

75. A — Alkalinity = (mL acid × N × 50,000) ÷ mL sample = (9.0 × 0.02 × 50,000) ÷ 100 = 9,000 ÷ 100 = 90 mg/L as $CaCO_3$. This standard calculation is the most frequently tested laboratory procedure on the WPI Class I certification exam.

76. C — If the ordering system calculates based on 12.5% but the actual product is 10%, each delivery contains 20% less available chlorine per gallon than the system assumes. The plant may run out of chemical before the next scheduled delivery because consumption (in gallons) is higher than projected to deliver the same chlorine dose.

77. D — Blended fluoride = [(600 × 0.3) + (400 × 0.8)] ÷ (600 + 400) = (180 + 320) ÷ 1,000 = 500 ÷ 1,000 = 0.50 mg/L. The flow-weighted average accounts for each well's proportional contribution. The supplemental fluoride dose would be the target (0.7) minus this blended background (0.50) = 0.20 mg/L.

78. B — A dead-end main unflushed for three years with increasing discoloration complaints requires unidirectional flushing to physically remove accumulated sediment, corrosion products, and biofilm. Establishing a regular flushing schedule (typically annually or semi-annually for dead-end mains) prevents future accumulation and maintains water quality.

79. A — Starting batteries at 11.2 volts (89% of full charge) started the engine under test conditions but may not provide sufficient cranking power during an actual emergency — especially in cold weather

when engine oil is thicker and batteries deliver less current. The battery charger must be repaired and the batteries restored to full charge to ensure reliable emergency starting.

80. D — Calcium hypochlorite is a strong oxidizer that can react exothermally with organic materials including wood, paper, cloth, grease, and certain plastics. At elevated temperatures (especially above 80°F), the risk of self-decomposition increases. Storing calcium hypochlorite on wooden pallets in a hot room combines a strong oxidizer with organic fuel — a recognized fire hazard.

81. A — At 0.85 mg/L, fluoride is slightly above the 0.7 mg/L target but well below both the secondary standard (2.0 mg/L) and the MCL (4.0 mg/L). The appropriate response is a minor feed rate reduction to bring the concentration back to target. No violation has occurred and no public notification is required.

82. C — Smaller diameter pipes have a higher surface-area-to-volume ratio than larger pipes. This means a greater proportion of the water in the 6-inch main is in direct contact with the pipe wall — where biofilm, corrosion products, and sediment consume chlorine. The increased proportional contact accelerates residual depletion compared to larger mains carrying the same water.

83. B — Four filters × 80,000 gal ÷ 36 hours average = approximately 2.67 backwashes per day × 80,000 gal = 213,333 gal/day. As a percentage: (213,333 ÷ 3,000,000) × 100 = 7.1%...

The backwash water consumption of approximately 3.6% to 7.1% (depending on the calculation approach) should be evaluated against industry guidelines to determine if optimization is warranted.

84. D — The safety stock calculation must account for the actual delivery lead time (typically 3–7 business days) plus a buffer for potential delays (weather, supplier stockouts, holiday periods, transportation issues). Simply having "a few days" of supply without a systematic calculation risks running out during an unexpected delay.

85. D — PAC requires maximum contact time with the target compounds (geosmin, MIB) for effective adsorption — early addition provides the longest contact. Additionally, the spent PAC must be physically removed from the water before distribution, which occurs naturally during sedimentation and filtration. Both reasons — contact time and removal — justify early addition.

86. C — Pressure below 35 psi creates backflow risk at cross-connections throughout the affected area. Under normal positive pressure, the system pushes outward against any cross-connection. When pressure drops below the external head (soil pressure, elevated non-potable sources), the direction reverses and contaminated water can be drawn into the distribution mains.

87. B — Excessive heat during polymer mixing can damage the long-chain molecular structure that gives polymer its bridging capability. Degraded polymer molecules are shorter and less effective at linking between particles. The manufacturer's mixing instructions specify cold water for precisely this reason — protecting the molecular integrity of the polymer chains.

88. D — All four filters showing the same gradual increase from 0.03 to 0.07 NTU while the settled water instrument reads steady at 0.8 NTU suggests either a subtle change in floc characteristics (making it slightly harder to capture) or an upstream instrument issue masking a settled water quality change. Temperature shifts, chemical aging, or minor raw water chemistry changes can alter floc properties enough to affect filtration without dramatically changing sedimentation performance.

89. A — Federal regulations require sanitary survey reports to be retained for 10 years or until the next survey is completed, whichever is longer. This extended retention ensures that findings, recommendations, and corrective actions from previous surveys remain available for reference during subsequent inspections and for compliance history tracking.

90. C — At 2.0 MGD: DT = 300,000 ÷ 1,389 = 216 min; T_{10} = 216 × 0.5 = 108 min; CT = 1.0 × 108 = 108 mg·min/L. At 2.5 MGD: DT = 300,000 ÷ 1,736 = 172.8 min; T_{10} = 172.8 × 0.5 = 86.4 min; CT = 1.0 × 86.4 = 86.4 mg·min/L. The 20% flow increase reduces CT by 20%, which must be compared against the required CT at current conditions.

91. D — A significant overnight pH change (7.2 to 6.0) alters the optimal coagulation conditions — the jar test performed at pH 7.2 may not apply at pH 6.0. Alum actually performs well at lower pH, but the optimal dose, floc characteristics, and alkalinity dynamics change. A new jar test at the current pH ensures the correct dose is applied.

92. B — Anionic polymers have negatively charged backbones that are attracted to the positively charged surfaces of alum floc particles. The polymer molecule attaches to one floc particle through charge attraction, extends across the gap, and attaches to another positively charged particle — creating the bridging mechanism that builds larger, stronger aggregates.

93. A — Volume = $\pi \times r^2 \times h = \pi \times 2^2 \times 6 = \pi \times 4 \times 6 = 75.4$ ft^3. Convert: 75.4 × 7.48 = 564 gallons. The radius is half the diameter (4 ÷ 2 = 2 feet). Using the diameter instead of the radius in the formula would quadruple the calculated volume — a common exam error.

94. C — UV system performance depends critically on the flow rate through the reactor matching the validated conditions. If the flow exceeds the validated maximum, the water passes through too quickly and receives less than the required UV dose. The operator must verify that the actual flow per reactor matches the bioassay validation conditions.

95. D — A gradual dose increase over six months with stable turbidity could result from multiple causes: the alum product may have changed formulation (less aluminum per gallon), the jar test procedure may have drifted (operator technique, expired reagents, different equipment), or the source water chemistry may have changed (increased NOM, decreased alkalinity). All three should be investigated systematically.

96. B — A "911-only" emergency contact list is inadequate for a water treatment plant. Operators need direct numbers for the state primacy agency, CHEMTREC (chemical emergencies), poison control, the plant supervisor, on-call operator, local health department, and utility management. Each contact serves a specific role during different types of emergencies.

97. A — The sequence proves the online turbidimeter was reading stagnant water: the sample flow was at zero, meaning the instrument measured the same water in the cell for an unknown period. The 0.04 NTU grab sample matched only because it was collected from the same stagnant sample line. Once flow was restored, the actual current CFE turbidity of 0.15 NTU appeared.

98. C — LRAA = (0.058 + 0.095 + 0.102 + 0.065) ÷ 4 = 0.320 ÷ 4 = 0.080 mg/L. The LRAA exactly equals the 0.080 mg/L TTHM MCL. The system is at the compliance boundary — any future quarter above approximately 0.083 mg/L would push the LRAA into violation. Immediate attention to DBP reduction at this location is warranted.

99. D — Effective sanitary survey preparation requires organized records, current SOPs, up-to-date monitoring data, resolution of previously identified deficiencies, and staff awareness of the survey process. The survey evaluates actual operational competence and documentation — not aesthetics. Thorough preparation demonstrates the system's commitment to compliance.

100. B — Non-revenue water at 14% is at the upper end of the acceptable range (10–15% is typical). This metric directly indicates potential water loss through leaks, metering inaccuracies, unauthorized use, or unaccounted consumption. Reducing non-revenue water improves both financial performance and system integrity through leak detection and meter verification programs.