Water Supply Engineering Test I

Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. Baylisturbidimeter is generally used to measure turbidities in the range of
(A) 0 – 10 mg/l (B) 0 – 5 mg/l
(C) 5 – 15 mg/l (D) 5 – 10 mg/l

2. Water supply projects, under normal circumstances, may be designed for a period of (from the completion of project)
(A) 10 years (B) 30 years
(C) 25 years (D) 25 years

3. The presence of silver, (Ag) in drinking water causes
(A) argyria (B) hypertension
(C) Anaemia (D) Blue baby disease

4. Ferric Chloride ($FeCl_3$) is used as a coagulant if the pH range is
(A) > 8.5 (B) < 6.5 and >8.5
(C) < 7 (D) None

5. Design a circular sedimentation (diameter (D) and depth (d) of tank) to capture flocculants particles after coagulant with a surface loading rate of 30 m^3/day/m^2. Detention time = 3 hrs to treat 15 MLD of water
(A) $D = 20.3$ m and $d = 5.6$ m
(B) $D = 25.2$ m and $d = 5.6$ m
(C) $D = 20.3$ m and $d = 3.12$ m
(D) $D = 25.2$ m and $d = 3.12$ m

6. Plain sedimentation follows
(A) Type – I settling
(B) Type – II settling
(C) Type – III settling
(D) Both B and C

7. Filtration helps in removing ___ from water.
(A) color and odour only
(B) turbidity
(C) Some pathogenic bacteria
(D) All the above

8. In water treatment, slow sand filters when compared to rapid sand filters produce
(A) lesser contaminated effluent
(B) More contaminated effluent
(C) Equally contaminated effluent
(D) Cannot be judged

9. An air bubble is present in water. If concentration of a gas (C_t) in water is more than saturated concentration (C_s), then
(A) absorption first, desorption next
(B) absorption takes place
(C) desorption takes place
(D) desorption first, absorption next

10. The valve which allows flow only in one direction is
(A) Reflux valve (B) Sluice valve
(C) Blow off valve (D) Air valve

11. Match Group – A with Group – B

	Group – A		Group – B
P.	Radial system	1.	More valves are used
Q.	Grid iron system	2.	Design calculations are simple
R.	Dead end system	3.	Distribution area divided into rectangular circular blocks.
S.	Ring system	4.	Suitable for direct pumping and gravity system

P Q R S P Q R S
(A) 3 4 1 2 (B) 2 3 4 1
(C) 1 2 3 4 (D) 4 1 2 3

12. Chlorine gas is used for disinfection combined with water to form hypochlorous acid (HOCl). The HOCl ionizes to form hypochlorite (OCl^-) in a reversible reaction: $HOCl \leftrightarrow H^+ + OCl^-$ ($k = 3 \times 10^{-8}$ at 20°C), the equilibrium of which is governed by pH. The sum of HOCl and OCl is known as free chlorine residual and HOCl is the more effective disinfectant. The 95% fraction of HOCl in the free chlorine residual is available at a pH value
(A) 5.38 (B) 6.24
(C) 7.82 (D) 8.38

Common Data for Questions 13 and 14:
In a rapid sand filter, the time for reaching particle breakthrough (T_B) is defined as the time elapsed from start of filter run to the time at which the turbidity of the effluent from the filter is greater than 2.5 *NTU*. The time for reaching terminal head loss (T_H) is defined as the time elapsed from the start of the filter run to the time when head loss across the filter is greater than 3 m.

13. The effect of increasing the porosity (while keeping all other conditions same) on T_B and T_H is
(A) T_B increases and T_H decreases
(B) T_B decreases and T_H increases
(C) Both T_B and T_H increase
(D) Both T_B and T_H decrease

14. The effect of increasing the concentration of impurities (while keeping all other conditions same) on T_B and T_H is
(A) T_B increases and T_H decreases
(B) T_B decreases and T_H increases
(C) Both T_B and T_H increase
(D) Both T_B and T_H decrease

15. A coagulation treatment plant with a flow of 0.7 m^3/s is dosing alum at 25 mg/L. No other chemicals are added. The raw water suspended solid concentration is 40 mg/L. The effluent suspended solids concentration is measured as 15 mg/L. Specific gravity of sludge solids is 3.01. Find the volume of sludge solids produced in m^3/day?

(A) 0.53 (B) 0.41
(C) 0.62 (D) 0.86

16. In a continuous flow settling tank 3.5 m deep and 60 m long, what flow velocity of water would you recommend for effective removal of 0.026 mm particles at 25°C. The specific gravity of particles is 2.5 and kinematic viscosity for water is 0.01 cm^2/sec. (take free board as 0.5 m)

(A) 0.8 cm/s (B) 1.1 cm/s
(C) 2.0 cm/s (D) 1.6 cm/s

17. Match the type of settling Group – A with where it occurs Group – B

	Group – A		Group – B
P.	Type – I settling	1.	Secondary settling tank
Q.	Type – II settling	2.	Sedimentation with coagulation
R.	Type – III settling	3.	Waste water treatment with excessive solid concentration
S.	Type – IV settling	4.	Plain sedimentation

P Q R S
(A) 4 2 1 3 (B) 2 4 3 1
(C) 1 3 2 4 (D) 3 1 4 2

18. Medium amount of coagulant dosage is used when turbidity (T) and Alkalinity (A) are

(A) T is high and A is low
(B) T is low and A is high
(C) Both T and A are high
(D) Both T and A are low

19. In order to test filtration process, clear water is made to pass through a bed of uniform sand at a filtering velocity of 4 m/hour. Sand bed has the following properties.

Depth of bed : 0.8 m
Sand grain size : 0.6 mm
Sand specific gravity : 2.65
Sand shape factor Φ : 0.9
Porosity of sand bed n : 0.5
Kinematic viscosity r : $1 \times 10^{-6} m^2/s$
Calculate the loss of head in filtration in (cm).

(A) 7.86 (B) 8.43
(C) 10.61 (D) 9.45

20. A water sample has pH of 10.3. The concentration of hydroxyl ions in the water sample is

(A) $10^{-10.3}$ moles/L
(B) 10^{-37} moles/L
(C) 3.39 mg/L
(D) 0.339 mg/L

Common Data for Questions 21 and 22:
Following chemical species were reported for water sample from a well:

Species	Concentration (milli equivalent/L)
Chloride (Cl–)	10
Sulphate (SO_4^{2-})	20
Carbonate (CO_3^{2-})	7
Bicarbonate (HCO_3^-)	25
Calcium (Ca^{2+})	15
Magnesium (Mg^{2+})	20
pH	9

21. Total hardness in mg/L as $CaCO_3$ is

(A) 120.8 (B) 32.16
(C) 1600 (D) 1750

22. Carbonate hardness (mg/L × as $CaCO_3$) present in the above water sample is

(A) 32.16 (B) 1600
(C) 88.64 (D) 1750

23. Match the Characteristics of water in Group – A with corresponding test used for measuring in Group – B.

	Group – A		Group – B
P.	Color	1.	Nephelometer
Q.	Turbidity	2.	EDTA
R.	pH	3.	Tintometer
S.	Hardness	4.	Potentiometer

P Q R S
(A) 3 1 4 2 (B) 4 3 1 2
(C) 1 4 3 2 (D) 2 1 3 4

24. Determine the future population of Mumbai town by Geometric increase method for the year 2021, given the following data.

Year	1951	1961	1971	1981	…	2021
Population in thousand	95	121	135	164	…	?

(A) 4,51,622 (B) 3,80,460
(C) 3,28,323 (D) 4,89,671

25. To treat 6 MLD of water 1 mg/L of bleaching power is added to water to have free chlorine residual of 0.1 mg/l. Find out Cl demand of water in mg/l and amount of bleaching powder/month in kgs if the available Cl in bleaching power is 40%.

(A) 0.9 mg/l and 180 kg/month
(B) 0.9 mg/l and 72 kg/month
(C) 0.3 mg/l and 72 kg/month
(D) 0.3 mg/l and 180 kg/month

Answer Keys

1. B	**2.** B	**3.** A	**4.** B	**5.** D	**6.** A	**7.** D	**8.** A	**9.** C	**10.** A
11. D	**12.** B	**13.** B	**14.** D	**15.** C	**16.** B	**17.** A	**18.** B	**19.** D	**20.** C
21. D	**22.** B	**23.** A	**24.** C	**25.** D					

Hints and Explanations

3. Argyria (blue-gray) discoloration of skin and also toxic to aquatic organisms. Choice (A)

5. Area $= \dfrac{Q}{v_o} = \dfrac{15\times10^6\times10^{-3}\ \text{m}^3/\text{day}}{30\ \text{m}^3/\text{day}/\text{m}^2} = 500\ \text{m}^2$

Volume $= Q \times DT$

$$\frac{15\times10^6\times10^{-3}}{24}\times 2.5$$

$= 1562.5\ \text{m}^3$

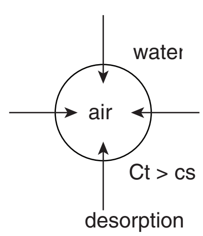
Depth $= \dfrac{\text{Volume}}{\text{Area}} = 3.125$ m

$$A = \frac{\pi}{4}d^2 = 500$$

$d = 25.2$ m Choice (D)

6. Type I settling i.e., settling under gravity because specific gravity of impurities is greater than water. Choice (A)

9.



Gas tries to reach to saturated concentration. Choice (C)

12. $\dfrac{[\text{HOCl}]}{[\text{HOCl}]+[\text{OCl}^-]}\times100 = \dfrac{1}{1+\dfrac{k}{\text{H}^+}}\times 100 = \%$ of HOCl

$$0.95 = \frac{1}{1+\dfrac{(3\times10^{-8})}{\text{H}^+}}$$

$[\text{H}^+] = 5.7\times10^{-7}$

pH $= -\log_{10}[\text{H}^+] = \log_{10}\left[\dfrac{1}{\text{H}^+}\right] = \log_{10}\left[\dfrac{1}{5.7\times10^{-7}}\right]$

pH $= 6.24$ Choice (B)

13. As porosity increases, more particles are allowed to pass through voids and turbidity reaches early

$\therefore$ T_B decreases

$$h_f = \frac{fLV^2}{gd}\times\frac{(1-n)}{n^3\phi}$$

$$h_f \propto \frac{(1-n)}{n^3} \propto \frac{1}{n^2}$$

n = porosity

$$\frac{1}{T_H} \propto h_f \propto \frac{1}{n^2}$$

$\therefore$ As porosity increases, head loss reduces and time for terminal head loss increases.

$\therefore$ T_H increases. Choice (B)

14. As concentration of impurities increase, as all voids get filled by impurities shearing off starts early.

$\therefore$ T_B (time for turbidity) reduces.

As concentration of impurities increase, more particles are clogged, more resistance to flow

$\Rightarrow$ more friction

$\therefore$ More head loss in less time

$\therefore$ T_H decrease Choice (D)

15. $Al_2(SO_4)_3.18H_2O + 3\ Ca(OH)_2$

(Alum)

$\rightarrow CaSO_4 + 2\ Al(OH)_3\downarrow + 18\ H_2O$

1 mole of Alum $\rightarrow$ 2 moles of $Al(OH)_3$

666 gm of Alum $\rightarrow 2\times78$ gm of $Al(OH_3)$

1 gm of alum $= \dfrac{2\times78}{666} = 0.24$ gm of $Al(OH)_3$

$\therefore$ 25gm of alum will produce

$= 25\times0.24 = 6$ mg/l of solid sludge $\rightarrow (1)$

Suspended solids (turbidity) removed

$= 40 - 15 = 25$ mg/l $\rightarrow (2)$

Total dry sludge (solids) removed

$= (1) + (2) = 31$ mg/l

Discharge of plant $= 0.7\ \text{m}^3/\text{s} = 0.7\times24\times60\times60$

$Q = 60480\ \text{m}^3/\text{day}$

Total dry sludge solids produced per day

$= 31\ \text{mg/l}\times60480\ \text{m}^3/\text{day}$

$= 31\ \text{gm/m}^3\times60480\ \text{m}^3/\text{day}$

$= 1.87\times10^6\text{gm/day} = 1.87$ t/day

Volume of solid sludge produced

$$= \frac{1.87}{\text{Density of sludge solids}} = \frac{1.87\ \text{t/day}}{3.01\ \text{t/m}^3}$$

$= 0.62\ \text{m}^3/\text{day}$ Choice (C)

16. Settling velocity for particles 0.026 mm (<0.1 mm) dia

$$V_s = \frac{g}{18}(S-1)\frac{d^2}{\vartheta}$$

$$V_s = \frac{981}{18}(2.5-1)\frac{(0.0026)^2}{0.01} = 0.055 \text{ cm/sec}$$

In settling tank,

$$\frac{V_S}{V_H} = \frac{H}{L}$$

$$\frac{V_S}{V_H} = \frac{30}{60}$$ [assuming freeboard = 0.5m,

$H = 3.5 - 0.5 = 3.0$m]

$$\frac{0.055}{V_H} = \frac{3}{60}$$

$V_H = 1.1$ cm/s

∴ Flow velocity = 1.1 cm/s   Choice (B)

19. $$R_e = \frac{\rho_w V d}{\mu} \times \phi = \frac{Vd}{\gamma} \times \phi$$

$$= \left(\frac{4}{60\times 60}\right) \times \left(\frac{0.6\times 10^{-3}}{1\times 10^{-6}}\right) \times 0.9 = 0.6$$

Friction factor $f = \dfrac{150(1-n)}{R_e} + 1.75$

$$= \frac{150(1-0.5)}{0.6} + 1.75 = 126.75$$

$$h_f = \frac{fLV^2}{gd}\frac{(1-n)}{n^3\phi}$$

$$= \frac{126.75\times 0.8\times}{9.81\times 0.6\times 10^{-3}}\left(\frac{4}{60\times 60}\right)^2 \times \left(\frac{1-0.5}{(0.5)^3\times 0.9}\right)$$

$= 0.0945$ m $= 9.45$ cm.   Choice (D)

20. $p[\text{H}] + p[\text{OH}] = 14$

$p[\text{OH}] = 14 - 10.3 = 3.7$

$-\log_{10}[\text{OH}] = 3.7$

Concentration of [OH]

$$= 10^{-3.7} \text{ moles/L} = 10^{-3.7} \times \frac{[17]}{1}$$

[∵ 17 is eqwt of OH]

$= 3.39 \times 10^{-3}$gm/L $= 3.39$ mg/l   Choice (C)

21. TH in mg/l as $CaCO_3$

$$= Ca^{++} \text{ in mg/l} \times \left[\frac{\text{eq wt of } CaCO_3}{\text{eq wt of } Ca^{2+}}\right]$$

$$+ Mg^{++} \text{ in mg/l} \times \left[\frac{\text{eq wt of } CaCO_3}{\text{eq wt of } Mg^{2+}}\right]$$

$[Ca^{2+}] = 15$ milli equivalent/L

$[Ca^{2+}] = 15 \times 10^{-3} \times 20$ gm/L

$= 0.3$ gm/L $= 300$ mg/l

$[Mg^{2+}] = 20$ mill equivalent/L

$$= 20 \times \left[\frac{24}{2}\right] \text{mg/l} = 240 \text{ mg/l}$$

$$[CO_3^{2-}] = 7 \times \left[\frac{60}{2}\right] = 210 \text{ mg/l}$$

$$[HCO_3^-] = 25 \times \left[\frac{61}{1}\right] = 1525 \text{ mg/l}$$

$$TH \text{ in mg/l as } CaCO_3 = Ca^{2+} \times \left[\frac{50}{20}\right] + Mg^{2+} \times \left[\frac{50}{12}\right]$$

$$= 300 \times \left[\frac{50}{20}\right] + 240 \times \left[\frac{50}{12}\right]$$

$= 1750$ mg/l as $CaCO_3$ Choice (D)

22. Alkalinity in mg/l as

$$CaCO_3 = CO_3^{2-} \times \left[\frac{50}{30}\right] + HCO_3^- \times \left[\frac{50}{61}\right]$$

$$= 210 \times \left[\frac{50}{30}\right] + 1525 \times \left[\frac{50}{61}\right]$$

$= 1600$ mg/l as $CaCO_3$

Alkalinity $< TH$

Carbonate hardness = least of both

$= 1600$ mg/l as $CaCO_3$ Choice (B)

24.

Year (1)	Population in Thousand (2)	Increase in Population in Thousands (3)	% increase in population = growth rate = $\frac{\text{Col}(3)}{\text{Col}(2)} \times 100$ (4)
1951	**95**		
1961	121	26	$\frac{26}{95} \times 100 = 27.37$
1971	135	14	11.57
1981	164	29	21.48

Constant growth rate assumed for future

r = geometric mean of past growth rates

$$= \sqrt[3]{27.37 \times 11.57 \times 21.48}$$

$= 18.95\%$ per decade

The population after n decades

$$P_n = P_o\left(1 + \frac{r}{100}\right)^n$$

P_{2021} = Population 4 decades from 1981

$$= P_{1981}\left(1 + \frac{18.95}{100}\right)^4 = 164000 \times (1.1895)^4$$

$= 3, 28,323$ Choice (C)

25. Cl_2 dose = 1 mg/l × 40% Cl_2 = 0.4 mg/l

Cl demand = Cl dose added – residual

$= 0.4 - 0.1 = 0.3$ mg/l

Total bleaching powder added

$= Q \times$ dosage of bleach $= 6 \times 1$ mg/l

$= 6$ kg/day $= (6 \times 30)$ kg/month

$= 180$ kg/month   Choice (D)