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Environment Engineering

CIVIL ENGINEERING

Date of Test : 08/10/2026

ANSWER KEY >

1. (c)	7. (d)	13. (a)	19. (d)	25. (a)
2. (a)	8. (c)	14. (c)	20. (a)	26. (c)
3. (b)	9. (b)	15. (d)	21. (d)	27. (b)
4. (c)	10. (c)	16. (c)	22. (b)	28. (a)
5. (d)	11. (a)	17. (d)	23. (c)	29. (d)
6. (a)	12. (b)	18. (b)	24. (b)	30. (d)

DETAILED EXPLANATIONS

1. (c)

Velocity gradient, $G = \sqrt{\frac{P}{\mu V}}$

Power input per unit volume $\left(\frac{P}{V}\right) = 600 \text{ W}$

$\therefore G = \sqrt{\frac{600}{10^{-3}}} \text{ sec}^{-1}$

$\Rightarrow G = 774.597 \text{ sec}^{-1} = 774.597 \times 60 \text{ min}^{-1}$

$\Rightarrow G = 46475.8 \text{ min}^{-1}$

2. (a)

Initial population = P_0

Final population = $2P_0$

$\therefore r = \left[\sqrt[n]{\frac{2P_0}{P_0}} - 1 \right] \times 100$

$\Rightarrow r = [4\sqrt{2} - 1] \times 100$

$\Rightarrow r = 18.92\%$

3. (b)

1 ml of 0.02N H_2SO_4 consumed = 1 mg of alkalinity as CaCO_3 .

$\therefore$ 50 ml of 0.02 N H_2SO_4 is required = 50 mg of alkalinity as CaCO_3 is present.

$\therefore \text{Total alkalinity} = \frac{50}{0.250} \text{ mg/l CaCO}_3$
 $= 200 \text{ mg/l as CaCO}_3$.

4. (c)

Dilution ration	Treatment
1. > 500	No treatment required
2. 300 - 500	Plain sedimentation
3. 150 - 300	Sedimentation (SS < 60 ppm)
4. < 150	Complete treatment (SS < 30 ppm; BOD < 20 ppm)

5. (d)

Discrete particles in dilute suspension $\rightarrow$ Type-I settling.

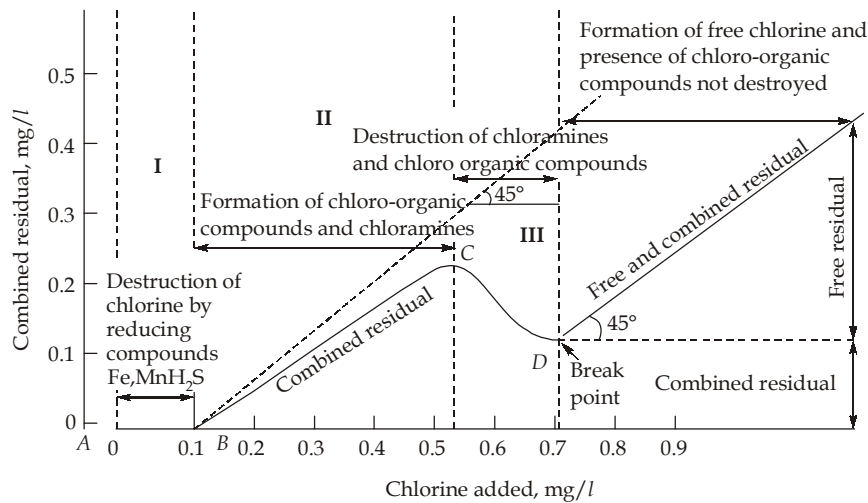
Flocculated particles in dilute suspension $\rightarrow$ Type-II settling.

Zone/Hindered settling (discrete particles in concentrated suspension) $\rightarrow$ Type -III settling.

Compression (flocculated particles in concentrated suspension) $\rightarrow$ Type -IV settling.

6. (a)

7. (d)



- At point C, bad smells start coming out. It is due to the fact that oxidation of organic matter starts at point C. Hence, residual amount decreases.
- Chloro-organic compounds are also destroyed. At point D, bad smells suddenly disappear. This implies that oxidation of organic matter is complete.

8. (c)

$$\text{BOD of sewage sample} = \frac{DO_i - DO_f}{DF} = \frac{(8.8 - 2.3) \text{ mg/l}}{0.02} = 325 \text{ mg/l}$$

9. (b)

Silver sulphate (Ag_2SO_4), mercuric chloride (HgCl_2) and copper sulphate (CuSO_4) are harmful for algae and thus disturb the symbiotic relationship in oxidation pond.

Therefore, we don't add them in oxidation pond.

Sodium nitrate (NaNO_3) can reduce bad odour obtained during oxidation of organic matter and is thus used.

10. (c)

Cl_2 is present at $\text{pH} < 5$

HOCl is predominant at $\text{pH} 5$ to 7

OCl^- is predominant at $\text{pH} > 8$

HOCl and OCl^- both are significant at $\text{pH} 7$ to 8

11. (a)

Since, 4% of filtered water is required for backwashing.

$$\therefore \text{Total filtered water required per day} = \frac{40 \times 10^6}{0.96} = 41.67 \text{ MLD}$$

Now, 30 minutes are lost each day in back washing.

$$\text{So, filtered water required per hour} = \frac{41.67}{23.5} = 1.77 \text{ ML/hour}$$

$$\therefore \text{Total area of filter required} = \frac{1.77 \times 10^6}{5252} = 337.01 \text{ m}^2$$

$$\therefore \text{Number of filters required} = \frac{337.01}{(4 \times 4)} = 21.06 \simeq 22$$

$\therefore$ Two additional filters are required so, $22 + 2 = 24$ filters are required.

12. (b)

50% of micro-organisms are killed in 10 minutes.

$$\Rightarrow \text{At time, } t = 10 \text{ min.}; N_t = 0.5 N_o$$

$$\text{But, } N_t = \frac{N_o}{1 + k(t)}$$

$$\Rightarrow \frac{N_t}{N_o} = \frac{1}{1 + k(10)} = 0.5$$

$$\Rightarrow k = 0.1 \text{ min}^{-1}$$

Percentage of micro-organism surviving after 15 minutes.

$$N_t = \frac{N_o}{1 + (0.1 \times 15)}$$

$$\Rightarrow N_t = 0.4 N_o$$

i.e. only 40% of micro-organisms are left after 15 minutes,

Now, when only 40% of micro-organisms are left and kill rate is doubled.

$$\therefore k' = 2 \times k = 0.2 \text{ min}^{-1}$$

$$N_t' = (0.1 N_o), \text{ as 90\% of initial micro-organisms are to be killed.}$$

$$N_o' = 0.4 N_o, \text{ as when rate of killing is doubled micro-organisms surviving are 40\% of initial micro-organisms.}$$

$$\text{So, } N_t' = \frac{N_o'}{1 + k't}$$

$$\Rightarrow 0.1 N_o = \frac{0.4 N_o}{1 + (0.2 \times t)}$$

$$\Rightarrow t = 15 \text{ minutes}$$

Now,

It takes 5 minutes in killing of micro-organisms from 50% to 60%, and 15 minutes from 60% to 90%. So, total time required for killing of micro-organisms from $0.5 N_o$ to $0.9 N_o$ is 20 minutes.

13. (a)

Component	% by mass	% Moisture	Energy (kJ/kg)	Dry (mass(kg))	Total Energy (kJ)
Food waste	20	70	4650	6	93000
Paper	40	6	16750	37.6	670000
Card board	15	5	16300	14.25	244500
Plastics	7.5	2	32600	7.35	244500
Garden trimming	7.5	60	6500	3	48750
Wood	5	20	18600	4	93000
Tin cans	5	3	700	4.85	3500
Total				77.05	

$$\text{Moisture content} = \left(\frac{100 - 77.05}{100} \right) \times 100 = 22.95\%$$

$$\text{Unit energy content} = \frac{\text{Total energy}}{\text{Total weight}} = \frac{1397250}{100} = 13972.50 \text{ kJ/kg}$$

∴ Energy content on ash-free dry basis

$$= 13972.50 \left(\frac{100}{100 - 22.95 - 5} \right) = 19392.78 \text{ kJ/kg}$$

14. (c)

Efficiency of trickling filter,

$$\eta = \frac{250 - 100}{250} \times 100 = 60\%$$

Now, as per NRC equation,

$$\eta = \frac{100}{1 + 0.44\sqrt{OLR}} \quad (\text{OLR is in kg/m}^3/\text{day})$$

$$\Rightarrow 60 = \frac{100}{1 + 0.44\sqrt{OLR}}$$

$$\Rightarrow 1 + 0.44\sqrt{OLR} = \frac{100}{60}$$

$$\Rightarrow OLR = 2.2957 \text{ kg/m}^3/\text{d}$$

But $OLR = \frac{\text{kg of BOD entering the filter/day}}{\text{Volume of the filter (V)}}$

$$\Rightarrow V = \frac{250 \text{ mg/l} \times 20 \times 10^6 \text{ l/d}}{2.2957 \text{ kg/m}^3/\text{d} \times 10^6 \text{ mg/kg}} = 2177.98 \text{ m}^3 \simeq 2178 \text{ m}^3$$

15. (d)

$$\therefore \text{pH} = 10 \quad (\because \text{At } 25^\circ\text{C}, \text{pH} + \text{pOH} = 14)$$

$$\Rightarrow \text{pOH} = 4$$

$$\therefore [\text{OH}^-] = 10^{-4} \text{ moles/l}$$

$$= 10^{-4} \times 17 \text{ g/l}$$

$$= 10^{-4} \times 17 \times 10^3 \text{ mg/l}$$

$$= \frac{10^{-4} \times 17 \times 10^3}{17 \text{ g}} \text{ mg/l} \times 50 \text{ g}$$

$$\therefore \text{Caustic alkalinity} = 5 \text{ mg/l as CaCO}_3$$

$$\text{Total alkalinity} = \text{Caustic Alkalinity} + \text{Carbonate Alkalinity}$$

$$= \left\{ 5 + \left(\frac{75}{30} \times 50 \right) \right\} \text{ mg/l as CaCO}_3$$

$$= 130 \text{ mg/l as CaCO}_3$$

$$\text{Total hardness, TH} = \left(\frac{50}{20} \times 50 + \frac{24}{12} \times 50 \right) \text{ mg/l as CaCO}_3$$

$$= 225 \text{ mg/l as CaCO}_3$$

Now, carbonate hardness,

$$\begin{aligned} \text{CH} &= \text{minimum} \left\{ \begin{array}{l} \text{Total hardness} \\ \text{Alkalinity} \end{array} \right\} \\ &= \text{minimum} \left\{ \begin{array}{l} 225 \\ 130 \end{array} \right\} = 130 \text{ mg/l as CaCO}_3 \end{aligned}$$

$$\begin{aligned} \therefore \text{Non-carbonate Hardness} &= \text{TH} - \text{CH} \\ &= 225 - 130 = 95 \text{ mg/l as CaCO}_3 \end{aligned}$$

16. (c)

$$\begin{aligned} d &= 0.05 \text{ mm} = 0.05 \times 10^{-3} \text{ m} \\ G_s &= 2.65 \\ \eta &= 88\% \\ \nu &= 10^{-6} \text{ m}^2/\text{s} \end{aligned}$$

Settling velocity as per Stoke's law is,

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

$$\begin{aligned} \Rightarrow V_s &= \frac{9.81}{18} \text{ m/s}^2 (2.65 - 1) \times \frac{(0.05 \times 10^{-3} \text{ m})^2}{10^{-6} \text{ m}^2/\text{s}} \\ &= 2.248 \times 10^{-3} \text{ m/s} = 2.248 \text{ mm/s} \end{aligned}$$

$$\eta = \frac{V_s}{V_0} \times 100$$

$$\Rightarrow 88\% = \frac{2.248}{V_0} \times 100$$

$$\Rightarrow V_0 = 2.5545 \text{ mm/s} \simeq 2.55 \text{ mm/s}$$

17. (d)

From Chick Waston model,

$$t_1 C_1^{n_1} = t_2 C_2^{n_2}$$

Given,

$$n_1 = n_2 = 1$$

t_1 and $t_2 \rightarrow$ Time of contact

C_1 and $C_2 \rightarrow$ Concentration of chlorine

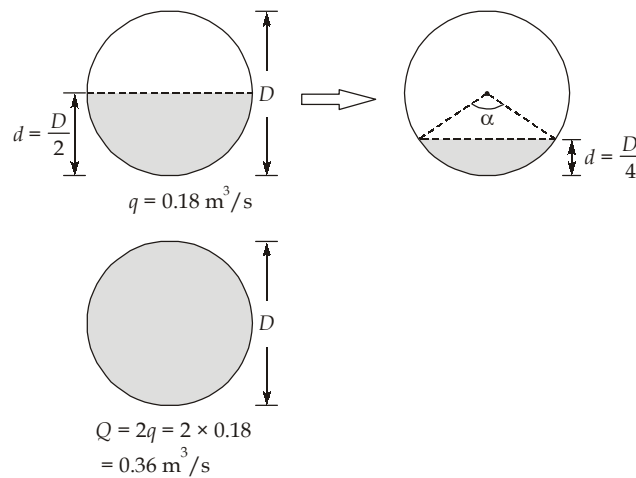
$$\text{For one day, } C_1 = \frac{30 \text{ kg}}{20 \text{ Ml}} = \frac{30 \times 10^6 \text{ mg}}{20 \times 10^6 \text{ l}} = 1.5 \text{ mg/l}$$

$$\therefore 10 \text{ min} \times 1.5 \text{ mg/l} = 12 \text{ min} \times C_2$$

$$\Rightarrow C_2 = 1.25 \text{ mg/l}$$

$$\therefore \text{Total quantity of chlorine required} = 1.25 \text{ mg/l} \times 30 \times 10^6 \text{ l/d} = 37.5 \text{ kg/d}$$

18. (b)



Now,

$$\frac{d}{D} = 0.25 = \frac{1}{2} \left(1 - \cos \frac{\alpha}{2} \right)$$

∴

$$\alpha = 120^\circ$$

∴

$$\frac{q}{Q} = \left(\frac{\alpha}{360} - \frac{\sin \alpha}{2\pi} \right) \left(\frac{\frac{a}{360} - \frac{\sin \alpha}{2\pi}}{\frac{\alpha}{360}} \right)^{2/3}$$

$$= 0.1955 \left(\frac{0.1955}{0.333} \right)^{2/3} = 0.137$$

$$q = 0.137 \times 0.36$$

$$= 0.049 \simeq 0.05 \text{ m}^3/\text{s}$$

19. (d)

Initial oxygen deficit (D_o) = 4.5 mg/lUltimate BOD of river (L_0) = 15 mg/l

$$K_R = 0.5 \text{ d}^{-1}$$

$$K_D = 0.28 \text{ d}^{-1}$$

Now,

$$\left[\frac{L_0}{D_C \cdot f} \right]^{f-1} = f \left[1 - (f-1) \frac{D_o}{L_0} \right]$$

Here,

$$f = \frac{K_R}{K_D} = \frac{0.5}{0.28} = 1.786$$

$$\therefore \left[\frac{15}{D_C \times 1.786} \right]^{1.786-1} = 1.786 \left[1 - (1.786-1) \times \frac{4.5}{15} \right]$$

$$\Rightarrow D_C = 5.65 \text{ mg/l}$$

Now,

$$D_C = \frac{K_D \cdot L_0}{K_R} e^{-K_D \cdot t_c}$$

$$\Rightarrow \frac{5.65 \times 0.5}{0.28 \times 15} = e^{-0.28 \times t_c}$$

$$\Rightarrow t_c = 1.416 \text{ days} \simeq 1.42 \text{ days}$$

20. (a)

$$\text{Mass of solids in raw sludge} = 42 \times 72.5 = 3045 \text{ kg/d}$$

$$\text{Weight of non-volatile solids} = 3045 \times 0.3 = 913.5 \text{ kg}$$

$$\text{Weight of raw volatile sludge} = 0.7 \times 3045$$

$$\begin{aligned} \text{Weight of volatile sludge remaining} &= 3045 \times 0.7 \times (1 - 0.6) \\ &= 852.6 \text{ kg/d} \end{aligned}$$

$$\text{Mass of solids in digested sludge} = 913.5 + 852.6 = 1766.1 \text{ kg/d}$$

$$\text{Weight of sludge (Solids + Water)} = \frac{1766.1}{0.05} = 35322 \text{ kg/d}$$

$$\text{Now, } \rho_{\text{sludge}} = 1040 \text{ kg/m}^3$$

$$\Rightarrow \text{Volume of digested sludge} = \frac{35322}{1040} = 33.96 \text{ m}^3$$

$$\text{Volume of sludge digester required} = \left[\frac{V_1 + V_2}{2} \right] \times t + V_2 T$$

$$\begin{aligned} \Rightarrow V &= \frac{72.5 + 33.96}{2} \times 30 + 33.96 \times 90 \\ &= 4653.3 \text{ m}^3 \approx 4660 \text{ m}^3 \end{aligned}$$

21. (d)

$$\frac{\mu\text{g}}{\text{m}^3} = \frac{\text{ppm} \times \text{molecular mass of pollutant}}{\text{Litres/mol of pollutants}}$$

Every gas at standard temperature (273 K) and pressure (1 atm) occupies 22.4 litre/mol

$$\therefore PV = nRT$$

$$\Rightarrow \frac{PV}{nT} = R = \text{constant}$$

$$\therefore \left(\frac{P_1}{T_1} \right) \left(\frac{V_1}{n_1} \right) = \left(\frac{P_2}{T_2} \right) \left(\frac{V_2}{n_2} \right)$$

$$\Rightarrow \left(\frac{1 \text{ atm}}{273 \text{ K}} \right) \times 22.4 \text{ l/mol} = \left(\frac{0.892 \text{ atm}}{(273 + 20)} \right) \times \left(\frac{V_2}{n_2} \right)$$

$$\Rightarrow \left(\frac{V_2}{n_2} \right) = 26.95 \text{ litre/mol}$$

$$\text{So, } 60 \frac{\mu\text{g}}{\text{m}^3} = \frac{\text{ppm} \times (32 + 2 \times 16) \times 1000}{26.95}$$

$$\therefore \text{SO}_2(\text{in ppm}) = 0.025$$

22. (b)

$$V_2 = \left(\frac{100 - p_1}{100 - p_2} \right) V_1$$

where p_1 and p_2 are initial and final moisture content.

$$= \left(\frac{100 - 90}{100 - 80} \right) V_1 = 0.5 V_1$$

$$\begin{aligned}\text{So, Percent decrease in volume} &= \frac{V_2 - V_1}{V_1} \times 100 \\ &= \left(\frac{0.5V_1 - V_1}{V_1} \right) \times 100 = 50\%\end{aligned}$$

23. (c)

$$\begin{aligned}\text{Water treated per day} &= 30000 \text{ m}^3 \\ &= 30 \times 10^6 \text{ litres/day}\end{aligned}$$

$$\begin{aligned}\text{Chlorine consumed per day} &= 11 \text{ kg} \\ &= 11 \times 10^6 \text{ mg/day}\end{aligned}$$

∴ Chlorine used per litre of water

$$= \frac{11 \times 10^6}{30 \times 10^6} = 0.367 \text{ mg/l}$$

$$\text{Also, chlorine residual} = 0.2 \text{ mg/l}$$

$$\therefore \text{Chlorine demand} = 0.367 - 0.2 = 0.167 \text{ mg/l}$$

24. (b)

$$\text{Sewage discharge, } Q_s = \frac{6 \times 10^6 \times 10^{-3}}{86400} = 0.06944 \text{ m}^3/\text{sec}$$

$$\begin{aligned}\text{BOD of mix} &= \frac{Q_s (\text{BOD})_s + Q_R (\text{BOD})_R}{Q_s + Q_R} \\ &= \frac{0.06944 \times 340 + 0.24 \times 1.9}{0.06944 + 0.24} \\ &= 77.77 \text{ mg/lit.}\end{aligned}$$

25. (a)

$$\text{SVI} = \frac{\text{Volume of sludge settled}}{\text{MLSS concentration}}$$

$$\Rightarrow \text{SVI} = \frac{200}{2.5} = 80 \text{ ml/gm}$$

$$\therefore \text{Sludge density index} = \frac{1}{\text{SVI}} = \frac{1}{80} = 0.0125 \text{ gm/ml}$$

26. (c)

Ultimate BOD is the oxygen required for oxidising the biodegradable organics of a given waste water while COD is the oxygen required to oxidize the both biodegradable organics and non biodegradable organics.

27. (b)

28. (a)

$$\text{Discharge per meter through gallery } (q) = k \frac{H^2 - H_0^2}{2R}$$

where, $k = 0.5 \text{ cm/sec} = 0.005 \text{ m/sec}$, $R = 15 \text{ m}$, $H = 6 \text{ m}$, $H_0 = 2 \text{ m}$

$$\begin{aligned} \therefore q &= 0.005 \times \frac{6^2 - 2^2}{2 \times 15} = 0.00533 \text{ m}^3/\text{sec}/\text{m} \\ &= 0.32 \text{ m}^3/\text{min}/\text{m} \end{aligned}$$

29. (d)

$$\text{Total alkalinity} = \frac{90}{600} \times 1000 = 150 \text{ mg/l as CaCO}_3$$

$$\text{OH}^- \text{ alkalinity} = 5 \text{ mg/l as CaCO}_3$$

$$\Rightarrow [\text{OH}^-] + \frac{1}{2} [\text{CO}_3^{2-}] = \frac{33}{600} \times 1000 = 55 \text{ mg/l as CaCO}_3$$

$$\Rightarrow 5 + \frac{1}{2} [\text{CO}_3^{2-}] = 55 \text{ mg/l as CaCO}_3$$

$$\text{Total alkalinity caused by } \text{CO}_3^{2-} \text{ ions} = 2 \times 50 = 100 \text{ mg/l as CaCO}_3$$

30. (d)

Flocculating particles have type-2 settling. The Stoke's law cannot be used because flocculating particles continuously change their shapes and size.

