WATER REQUIREMENTS

QUALITY STANDARDS

Physical Characteristics

1. **Colour.**
   - **Measured by:**
     (a) Comparing colour with standard Nesslar tubes.
     (b) Platinum Cobalt method.
     (c) Tintometer.
   - *Standard permissible limit*: 5-20 ppm (in Platinum Cobalt Scale)
2. **Taste and Odour.**
   - Taste is expressed as FTN or Flavor Threshold Number.
   - Odour is expressed as TON or Threshold Odour Number.
   - Odour is measured by Osmoscope. The number of times the sample is diluted represents TON.

     Dilution ratio or $\quad \text{TON} = \dfrac{A+B}{A}$

     A – volume of raw sample.
     B – volume of diluted water.
   - *Standard permissible limit*: 1-3.
3. **Temperature**
   Temperature should be between 10°C and 25°C.
4. **Turbidity**
   - It may be due to organic or inorganic materials.
   - It is measured by different types of turbidity meters or turbidity rod.
   - It is expressed in ppm or mg/*l* of suspended matter.
     Permissible limit: 5-10 ppm.
5. **Specific Conductivity**
   To know dissolved salt content, specific conductivity of the water is measured.
   It is measured by Dionic Water Tester.

Chemical Characteristics

1. **Total solids**
   Total solids = suspended solids + dissolved solids
   Total permissible limit = upto 500 ppm.
2. **Hardness.**
   Types of Hardness:
   (a) Temporary hardness (carbonate hardness)
   — caused by carbonates (CO_3) and bicarbonates (HCO_3) of calcium and magnesium.
   —can be removed by boiling or adding lime.
   (b) Permanent Hardness (non-carbonate hardness)
   —caused by sulphates (SO_4^{2-}), chlorides (Cl^-) and nitrates (NO_3^-) of calcium and magnesium.
   —can be removed by lime soda process, zeolite process or demineralisation process.
   - Measured by EDTA method (Ethylene Diamine Tetra-acetic Acid). Erichrome Black T is used as the indicator.
     Total hardness in mg/*l* of $CaCO_3$

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

3. **pH Value**
   pH value is the negative log of hydrogen ion concentration.
   $pH = -\log[H^+]$
   When hydrogen ion (H^+) concentration increases, pH decreases and solution becomes more acidic and vice-versa.

Permissible limit: 6.6 – 8.4.

4. **Chloride**
   Chloride content is measured by titration with standard silver nitrate solution using potassium chromate as indicator.
   Permissible limit: up to 250 ppm or 250 mg/*l*.
5. **Nitrogen content**
   Nitrogen is available in different forms. The permissible limit of each form is given below:

Forms of nitrogen	Permissible limit
Free ammonia	0.15 mg/*l*
Albuminous or organic nitrogen	0.3 mg/*l*
Nitrites	zero
Nitrates	45 mg/*l*

6. Metals and chemicals

Metals and chemicals	Permissible limit
Iron	< 0.3 ppm
Manganese	< 0.05 ppm
Copper	1-3 ppm
Sulphate	< 250 ppm
Flouride	1 to 1.5 ppm (should not be less or more than this limit)

7. Dissolved oxygen

- Concentration of dissolved oxygen is found out by Wrinkler's method.
- Deficiency of dissolved O_2 indicates organic matter decomposition.
- *Permissible limit*: 5 - 10 ppm.

8. Other dissolved gases.

(a) H_2S– it gives bad taste and odour.

(b) N_2– indicate presence of organic matter.

(c) CH_4 – can cause fire.

(d) CO_2– can cause corrosion.

(e) NH_3– cause odour, alkalinity.

WATER TREATMENT

Processes in Treatment of Water

1. Screening:

- Used to remove bigger floating bodies.
- Screens are kept 45° – 60° inclined to horizontal to increase efficiency.
- Frequently screens are cleaned to avoid clogging.

2. Plain sedimentation:

Types of sedimentation tank:

(a) *Intermittent sedimentation tank*: Water is kept rest for sometime for setting. It is obsolute now.

(b) *Continuous function sedimentation tank*: The length of tank and velocity of travel is designed in such a way that time taken by the particle to travel from one end to another is slightly more than time taken for setting of suspended particle.

Theory of Sedimentation

(i) Time taken by the suspended particle to settle at bottom is calculated.

Settling velocity (V_s)

$$V_s = 418(G-1)d^2\left(\frac{3T+70}{100}\right), \text{ if } d < 0.1 \text{ mm } (Re < 0.5)$$

$$V_s = 418(G-1)d\left(\frac{3T+70}{100}\right), \text{ if } 0.1 \text{ mm} < d < 1 \text{ mm}$$

$$V_s = 1.8\sqrt{(G-1)gd}, \qquad \text{if } d > 1 \text{ mm } (Re > 1000)$$

when, $d < 0.1$:

another equation for V_s

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

$$= \frac{g}{18\mu}(\rho_p - \rho_w)d^2$$

where, G = specific gravity of particle = $\frac{\rho_p}{\rho_w}$.

d = diameter of particle.

T = temperature in °C.

υ = kinematic viscosity = $\frac{\mu}{\rho_w}$.

μ = dynamic viscosity

(2) **Design of sedimentation tank**

Flow velocity, $V_h = \frac{Q}{A} = \frac{Q}{BH}$

where,

B – breadth of tank.

Q – discharge.

From the figure,

$$\frac{V_h}{V_s} = \frac{L}{H}$$

$$\therefore \quad V_s = \frac{V_h H}{L} = \frac{Q}{BH}\cdot\frac{H}{L} = \frac{Q}{BL}$$

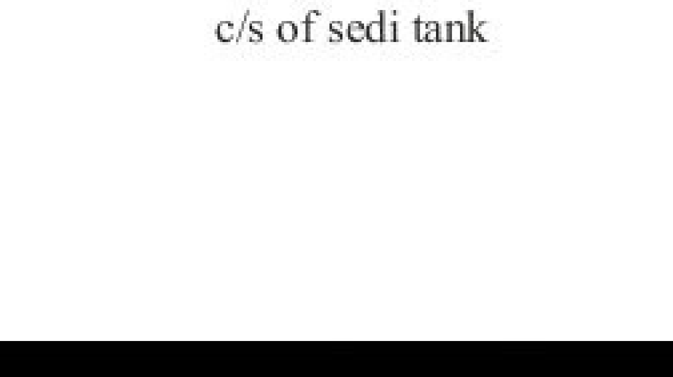
From this equation, it is clear that settling velocity is independent of height of the tank.

The term $\frac{Q}{BL}$ represents the minimum settling velocity of the slowest moving particle which will be 100% removed in the tank. This ratio is called Surface Overflow Rate (SOR). Here, BL is the plan area of the tank.

For a particle to settle, V_s has to be greater than or equal to SOR.

$$V_s \geq SOR$$

Efficiency of sedimentation tank = $\frac{V_s}{SOR} \times 100$.



c/s of sedi tank

Design Considerations of Sedimentation Tank

(i) ***Surface Overflow Rate (SOR)*:**

For plain sedimentation tank : SOR = 500 – 750 l/m^2/hour.

For sedimentation tank with coagulants :

SOR = 1000 – 1250 l/m^2/hour.

SOR value has to be lower to increase efficiency. By decreasing overflow rate smaller particles also settle.

(ii) ***Depth of tank*:**

SOR (velocity of settling) does not depend upon depth of the tank. Usually depth of tank is between 3 – 4.5 m. It is not provided more than 6 m or less than 2 m.

(iii) ***Detention period*:**

Average time for which water is retained/detained in the tank.

$$\text{Detention time,} \quad t = \frac{\text{Volume of tank}}{\text{Rate of flow}}$$

$$\text{For rectangular tank,} \quad t = \frac{BLH}{Q}$$

$$\text{For circular tank,} \quad t = \frac{d^2\left(0.011d + 0.785H\right)}{Q}$$

where, d is diameter of tank.

For plain sedimentation tank, t = 4 to 8 hours and

for sedimentation tank with coagulants, t = 2 to 4 hours.

(iv) ***Width of tank*:**

Width of tank is usually between 10-12 m. The width usually will not exceed 12 m.

(v) $\frac{L}{B}$ **ratio** is usually given 3 and should not exceed 4 m

$$\frac{L}{B} = 3 \qquad \frac{L}{B} \not> 4$$

Length of tank = Flow velocity × detention time.

(vi) ***Horizontal flow velocity (V_h)*:**

V_h should be within 0.15 to 0.9 m/minute. It is usually given 0.3 m/minute.

(vii) ***Flowing through period*:**

The ratio of flow through period and detention period is called displacement efficiency.

$$\text{Displacement efficiency} = \frac{\text{Flowing through period}}{\text{Detention period}}$$

$$\approx 0.25 \text{ to } 0.5$$

(viii) ***Sludge storage zone*:**

For manually cleaning tank, an additional depth of about 0.8 to 1.2 m is provided called the sludge storage zone.

3. Sedimentation with coagulation:

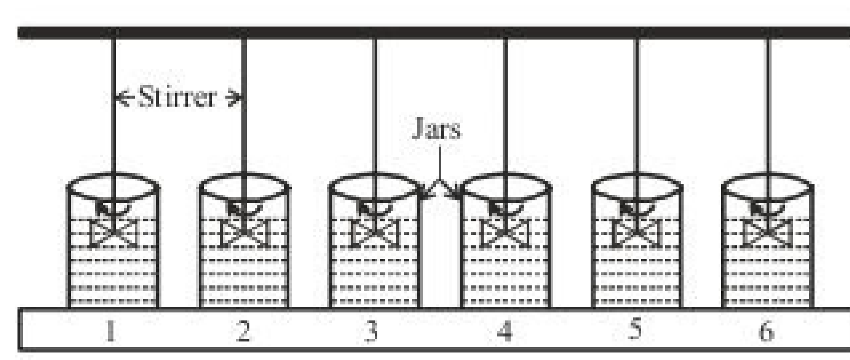
The charged colloids present in water repels each other and will not settle in normal sedimentation tank. To overcome this energy barrier, we add chemical compound called coagulants to water. Upon mixing, they form a gelatenous precipitate called flocs, which attracts the fine particles present in water and they increase in mass and settle down easily. Commonly used coagulants are

- hydrated alum (aluminium sulphate) $Al_2(SO_4)_3 \cdot 18H_2O$ commonly known as filter alum.
- ferric chloride.
- copperas (ferrous sulphate + lime).
- ferric sulphate.
- sodium sulphate.

4. ***Jar Test*:**

Jar test is conducted to find the optimum dosage of coagulant that is to be added.

There are six jars of uniform size and shape each of one litre capacity. Water whose pH, turbidity and alkalinity are predetermined is filled in the jars with different quantities of coagulants. It is rapidly stirred for 1 minute, slowly mixed for 15-20 minutes and is allowed to settle for 30 minutes. Later the turbidity of water is tested and optimum quantity of coagulant to be added is found out.



4. ***Filteration*:**

Process of passing water through a filter media to remove colloidal particles, bacteria, odour, colour, turbidity, etc.

Types of filters:

(a) Slow sand filter.
(b) Rapid sand filter.
(c) Pressure filter.

Points to be noted:

- Slow sand filters have large plan area than the other two filters.
- Slow sand filters are very good in removing bacteria but not so efficient in removing odour and turbidity and opposite for rapid sand filter.

Points to be noted:

- Number of filter beds needed for rapid sand filter is given by

$$N = 1.266\sqrt{Q}$$

Q is discharge in MLD.

- Rate of filteration of slow sand filter is 100–200 l/m^2/hour and that of other filter is 3000–6000 l/m^2/h.

5. Disinfection:

Disinfection is the process of killing of pathogenic microbes in water.

Methods of disinfection:

I. Indirect treatment:

(a) *Boiling of water*: Can kill germs in water but not future contamination. Used in small scale like household purposes.

(b) *Treatment with ozone*: More powerful than chlorine but costly.

(c) *Treatment with UV rays*.

II. Direct method (by addings compounds or chemicals):—

(a) *Treatment with excess lime*: More lime is added to water than needed for water softening. It kills bacteria in water but does not take care of future contamination.

(b) *Treatment with potassium permanganate* ($KMnO_4$): Used for treatment of water which is contaminated with bacteria in lower concentration. It also oxidise organic matter.

(c) *Treatment with iodine and bromine pills*: Provide long lasting protection but costly.

(d) *Treatment with silver*: It removes bacteria and algae but is also costly.

(e) *Chlorination*.

6. Aeration:

Aeration is the process by which water is brought into contact with air so that it kills bacteria, absorb oxygen removing CO_2, H_2S, iron and manganese to an extend.

Methods of Aeration:

(a) Using tray aerator.
(b) Using cascades.
(c) Using spray nozzles.
(d) By air diffusion.
(e) Using trickling beds.

7. Water Softening:

Methods to remove hardness from water. Hardness can be temporary or permanent as discussed earlier.

Removing temporary hardness

Methods

(1) By boiling:

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow + CO_2\uparrow + H_2O$$

(2) By adding lime ($Ca(OH)_2$):

$$MgCO_3 + Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + CaCO_3\downarrow$$

Removing permanent hardness

Methods

(1) Lime soda process:

Lime ($Ca(OH_2)$) and soda ash (Na_2CO_3) are used.

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + NaCl$$

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + Na_2SO_4\downarrow$$

(2) Zeolite process:

General formula of zeolite is $Na_2O{\cdot}Al_2O_3{\cdot}\ xSiO_2{\cdot}\ yH_2O$. Ca^{2+} and Mg^{2+} ions in hard water gets replaced by Na^+ ions in zeolite. Zeolite is regenerated by titrating with sodium chloride (NaCl or salt water).

(3) Demineralisation:

In this process, water is passed through a bed of cation exchange resins and then through a bed of anion exchange resins. The Ca^{2+} and Mg^{2+} ions gets replaced by hydrogen ions.

8. Miscellaneous Treatment:

(a) *Using activated carbon:* Activated carbon adsorbs gases, liquids and finely divided solids. It is used in powdered form or as granular form (as filter media).

(b) *Flouridation and Deflouridation:* Process of adding flouride compounds to water is called flouridation and removal of flourides compounds is called deflouridation.

Flouridation is usually done by adding sodium flouride (NaF). Deflouridation is done by limesoda process, cation exchange or by using manganese zeolite.

Desalination:

Process of removing salts like sodium chloride (NaCl) from water.

Methods:

(a) By evaporation and distillation.
(b) Solar evaporation.
(c) Solar distillation.
(d) Freezing.
(e) Reverse osmosis.
(f) Electrodialysis.
(g) Demineralisation.

EXERCISE

1. A synthetic sample of water is prepared by adding 100 mg Kaolinite (a clay mineral), 200 mg glucose, 168 mg NaCl, 120 mg $MgSO_4$ and 111 mg $CaCl_2$ to 1 litre of pure water. The concentrations of total solids (TS) and fixed dissolved solids (FDS) respectively in the solution in mg/L are equal to
   (a) 699 and 599 (b) 599 and 399
   (c) 699 and 199 (d) 699 and 399
2. The presence of hardness in excess of permissible limit causes
   (a) cardio vascular problems
   (b) skin discolouration
   (c) calcium deficiency
   (d) increased laundry expenses
3. A water treatment plant is required to process 28800 m^3/d of raw water (density = 1000 kg/m^3, kinematic viscosity = 10^{-6} m^2/s). The rapid mixing tank imparts a velocity gradient of 900s^{-1} to blend 35 mg/l of alum with the flow for a detention time of 2 minutes. The power input (W) required for rapid mixing is
   (a) 32.4 (b) 36
   (c) 324 (d) 32400
4. Consider the following unit processes commonly used in water treatment; rapid mixing (RM), flocculation (F), primary sedimentation (PS), secondary sedimentation (SS), chlorination (C) and rapid sand filteration (RSF). The order of these unit processes (first to last) in a conventional water treatment plant is
   (a) PS $\to$ RSF $\to$ F $\to$ RM $\to$ SS $\to$ C
   (b) PS $\to$ F $\to$ RM $\to$ RSF $\to$ SS $\to$ C
   (c) PS $\to$ F $\to$ SS $\to$ RSF $\to$ RM $\to$ C
   (d) PS $\to$ RM $\to$ F $\to$ SS $\to$ RSF $\to$ C
5. Anaerobically treated effluent has MPN of total coliform as 10^6/100 ml. After chlorination, the MPN value declines to 10^2/100 ml. The per cent removal (%R) and log removal (log R) of total coliform MPN is
   (a) %R = 99.90; log R = 4
   (b) %R = 99.90; log R = 2
   (c) %R = 99.99; log R = 4
   (d) %R = 99.99; log R = 2
6. A water sample has a pH of 9.25. The concentration of hydroxyl ions in the water sample is
   (a) $10^{-9.25}$ moles/l (b) $10^{-4.75}$ moles/l
   (c) 0.302 mg/l (d) 3.020 mg/l
7. A town is required to treat 4.2 m^3/min of raw water for daily domestic supply. Flocculating particles are to be produced by chemical coagulation. A column analysis indicated that an overflow rate of 0.2 mm/s will produce satisfactory particle removal in a settling basin at a depth of 3.5 m. The required surface area (in m^2) for settling is
   (a) 210 (b) 350
   (c) 1728 (d) 21000
8. Water distribution systems are sized to meet the
   (a) max hourly demand
   (b) Avg. hourly demand
   (c) max daily demand and fire demand
   (d) Avg. daily demand and fire demand
9. The microbial quality of treated piped water supplies is monitored by
   (a) Microscopic examination
   (b) Plate count of heterotrophic bacteria
   (c) Coliform MPN test
   (d) Identification of all pathogens
10. What factors is multiplied to max daily demand to obtain peak hourly demand?
    (a) 1.8 (b) 1.5
    (c) 2.5 (d) 2.8
11. Temporary hardness in water is caused by presence of
    (a) Bicarbonates of Ca and Mg
    (b) Sulphates of Ca and Mg
    (c) Chlorides of Ca and Mg
    (d) Nitrates of Ca and Mg
12. In natural water, hardness is mainly caused by
    (a) Ca^{++} and Mn^{++} (b) Ca^{++} and Fe^{++}
    (c) Na^+ and K^+ (d) Ca^{++} and Mg^{++}
13. The results of analysis of a raw water sample is given below:

Turbidity	5 mg/1
pH	7.4
Fluorides	2.5 mg/1
Total Hardness	300 mg/1
Iron	3.0 mg/1
MPN	50 per 100 ml

    From the data given above, it can be inferred that water needs removal of
    (a) Turbidity followed by disinfection
    (b) fluorides and Hardness
    (c) Iron, followed by disinfection
    (d) Both (b) and (c)
14. The velocity of flow in sedimentation tank is usually
    (a) 15-30 cm/hr (b) 15-30 cm/min
    (c) 15-30 cm/sec (d) 15-30 cm/day
15. Maximum BOD removal efficiency is for
    (a) Oxidation pond (b) Orientation ditch
    (c) trickling filter (d) Aerated lagoon
16. Most of the turbidity meters work on the scattering principle. The rabidity value OS obtained is expressed in
    (a) CFU (b) FTU
    (c) JTU (d) NTU

17. Hardness of water is directly measured by titration with ethylene-di-amine-tetracetic acid (EDTA) using
(a) eriochrome black T indicator
(b) ferroin indicator
(c) methyl orange indicator
(d) phenolphthalein indicator

18. TCU is equivalent to the colour produced by
(a) 1 mg/L of chlorplatinate ion
(b) 1 mg/L of platinum ion
(c) 1 mg/L Platinum in form of chlorplatinate ion.
(d) 1 mg/L of organo-chlorplatinate ion

19. The alkalinity and the hardness of a water sample are 250 mg/L and 350 mg/L as $CaCo_3$, respectively. The water has
(a) 350 mg/L, carbonate hardness and zero non-carbonate hardness.
(b) 250 mg/L carbonate hardness and zero non-carbonate hardness
(c) 250m/L carbonate hardness and 350 mg/L non-carbonate hardness
(d) 250 mg/L carbonate hardness and 100 mg/L non-carbonate hardness

20. Two sample of water A and B have pH values of 4.4 and 6.4 respectively. How many times more acidic sample A is than sample B?
(a) 0 (b) 15
(c) 100 (d) 200

21. Results of a water sample analysis are as follows:

Cation	Concentration mg/*l*	Equivalent Weight
Na^+	40	23
Mg^{+2}	10	12.2
Ca^{+2}	55	20
$-K^+$	2	39

(The multi equivalent weight of $CaCO_3$ = 50mg/meg). Hardness of water sample in mg/l as $CaCO_3$ is
(a) 44.8 (b) 89.5
(c) 119 (d) 358

22. Minimum (Do) required for aquatic life in river water is
(a) 2ppm (b) 6ppm
(c) 4ppm (d) 10ppm

23. What is the maximum permissible value of total solid in water used for domestic purposes?
(a) Zero (b) 100 ppm
(c) 500ppm (d) 1000ppm

24. Zero hardness of water is obtained by which process
(a) ion exchange process
(b) lime soda process
(c) excess lime treatment
(d) excess alum and lime treatment

25. A standard multiple-tube fermentation test was conducted on a sample of water from a surface stream. The result of the analysis of the confirmed test are given below.

Sample Size (ml)	No. of positive results out of 5 tube	No. of negative results out of 5 tubes
1	4	1
0.1	3	2
0.01	1	4

MPN index and 95% confidence limits for combination of positive results when five tubes used per dilutions (10 ml, 1.0 ml, 0.1 ml)

Combination of positive	MPN index per 100 ml	95% confidence	
		Lower limit	Upper limit
4-2-1	26	12	65
4-3-1	33	15	77

Using the above MPN index table, the most probable numbers (MPN) of the sample is
(a) 26 (b) 33
(c) 260 (d) 330

26. Group I contains some properties of water/wastewater and group II contains list of some tests on water/waste water. Match the property with corresponding test

	Group I		Group II
P.	Suspended solids concentration	1.	BOD
Q.	Metabolism of biodegradable organics	2.	MPN
R.	Bacterial concentration	3.	Jar test
S.	Coagulant dose	4.	Turbidity

Codes:

	P	Q	R	S		P	Q	R	S
(a)	2	1	4	3	(b)	4	1	2	3
(c)	2	4	1	3	(d)	4	2	1	3

27. In a continuous flow sedimentation tank, setting velocity of particles that is to be removed should be:
(a) more than SOR
(b) equal to SOR
(c) less than SOR
(d) does not depend on SOR

28. Flocculation is a process
(a) that removes algae from stabilization pond effluent
(b) that promotes the aggregation of small particles into larger particles to enhance their removal bye gravity.
(c) All the above
(d) None of these

29. Design parameters for rapid mixing units are
(a) velocity gradient and the volume of mixing basin
(b) viscosity and velocity gradient
(c) viscosity, velocity gradient and the volume of the mixing basin
(d) detention time and viscosity of water

30. Pathogens are usually removed by
(a) Chemical precipitation
(b Chlorine
(c) Ozone
(d) UV-radiation

31. Coagulation-flocculation with alum is performed
(a) immediately before chlorination
(b) immediately after chlorination
(c) after rapid sand filtration
(d) before rapid sand filtration

32. For a flow of 5.7 MLD (million liters per day) and a detention time of 2 hours, the surface area of a rectangular sedimentation tank to remove all particles have setting velocity of 0.33 mm/s is
(a) $20m^2$ (b) $100m^2$
(c) $200m^2$ (d) $400m^2$

33. Use of coagulants such as alum
(a) results in reduction of pH of the treated water.
(b) results in increases of pH of the treated water.
(c) results in no change in pH of the treated water.
(d) May cause and increase or decrease of pH of the treated water.

34. The following chemical is used for coagulation
(a) Ammonium Chloride
(b) Aluminum Chloride
(c) Aluminum Sulphate
(d) Copper sulphate

35. A town has an existing horizontal flow sedimentation tank with an overflow rate of $17m^3/day/m^2$, and it is desirable to remove particles that having setting velocity of 0.1mm/sec. Assuming the tank is an ideal sedimentation tank, the percentage of particles removal is approximately equal to
(a) 30% (b) 50%
(c) 70% (d) 90%

36. For a water treatment plant having a flow rate of $432m^3/hr$, what is the required plan area of a type I settling tank to remove 90% of the particles having a setting velocity of 0.12 cm/sec is
(a) $120m^2$ (b) $111m^2$
(c) $90m^2$ (d) $100m^2$

37. An ideal horizontal flow settling basin is 3m deep having surface area $900m^2$. Water flows at the rate of 8000 m^2/d, at water temperature $20^0C(m = 10^{-3}\ kg/m.s)$ and ρ 1000kg/ m^3). Assuming stokes law to be valid, the proportion (percentage) of spherical sand particles (0.01 mm in diameter with specific gravity 2.65), that will be removed, is
(a) 32.5 (b) 67
(c) 87.5 (d) 95.5

38. Match the following

Type of water impurity	Method of Treatment
(P) Hardness	(1) Reverse Osmosis
(Q) Brackish water from sea	(2) Cholorination
(R) Residual mpn from filter	(3) Zeolite treatment
(S) Turbidity	(4) Coagulation and flocculation
	(5) Coagulation, flocculation, filtration

Option :

	P	Q	R	S
(a)	1	2	4	5
(b)	3	2	2	4
(c)	2	1	3	5
(d)	3	1	2	5

39. Zero hardness is achieved by
(a) Lime soda process
(b) Excess lime treatment
(c) ion exchange process
(d) excess lime and lime treatment.

40. The design parameter for flocculation is given by a dimensionless number Gt, where G is the velocity gradient and t is the detention time. Values of Gt ranging from ^{104} to 10^5 are commonly used, with t ranging from 10 to 30mm. The most preffered combination of G and t to produce smaller and denser flocs is
(a) large G values with short t
(b) large G values with long t
(c) small G values with short t
(d) small G values with short t

41. What is the surface overflow rate in the sedimentation tank?
(a) $20m^3/m^2/day$ (b) $40m^3/m^2/day$
(c) $67m^3/m^2/day$ (d) $133m^3/m^2/day$

42. The disinfection efficiency of chlorine in water treatment
(a) is not dependent on pH value
(b) is increased by increase in pH value
(c) will remain constant at all pH value
(d) is reduced by increase pH value

43. Chlorine gas used in disinfection combines with water to form hypochlorous acid(HOCl), the HOCl ionizes to form hypochlorite(OCl^-) in a reversible reaction $HOCl \rightleftharpoons H^+ + OCl^-(k = 2.7 \times 10^{-6}$ at 20^oC), the equilibrium of which is governed by pH. The sum of HOCl and OCl^- is known as free chlorine residual and HOCl is more effective disinfectant. The 90% fraction of HOCl in free chlorine residual is available at pH value.
(a) 4.8 (b) 6.6
(c) 7.5 (d) 9.4

44. The absorbent most commonly used in water and waste treatment
(a) Sand of grain size from 0.1 to 2 mm
(b) Activated carbon granules of size 0.1 to 0.2mm greater than or less than COD
(c) Stand of grain size from 3 to 5 mm.
(d) None of these

45. In a certain situation, wastewater discharged into a river, mixes with the river water instantaneously and completely. Following is the data available.

Wastewater :	DO=2.00 mg/L
Discharge rate	$= 1.10\ m^3/s$
River water	DO = 8.3 mg/L
	Flow rate = $8.70\ m^3/s$
	Temperature = 20^0C

the initial amount of DO in mixture of waste and river is
(a) 5.3 mg/l (b) 6.5 mg/l
(c) 7.6 mg/l (d) 8.4 mg/l

ANSWER KEY

1	(a)	6	(c)	11	(a)	16	(a)	21	(c)	26	(b)	31	(d)	36	(c)	41	(a)
2	(d)	7	(b)	12	(d)	17	(a)	22	(c)	27	(a)	32	(c)	37	(c)	42	(d)
3	(d)	8	(d)	13	(d)	18	(a)	23	(c)	28	(b)	33	(b)	38	(d)	43	(b)
4	(d)	9	(c)	14	(b)	19	(d)	24	(a)	29	(c)	34	(c)	39	(c)	44	(b)
5	(c)	10	(b)	15	(b)	20	(c)	25	(d)	30	(d)	35	(b)	40	(a)	45	(c)

HINTS & EXPLANATIONS

1. **(a)** Total solids = 100 + 200 + 168 + 120 + 111 = 699 mg/l
Fixed dissolved solids = 200 + 168 + 120 + 111
= 599 mg/l
Kaolinite is insoluble.

3. **(d)** Velocity gradient,

$$G = \sqrt{\frac{P}{\mu v}}$$

$$\therefore \quad P = G^2 \mu v$$

$$= 900^2 \times (10^{-6} \times 1000) \times \frac{(28800 \times 2)}{24 \times 60}$$

= 32400 w

6. **(c)** $pH = -\log[H^+]$

$9.25 = -\log[H^+]$

$\therefore \quad [H^+] = 10^{-9.25}$ mol/l

$[H^+][OH^-] = 10^{-14}$

$$[OH^-] = \frac{10^{-14}}{10^{-9.25}} = 10^{-4.75} \text{ mol}/l$$

$= 10^{-4.75} \times 17 \times 1000$

= 0.302 mg/l.

7. **(b)** $Q = 4.2\ m^3/min = 0.07\ m^3/s$

$V_o = 0.2\ mm/s = 0.2 \times 10^{-3}\ m/s$

$$V_o = \frac{Q}{A}$$

$$\therefore \quad A = \frac{Q}{V_o}$$

$$= \frac{0.07}{.2 \times 10^{-3}} = 350\ m^2.$$

20. **(c)** P/H (A) = 4.4

$$P/_H = -\log\left[H^+\right]$$

$$\therefore [H^+] = 10^{-pH}$$

$$\therefore [H^+]_A = 10^{-4.4}$$

$$P_H(B) = 6.4$$

$$\therefore [H^+]_B = 10^{-6.4}$$

$$\therefore \frac{\left[H^+\right]_A}{\left[H^+\right]_B} = \frac{10^{-4.4}}{10^{-6.4}} = 10^{-4.4+6.4} = 10^2 = 100$$

Shortcut

For similar question, just take the difference of P_H and put it as power of 10. i.e., if difference of $P/_H$ is n then answer is 10^n

21. **(c)** Total hardness $= 55 \times \frac{50}{20} + 10 \times \frac{50}{12} = 179\ mg/l$

25. **(d)** Positive combination is : 4 – 3 – 1
MPN = 33

$$\text{Correct MPN} = \frac{33}{\text{Largest volume}} \times 100$$

$$= \frac{33}{10} \times 100 = 330$$

32. **(c)** All particles settle, efficiency (n) = 100%

35. **(b)** $\eta = \frac{V_s}{V_0} \times 100 = \frac{0.1}{\frac{17 \times 1000}{29 \times 3600}} = 50.8\%$

45. **(c)** $$DO = \frac{A_S DO_R + A_R DO_R}{A_S + A_R}$$

$$= \frac{(1.1 \times 2) + (8.7 \times 8.3)}{1.1 + 8.7} = 7.6\ mg/l$$