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Environmental Engineering

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Environmental Engineering

Date of Test : 24/05/2019

Answer Key

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

DETAILED EXPLANATIONS

3. (b)

When bacteria are introduced into a synthetic liquid medium, reproduction takes place by binary fission, each cell divides producing two new cells, the increase in population follows geometric progression.

7. (d)

Sludge volume index, $SVI = \dfrac{200}{\left(\dfrac{4000}{1000}\right)} = 50 \text{ m}l/\text{gm}$

8. (a)

Given: $TH = 200$ mg/L as $CaCO_3$

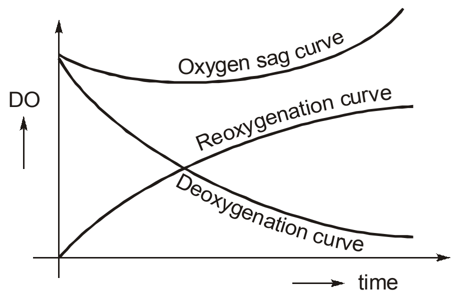
Alkalinity $= 260$ mg/L as $CaCO_3$

∴ Carbonate hardness $CH = $ minimum (TH, alkalinity)

$= 200$ mg/L as $CaCO_3$

$\Rightarrow$ $NCH = 0$

9. (a)



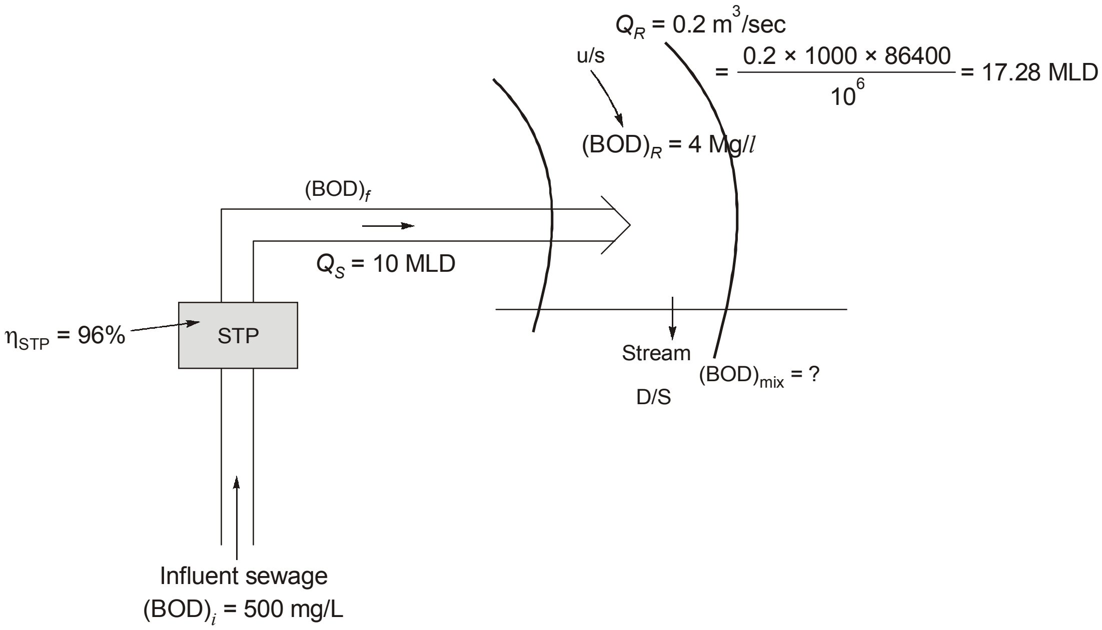
10. (c)

Global Warming : As the concentration of CO_2 keeps increasing, more and more heat will be built up in the atmosphere and on Earth's surface. Thus, the atmospheric temperature will increase due to the effect of green house.

Acid Rain : Acid rain results when gaseous emissions of sulphur oxides (SO_x) and nitrogen oxides (NO_x) interact with water vapour and sunlight and are chemically converted to strong acidic compound (H_2SO_4 and HNO_3).

11. (c)

Given, as per question



$$Q_s = 10 \text{ MLD}$$

$$(\text{BOD})_i = 500 \text{ mg}/l$$

$$\eta_{STP} = \frac{(\text{BOD})_i - (\text{BOD})_f}{(\text{BOD})_i} \times 100$$

$$96 = \frac{500 - (\text{BOD})_f}{500} \times 100$$

$$(\text{BOD})_f = 20 \text{ mg}/l$$

BOD of stream on D/S

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

$$= \frac{10 \times 20 + 17.28 \times 4}{17.28 + 10} = 9.865 \simeq 9.87 \text{ mg}/l$$

12. (d)

Combined sewer is designed for maximum sewage discharge and the maximum runnoff discharge and the maximum run off discharge under designed condition, sewer is assumed to be run full.

∴
$$Q_{s,(peak)} = 3 \times Q_{DWF}$$

$$= 3\,(50{,}000 \times 135 \times 0.75) = 15187500 \text{ lit/day}$$

$$= \frac{15187500 \times 10^{-3}}{86400} = 0.175 \text{ m}^3/\text{sec}$$

Storm water peak flow rate (i.e. maximum runoff discharge)

$$Q_{runoff(paek)} = \frac{1}{36} P_c\, k.A$$

$$A \text{ (in ha)} = 80 \text{ ha}$$

$$P_c\text{(in cm/hr)} = 1.6\text{ cm/hr}$$
$$k = 0.7$$
$$Q_{R,\text{(peak)}} = \frac{1}{36}\times 0.7\times 1.6\times 80 = 2.488\text{ m}^3\text{/sec}$$
$$\therefore \quad Q_{\text{design}} = Q_{S\text{ (peak)}} + Q_{R\text{ (peak)}} = 0.175 + 2.488 = 2.663 \simeq 2.66\text{ m}^3\text{/sec}$$

13. (d)

Given,
$$Q = 30{,}000\text{ m}^3\text{/d}$$
$$\text{Dose of alum} = 35\text{ mg/L}$$
$$\text{Detention time, } D_t = 2\text{ min}$$
$$\text{depth of tank} = 1.5\text{ m}$$
$$\mu = 1\times 10^{-3}\text{ N-s/m}^2$$
$$G = 900\text{ s}^{-1}$$
$$\text{Volume of tank} = Q\times D_t$$
$$V = 30{,}000\times\frac{2}{60\times 24} = 41.66\text{ m}^3$$
$$\therefore \text{ Power, } P = \mu\,.\,VG^2 \qquad \left[G = \left(\frac{P}{\mu V}\right)^{1/2}\right]$$
$$= 1\times 10^{-3}\times 41.66\times (900)^2 = 33750\text{ Watt}$$

14. (c)

Since growth of population is exponential

i.e.
$$\frac{dp}{dt} \propto p$$
$$\frac{dp}{dt} = RP \qquad (R = \text{growth rate})$$
$$\int_{P_1}^{P_2}\frac{dp}{p} = \int_{t_1}^{t_2} R\,dt$$
$$[ln\,P]_{P_1}^{P_2} = R[t]_{t_1}^{t_2}$$
$$ln(P_2) - lnP_1 = R\,(t_2 - t_1)$$
$$ln\left(\frac{P_2}{P_1}\right) = R\,(t_2 - t_1)$$
$$\frac{P_2}{P_1} = e^{R(t_2 - t_1)}$$

Given, P_2 = 4 billion, P_1 = 0.5 billion, $(t_2 - t_1)$ = 300 yrs

$$\therefore \quad \frac{4}{0.5} = e^{R(300)}$$
$$\therefore \quad R(300) = ln = 2.079$$
$$R = \frac{2.079}{300} = 6.93\times 10^{-3}\text{ per yr} = 0.693/100\text{ yr}$$

15. (b)

$$1\ \mu g/m^3 = \frac{\text{ppm} \times \text{mol.wt.} \times 10^3}{\text{volume of T°C (in lit/mol)}}$$

$$V_2 = V_1\left(\frac{273+T_2}{273}\right)$$

$T_1 = 0°C$, $V_1 = 22.4$ lit/mol, $T_2 = 25°C$

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

$$\text{CO (in ppm)} = 9$$

$$\text{Mol. wt. of CO} = 28 \text{ gm}$$

$$\therefore \quad \text{CO } (\mu g/m^3) = \frac{9 \times 28 \times 1000}{24.45} = 10306.74 \simeq 10307$$

16. (b)

Anaerobic treatment of complex wastes involves three stages. In the first stage organic matter is hydrolyzed particle matter converted into soluble compounds. In the second stage (known as acid fermentation) complex organic materials are broken down mainly to short chain acids and alcohols. In the third stage (known as methane fermentation), these materials are converted to gases, primarily methane and carbon-dioxide.

17. (a)

From Manning's formula

As we know that

$$v = \frac{1}{n}.R^{2/3}.s^{1/2}$$

Case-I

$$\text{diameter} = 300 \text{ mm}$$

$$\text{slope} = \frac{1}{400}$$

Flowing full,

$$R = \frac{D}{4}$$

$$v = 0.7 \text{ m/sec}$$

$$v = \frac{1}{n}\left(\frac{D}{4}\right)^{2/3}.(s)^{1/2}$$

$$v = \frac{1}{n}\left(\frac{300}{4}\right)^{2/3}.\left(\frac{1}{400}\right)^{1/2} = 0.7 \qquad \text{...(i)}$$

Case-II

$$\text{diameter} = 600 \text{ mm}$$

$$\text{slope} = \frac{1}{200}$$

Flowing half full,

$$R = \frac{D}{4} \qquad \text{(for half full)}$$

$$v = \frac{1}{n}\left(\frac{600}{4}\right)^{2/3}\left(\frac{1}{200}\right)^{1/2} \qquad \text{...(ii)}$$

By solving equation (i) and (ii)

$$\frac{v}{0.7} = \frac{(150)^{2/3}\left(\frac{1}{200}\right)^{1/2}}{(75)^{2/3}\left(\frac{1}{400}\right)^{1/2}}$$

$$v = 1.57 \text{ m/sec}$$

18. (c)

$$\text{Molecular weight of } H_2SO_4 = 2 \times 1 + 32 + 4 \times 16 = 98 \text{ gm}$$

$$\text{No. of moles of } H_2SO_4 \text{ in litre of solution} = \frac{100 \times 10^{-3}}{98 \times 1} = 1.02 \times 10^{-3} \text{ moles/lit}$$

The reaction is

$$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$$

∴ 1 moles of H_2SO_4 = 2 moles of H^+

$$\therefore \quad [H^+] = 2 \times 1.02 \times 10^{-3} \text{ M} = 2.04 \times 10^{-3} \text{ M}$$

$$\therefore \quad pH = -\log [H^+] = -\log [2.04 \times 10^{-3}] = 2.69 \simeq 2.7$$

19. (b)

Energy (ash) free dry basis

$$= \text{Energy (as discarded)} \times \frac{100}{100 - \%ash - \%m.c}$$

$$= 12000 \times \frac{100}{100 - 4 - 18} = 15384.62 \text{ kJ/kg}$$

20. (a)

$$\text{Molecular weight of glumatic acid} = 5 \times 12 + 9 \times 1 + 4 \times 16 + 14 = 147 \text{ gm}$$

$$\text{Total oxygen used in the reaction} = 6.5 \times 32 = 208 \text{ gm}$$

∴ 147 gm of glumatic acid requires 208 gm of oxygen

$$\text{ThoD} = 63 \times \frac{208}{147} = 89.14 \text{ mg}/l \simeq 89 \text{ mg}/l$$

21. (c)

1. Anaerobic reactions are more complex because they occur in two stages carried out by different species of bacteria.
2. Acid forming bacteria initially convert complex organics into organic acids and alcohols.
3. The end product of anaerobic reactions still contain considerable amount of energy, notably in methane.

22. (c)

Catabolic reactions are those in which food is broken down to release energy.

The end products of aerobic catabolism are low-energy, stable compounds with most of the energy being stored in cellular material.

23. (b)

$$TH_{(\text{in mg}/l \text{ as } CaCO_3)} = Ca^{2+} \times \frac{50}{20} + Mg^{2+} \times \frac{50}{12} + Sr^{2+} \times \frac{50}{43.8}$$

$$T_H = 180 = x \times \frac{50}{20} x \times \frac{50}{12} + x \times \frac{50}{43.8}$$

$$x = 23.05 \text{ mg/lit}$$

24. (a)

Total average demand = $50,000 \times 180 = 9 \times 10^6$ l/day

q = 9 MLD

∴ Maximum daily demand = $1.8q = 1.8 \times 9 = 16.2$ MLD

(Q) Rate of filtration, f_r = 150 lit/hr/m²

$$\therefore \text{Total area of filters, } A = \frac{Q}{f_r} = \frac{16.2 \times \frac{10^6}{24} \text{ lit/hr}}{150 \text{ lit/hr/m}^2} = 4500 \text{ m}^2$$

Area of each filter unit = 750 m²

$$\therefore \text{No. of working units required} = \frac{4500}{750} = 6$$

∴ Total no. of filter units required keeping one unit as stand by = 6 + 1 = 7

25. (a)

Chloro-organics and chloramines are get destructed and bad smell suddenly disappears. Any further chlorine addition simply appears are free chlorine. This point is called break point.

26. (a)

Surface area, A = 100 m²

Discharge Q = 20 MLD

$$\therefore \text{Overflow rate } V_0 = \frac{20 \times 10^3}{86400 \times 100} \text{ m/sec} = \frac{1}{432} \text{ m/sec}$$

$= 0.231 \text{ cm/sec} \simeq 0.23 \text{ cm/sec}$

Size	Quantity	V_s (settling velocity) cm/sec	%age removal $\eta = \frac{V_s}{V_0} \times 100$
0.1	10%	0.08	$\frac{0.08}{0.23} \times 100 = 34.78\%$
0.2	30%	0.22	$\frac{0.22}{0.23} \times 100 = 95.65\%$
0.3	20%	0.38 > 0.23	100%
0.4	15%	0.49 > 0.23	100%
0.5	25%	0.62 > 0.23	100%

$$\therefore \text{Overall efficiency of sedimentation tank} = \frac{\text{Total weight settled}}{\text{total weight entered}} \times 100$$

$$= \frac{(0.1 \times 0.3478 + 0.3 \times 0.9565 + 0.2 \times 1 + 0.15 \times 1 + 0.25 \times 1)W}{W} \times 100$$

= (0.9217 × 100) = 92.17%

27. (a)

Given, $(\text{BOD})_{5\text{day}}$ = 150 mg/l at 20°C

k(base 10) = 0.2 d⁻¹

$$\text{To find (BOD)}_{8\text{day}} = \text{? at } 15°\text{C}$$
$$\text{Temperature coefficient} = 1.145$$
$$Y_5 = l_0 (1 - 10^{-K_D t})$$
$$50 = l_0 (1 - 10^{-0.2\times5})$$
$$l_0 = \frac{150}{1-10^{-1}} = 166.67 \text{ mg/lit}$$
$$K_{D(T=15°C)} = K_{D(T=20°C)} (1.145)^{T-20}$$
$$= 0.2 (1.145)^{15-20} = 0.1016 \text{ d}^{-1}$$

8 day BOD

$$\therefore \quad Y_8 = l_0 (1 - 10^{-K_D \times 8})$$
$$= 166.67 (1 - 10^{-0.1016\times8}) = 141.03 \text{ mg/lit}$$

28. (b)

The settling/sedimentation involved in row and waste waters has generally been divided into following four types.

Type-1 settling : This type of settling refers to the settling of discrete particles, such as removal of grit and sand from row waters, containing low concentration of solids. The settling of discrete particles in dilute concentrations is this covered under this type of settling.

Type-2 settling : This type of settling refers to the settling of flocculent particles in rather dilute suspensions.

Type-3 settling : This type of settling, called hindered or zoned settling, involves the settling of flocculent particles in concentrated suspensions.

Type-4 settling : When solids are present in excessive concentrations there by forming a structure or sludge blanket such as at the bottom of a deep secondary settling tank or in a sludge thicker unit, the settling occurs only by compression caused by the weights of the particles which are constantly being added to the structure by settling from the supernatant liquid.

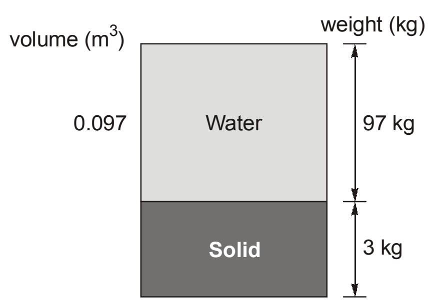
29. (d)

$$L_{eq} = 10 \log . \Sigma\, 10^{L_i/10} \times t_i$$
$$= 10\log\left[10^{50/10}\times\frac{55}{60}+10^{90/10}\times\frac{5}{60}\right]$$
$$= 79.2 \text{ dB}$$

30. (c)

Solid content = 3%

⇒ 3 kg of solids make 100 kg of sludge



$$V_s = \frac{W_s}{G_s P_w} = \frac{3}{2.45\times1000}$$
$$= 1.224 \times 10^{-3}$$
$$\therefore \quad P_{sludge} = \frac{100}{\left(0.097+1.224\times10^{-3}\right)}$$
$$= 1018 \text{ kg/m}^3$$

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