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Environmental Engineering

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 16/07/2019

ANSWER KEY ➤ Environmental Engineering

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

DETAILED EXPLANATIONS

2. (b)

Total hardness

$$TH(\text{in mg}/l \text{ as } CaCO_3) = (\text{milli. eq. of } Ca^{2+}) \times \text{eq. wt. of } CaCO_3 + (\text{milli. eq. of } Mg^{2+}) \times \text{eq. wt of } CaCO_3$$

$$= 40 \times 50 + 20 \times 50 = 3000$$

$\therefore$ $TH > \text{Alkalinity}$

$\therefore$ $CH = \text{Alkalinity} = 2250 \text{ mg}/l \text{ as } CaCO_3$

$\therefore$ $NCH = 3000 - 2250 = 750 \text{ mg}/l \text{ as } CaCO_3$

5. (b)

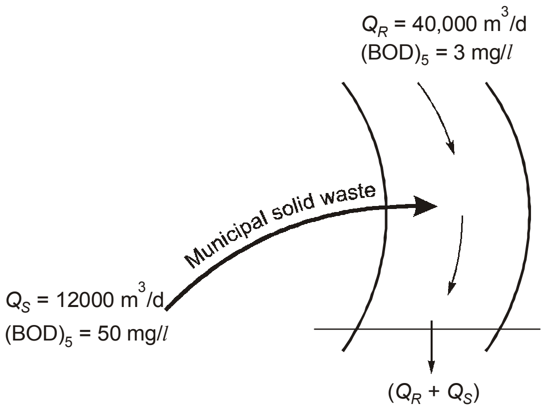
$$V_1(100 - P_1) = V_2(100 - P_2)$$

$$V_1(100 - 98) = V_2(100 - 90)$$

$$V_2 = 0.2\, V_1$$

$\therefore$ 80% decrease.

8. (b)



$$(BOD)_{mix} = \frac{Q_S \times (BOD)_S + Q_R + (BOD)_R}{Q_R + Q_S}$$

$$= \frac{12000 \times 50 + 40000 \times 3}{12000 + 40000}$$

$$= 13.846 \simeq 13.85 \text{ mg}/l$$

9. (d)

Sanitary land filling is a site for disposal of waste material by burial. It is process of dumping of solid waste in a scientifically designed, dried, area by spreading waste in form of thin layers. It is economical, simple and efficient measure of natural decomposition of wastes.

11. (b)

Y_1 (i.e. BOD for one day) = 110 mg/lit at 30°C

$$k_D = 0.1 \text{ d}^{-1} \text{ at } 20°C$$

$$k_{D(T=30°C)} = k_{D(T=30°C)}(1.047)^{T-20}$$

$$= 0.1 \times (1.047)^{30-20} = 0.158 \text{ d}^{-1}$$

$\therefore$ $$l_0(1 - 10^{-0.158 \times 1}) = 110$$

$$l_0(\text{ultimate BOD}) = \frac{110}{1-10^{-0.158}} = 360.68 \text{ mg/lit}$$

Now, 5 day BOD at 20°C

$$Y_5 = l_0(1 - 10^{-k_D t})$$
$$= 360.68\,(1 - 10^{-0.1\times5}) = 246.62 \text{ mg/lit}$$

12. (a)

Given,

$$\text{Population} = 20{,}000$$
$$\text{BOD}_5 \text{ of persons} = 70 \text{ gm per capita}$$
$$\text{BOD}_5 \text{ of industry} = 450 \text{ mg}/l$$
$$\text{Discharge of industries} = 50{,}000\ l/\text{d}$$

Total BOD_5 of combined sewage

$$= (20{,}000 \times 70) + (450 \times 50{,}0000 \times 10^{-3}) = 1422500 \text{ gm/day}$$

$$\therefore \quad \text{Population equivalent} = \frac{\text{Total BOD}_5}{80 \text{ gm/day/person}} = \frac{1422500}{80} = 17781.25$$

13. (d)

- Fluorides are removed with aluminum oxide.
- Hexavalent chromium can be removed by reduction and followed by precipitation.
- Iron and manganese can be removed by aeration followed by coagulations, sedimentation and filtration.
- Toxic organics can be removed by activated carbon treatment.

14. (a)

Given,

$$\text{Drainage discharge} = 1.3 \text{ m}^3/\text{sec}$$
$$\text{Area of town} = 20 \text{ ha}$$

Critical rainfall intensity, $p_c = 6$ cm/hr

From, Retinol formula

$$Q_P = \frac{1}{36} k_{eq} \cdot p_c\, A \qquad (A \text{ in ha, } P_c \text{ in cm/hr})$$

$$1.3 = \frac{1}{36}\left(\frac{k_1A_1 + k_2A_2 + k_3A_3}{A_1 + A_2 + A_3}\right) \times 6 \times 20$$

$$1.3 = \frac{1}{36}\left(\frac{\left(0.8\times\frac{x}{100} + 0.2\times\frac{40}{100} + 0.15\times\frac{60-x}{100}\right)}{\left(\frac{x}{100} + \frac{40}{100} + \frac{60-x}{100}\right)A}\right)\times 6\times 20$$

$$x = 33.846 \simeq 34\%$$

15. (d)

$$\text{BOD loading rate} = 250 \text{ kg/ha/day}$$

Waste water flow $Q = 1$ MLD with BOD $= 250$ mg/lit

$$\therefore \quad \text{Surface area of pond} = \frac{\text{BOD applied}}{\text{BOD loading rate}}$$

∴ Surface area of pond $= \frac{(1\times 250)\text{ kg/day}}{250\text{ kg/ha/day}} = 1\text{ ha}$ (MLD × mg/l = kg/day)

∴ Volume of pond (V) = Surface area × depth = 1 ha × 1 = $10^4 \times 1 = 10^4\text{ m}^3$

∴ Detention time (D_t) $= \frac{V}{Q} = \frac{10^4}{\left(\frac{1\times 10^6}{10^3}\right)} = 10\text{ days}$

16. (a)

Concentration of SO_2 (in 1 μ g/m^3) = 42 μ g/m^3 at STP

$$\mu\text{ g/m}^3 = \left(\frac{\text{ppm} \times \text{mol.wt} \times 10^3}{\text{volume at T°C in lit/mol}}\right)$$

$$V_2 = V_1\left(\frac{273+25}{273}\right) = 22.4\left(\frac{298}{273}\right) = 24.45\text{ lit/mol}$$

$$42 = \frac{\text{ppm}\times 64\times 10^3}{24.45}$$

SO_2 (in ppm) = 0.016 ppm

17. (d)

Given, Free chlorine residual = 0.2 mg/l

i.e. $[\text{HOCl}] + [\text{OCl}^-] = 0.2\text{ mg}/l$ ..(i)

$$\text{HOCl} \rightleftharpoons \text{H}^+ + \text{OCl}^-$$

$k = 2.7 \times 10^{-8}$

pH = 7.2

⇒ $[\text{H}^+] = 10^{-7.2}$

∴ $$k = \frac{[\text{H}^+][\text{OCl}^-]}{[\text{HOCl}]}$$

∴ $$\frac{[\text{OCl}^-]}{[\text{HOCl}]} = \frac{2.7\times 10^{-8}}{10^{-7.2}} = 0.4279$$

∴ From equation (i)

$$\left[\text{OCl}^-\right] + \frac{[\text{OCl}^-]}{0.4279} = 0.2$$

$[\text{OCl}^-] = 0.06\text{ mg}/l$

∴ $[\text{HOCl}] = 0.14\text{ mg}/l$

18. (b)

Given, Size of particle, d = 0.025 mm

G_S = 2.65

Dynamic viscosity of water, $\mu = 10^{-3}\text{ N-s/m}^2$

Surface overflow rate SOR = 0.065 cm/sec

∴ Settling velocity, $V_s = \frac{g}{18}(G_S - 1)\frac{d^2}{\nu} = \frac{9.81}{18}(2.65-1) \times \frac{(0.025 \times 10^{-3})^2}{\left(\frac{10^{-3}}{1000}\right)}$

$= 0.000562$ m/sec $\quad \left[\nu = \frac{\mu}{\rho}\right]$

%age of suspended particles likely to be settled in sedimentation tank i.e. efficiency of sedimentation tank

$$\eta = \frac{V_s}{V_0} \times 100 = \frac{0.000562}{0.065 \times 10^{-2}} \times 100 = 86.46\% \simeq 86\%$$

19. (c)

1. Circular sewer section are mostly used for separate sewage system. But the advantage of circular sewer is obtained only when the section runs atleast half full.
2. If a circular sewer is used for combined system. It will be effective only during maximum rain water flow, but during dry weather flow, velocity generated would be very less.

20. (b)

Nitrogen in any soluble from i.e. NH_3, NH_4^+, NO_2^- and NO_3^- excluding N_2 gas is a nutrient and may need to be removed from waste water to help control algal growth in the receiving body.

21. (a)

As per Chick's law,

$$\frac{N_t}{N_0} = e^{-kt}$$

98% killing of bacteria; $k = 3 \times 10^{-2}$ s^{-1}

i.e. $\quad \frac{N_t}{N_0} = 0.02$

$$0.02 = e^{-3 \times 10^{-2} \times t}$$

$$t = 130.4 \text{ sec} \simeq 2.17 \text{ min}$$

22. (a)

Total solids, $\frac{0.952}{1000} \times 10^6 = 952$ ppm

Fixed solium, $\frac{0.516}{1000} \times 10^6 = 516$ ppm

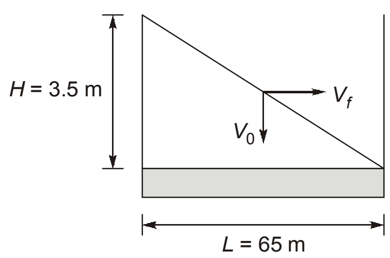
Volatile solids = $S_V = S_T - S_F = 952 - 156$
= 436 ppm

23. (b)

V_f = 1.22 cm/sec

G_S = 2.65

ν = 0.01 cm^2/sec



$$D_t = \frac{l}{V_f} = \frac{H}{V_0}$$

$$\frac{65}{1.22} = \frac{3.5}{V_0}$$

$$V_0 = \frac{3.5 \times 1.22}{65} = 0.065 \text{ cm/sec}$$

For 100% removal (let d (in cm) be the size of particle)

$$V_s = V_0$$

$$\frac{g}{18}(G_S - 1)\frac{d^2}{\nu} = V_0$$

$$\frac{981}{18}(2.65 - 1)\frac{d^2}{0.01} = 0.065$$

$$d = 0.0027 \text{ cm}$$

$$d = 0.027 \text{ mm}$$

24. (a)

Year	Population	Increase in population	%age inc.
1971	8,00,000	—	
1981	9,50,000	150000	$\frac{150000}{800000} \times 100 = 18.75\ (r_1)$
1991	11,20,000	170000	$\frac{170000}{950000} \times 100 = 17.89\ (r_2)$
2001	13,45,000	225000	$\frac{225000}{1120000} \times 100 = 20.09\ (r_3)$

∴ Average %age increase,

$$r = (r_1\, r_2\, r_3)^{1/3} = (18.75 \times 17.89 \times 20.09)^{1/3}$$

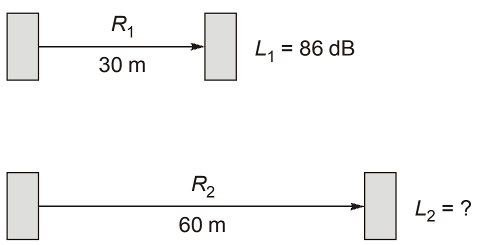
$$= 18.89\%$$

Population at the end of 2031 i.e. after 3-decades. As by geometrical increase method, we know that

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

$$P_2 = 13{,}45{,}000\left(1 + \frac{18.89}{100}\right)^3 = 2260259$$

25. (b)

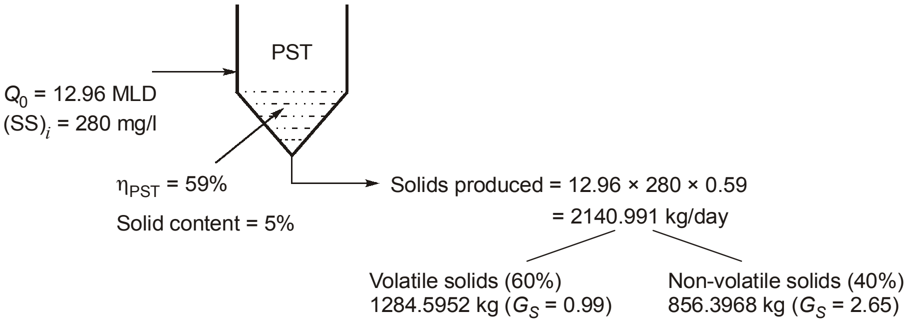


Since linear source,

$$\therefore \quad L_2 = L_1 - 10\log_{10}\left(\frac{R_2}{R_1}\right)$$

$$= 86 - 10\log_{10}\left(\frac{60}{30}\right) = 82.98 \text{ dB}$$

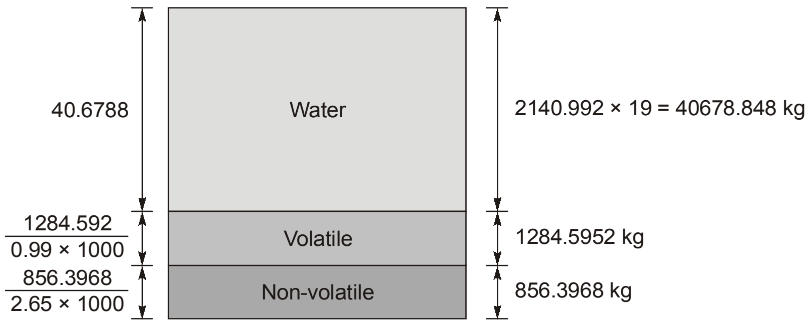
26. (a)



5 kg of solids $\simeq$ 100 kg of sludge

or, 5 kg of solids $\cong$ 95 kg of water

1 kg of solids $\cong$ 19 kg of water



$$\therefore \quad \text{Daily sludge volume production} = \left(40.6788 + \frac{1284.592}{0.99 \times 1000} + \frac{856.3968}{2.65 \times 1000}\right)$$

$$= 42.299 \simeq 42 \text{ m}^3$$

27. (a)

Given, Q_0 = 3.5 MLD

$(BOD)S_0$ = 130 mg/l

$(SS)_i$ = 150 mg/l

Dimension of aeration tank (30 m × 9 m × 4 m)

MLSS concentration X = 1800 mg/lit

$$\therefore \quad \text{BOD loading rate} = \frac{Q_0 S_0}{V} = \frac{3.5 \text{ MLD} \times 130 \text{ mg}/l}{\left(\frac{30 \times 9 \times 4}{10^4}\right)\text{ha-m}}$$

$$= 4212.96 \text{ kg/ha-m/day} \qquad (\text{MLD} \times \text{mg}/l = \text{kg/day})$$

29. (a)

Given, η (efficiency of high rate trickling filter) = 82%

Volume of filter, $V = 1365\ m^3 = 0.1365$ ha-m

Recirculation ratio, $R = 1.5$

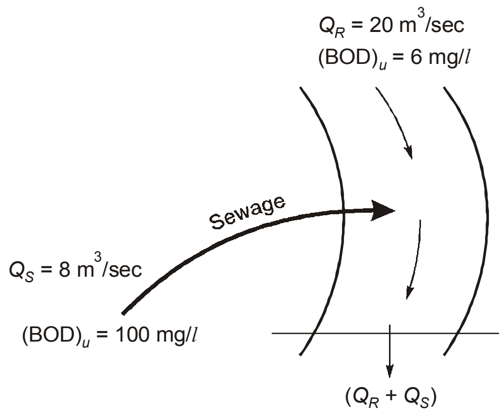
$$\eta = \frac{100}{1+0.0044\sqrt{\frac{w}{VF}}}$$

$$F = \frac{1+R}{(1+0.1R)^2} = \frac{1+1.5}{(1+0.1\times 1.5)^2} = 1.89$$

w = BOD_5 (in kg/day) entering the filter

w = 642.105 kg/day

30. (b)



Given, Cross section area of river = 80 m^2

∴ Velocity of river after mixing $V = \frac{(20+8)}{80} = 0.35$ m/sec

$$(\text{BOD})_{u,\text{ mix}} = \frac{Q_S(\text{BOD})_{uS} + (Q_R)\times(\text{BOD})_{uR}}{Q_S + Q_R}$$

$$(\text{BOD})_{u,\text{ mix}} = \frac{8\times 100 + 20\times 6}{8+20} = 32.86 \text{ mg}/l$$

Also, given BOD remaining in the river = 5 mg/l

$$l_t = l_0\, e^{-kt}$$

$$5 = 32.86\, e^{-0.252\times t}$$

$$t = 7.47 \text{ days}$$

∴ Distance after which BOD remaining (= 5 mg/l)

$$S = Vt$$

$$= \frac{0.35\times 7.47\times 86400}{1000} \text{ km} = 225.94 \text{ km}$$

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