CLASS TEST

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ENVIRONMENT ENGINEERING

CIVIL ENGINEERING

Date of Test : 08/04/2022

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)

$$\text{BOD}_5 = L(1 - 10^{-k_D \cdot t})$$
$$k_D = 0.434 \times k$$
$$= 0.434 \times 0.23 = 0.0998$$
$$\text{BOD}_5 = L(1 - 10^{-0.0998 \times 5})$$
$$L = \frac{230}{1 - 10^{-0.0998 \times 5}}$$
$$L = 336.73 \text{ mg}/l$$

3. (d)

Solid content = 3%

$\Rightarrow$ Water content = 97 %

and, $$\frac{100}{G_{\text{sludge}}} = \frac{\%\,\text{water}}{G_{\text{water}}} + \frac{\%\,\text{solid}}{G_{\text{solid}}}$$

$\Rightarrow$ $$\frac{100}{G_{\text{sludge}}} = \frac{97}{1} + \frac{3}{2.45}$$

$\Rightarrow$ $G_{\text{sludge}} = 1.018$

$\therefore$ Density of sludge $= 1.018 \times 1000 = 1018 \text{ kg/m}^3$

5. (c)

$$\text{Percent Removal} = \frac{MPN \text{ value before chlorination} - MPN \text{ value after chlorination}}{MPN \text{ value before chlorination}}$$
$$= \frac{10^5 - 10^3}{10^5} \times 100 = 99\%$$

7. (a)

When alum is added, CO_2 gas is involved which is responsible for reduction in pH as CO_2 leads to formation of carbonic acid.

9. (b)

$$S_y = n - S_R$$
$$= 40 - 15 = 25\%$$
$$= 0.25$$
$$\text{Change in storage} = S_y \times \text{Area} \times \text{Drop in the level of water}$$
$$= 0.25 \times 32 \times 1.2$$
$$= 9.6 \text{ ha-m}$$

10. (c)

The principal mechanism of particle removal is straining, and it will start when the filter is clean. The particles larger than the pore space of the filtering medium are strained out mechanically while smaller particles are tapped by chance contact.

Flocculation and sedimentation will follow straining. Finally when pore volume will reduce by biological growth, the biological action will take place.

11. (c)
Reverberation time is the time required to reduce the intensity to one-millionth of its initial value.

$$\text{Sound level (dB)} = 10 \log\left(\frac{I_1}{I_2}\right)$$

$$= 10 \log (10^6) = 60 \text{ dB}$$

TTS (Temporary Threshold Shift) is temporary impairment of hearing acuity as indicated by change in the threshold of audibility PTS (Permanent Threshold Shift) is related to permanent hearing loss. The sound foci are formed when sound waves are reflected from concave surface.

12. (c)
Step aeration: Influent addition at several intermediate points to provide more uniform BOD removal throughout tank. The return sludge is introduced at initial point.
Completely mix: Incoming waste and return sludge distributed uniformly.
Extended aeration: High hydraulic retention time compared to conventional plants.
Short term aeration: It is a part of combined aerobic treatment process called trickling filter/solids contact process. Herein short aeration periods are needed.

13. (a)
For a developing town average sewage flow will increase yearly. Also for combined sewers hourly fluctuation in discharge will be enormous. Egg shaped sewers maintain nearly uniform hydraulic depth and little higher velocities than provided by hydraulically equivalent circular sections at low discharge.

14. (b)

Sewage produced = 1200000 litres/day
5 day BOD of sewage = 210 ppm = 210 mg/litre
BOD of effluent = 22 mg/litre
∴ BOD removed by pond = (210 – 22) = 188 mg/litre
∴ BOD removed, per day = 1200000 × 188
= 225.6×10^6 mg = 225.6 kg

It is given that organic loading = 60 kg/ha/day

$$\therefore \quad \text{Required area} = \frac{\text{Sewage consumed}}{\text{Organic loading}} = \frac{225.5}{60} = 3.76 \text{ ha}$$

15. (d)

$$\frac{d}{D} = \frac{1}{2}\left(1-\cos\frac{\alpha}{2}\right) = 0.3$$

$$\alpha = 132.84°$$

$$\therefore \quad \frac{a}{A} = \left\{\frac{\alpha}{360°} - \frac{\sin\alpha}{2\pi}\right\}$$

$$\therefore \quad \frac{p}{P} = \frac{\alpha}{360°}$$

$$\frac{r}{R} = \frac{a/A}{p/P}$$

$$\therefore \qquad \frac{v}{V} = \frac{N}{n}\frac{r^{\frac{2}{3}}}{R^{\frac{2}{3}}}$$

Assuming n does not vary with depth, n = N

$$\text{So} \qquad \frac{v}{V} = \frac{r^{\frac{2}{3}}}{R^{\frac{2}{3}}} = \left[1-\frac{360° \sin\alpha}{2\pi\alpha}\right]^{\frac{2}{3}}$$

Discharge when running full Q = A × V

$$\therefore \qquad \frac{q}{Q} = \frac{a\times v}{A\times V} = \left[\frac{\alpha}{360°}-\frac{\sin\alpha}{2\pi}\right]\left[1-\frac{360° \sin\alpha}{2\pi\alpha}\right]^{\frac{2}{3}}$$

Putting α = 132.84° in above relation we get $\frac{q}{Q}$ = 0.196.

16. (b) $$P_S = \frac{2P_0P_1P_2 - P_1^2(P_0+P_2)}{P_0P_2 - P_1^2}$$

Here
$$n = 20 \text{ years}$$
$$P_0 = 50{,}000;\ P_1 = 1{,}10{,}000;\ P_2 = 1{,}60{,}000$$
$$P_S = \frac{2\times 50{,}000\times 1{,}10{,}000\times 1{,}60{,}000-(1{,}10{,}000)^2(50{,}000+1{,}60{,}000)}{50{,}000\times 1{,}60{,}000-(1{,}10{,}000)^2}$$
$$\approx 190488$$

17. (c)

Type 1: Discrete Settling: This corresponds to the sedimentation of discrete particles in a suspension of low solids concentration. This is also known as free settling since the particles have little tendency to flocculate or coalesce upon contact with each other.

Type 2: Flocculent settling: This type of settling refers to rather dilute suspension of particles that coalesce or flocculate during sedimentation process. Due to flocculation, particles increase in mass and settle at a faster rate.

Type 3: Hindered or zone settling: This type of settling refers to flocculent suspension of intermediate concentration. Inter particles forces hold the particles together and hence the mass of the particles subside as a whole.

Type 4: Compression settling: This refers to flocculent suspension of so high concentration that particles actually come in contact with each other, resulting in the formation of a structure. Further settling can occur only by compression of structure brought about due to weight of particles which are constantly being added to the structure.

18. (a)

$$L_{eq} = 10 \log \sum_{i=1}^{i=n} (10)^{\frac{Li}{10}} \times t_i$$

$$\sum_{1}^{3} (10)^{\frac{Li}{10}} \times t_i = \left[(10)^{\frac{80}{10}} \times \frac{10}{95} + (10)^{\frac{60}{10}} \times \frac{80}{95} + (10)^{\frac{100}{10}} \times \frac{5}{95} \right]$$

$$= 1.053 \times 10^7 + 0.842 \times 10^6 + 0.52632 \times 10^9$$

$$= 10^6 [10.53 + 0.84 + 526.32] = 537.69 \times 10^6$$

$\therefore$ $$L_{eq} = 10. \log_{10} (537.69 \times 10^6) = 87.3 \text{ dB}$$

19. (b)

$$\text{Total hardness} = [Mg^{+2}] \times \frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } Mg^{+2}} + [Ca^{+2}] \times \frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } Ca^{+2}} + [Al^{+3}] \times \frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } Al^{+3}}$$

$$= 18 \times \frac{50}{12} + 12 \times \frac{50}{20} + 27 \times \frac{50}{9}$$

$$= 75 + 30 + 150$$

$$= 255 \text{ mg/litre as } CaCO_3$$

Na^+, K^+ do not contribute in Hardness.

20. (c)

Total alkalinity in water consist of alkalinity caused by CO_3^{-2}, HCO_3^-, OH^-

[Cl^-, SO_4^{-2} do not contribute]

$\therefore$ $$\text{Total alkalinity} = [HCO_3^-] \times \frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } HCO_3^-} + [CO_3^{-2}] \times \frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } CO_3^{-2}}$$

$$= 183 \times \frac{50}{61} + 60 \times \frac{50}{60}$$

$$= 150 \text{ mg/litre} + 50 \text{ mg/litre}$$

$$= 200 \text{ mg/litre}$$

Carbonate hardness is equal to the total hardness or alkalinity whichever is less.
So carbonate hardness = 200 mg/litre
Non carbonate hardness = Total hardness – Carbonate hardness

$$= 255 - 200 = 55 \text{ mg/litre}$$

21. (c)

Volume of water sample = 20 ml

Given, volume of titrant, V = 10 ml

Normality, N = 0.01

$$\text{Total acidity} = \frac{V \times N \times \text{equivalent weight of } CaCO_3}{\text{Volume of water sample}} \times 1000$$

$$= \frac{10 \times 0.01 \times 50 \times 1000}{20} = 250 \text{ mg/}l$$

22. (a)

$$pH \text{ of incoming water, } (pH)_1 = 7.2$$

$$\Rightarrow \quad -\log_{10}[H^+]_1 = 7.2$$

$$\Rightarrow \quad [H^+]_1 = 10^{-7.2} \text{ moles}/l$$

$$pH \text{ of outgoing water } (pH)_2 = 8.4$$

$$\Rightarrow \quad -\log_{10}[H^+]_2 = 8.4$$

$$\Rightarrow \quad [H^+]_2 = 10^{-8.4} \text{ moles}/l$$

$$\text{Average value of } [H^+] = \frac{[H^+]_1 + [H^+]_2}{2} = \frac{10^{-7.2} + 10^{-8.4}}{2}$$

$$= 10^{-8.4}\left[\frac{10^{1.2}+1}{2}\right] = 8.42 \times 10^{-8.4} \text{ moles}/l$$

$$\text{Average value of } pH = -\log_{10}[8.42 \times 10^{-8.4}]$$

$$= -[\log_{10} 8.42 + \log_{10} 10^{-8.4}]$$

$$= -[0.925 + (-8.4)] = 7.475 \approx 7.48$$

23. (b)

Given,

$$\text{Diameter of bag, } D = 0.4 \text{ m}$$

$$\text{Length of bag, } L = 7 \text{ m}$$

$$\text{Cloth area required} = \frac{10 \text{m}^3/\text{s}}{2 \text{m/min}} = \frac{10}{2/60} = \frac{10 \times 60}{2} = 300 \text{m}^2$$

$$\text{Area of one bag} = \pi DL = \pi \times 0.5 \times 7 = 10.99 \simeq 11 \text{ m}^2$$

$$\text{Total no. of bags} = \frac{300}{11} = 27.3 \simeq 28$$

Use 28 number of bags.

24. (b)

Solids removed in primary clarification units of the trickling filter plant = 60% of the influent suspended solids.

$$= \frac{60}{100} \times 225 = 135 \text{mg}/l$$

$$= \frac{135 \times 10^{-6}}{10^{-3}} \text{kg/m}^3 = 135 \times 10^{-3} \text{ kg/m}^3$$

$$\therefore \quad \text{Solids removed per day} = (135 \times 10^{-3}) \times 1600 = 216 \text{ kg}$$

BOD_5 removed in primary clarification = 30%

$$\therefore \quad \text{BOD applied to filters} = 100 - 30 = 70\%$$

$$\therefore \text{Total BOD applied to filters} = \frac{70}{100} \times \frac{200 \times 10^{-6}}{10^{-3}} \times 1600 = 224 \text{ kg/day}$$

$$\text{Solid production in filters} = 0.5 \text{ kg/kg of BOD applied}$$

$$= 0.5 \times 224 = 112 \text{ kg/day}$$

$\therefore$ Total solid production = Solids removed in primary clarification + Solids produced in filters

$$= 216 + 112 = 328 \text{ kg/day}$$

25. (b)

$$\text{Overflow rate} = \frac{(10\times10^6)\times10^{-3}}{300\times24\times60\times60} = 3.858\times10^{-4} \text{ m/sec}$$

$$V_s = 418(2.65-1)(d^2)\left(\frac{3T+70}{100}\right)$$

Here, d = Diameter of particle (in mm)

T = Temperature (in °C)

V_S = Settling velocity in mm/sec

$$\Rightarrow \quad 0.3858 \text{ mm/sec} = 418(1.65)(d^2)\left(\frac{3\times26+70}{100}\right)$$

$$d = 0.019 \text{ mm}$$

26. (a)

Initial DO of the river = 12 mg/litre,

DO of mixture at, t = 0

$$DO_{mix} = \frac{2000\times12+250\times0}{2000+250} = 10.67 \text{ mg/litre}$$

$\therefore$ Initial oxygen deficit, D_0 = 12 – 10.67 = 1.33 mg/litre

5 day BOD of mixture of sewage and river water

$$C = \frac{C_SQ_S+C_RQ_R}{Q_S+Q_R} = \frac{250\times350+0\times2000}{2000+250} = 38.89 \text{ mg/litre}$$

Ultimate BOD of mixture, L = 1.5 × 38.89 = 58.34 mg/litre

Now,

$$\left(\frac{L}{fD_C}\right)^{f-1} = f\left[1-\frac{D_o}{L}(f-1)\right]$$

$$\Rightarrow \quad \left(\frac{58.34}{3\times D_C}\right)^2 = 3\left[1-\frac{1.33}{58.34}(3-1)\right]$$

$$D_C = 11.49 \text{ mg/litre}$$

27. (a)

In this disinfection process, we have the relationship,

$$tC^n = k$$

where, t = time required to kill all organisms

C = concentration of disinfectant

n = dilution coefficient

k = constant

$$\Rightarrow \quad t_1C_1^n = t_2C_2^n \quad \text{...(i)}$$

In our case, n = 1

$$t = \frac{L}{V}$$

L = length of pipe, V = velocity of flow

$$t = \frac{L}{Q/A} = \frac{L \times A}{Q}$$

$$C = \frac{W}{Q}$$

where, W = weight of disinfectant per day

Q = discharge per day

Keeping C and t in equation (i),

$$\Rightarrow \quad \frac{L \times A}{Q_1} \times \frac{W_1}{Q_1} = \frac{L \times A}{Q_2} \times \frac{W_2}{Q_2}$$

$$\Rightarrow \quad W_2 = \frac{Q_2^2}{Q_1^2} \times W_1 = \left(\frac{28}{22}\right)^2 \times 40 \text{ kg/d} = 64.79 \text{ kg/day}$$

28. (c)

Daily water demand of filtered water = 105% of water required daily (5% more for backwashing)

$$= \frac{105 \times 345000 \times 225}{100} = 81.5 \text{ MLD}$$

Effective time for working of filter units = 24 – backwashing time (0.5 hours) = 23.5 hours

$\therefore$ Water filtration required per hour $= \frac{81.5}{23.5} = 3.468$ ML/h

Now, filtration rate = 15 $m^3/m^2/h$

$$\therefore \quad \text{Area of filter required} = \frac{\left[\frac{3.468 \times 10^6}{10^3}\right]}{15} = 231.2 \text{ m}^2$$

Area of one filter unit = 50 m^2

$\therefore$ Number of units required $= \frac{231.2}{50} = 4.624$ say 5 units

Using one filter unit as standby unit, so total number of filters required = 5 + 1 = 6

29. (b)

Let its volume be V_1 at a moisture content of P_1(%) and V at a moisture content of P (%)

$$\therefore \quad V(100 - P) = V_1(100 - P_1)$$

$$\Rightarrow \quad 20(100 - 96) = V_1 \times 20$$

$$\Rightarrow \quad V_1 = \frac{20 \times 4}{20} = 4.0 \text{ m}^3$$

30. (c)

$$\text{Solid content} = 4.5\%$$

$$\text{Water content} = 100 - 4.5 = 95.5\%$$

$$\frac{100}{S_{sludge}} = \frac{\%\,\text{Water}}{S_{water}} + \frac{\%\,\text{Solid}}{S_{solid}}$$

$$\Rightarrow \quad \frac{100}{S_{sludge}} = \frac{95.5}{1} + \frac{4.5}{2.35}$$

$$\Rightarrow \quad S_{sludge} = 1.02654$$

$$\therefore \quad \rho_{sludge} = 1.02654 \times 1000 = 1026.54 \text{ kg/m}^3$$

$$\text{After thickening, } V_2 = \frac{V_1}{2}$$

$$\Rightarrow \quad V_2 = \left(\frac{100 - P_1}{100 - P_2}\right) \times V_1$$

$$\Rightarrow \quad \frac{V_1}{2} = \left(\frac{100 - 95.5}{100 - P_2}\right) \times V_1$$

$$\Rightarrow \quad 100 - P_2 = 200 - 191$$

$$\Rightarrow \quad P_2 = 91\%$$

$$\therefore \quad \text{Solid content} = 100 - 91\% = 9\%$$

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