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Environment Engineering

CIVIL ENGINEERING

Date of Test : 25/05/2026

ANSWER KEY >

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

DETAILED EXPLANATIONS

1. (c)

Nitrite : Color induced by addition of sulphonic acid and naphthamine.

Nitrate: Color induced by addition of phenol di-sulphonic acid and KOH.

Fluoride: Color induced by addition of zirconium and alizarine.

2. (d)

Quality parameter	Permissible limit (mg/l)
Fluoride	1
Nitrite	0
Copper	0.05
Free ammonia	0.3

3. (d)

$$\text{Alkalinity} = \frac{500}{2} \text{ mg/l} = 250 \text{ mg/l}$$

$$\text{Hardness} = \frac{450}{2} \text{ mg/l} = 225 \text{ mg/l}$$

$$\begin{aligned} \text{Carbonate hardness} &= \min. \{ \text{Alkalinity, Hardness} \} \\ &= 225 \text{ mg/l} \end{aligned}$$

$$\begin{aligned} \text{Non-carbonate hardness} &= \text{Hardness} - \text{Carbonate hardness} \\ &= 225 - 225 = 0 \text{ mg/l} \end{aligned}$$

∴ Non-carbonate hardness is zero.

4. (c)

Density before compaction = 110 kg/m³

Area of landfill site = 1 m³

Let thickness of waste before compaction = x m

∴ Total weight of waste = 110 x kg

Total weight of waste after compaction = 400 × 1 × 0.14 = 56 kg

∴ Total weight of waste remains the same

$$\therefore 110x = 56$$

$$\Rightarrow x = 0.509 \simeq 0.51 \text{ m}$$

5. (a)

Heterotrophs: Derive both energy and material from organic compounds.

Autotrophs: Derive both energy and mass from inorganic compounds.

Phototrophs: Derive energy from sunlight.

6. (d)

$$\text{SVI} = \frac{V_{ob} (\text{ml/l})}{X_{ob} (\text{mg/l})} = \frac{V_{ob}}{X_{ob}} \times 100 \text{ ml/g}$$

V_{ob} = Settled volume sludge per liter

$$= \frac{850}{2} = 425 \text{ ml/l}$$

$$V_{ob} = 3000 \text{ mg/l}$$

$$SVI = \frac{425}{3000} \times 1000 = 141.667 \approx 142 \text{ ml/g}$$

7. (b)

Waste stabilization pond is also known as algal pond. It is the simplest method of treatment. This method relies on the use of shallow pond in which the waste water is held for several days under which algae can flourish and at the same time provide oxygen through photosynthesis.

8. (c)

$$\begin{aligned} \text{Head loss} &= h(1-n)(G-1) \quad [G = \text{Specific gravity} = 2.5] \\ &= 0.6(1-0.5)(2.5-1) \\ &= 0.45 \text{ m} \end{aligned}$$

9. (b)

$$Q = \frac{2\pi KDS}{2.303 \log_{10} \left(\frac{R}{r_w} \right)}$$

$$\Rightarrow 0.03 = \frac{2\pi K \times 27 \times 3}{2.303 \log_{10} \left(\frac{200}{0.08} \right)}$$

$$\begin{aligned} K &= 4.613 \times 10^{-4} \text{ m/sec} \\ &= 39.856 \text{ m/day} \end{aligned}$$

10. (c)

Design of anaerobic ponds is favourable to methane fermentation.

11. (a)

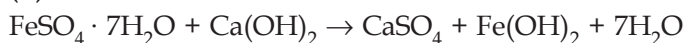
$$\text{Vehicles: } \frac{300000 \times 10000 \times 1}{10^6} = 3000 \text{ tonnes}$$

$$\text{Oil based paints: } \frac{2 \times 1.5 \times 1.5 \times 10^6}{10^3} = 4500 \text{ tonnes}$$

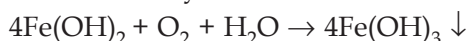
$$\text{Dry cleaning solvent: } \frac{1.2 \times 1.5 \times 10^6}{10^3} = 1800 \text{ tonnes}$$

$$\text{Total hydrocarbons discharged} = 3000 + 4500 + 1800 = 9300 \text{ tonnes}$$

12. (b)



The ferrous hydroxide formed, further oxidised



Means 1 mole of copperas makes one mole of Fe(OH)_2 and one mole of Fe(OH)_2 make one mole of Fe(OH)_3 ↓

$$\begin{aligned} \therefore \text{Quantity of copperas required to treat 20 million litres of water per day} \\ &= 20 \times 10^6 \times 9 \times 10^{-6} = 180 \text{ kg/day i.e., } 7.5 \text{ kg/hour} \end{aligned}$$

Now, 277.8 gm of copperas finally leads to form 106.8 gm of Fe(OH)_3

$$\therefore 7.5 \text{ kg/hour of copperas will make} = \frac{106.8}{277.8} \times 7.5 = 2.883 \text{ kg/hour i.e., } 2883 \text{ gm/hour}$$

13. (d)

Sample size (1 ml)

$$\text{No. of positive tubes} = \frac{288}{360} \times 5 = 4$$

Sample size (0.1 ml)

$$\text{Number of positive tubes} = \frac{144}{360} \times 5 = 2$$

Sample size (0.01 ml)

$$\text{Number of positive tubes} = \frac{72}{360} \times 5 = 1$$

Positive combination is 4 - 2 - 1 and negative combination is 1 - 3 - 4.

But dilution of standard used is 10 ml, 1 ml, 0.1 ml.

So, MPN index for negative results = $38 \times 10 = 380$

14. (c)

Relative stability for a sample is given by,

$$s = \frac{\text{O}_2 \text{ available in effluent}}{\text{Total O}_2 \text{ required for 1st stage BOD}}$$

$$\begin{aligned} \text{Carbonaceous demand (1st stage BOD)} &= \text{Total oxygen demand} - \text{Nitrogenous demand} \\ &= 110 - 60 = 50 \text{ mg/l} \end{aligned}$$

$$\therefore s = \frac{40}{50} \times 100 = 80\%$$

15. (b)

General equation of kinetics is

$$\frac{dC_A}{dt} = -kC_A^n$$

Order = 2

$$\therefore \int_{C_0}^{C_t} \frac{dC_A}{C_A^2} = \int_0^t -k dt$$

$$\Rightarrow \left(\frac{1}{C_0} - \frac{1}{C_t} \right) = -kt$$

Given, $C_0 = 0.25 \text{ mg/l}$, $k = 0.5 \text{ per day}$, $t = 2 \text{ days}$

$$\Rightarrow \frac{1}{C_t} = \frac{1}{0.25} + 1$$

$$\Rightarrow C_t = 0.2 \text{ mg/l}$$

16. (d)

	[TS]	+	[SS]	→	[DS]
	Test sample		Seeded sample		Diluted sample
	5 mL		295 mL		300 mL
Initial DO:	5 mg/l		7 mg/L		x
Final DO:	-		-		y

$$x = \frac{5 \times 5 + 7 + 295}{300} = 6.967 \text{ mg/l}$$

Also, $x - y = 6.967$ (after 5 days of incubation)

$$\Rightarrow y = 0 \text{ mg/l}$$

∴ Final DO of diluted sample is zero.

Hence, the readings should be discarded.

17. (d)

Initial oxygen deficit (D_o) = 4.5 mg/l

Ultimate BOD of river (L_0) = 15 mg/l

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

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

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

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

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

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

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

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

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

18. (c)

Percentage of waste placed in landfill = $1 - 0.20 - (0.15 \times 0.40) = 0.74 = 74\%$

The amount of waste generated by population per day

$$= 0.74 \times 400000 \times \frac{14}{7} \text{ kg/day} = 592000 \text{ kg}$$

$$\therefore \text{Volume of waste placed in landfill} = \frac{592000}{160} = 3700 \text{ m}^3$$

19. (a)

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

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

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

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

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

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

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

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

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

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

20. (d)

$$\text{Outlet concentration} = 15 \text{ mg/l}$$

$$\text{Detention time, } t = \frac{V}{Q} = \frac{2 \times 3 \times 1}{1} = 6 \text{ days}$$

$$k_d = 0.1/\text{day}$$

$$\text{Organic matter decomposed, } L_t = L_0 (10^{-k_d \times t})$$

$$L_t = 15 \text{ mg/l}$$

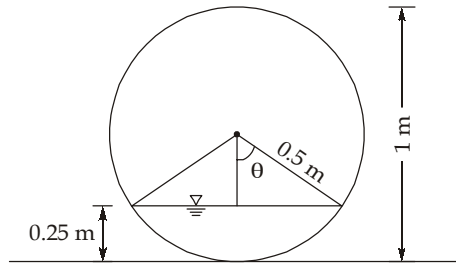
$$\therefore 15 = L_0 (10^{-0.1 \times 6})$$

$$\Rightarrow L_0 = 59.716 \text{ mg/l} \approx 59.7 \text{ mg/l}$$

21. (c)

AQI	Designation	Possible health impacts
0-50	Good	Minimal impact
51-100	Satisfactory	Minor breathing discomfort to sensitive people
101-200	Moderate	Breathing discomfort to the people with lungs, asthma and heart disease
201-300	Poor	Breathing discomfort to most people on prolonged exposure
301-400	Very poor	Respiratory illness on prolonged exposure
401-500	Severe	Affects healthy people and seriously impacts those with existing disease

22. (b)



$$\cos \theta = \frac{0.5 - 0.25}{0.5} = \frac{0.25}{0.5} = \frac{1}{2}$$

$$\Rightarrow \theta = \frac{\pi}{3}$$

$$\text{Cross-sectional area of flow, } A = r^2 \left[\theta - \frac{\sin 2\theta}{2} \right]$$

$$\Rightarrow A = (0.5^2) \left[\frac{\pi}{3} - \left\{ \sin \left(2 \times \frac{\pi}{3} \right) \right\} \frac{1}{2} \right]$$

$$\Rightarrow A = \frac{1}{4} \left[\frac{\pi}{3} - \frac{\sqrt{3}}{4} \right]$$

$$A = 0.1535 \text{ m}^2$$

$$\text{Wetted perimeter of flow} = r(2\theta)$$

$$= 0.5 \times 2 \times \frac{\pi}{3} = 1.047 \text{ m}$$

$$\therefore \text{Hydraulic radius} = \frac{A}{P} = \frac{0.1535}{1.047} = 0.147 \text{ m}$$

23. (d)

$$\text{Given, } L_e = 1.5 L$$

$$\frac{L_e}{L} = \frac{1 - \eta}{1 - \eta_e} \quad (\eta = \text{Porosity})$$

$$1.5 = \frac{1 - 0.4}{1 - \eta_e}$$

$$\eta_e = 0.6$$

$$V_s = \frac{(G - 1)gd^2}{18\nu} = \frac{(2.65 - 1) \times 981 \times (0.066)^2}{18 \times 1.31 \times 10^{-2}}$$

$$V_s = 29.9 \text{ cm/sec}$$

$$\eta_e = \left(\frac{\bar{V}_s}{V_s} \right)^{0.22} \quad (\bar{V}_s = \text{Backwash velocity})$$

$$0.6 = \left(\frac{\bar{V}_s}{29.9} \right)^{0.22}$$

$$\bar{V}_s = 2.933 \text{ cm/sec}$$

24. (a)

Efficiency of standard rate trickling filter as given by National Research Council (NRC) formula:

$$\eta = \frac{100}{1 + 0.0044\sqrt{u}} \quad u = \text{organic loading rate in kg/hac-m/day}$$

$$u = 160 \text{ gm/m}^3/\text{day}$$

$$= \frac{160 \times 10^4}{10^3} \text{ kg/hac-m/day}$$

$$= 1600 \text{ kg/hac-m/day}$$

$$\therefore \eta = \frac{100}{1 + 0.0044\sqrt{1600}} = 85.034\% \approx 85.03\%$$

25. (a)

Total mass (solid + water) = 100 kg

$$\begin{aligned} \text{Total moisture} &= \frac{1}{100} (15 \times 6 + 24 + 6 + 33 \times 5 + 4.2 \times 0.5 + 0.49 \times 2 + 0.13 \times 0.5 \\ &\quad + 1.18 + 0.5 + 0.35 \times 0.5 + 17.97 + 60 + 1.67 + 6 + 2.01 \times 8) \\ &= 15.9739 \text{ kg} \end{aligned}$$

$$\text{Mass of solids} = 100 - 15.9739 = 84.0261 \text{ kg}$$

$$\text{Total moisture (on dry basis)} = \frac{\text{Mass of water}}{\text{Mass of solids}} = \frac{15.9739 \times 100}{84.0261} = 19.01\%$$

26. (d)

DO of diluted sample at $t = 0$

$$= \frac{4 \times 0.5 + 96 \times 4}{100} = 3.86 \text{ mg/lt}$$

$$\text{BOD}_5 = (3.86 - 0.8) \times \frac{100}{4} = 76.5 \text{ mg/lt}$$

$$L_0 = \frac{L_t}{1 - 10^{-k_D t}} = \frac{76.5}{1 - 10^{-0.12 \times 5}} = 102.16 \text{ mg/lt}$$

27. (a)

For SO₂ emission,

Minimum chimney height, $h = 14 (Q_s)^{1/3}$ (where, Q_s is in kg/hr)

$$Q_s = 60 \text{ t/years}$$

$$= \frac{60 \times 10^3}{365 \times 24} = 6.85 \text{ kg/hr}$$

$$\therefore h = 14 (6.85)^{1/3}$$

$$= 26.59 \text{ m}$$

28. (b)

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

$$\text{BOD of mix} = \frac{Q_s (\text{BOD})_s + Q_R (\text{BOD})_R}{Q_s + Q_R}$$

$$= \frac{0.06944 \times 340 + 0.24 \times 1.9}{0.06944 + 0.24}$$

$$= 77.77 \text{ mg/lit.}$$

29. (a)

$$\text{Total surface area required} = \frac{60}{(5.8/60)} = 620.7 \text{ m}^2$$

$$\text{Surface area of one unit} = \pi dl$$

$$= \pi \times 0.82 \times 40$$

$$= 103.04 \text{ m}^2$$

$$\therefore \text{No. of units required} = \frac{620.7}{103.04} = 6.024 \approx 7$$

30. (d)

$$P_n = P_0 \left(1 + \frac{r}{100} \right)^n$$

$$\Rightarrow 47000 = 25000 \left(1 + \frac{r}{100} \right)^2$$

$$\Rightarrow r = 37.113\% = \text{Rate of increase of population per decade.}$$

$$\therefore P_{2016} = P_{2000} \left(1 + \frac{r}{100} \right)^n$$

$$= 47000 \left(1 + \frac{37.113}{100} \right)^{1.6}$$

$$= 77879.59 \approx 77880$$

