5
CHAPTER

Purification of Water

Q.1 The rate of filtration of rapid sand filter is about how much time that of slow sand filter?
(a) 20 (b) 15
(c) 30 (d) 40

Q.2 Assertion (A): Tapered flocculation is more efficient when compared to conventional process of flocculation.
Reason (R): In tapered flocculation, velocity gradient at inlet is less than velocity gradient at outlet of flocculation unit.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.3 For a given discharge, the efficiency of sedimentation tank can be increased by
(a) increasing the depth of tank
(b) decreasing the depth of tank
(c) increasing the surface area of tank
(d) decreasing the surface area of tank

Q.4 The detention period in coagulation tank is usually kept as
(a) 1 to 2 minutes (b) 30 to 45 minutes
(c) 2 to 4 hours (d) 2 to 6 days

Q.5 The effective size of sand particles used in slow sand filters is
(a) 0.25 to 0.35 mm
(b) 0.35 to 0.60 mm
(c) 0.60 to 1.00 mm
(d) 1.00 to 1.80 mm

Q.6 The disinfection efficiency of chlorine increases by
1. decreasing the time of contact
2. decreasing the temperature of water
3. increasing the temperature of water
The correct answer is
(a) only 1 (b) both 1 and 2
(c) both 1 and 3 (d) only 3

Q.7 The process in which the chlorination is done beyond the break point is known as
(a) pre chlorination
(b) post chlorination
(c) super chlorination
(d) break point chlorination

Q.8 Which of the following can be taken as detention period for sedimentation tank aided with coagulation?
(a) 4 hr (b) 6 hr
(c) 3 hr (d) 5 hr

Q.9 Which of the following expression is used to calculate the detention time for a circular sedimentation tank?

(a) $d^2\dfrac{(0.785d+0.011H)}{Q}$

(b) $d^2\dfrac{(0.011d+0.0785H)}{Q}$

(c) $d\dfrac{\left(0.755d^2+0.011H^2\right)}{Q}$

(d) $d\dfrac{\left(0.011d^2+0.765H^2\right)}{Q}$

Q.10 What is the number of rapid sand filter units required for a discharge of 0.116 m^3/s?
(a) 5 (b) 10
(c) 4 (d) 8

Q.11 For designing lateral for a rapid sand filter, the ratio of length of lateral to the diameter of the lateral shall not be less than
(a) 30 (b) 40
(c) 50 (d) 60

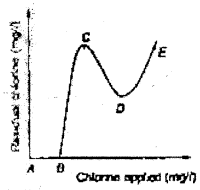
Q.12 Which of the following statement related to disinfection with ozone is false?
(a) Doesn't safeguard against recontamination
(b) Very costly
(c) Gives unpleasant taste
(d) Residual ozone is measured by orthotoulidine test

Q.13 Consider the following statements:
1. For ground water having only CO_2 and odourous gases, aeration and disinfection are sufficient.
2. The last unit of any treatment plant will always be the disinfection unit.
3. To kill algae, we use $CuSO_4$ and Cl_2.
4. $NaNO_3$ facilitates the growth of algae.
Which of these statements are correct?
(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4. (d) 1, 2, 3 and 4

Q.14 The ideal position for a micro-strainer is earlier to rapid gravity or slow sand filters whose output is increased as much as
(a) 50% (b) 60%
(c) 70% (d) 80%

Q.15 For proper slow mixing in the flocculator of a water treatment plant, the temporal mean velocity gradient needs to be of the order of
(a) 5 to 10 s^{-1}
(b) 20 to 80 s^{-1}
(c) 100 to 200 s^{-1}
(d) 250 to 350 s^{-1}

Q.16 In the diagram given below, the part CD represents



(a) Oxidation of organic matter
(b) Formation of chloro-organic compounds and chloramines
(c) Combined and free residual-chlorine
(d) Destruction of chlorine by reducing compounds

Q.17 Assertion (A): Alum is the most commonly used coagulant in water treatment.
Reason (R): Alum is very effective in killing pathogens present in water.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.18 Which of the following are common problems associated with the operation of rapid sand filter?
1. Air binding
2. Cracking of sand beds
3. Bumping of filter beds
4. Mud balls
Select the correct answer using codes given below:
(a) 1 and 2 (b) 2 and 3
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.19 Which of the following treatment processes are necessary for removing suspended solids from water?
1. Coagulation 2. Flocculation,
3. Sedimentation 4. Disinfection
Select the correct answer using the codes given below:
(a) 1 and 2 (b) 1, 2 and 3
(c) 2 and 4 (d) 1 and 4

Q.20 Dechlorination of water is achieved by adding
(a) sodium thiosulphate
(b) sodium sulphate
(c) sodium hexametaphosphate
(d) sodium bisulphate

Q.21 The settling velocity of a spherical particle of diameter less than 0.1 mm as per Stoke's law, is

(a) $V_s = 418(G_s - 1)d\left[\frac{3T+70}{100}\right]$

(b) $V_s = 418(G_s - 1)d^2\left[\frac{3T+70}{100}\right]$

(c) $V_s = 218(G_s - 1)d^2\left[\frac{3T+70}{100}\right]$

(d) $V_s = 218(G_s - 1)d\left[\frac{3T+70}{100}\right]$

Q.22 The best quality of filter material is obtained from quartzite if it does not lose weight when placed in hydrochloric acid for 24 hours, more than
(a) 5% (b) 8%
(c) 10% (d) 12%

Q.23 The void spaces in the filtering material acts like a
(a) drain
(b) inlet
(c) tiny settling basin
(d) outlet

Q.24 The maximum daily demand of water is 36 million litres per day. Assuming a detention period of 6 hours, the velocity of flow is 25 cm per minute, and depth of tank is 4 m without free board, match List I with List II and select the correct answer using codes given below the lists:

List-I	List-II
A. Capacity of the tank	1. 90 m
B. Length of the tank	2. 100 m^2
C. Cross-sectional area of the tank	3. 25 m
D. Width of the tank	4. 9000 m^3

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	1	2	3
(c)	4	3	2	1
(d)	1	4	3	2

Q.25 Match List-I (Coagulant) with List-II (Effect) and select the correct answer using codes given below the lists:

List-I
A. Alum ($Al_2(SO_4)_3.18H_2O$)
B. Copperas ($FeSO_4.7H_2O$)
C. Chlorinated copperas
D. Sodium Aluminate ($Na_2Al_2O_4$)

List-II
1. Raw water not to be coloured
2. Removes colours of raw water of less pH value
3. For boiler fed water of low values of hardness
4. Presence of an alkali is required

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	1	3	2
(c)	4	3	1	2
(d)	4	1	2	3

Q.26 Which one of the following is not a specific criterion for calculating surface overflow rate in sedimentation tank design?
(a) Total quantity of water to be treated
(b) Total surface area available in the tank
(c) Total length of tank
(d) Total depth of tank

Q.27 A flash mixer of 3 m^3, with a velocity gradient of mixing mechanism equal to 500 s^{-1}, and fluid's absolute viscosity of 1×10^{-3} Ns/m^2 is continuously operated. What is the power input?
(a) 360 W (b) 750 W
(c) 1440 W (d) 550 W

Q.28 Chlorides from water are removed by
(a) Lime soda process
(b) Reverse osmosis
(c) Cation exchange process
(d) Chemical coagulation

Q.29 Which of the following are associated with alum coagulation?
1. A decrease in alkalinity of treated water.
2. Formation of hydroxide flocs of aluminium.
3. A slight decrease in pH of treated water.
4. An increase in permanent hardness.

Select the correct answer using the codes given below:
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 1, 2, 3 and 4 (d) 2 and 4

Q.30 Consider the following statements:
1. In a continuous flow type sedimentation tank, the particles to be removed, should have their settling velocity more than the surface loading rate.
2. In a continuous flow type sedimentation tank, the particles which are settling, move vertically down to the bottom.
3. Coagulant added to the water containing alkalinity results in the formation of its hydroxide compound.
4. Flocculation is the process of vigorous mixing of coagulant added to water.

Which of these statements are correct?
(a) 1, 3 and 4 (b) 1, 2 and 4
(c) 2, 3 and 4 (d) 1 and 3

Q.31 Significant removal of dissolved organic matter occurs in
1. Slow sand filters
2. Trickling filters
3. Rapid sand filters
4. Dual media filters

Select the correct answer using the codes given below:
(a) 3 only (b) 2 only
(c) 1 and 2 (d) 3 and 4

Q.32 Which of the following pairs are correctly matched?
1. Lime soda process : Softening
2. Nalgoda technique : Fluoride removal
3. Aeration : Coagulation
4. Ozonation : Disinfection

Select the correct answer using the codes given below:
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 1, 2 and 4 (d) 2, 3 and 4

Q.33 In double filtration, the roughening filter unit is placed
(a) prior to slow sand filter
(b) after slow sand filter
(c) any of (a) and (b) as above
(d) None of the above

Q.34 Match List-I with List-II and select the correct answer using codes given below the lists:

List-I
A. Mechanical straining
B. Flocculation and sedimentation
C. Biological metabolism
D. Electrolytic changes

List-II
1. Ionization
2. Organic impurities
3. Formation of mat on top of the filter bed
4. Gelatinous mass

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	2	1
(c)	3	1	2	4
(d)	2	4	3	1

Q.35 Match List-I (Type of water source) with List-II (Treatment to be given) and select the correct answer using codes given below the lists:

List-I
A. Surface water (river or canal)
B. Water from infiltration gallery
C. Lake/pond water
D. Tube well water

List-II
1. Aeration, coagulation, sedimentation and disinfection
2. Disinfection
3. $CuSO_4$ treatment, coagulation, sedimentation, filtration and disinfection
4. Coagulation, sedimentation, filtration and disinfection

Codes:

	A	B	C	D
(a)	4	1	3	2
(b)	1	4	3	2
(c)	1	4	2	3
(d)	4	1	2	3

Q.36 Match List-I (Water treatment units) with List-II (Detention time) and select the correct answer using the codes given below the lists:

List-I
A. Rapid mixing unit
B. Flocculator
C. Propeller mixing unit
D. Sedimentation tank

List-II
1. 1.5 hours
2. 10 seconds
3. 30 seconds
4. 30 minutes

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	1	2
(c)	4	3	2	1
(d)	3	4	1	2

Q.37 Consider the following statements:
1. Coarse screens are normally inclined at about 45°-60° to the horizontal so as to increase the opening area to reduce the flow velocity.
2. Velocity of flow through the screens should not be more than 0.8 to 1.0 m/sec.
3. Fine screens are avoided as finer particles are separated in sedimentation rather than in screening.

Which of these statement/s is/are correct?
(a) Only 1 (b) Both 1 and 3
(c) Both 2 and 3 (d) 1, 2 and 3

Q.38 Consider the following statements :
1. Iron salts are used as coagulants more frequently for treating sewage and alum is used for treating raw waters.
2. Iron salts produce heavy floc and can remove much more suspended matter than alum.
3. Iron salts can be used over a wide range of pH values.

Which of these statement/s is/are correct?
(a) Only 2 (b) Both 1 and 2
(c) Both 2 and 3 (d) 1, 2 and 3

Q.39 A city supply of 15000 cubic metres of water per day is treated with a chlorine dosage of 0.5 ppm. For this purpose, the requirement of 25% bleaching powder per day would be
(a) 300 kg (b) 75 kg
(c) 30 kg (d) 7.5 kg

Q.40 A town has an existing horizontal flow sedimentation tank with an overflow rate of 17 $m^3/day/m^2$, and it is desirable to remove particles that have settling velocity of 0.1 mm/sec. Assuming the tank is an ideal sedimentation tank, the percentage of particles removed is approximately equal to
(a) 30% (b) 50%
(c) 70 % (d) 90%

Q.41 Zeta potential which is used in diffused double layer theory is defined as
(a) $\frac{4\pi\delta q}{D}$ (b) $\frac{2\pi\delta q}{D}$
(c) $\frac{8\pi\delta q}{D}$ (d) None of these

Q.42 Which of the following statement/s is/are correct?
1. Quantity rather than nature of ion is of prime importance in theory of adsorption and charge neutralization.
2. Van-der Waal's force plays a very important role in ionic layer compression mechanism of coagulation.
3. Selection of optimum dose of coagulant is determined experimentally by jar test.

Select the correct answer using the codes given below:
(a) 3 only (b) 1 and 2
(c) 2 and 3 (d) 1, 2 and 3

Q.43 How much aluminium hydroxide is given by 500 gm of alum in coagulation?
(a) 107 gm (b) 117 gm
(c) 156 gm (d) 176 gm

Q.44 Consider the following statements related to iron salts to be used as coagulant?
1. Iron salts can be used over a wider range of pH values as compared to alum.
2. Iron salts can remove hydrogen sulphide and its corresponding tastes and odours from water.
3. Iron salts produce heavy flocs.
4. Iron salts cause staining and promote growth of iron bacteria in distribution system.
Which of these statement/s is/are incorrect?
(a) 1 only
(b) 1 and 2
(c) 1 and 3
(d) All the statements are correct

Q.45 The settling velocity of inorganic particles of diameter less than 0.1 mm varies with the diameter (d), in proportion to
(a) d^0
(b) d^2
(c) d
(d) none of them, as dia does not affect the settling velocity

Q.46 Sedimentation can remove inorganic particles, having specific gravity more than say:
(a) 2.65 (b) 1.65
(c) 1.2 (d) 1.03

Q.47 The amount of coagulant needed in water treatment increases with the
(a) increase in temperature of water
(b) increase in turbidity of water
(c) decrease in turbidity of water
(d) none of the above

Q.48 Back washing of rapid gravity filters, may face rough weather, due to
(a) air-binding
(b) mud-balls
(c) negative head
(d) cracking of filters

Q.49 Which of the following chemical compounds can be used for dechlorination of water?
(a) Carbon dioxide
(b) Bleaching powder
(c) Sulphur dioxide
(d) Chloramines

Q.50 Which of the following are removed by rapid sand filter from water?
1. Dissolved solids
2. Suspended solids
3. Bacteria
4. Helminths
Select the correct answer using the codes given below:
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 2, 3 and 4

Q.51 In water treatment, the optimum time of flocculation is usually given as 30 minutes. In case the time of flocculation is increased beyond this value, the flocs will
(a) become heavy and settle down in flocculation itself
(b) entrap air and will float in the sedimentation tank
(c) break up and defeat the purpose of flocculation
(d) stick to the paddles

Q.52 Disinfection efficiency is
(a) reduced at higher pH value of water
(b) unaffected by pH value of water
(c) increased at higher pH value of water
(d) highest at pH value equal to 7

Q.53 Removal of iron from water may be done
(a) by oxidation with Cl_2
(b) by oxidation with Br_2
(c) by oxidation with potassium permanganate
(d) both (a) and (c)

Q.54 The industrial process that generates industrial waste water containing chromium is
(a) food processing
(b) tannery
(c) potteries
(d) soap manufacturing

Q.55 In water treatment process, the chemical used for defluoridation is
(a) alum
(b) lime
(c) potassium permanganate
(d) sodium aluminate

Q.56 Consider the following statements:
1. Most colloidal particles in water are negatively charged.
2. The surface charge on colloidal particles is the major contributor to their long term stability.
Which of these statement/s is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.57 Which of the following things will occur in a clariflocculator?
(a) Floc formation and its subsequent removal by filtration
(b) Floc formation and its subsequent removal by sedimentation
(c) Floc formation and its subsequent removal by decantation
(d) Removal of bacteria by filtration and chlorination

Q.58 A surface water flow of 28000 m^3/day is coagulated by adding 75 mg/l of ferrous sulphate and an equivalent dose of lime. How much lime is required at a purity of 90% CaO?
(a) 500 kg/day (b) 470 kg/day
(c) 550 kg/day (d) 450 kg/day

Q.59 Consider the following statements regarding slow sand filter:
1. Flow of water during back washing is laminar flow.
2. Flow of water during filteration is in transition.
Which of the above statement/s is/are correct?
(a) 1 only (b) 2 only
(c) Both (1) and (2) (d) None of these

Q.60 Rate of filteration in case of pressure filter is
(a) 2000-10000 l/m^2 hr
(b) 6000-15000 l/m^2 hr
(c) 9000-16000 l/m^2 hr
(d) 12000-16000 l/m^2 hr

Q.61 Consider the following statements:
Assertion (A): It is not necessary to remove hardness completely from drinking water.
Reason (R): It gives the water palatable taste.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.62 Consider the following statements:
1. Higher the zeta potential, less stable is the particle.
2. Larger G and smaller t_d will make small and dense floc.
3. Efficiency of slow sand filter in bacteria removal is 97-98%.
4. Fairly alkaline water containing more concentrations of nitrates and phosphates are prone to algae growth.
Which of these statements are correct?
(a) 1, 2 and 3 (b) 2 and 3
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.63 A power plant pumps 25 ft^3/sec from stream with flow of 180 ft^3/sec. The discharge of the plants ash pond is 22 ft^3/sec. The boron concentrations for upstream water and effluent are 0.053 and 8.76 mg/L respectively. The boron concentration in stream after complete mixing is
(a) 1.13 mg/l (b) 1.91 mg/l
(c) 2.31 mg/l (d) 2.91 mg/l

Q.64 Assume that a large stream has reoxygenation constant, K_2 of 0.4/days, a flow velocity of 5 miles/hour and at point of pollutant discharge, the stream is saturated with oxygen at 10 mg/l. The wastewater flow rate is very small compared with stream flow. So the mixture is assumed to be saturated with dissolved oxygen and to have an oxygen demand of 20 mg/l. The deoxygenating constant K_1 is 0.2/day. The DO level 30 miles downstream is ($e^{-0.95} = 0.951$ and $e^{-0.1} = 0.905$).
(a) 6 mg/l (b) 7 mg/l
(c) 9 mg/l (d) 10 mg/l

■■■■

Answers Purification of Water

1. (c)	2. (c)	3. (c)	4. (c)	5. (a)	6. (d)	7. (c)	8. (c)	9. (b)	10. (c)
11. (d)	12. (c)	13. (d)	14. (a)	15. (b)	16. (a)	17. (c)	18. (d)	19. (b)	20. (a)
21. (b)	22. (a)	23. (c)	24. (b)	25. (d)	26. (d)	27. (b)	28. (b)	29. (c)	30. (d)
31. (b)	32. (c)	33. (a)	34. (b)	35. (a)	36. (a)	37. (d)	38. (d)	39. (c)	40. (b)
41. (a)	42. (c)	43. (b)	44. (d)	45. (b)	46. (c)	47. (b)	48. (b)	49. (c)	50. (d)
51. (b)	52. (a)	53. (d)	54. (b)	55. (a)	56. (c)	57. (b)	58. (b)	59. (d)	60. (b)
61. (a)	62. (c)	63. (a)	64. (c)						

Explanations Purification of Water

2. (c)
In tapered flocculation, velocity gradient at inlet is more than velocity gradient at outlet of flocculation unit.

3. (c)
Over flow rate = $\frac{Q}{BL}$
By decreasing over flow rate small particles will also settle down. Hence efficiency of sedimentation tank increases. So for given discharge if we increase the surface area, over flow rate will decrease.

4. (c)
Detention period for plain sedimentation tank is about 4-8 hours.
Detention period for coagulation tank is about 2-4 hours.

5. (a)
Effective size of sand particles for slow sand filter is 0.20 to 0.35 mm
Effective size of sand particles for rapid sand filter is 0.35 to 0.55 mm

7. (c)
Pre chlorination – Apply chlorine before filtration
Post chlorination – Apply chlorine at the end of filtration
Super chlorination – Addition of excess amount of chlorine beyond break point.
Break point chlorination – Represents that dose of chlorine added beyond which any further addition will appear as free residual chlorine.

10. (c)
No. of units required = $1.22\sqrt{Q}$
where Q is plant capacity in MLD
$Q = 0.116\ m^3/sec$
$= 0.116 \times 10^3 \times 24 \times 3600$ lit/day
$= 10.02$ MLD
So, no. of units required
$= 1.22\sqrt{10.02} = 3.86 \simeq 4$
So, four units are required.

12. (c)
Treatment with ozone adds pleasant taste to water.

16. (a)
In the given diagram,
AB = Destruction of chlorine by reducing compounds
BC = Formation of chloro-organic compounds and chloramines
CD = Oxidation of organic matter
After D = Combined and free residual -chlorine.

17. (c)
Alum is most commonly used coagulant because it is cheap and flocs formed are stable. Alum is not very effective in killing pathogens in comparison to other coagulants.

21. (b)
For $d < 0.1$ mm, settling velocity V_s is given by Stoke's equation.
$$V_s = 418(G_s - 1)d^2\left[\frac{3T + 70}{100}\right]$$
For $d > 0.1$ mm – 1 mm V_s is given by Hazen's equation.
$$V_s = 418(G_s - 1)d\left[\frac{3T + 70}{100}\right]$$
For $d > 1.0$ mm V_s is given by Newton's equation.
$$V_s = 1.8\sqrt{gd(G_s - 1)}.$$

22. (a)
Filter material is obtained by quartz should be free from dirt, uniform in nature and size, hard & resistant and should not lose more than 5% of its weight after being placed in hydrochloric acid for 24 hours.

24. (b)
$Q_{max} = 36 \times 10^5$ litres/day $= 0.417\ m^3/s$
$t_d = 6$ hours
Flow velocity,
$$V_f = \frac{25 \times 10^{-2}}{60}\ m/s = 4.17 \times 10^{-3}\ m/s$$
$h = 4$ m
Capacity of tank
$$V = Q_{max} \times t_d$$
$$= \frac{36 \times 10^5 \times 10^{-3} m^3 \times 6}{24 hr}$$
$$= 9000\ m^3$$
We know that
$V_f = Q/Bh$
$\Rightarrow$ Width of tank
$$B = \frac{0.417}{4.17 \times 10^{-3} \times 4} = 25\ m$$
Now, length of tank
$$L = \frac{V}{BH} = \frac{9000}{25 \times 4} = 90\ m$$

25. (d)
Alum requires alkalinity in water. If it is not present in water it may be added from external sources. Copperas is used as a coagulant for raw waters that are not coloured. For coloured raw water it is not used as it does not give satisfactory results.
Sodium aluminate reduces the temporary as well as permanent hardness present in raw supplies. This is therefore, widely used for treating boiler feed waters, which permit very low values of hardness.

27. (b)
Velocity gradient,
$$G = \sqrt{\frac{P}{\mu V}}$$
Where, $\mu = 1 \times 10^{-3}$ Ns/m^2
$V = 3\ m^3$
$G = 500\ s^{-1}$
So, $500 = \sqrt{\frac{P}{10^{-3} \times 3}}$
So, $P = 3 \times 500^2 \times 10^{-3}$
$= 750$ W

39. (c)
City supply = 15000 m^3/day
$= 15000 \times 10^3$ l/day
Chlorine dosage
$= 0.5$ ppm
$\therefore$ Chlorine requirement
$= 0.5 \times 10^{-6} \times 15000 \times 10^3$ kg $= 7.5$ kg
$\therefore$ Requirement of 25% bleaching powder
$$= \frac{7.5}{0.25} = 30\ kg$$

40. (b)
$$V_0 = 17\ m^3/m^2/day$$
$$= \frac{17 \times 1000\ mm}{24 \times 60 \times 60\ sec}$$
$$= 0.197\ mm/sec$$
$\therefore$ Percentage of removal
$$= \frac{V_s}{V_0} \times 100 = \frac{0.1}{0.197} \times 100$$
$= 50.76\% = 50\%$ (say)

42. (c)
Nature rather than quantity of ions is of prime importance in theory of adsorption and charge neutralization.

43. **(b)**
1 mole of alum gives 2 moles of $Al(OH)_3$
i.e., 666 gm of alum gives 2×78 gm of $Al(OH)_3$
So. 500 gm of alum will give

$$= \frac{2 \times 78 \times 500}{666} \text{ gm } Al(OH)_3$$

$$= 117.12 \text{ gm of } Al(OH)_3$$

45. **(b)**
Settling velocity for particle size less than 0.1 mm

$$V_s = 418(S_s - 1)d^2\left(\frac{3T + 70}{100}\right)$$

V_s in mm/s
d in mm
T is temperature of water in °C

46. **(c)**
The common particles present in turbid waters do have a specific gravity ranging between 2.65 for discrete sand particles to about 1.03 for flocculated mud particles. The particles having specific gravity more than 1.2 can settle easily, while the lighter particles do not settle easily.

48. **(b)**
The mud from the atmosphere accumulates on the sand surface and may sink down into the sand bed. These mud balls go on increasing in size and weight and interferes with the upward movement of wash water during cleaning.

49. **(c)**
The common dechlorinating agents are: Sulphur dioxide gas ($SO_2\uparrow$), activated carbon, sodium thiosulphate ($Na_2S_2O_3$), sodium meta-bisulphate ($Na_2S_2O_5$), sodium sulphite (Na_2SO_3), sodium bisulphite ($NaHSO_3$), and ammonia as NH_4OH.

50. **(d)**
Dissolved solids cannot be removed in rapid sand filter. Helminth eggs, which range in size from about 10 mm to more than 100 mm, can be removed by many commonly used waste water-treatment processes such as sedimentation, filtration and stabilization ponds. However, some helminth eggs are extremely resistant to environmental stresses and may survive usual waste water and sludge disinfection procedure. Chlorine disinfection and mesophilic anaerobic digestion, for example, are not effective at inactivating many helminth eggs.

52. (a)
When chlorine is added to water it forms hypochlorous acid

$$Cl_2 + H_2O \xrightarrow{pH>5} HOCl + HCl,$$

$$HOCl \underset{pH<7}{\overset{pH>8}{\rightleftharpoons}} H^+ + OCl^-$$

The hypochlorous acid is the most destructive and more effective than hypochlorite ions (OCl^-). Thus at high pH, HOCl dissociates into OCl^- ions and disinfection efficiency is reduced.

53. (d)
When iron and manganese are present in combination with organic matter, it becomes difficult to break the bond between them and to cause their removal. However, when once this bond is broken, they can be removed. This bond may be removed either by adding lime, and thereby increasing the pH value of water to about 8.5 to 9; or by adding chlorine or potassium permanganate.

55. (a)
For defluoridation, activated alumina and bone char can be used. In Nalgoda technique, alum is added to lime or soda mixed water. Lime or soda ensure adequate alkalinity. This technique involves precipitation, settling and filtration.

56. (c)
The most important factor contributing to the stability of colloidal suspensions is the excessively large surface to volume ratio from their very small size. The surface phenomenon results in accumulation of electrical charge at the particle surface.

57. (b)
In a clariflocculator, the chemical coagulant is, first of all, fed (either dry or in solution form) into the raw water through the feeding device. This mixture is then thoroughly mixed and agitated in the mixing basin. The 'floc', which is formed as a result of the chemical reaction taking place in the mixing basin, is then allowed to consolidate in the flocculation tank. The flocculated water is finally passed into the sedimentation tank where these flocculated particles settle down and get removed.

58. (b)
Ferrous sulphate consumption

$$= \frac{75 \text{ mg/l} \times 28000 \text{ m}^3/d \times 10^3 \times 10^{-3}}{1000}$$

$$= 2100 \text{ kg/day}$$

An equivalent of $FeSO_4$ (139) would react with an equivalent of 90% CaO which is

$$\frac{28}{0.9} = 31.11$$

$$\therefore \text{ Lime dose} = 2100 \times \frac{31.11}{139} = 470 \text{ kg/day}$$

62. (c)
Higher the zeta potential, more stable is the particle.

63. (a)

$$C_d = \frac{Q_s C_s + Q_w C_w}{Q_s + Q_w}$$

$$= \frac{(180 - 25)0.033 + 22 \times 8.7}{(180 - 25) + 22}$$

$$= 1.13 \text{ mg/L}$$

64. (c)
Stream velocity = 5 miles/hour, hence it takes

$\frac{30}{5}$ 6 hr to travel 30 miles.

Therefore,

$$t = \frac{6}{24} = 0.25 \text{ day}$$

and $D_0 = 0$ because the stream is saturated

$$D = \frac{(0.2) \times (20)}{(0.40 - 0.20)}\left\{e^{-0.2 \times 0.25} - e^{-0.40 \times 0.25}\right\}$$

$$= 1.0 \text{ mg/L}$$

The dissolved oxygen 30 miles downstream will be saturation level minus the deficit, or
10 – 1.0 = 9 mg/l

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